

2

Body Fluids and Electrolytes

- Very important
- Extra information
- Terms

عن أبي هريرة أن رسول الله صلى الله عليه وسلم قال: (إذا مات الإنسان انقطع عنه عمله إلا من ثلاثة إلا من صدقة جارية أو علم ينتفع به أو ولد صالح يدعو له) صحيح مسلم



Objectives :

- **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 (ECF), interstitial fluid, trans-cellular fluid and total body water (TBW).**
- **Describe the composition of each fluid compartment, in terms of volume and ions and represent them in graphic forms.**
- **Physiology factor influencing body fluid: age, sex, adipose tissue, etc. Pathological factors: Dehydration, fluid infusion.**

Composition of the human body

1- Body water

Human body contain
50-70% water.

Example :
70 kg man has 42 L of
water.

2- Protein

Is the second largest
component in the
human body,
largest amount found
in skeletal muscle.

3- Fat

The third largest
component in lean
individual. It is found
in adipose tissue.

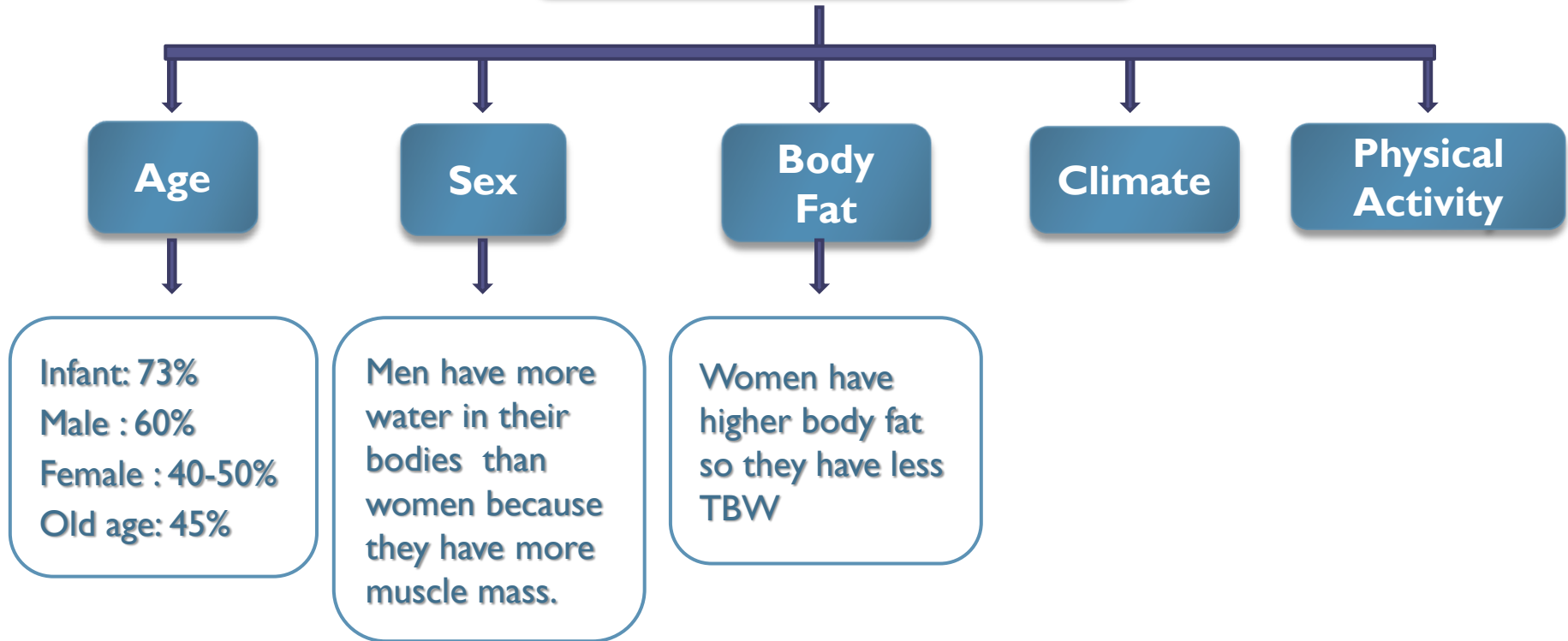
4- Minerals

present in the human body in relatively small quantities with the exception
of calcium. Found in bones

