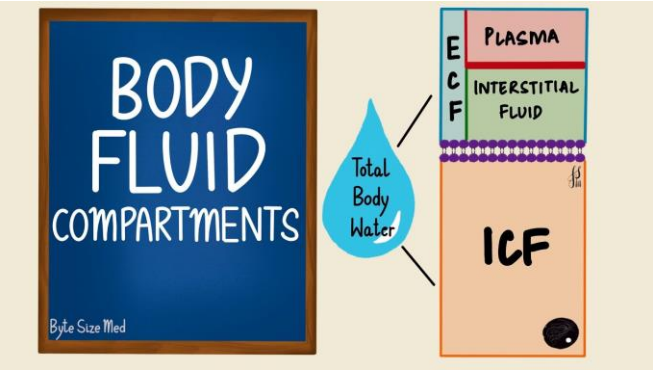
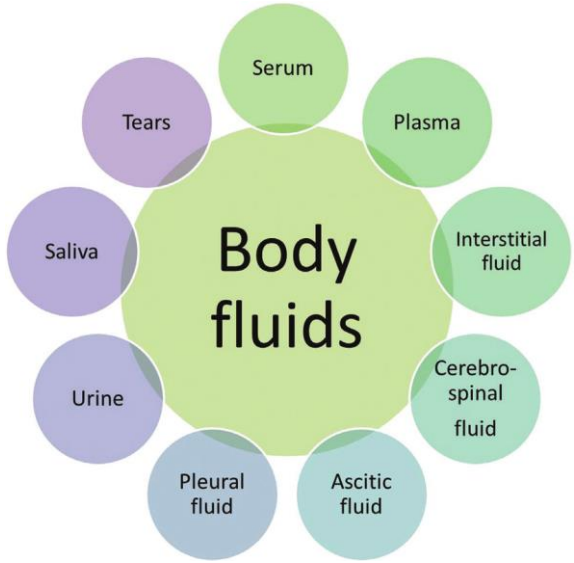
Ashur University
College of Medicine

Grade 2
Neuroscience

Physiology of body fluids

Lecture 1





Ass. Professor Internal Medicine

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05/10/2024

Objectives

- Describe the Daily Intake of Water.
- Describe the Daily Loss of Body Water.
- Explain the Body Fluid Compartments.
- Describe the Regulation of Fluid Exchange and Osmotic Equilibrium Between Intracellular and Extracellular Fluid.
- Define Osmolality and Osmolarity.

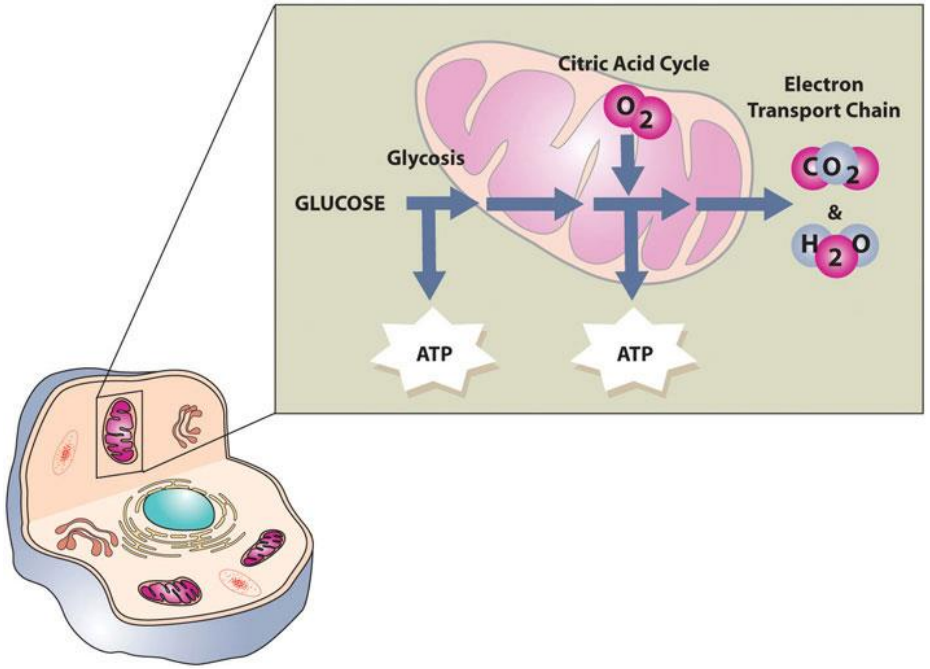
Daily Intake of Water

Water is added to the body by **two major sources**:

(1) Water is **ingested in the form of liquids or water in the food**, which together normally add **about 2100 ml/day** to the body fluids.

(2) it is **synthesized in the body** as a result of oxidation of carbohydrates, adding **about 200 ml/day**. This provides a **total water intake of about 2300 ml/day**. Intake of water, is highly variable among different people and even within the same person on different days, depending on climate, habits, and level of physical activity.





Daily Loss of Body Water

(1) Insensible Water Loss

(2) Fluid Loss in Sweat

(3) Water Loss in Feces

(4) Water Loss by the Kidneys

Average DAILY WATER LOSS	
Kidneys	1.5 L
Respiratory tract	0.4 L
Gastrointestinal tract	0.2 L
Skin	0.5 L
TOTAL	2.6 L

(1) Insensible Water Loss

There is a continuous loss of water by: **evaporation from the respiratory tract** and **diffusion through the skin**, which together account for **about 700 ml/day** of water loss under normal conditions. This is termed **insensible water loss** because we are not consciously aware of it, even though it occurs continually in all living humans .The average **water loss by diffusion through the skin is about 300 to 400 ml/day**. This loss is minimized by the cholesterol-filled cornified layer of the skin, which provides a barrier against excessive loss by diffusion.

When the cornified layer becomes denuded (damaged or removed)as occurs with extensive burns the rate of evaporation can increase as much as 10-fold,

to 3 to 5 L/day.

- **Insensible water loss through the respiratory tract** averages about **300 to 400 ml/day.**

(2) Fluid Loss in Sweat : The amount of water lost by sweating is highly variable, depending on physical activity and environmental temperature.

The volume of sweat normally is about 100 ml/day, but in very hot weather or during heavy exercise, water loss in sweat occasionally increases to 1 to 2 L/hour.

(3) Water Loss in Feces: Only a small amount of water **100 ml/day** normally is lost in the feces. This can increase to several liters a day in people with severe diarrhea.

(4) Water Loss by the Kidneys : occurs in the urine excreted by the kidneys.

For example, urine volume can be as **low as 0.5 L/day** in a dehydrated person or as **high as 20 L/day** in a person who has been drinking tremendous amounts of water.

Table : Daily Intake (Input) and Output of Water (ml/day)

Intake or Output	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

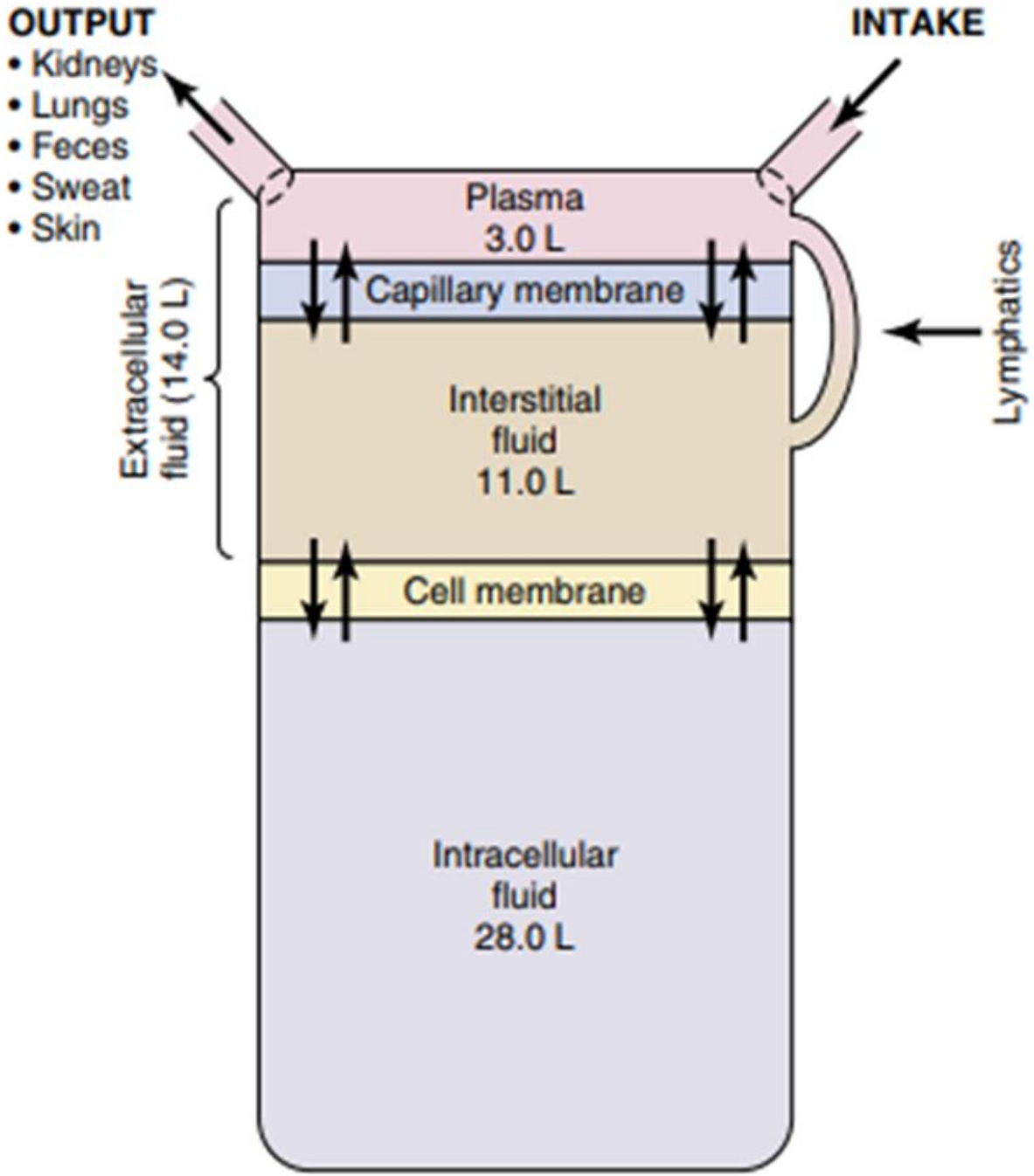
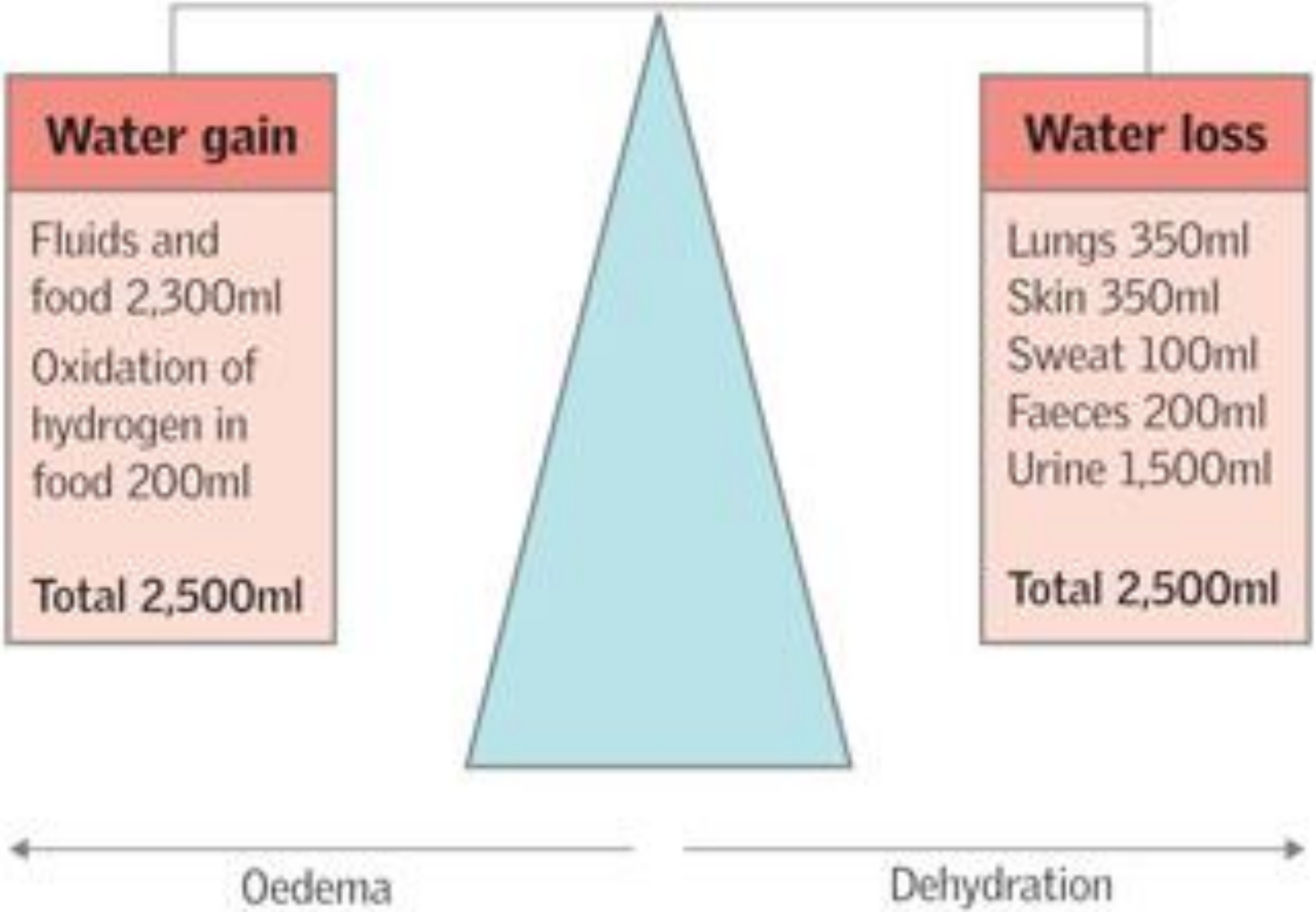
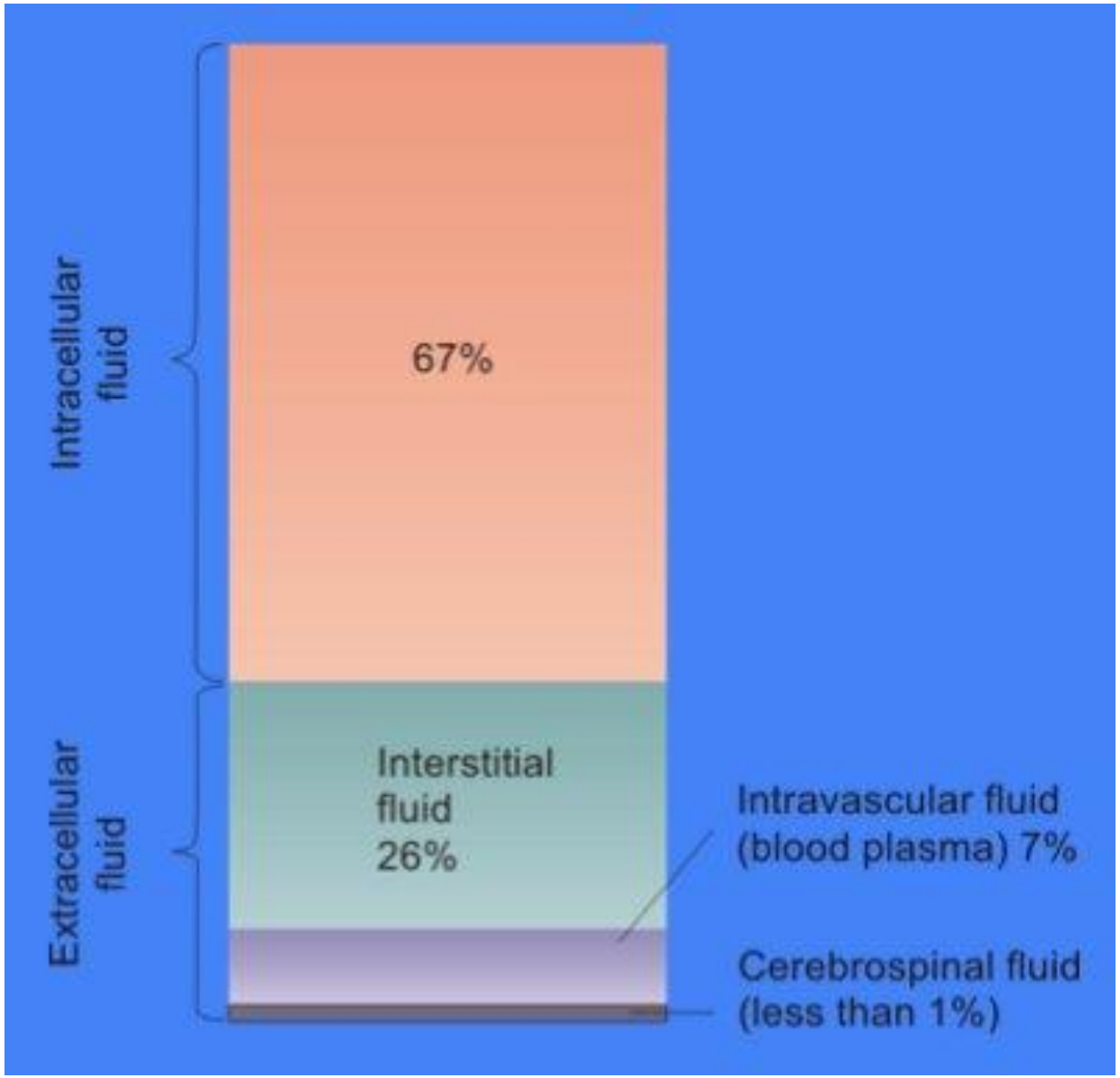
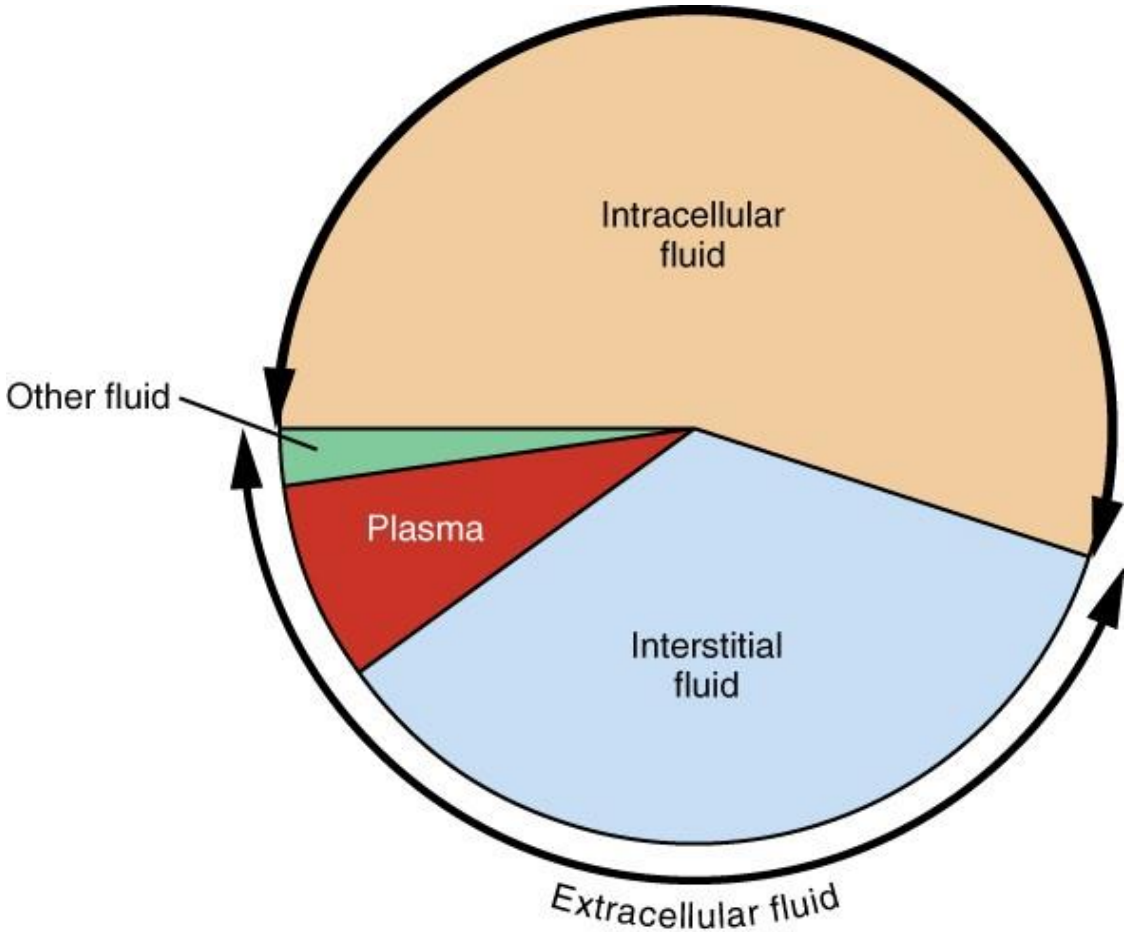