Minerals and electrolytes are found in the body fluids in minute
concentrations, which are closely regulated to maintain the composition of
the internal environment

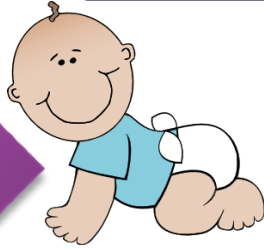
Factors that affect Total Water in our bodies (TBW) :

Physiological factors



Physiological factors:

**Low body fat
Low bone mass
73% or more water**



**Higher body fat
Smaller amount of
skeletal muscles
40-50% water**



**60% of body weight
is water**



**Only about 45% of
body weight is
water**



Pathological factors

- Vomiting
- Diarrhea
- Diseases with excessive loss of water (DM, excessive sweating).
- Blood loss

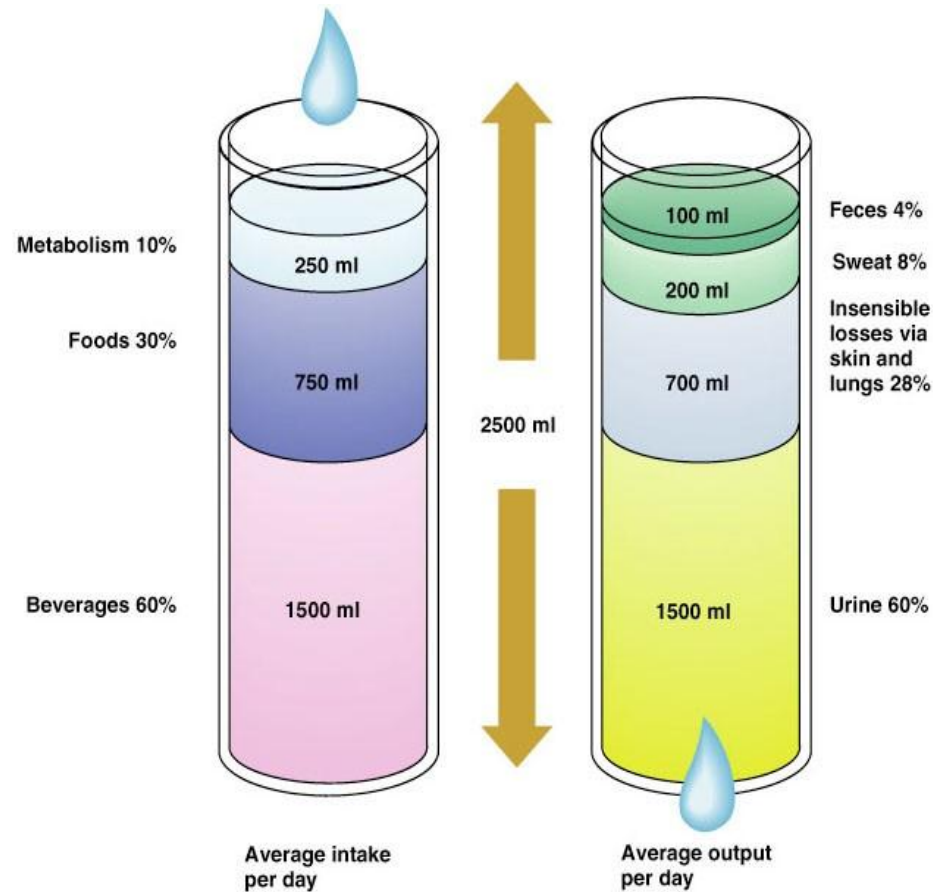
The TBW is distributed as follows:

- Muscle (50%)
- Skin (20%)
- Other organs (20%)
- Blood (10%)

Daily intake of water :

Steady state : water intake = water loss

| | 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 |



Output:

1) Insensible Water loss: (700 ml) Termed insensible water loss because we are not consciously aware of it.