Figure : Summary of body fluid regulation, including the major body fluid compartments and the membranes that separate these compartments


Water gain
Fluids and food 2,300ml
Oxidation of hydrogen in food 200ml
Total 2,500ml
Water loss
Lungs 350ml
Skin 350ml
Sweat 100ml
Faeces 200ml
Urine 1,500ml
Total 2,500ml
Oedema
Dehydration


Intracellular fluid
67%
Extracellular fluid
Interstitial fluid 26%
Intravascular fluid (blood plasma) 7%
Cerebrospinal fluid (less than 1%)


Intracellular fluid
Other fluid
Plasma
Interstitial fluid
Extracellular fluid

Body Fluid Compartments

- The total body fluid is distributed mainly between **two compartments**:

(1) The extracellular fluid (ECF) approximately **20%** of **Total Body Water (TBW)** .

(2) The intracellular fluid (ICF) approximately **40%** of the **TBW**.

The extracellular fluid (ECF) is divided into :

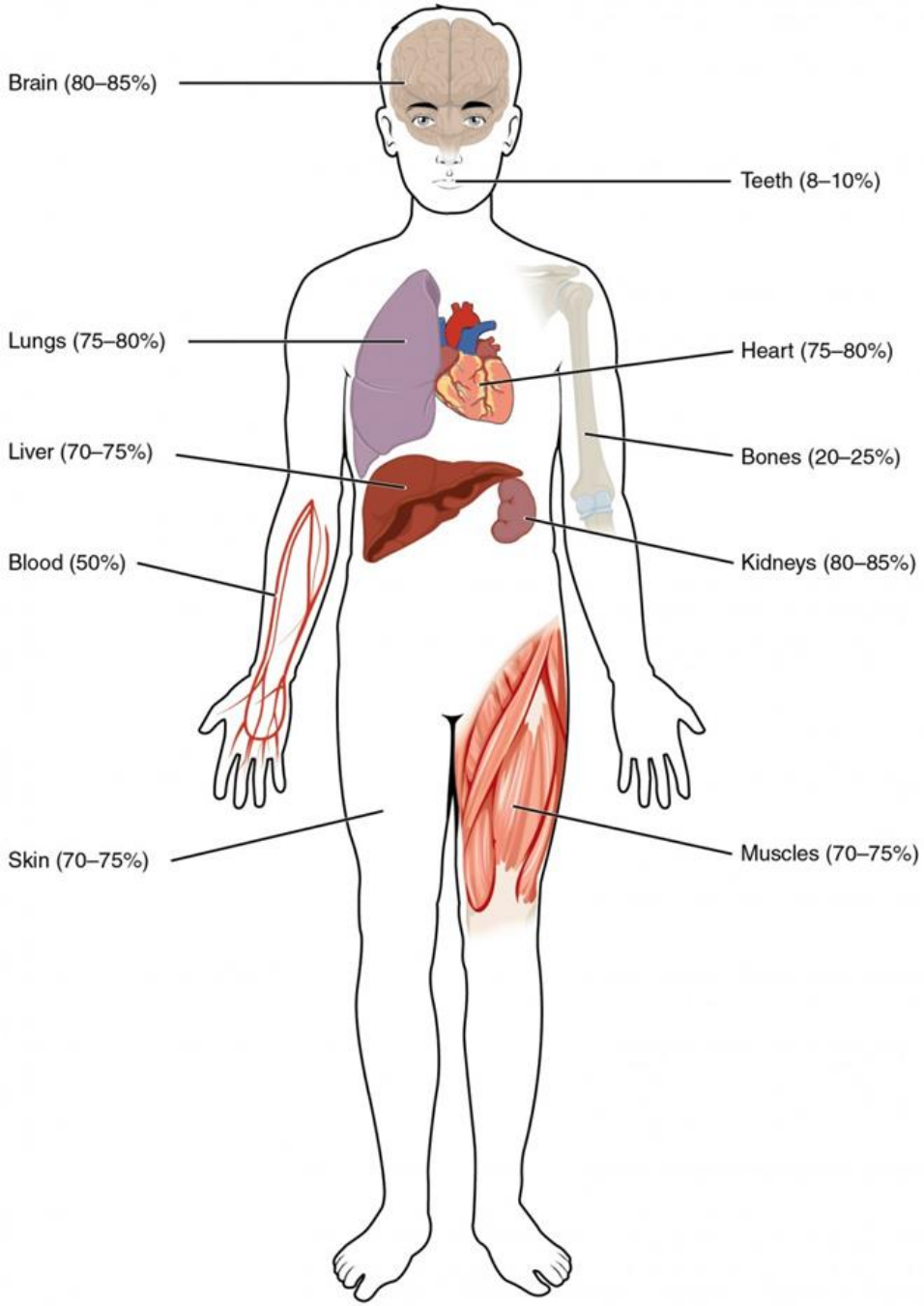
(1) The interstitial fluid about **15%** of the **TBW**.