-Via skin(350 ml) a sweating through evaporation (present even in people who are born without sweat gland)

-Via respiratory tract(350 ml)

2) Fluid loss is sweat.(100ml) by sweat gland

3) Water loss is Feces.(100ml)

4) Water loss by the kidney. (1400ml)

Regulation of water intake :

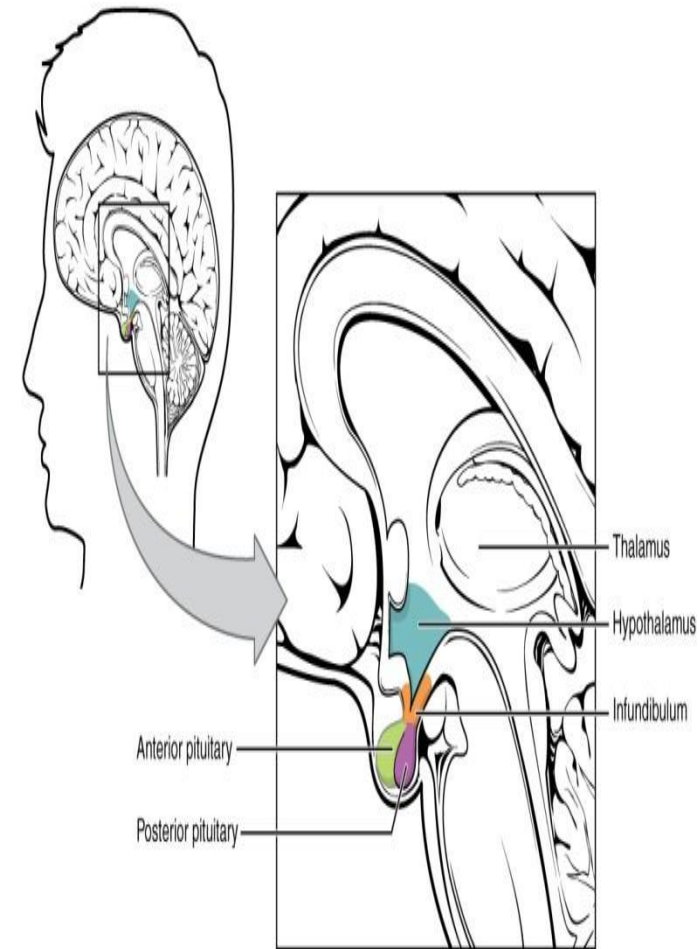
1. Climate
2. Habits
3. Level of physical activity.

- The hypothalamic **thirst center** is stimulated:

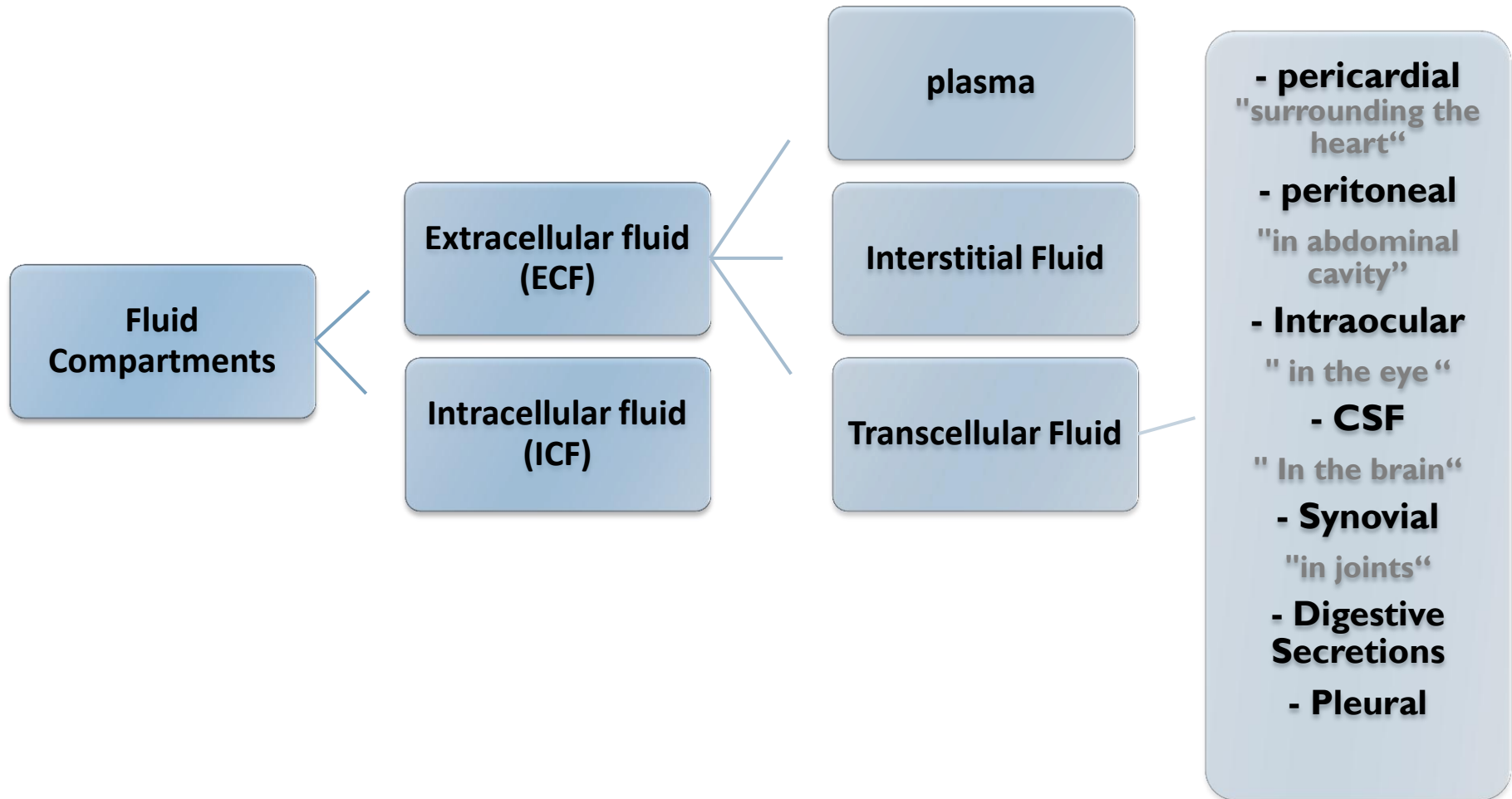
- By a **decline** in plasma volume of 10%–15%
- By **increases** in plasma osmolality of 1–2%

More explanation:

If there is decline or a decrease in the plasma volume by 10-15% , **the thirst center** in the **hypothalamus** will be stimulated