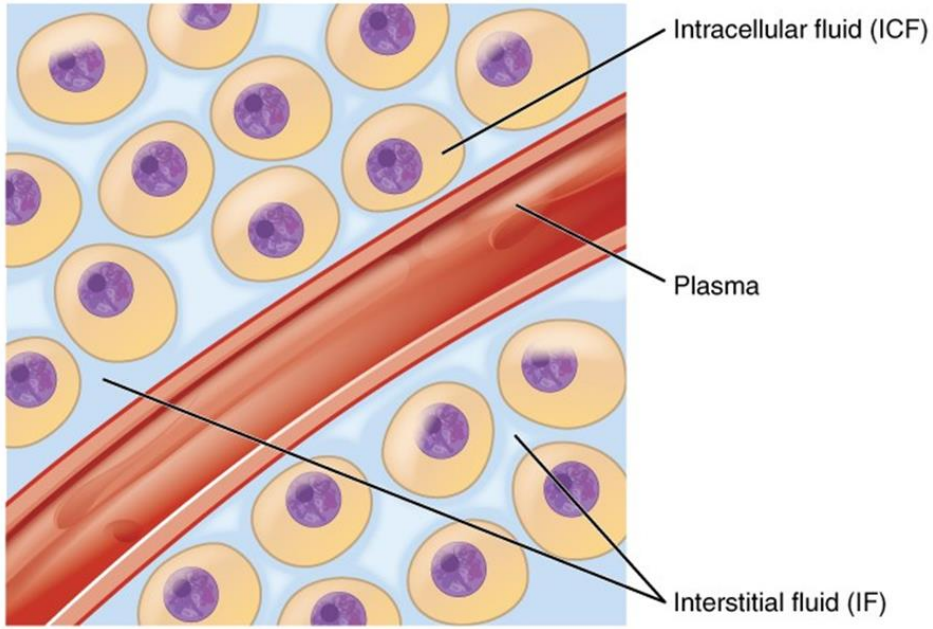
(2) The blood plasma about **4%** of the **TBW.**

There is another small compartment of fluid that is referred to as

(3) Transcellular fluid about **1%** of the **TBW**. this compartment includes fluid in the **gastrointestinal , biliary** , **synovial** , and **intraocular spaces** and the **cerebrospinal fluid (CSF)** and fluids **in serosal spaces** (such as the **pleural**, **peritoneal**, and **pericardial** fluid) .it is usually considered to be a specialized type of extracellular fluid. All the transcellular fluids together constitute about 1 to 2 liters.

Figure : Water content varies in different body organs and tissues, from as little as **8 percent in the teeth** to as much as **85 percent in the brain**.





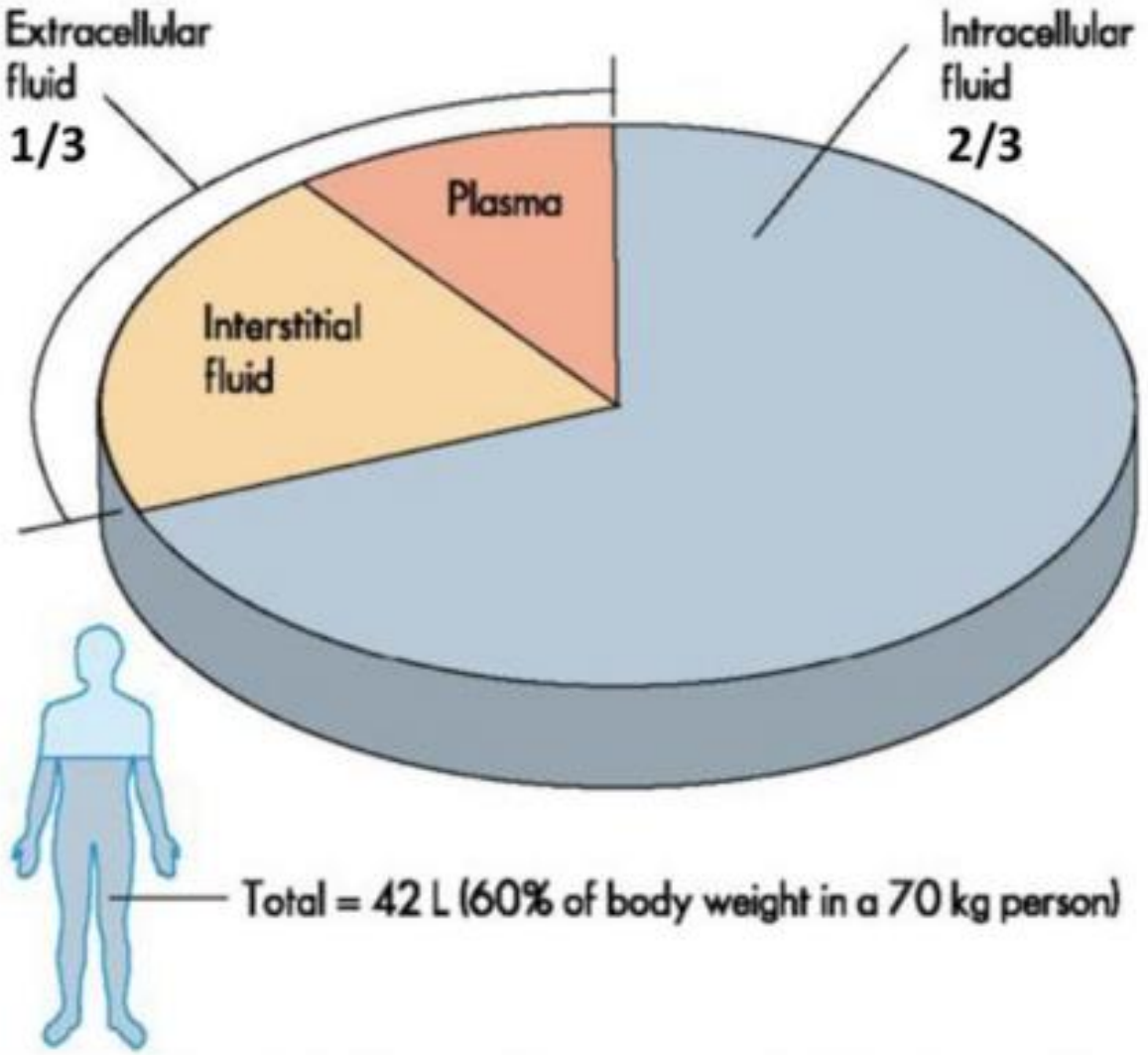
- In the average 70-kilogram adult human:

The total body water is about

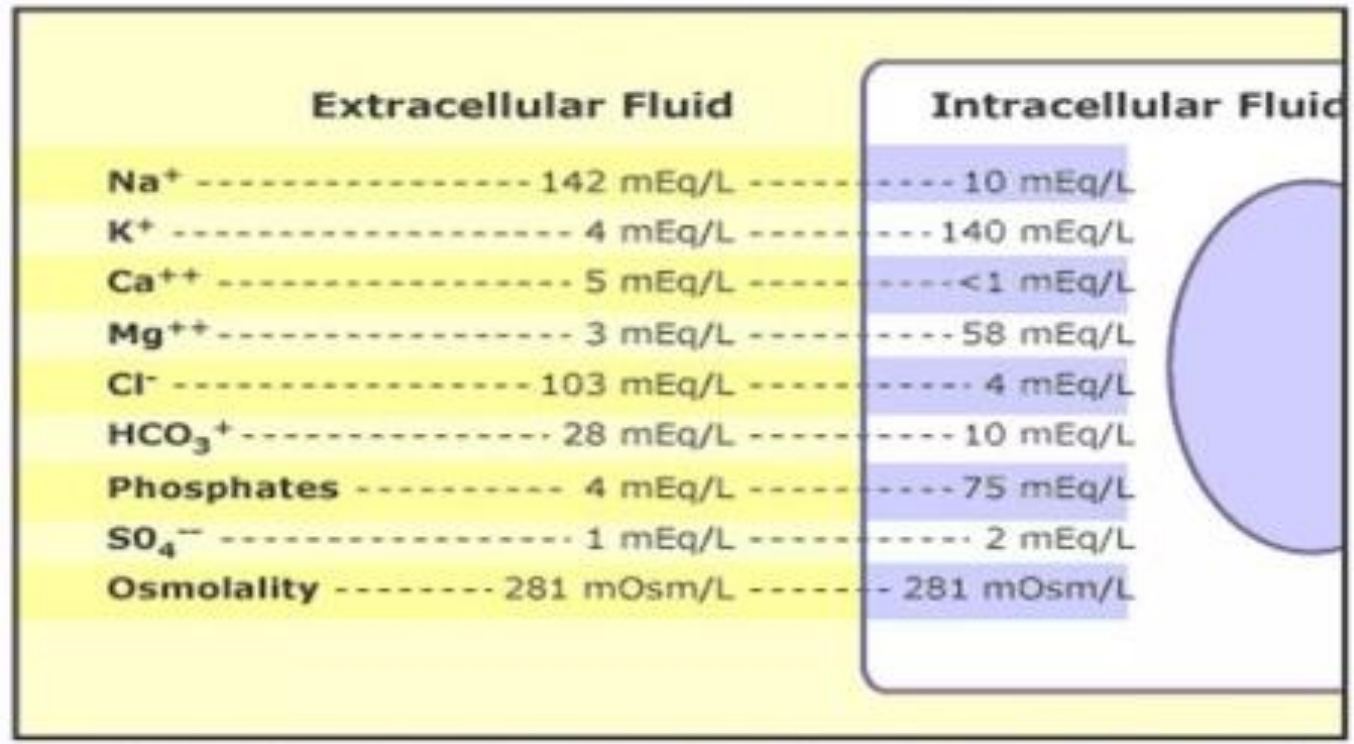
60 percent of the body weight,

or about 42 liters.

As a person grows older, the percentage of total body weight that is fluid gradually decreases.



Total Body Water	60%	42L
Intracellular Volume	40%	28L
Extracellular Volume	20%	14L
Interstitial Volume	15%	10.5L
Plasma Volume	5%	3.5L



Intracellular Fluid Compartment (ICF) :

- **The intracellular fluid constitutes about :**

  40 per cent of the total body weight in an “average” person.
- The intracellular fluid is separated from the extracellular fluid by a **cell membrane** that is highly permeable to water but not to most of the electrolytes in the body.
- It contains: large amounts of **potassium** and **phosphate ions** plus moderate quantities of **magnesium and sulfate ions**, Also, cells contain large amounts of **protein**, almost four times as much as in the plasma. It contains only **small quantities of sodium and chloride ions** and **almost no calcium ions.**