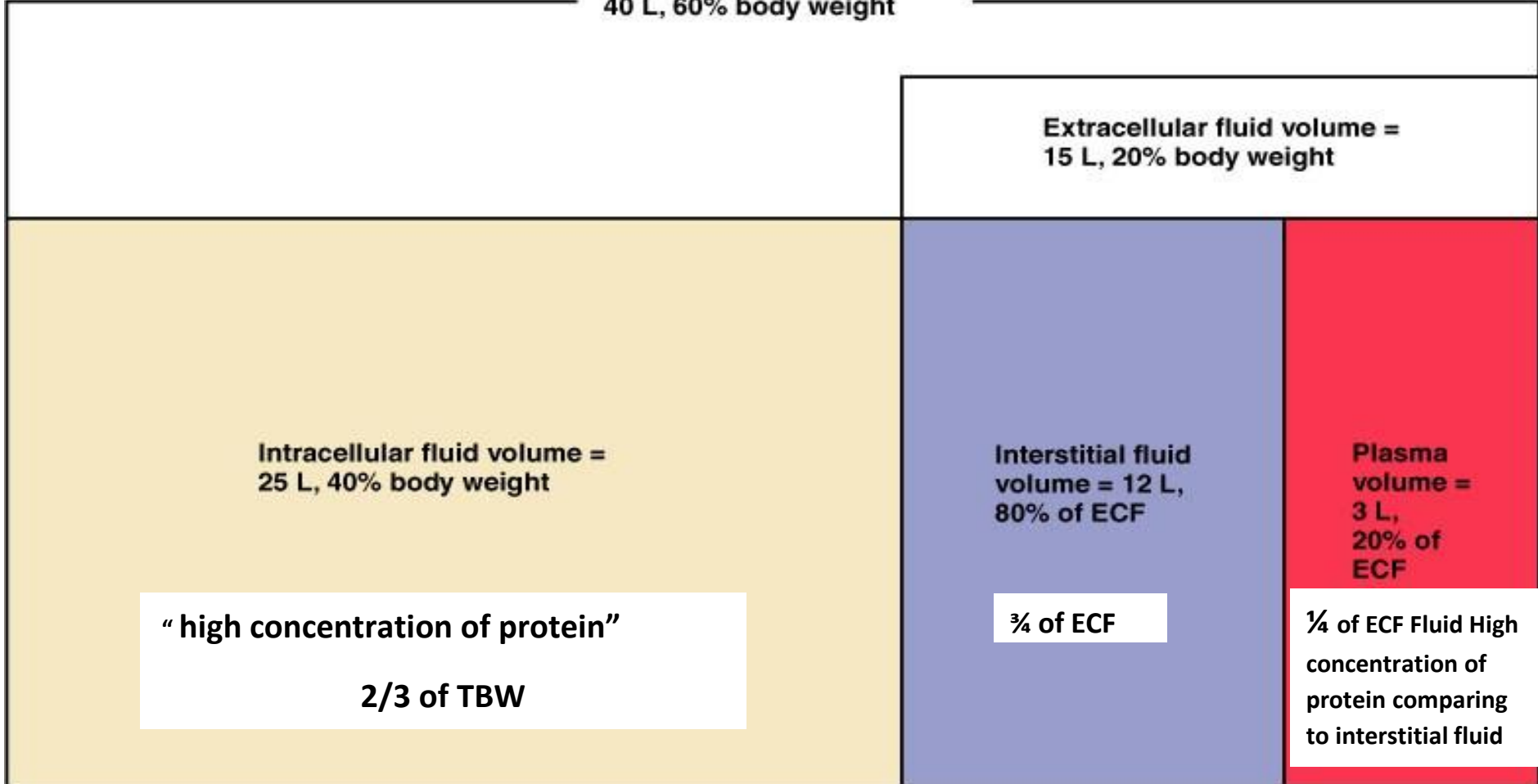


Fluid Compartments



Fluid Compartments

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



The water content of the body is divided into two compartments :

1) Intracellular compartment:

Contained within the cell, represent approximately 67% of the total body water, 40% of total body weight.

2) Extracellular Compartment:

Contained within the vessels of the cardiovascular system, is the remaining 33% of the total body water, about 20 % of total body weight.

Extracellular fluid

1- Plasma :

- Fluid circulating in the blood vessels.
- Blood volume, approximately 80 ml/kg of body weight (8%).

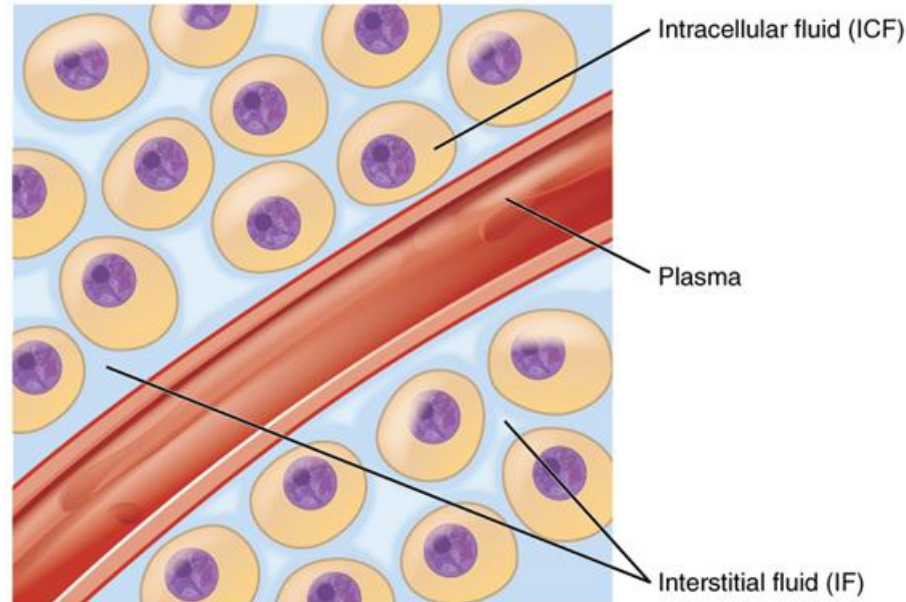
2- Interstitial fluid :

- Fluid bathing the cell .
- Ultra filtration of plasma .
- contained in a gel-like extracellular matrix .
- surrounds all cells except blood cells .

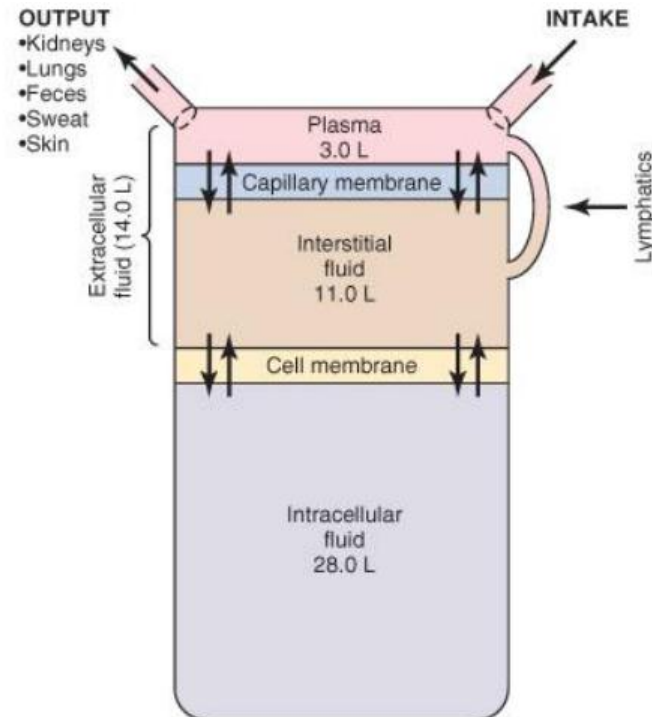
Note: Plasma and interstitial fluid are almost having the same composition **except for high protein concentration** in plasma.

3- Transcellular fluid volume :

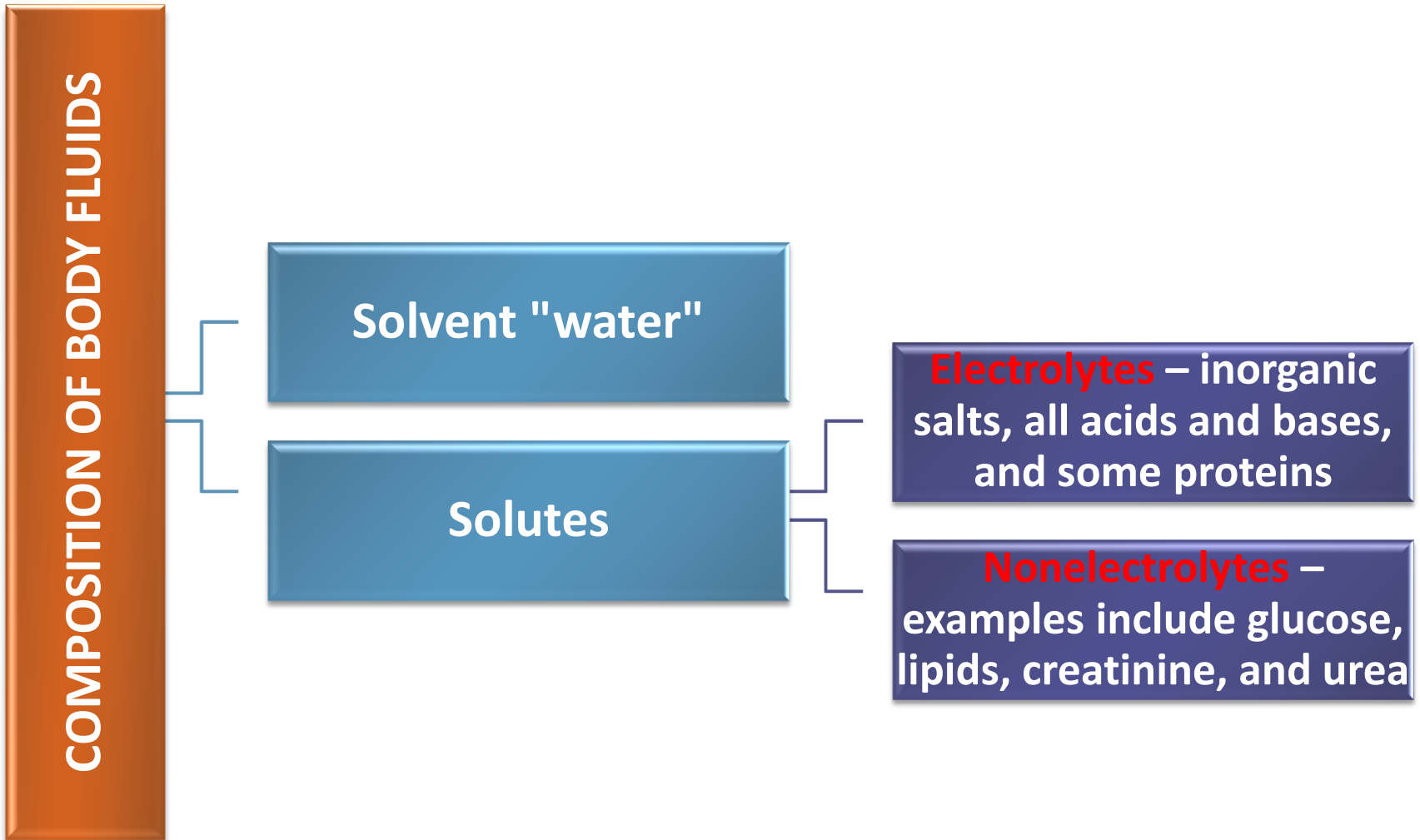
- small amount.
- Represents fluid in the lumen of structures lined by epithelium and includes digestive secretions, sweat, CSF, pleural, peritoneal, synovial, intraocular, pericardial fluids, bile, thyroid, and cochlea.



- The plasma and interstitial fluid are separated only by highly permeable **capillary membranes**, their ionic composition is similar but protein is higher in the plasma.
- The intracellular fluid is separated from extracellular fluid by a **cell membrane** that is highly permeable to water but not to most of the electrolytes in the body.



© Elsevier. Guyton & Hall: Textbook of Medical Physiology 11e - www.studentconsult.com



Composition of the body fluids

Extracellular fluids :

- Sodium is the chief cation(+) "Na"

- Chloride is the chief anion (-) "Cl"

Intracellular fluids :

- Potassium is the chief cation(+) "K"

- Phosphate is the chief anion(-)

| | 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) |

Calcium , chloride , sodium , protein , phosphate , potassium , glucose
"IMPORTANT"



Electroneutrality :

Each compartment must have almost the same concentration of positive charge (cations) as of negative charge (anion).

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 |

“We can see that the ECF and ICF have the same osmolality”.

Clinical abnormalities of fluid volume regulation

Abnormalities related to potassium ion

Hypokalemia decrease in K concentration in ECF. 1-2 mEq/L

Hyperkalemia increase in K 60-100% above normal

Abnormalities related to Sodium ion

Hyponatremia decrease in Na concentration in ECF

Hypernatremia increase in Na concentration in ECF



[Click here](#) and check your understanding !

Physiology Team

- خولة العماري
- الهنوف الجلعود
- إلهام الزهراني
- رغد النفيسة
- نورة القحطاني
- منيرة الحسيني
- منيرة السلولي
- ريم البهلال
- عريب العقيل
- ملاك الشريف
- منيال باوزير
- فتون الصالح
- عمر العتيبي
- رواف الرواف
- حسن البلادي
- عمر الشهري
- عادل الشهري
- عبدالله الجعفر
- عبدالرحمن البركة
- خليل الدريبي
- عبدالعزيز الحماد
- عبدالعزيز الغنايم
- عبدالمجيد العتيبي
- عبدالعزيز رضوان