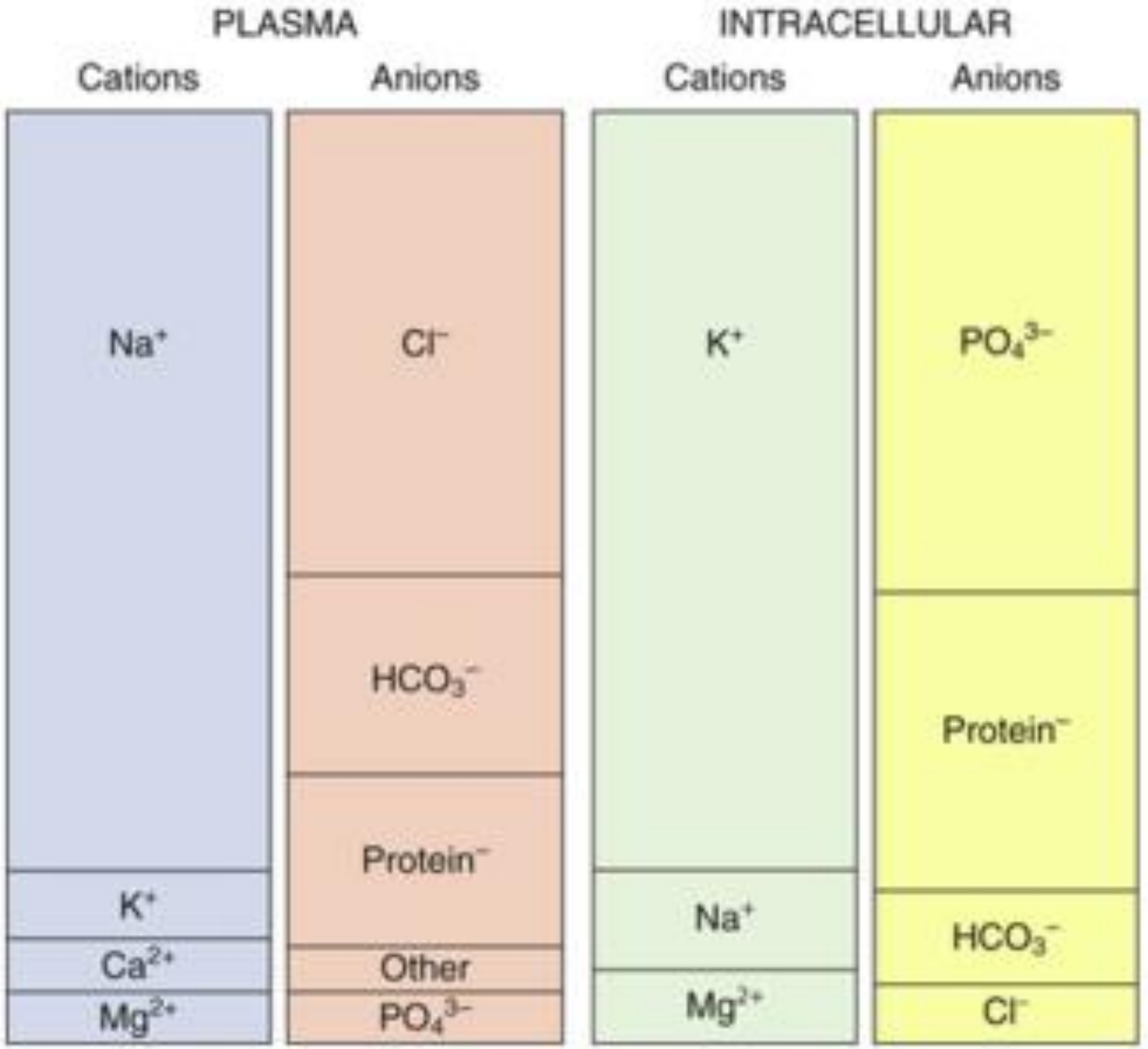
Extracellular Fluid Compartment

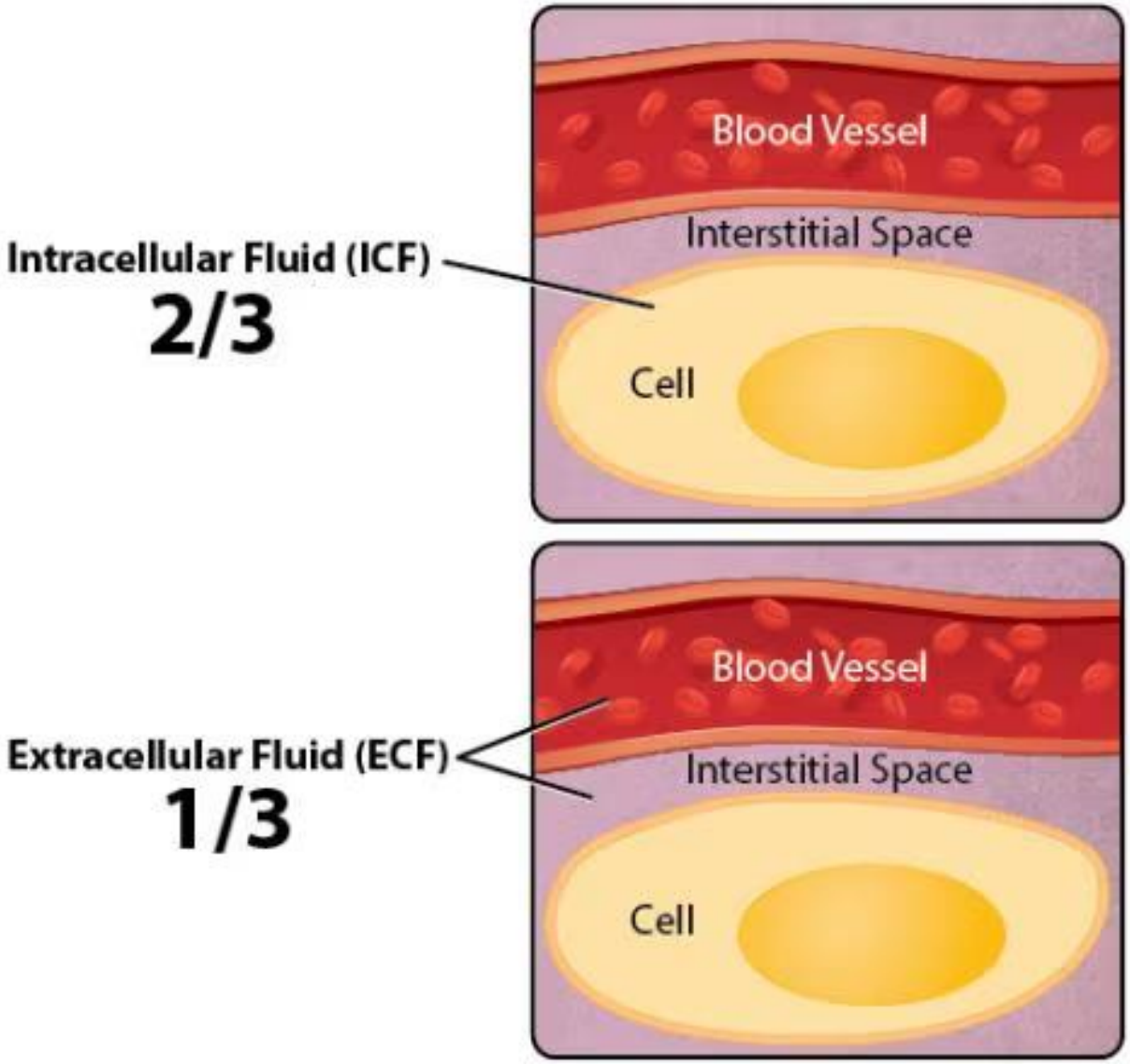
- All the fluids outside the cells are collectively called the **extracellular fluid (ECF)** account for about **20 per cent of the body weight**, or about 14 liters in a normal 70-kilogram adult.
- The two largest compartments of the extracellular fluid are:

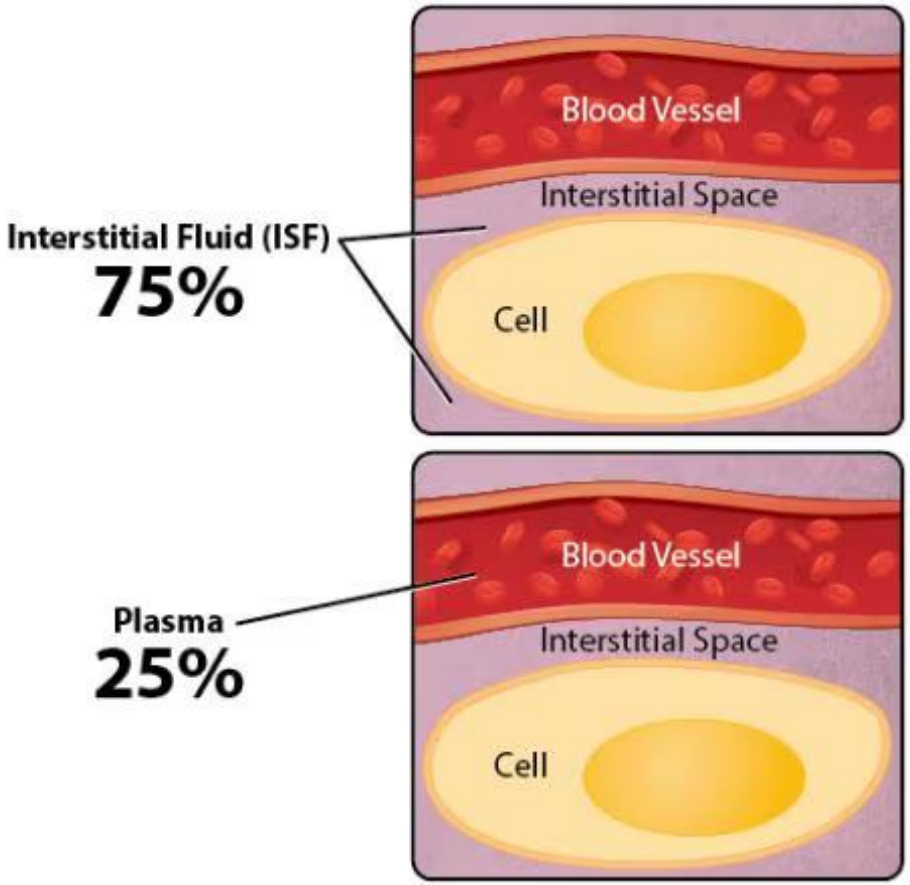
(1) The interstitial fluid, which makes up **more than three fourths (3/4)** of the extracellular fluid (about **15%** of the **TBW**)

(2) The plasma, which makes up **almost one fourth (1/4)** of the extracellular fluid, or about 3 liters. The plasma is the non-cellular part of the blood.

Plasma contains **large amounts of sodium and chloride ions**, reasonably **large amounts of bicarbonate ions**, but **only small quantities of potassium**, **calcium**, **magnesium**, **phosphate**, and **organic acid ions**.

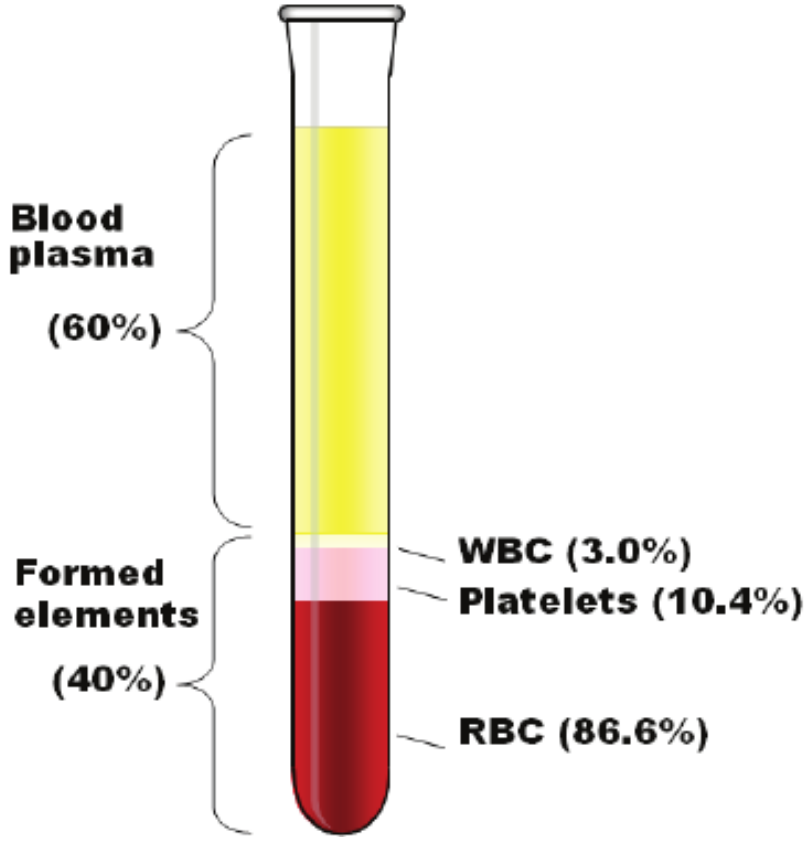



Intracellular Fluid (ICF)
2/3
Blood Vessel
Interstitial Space
Cell
Extracellular Fluid (ECF)
1/3
Blood Vessel
Interstitial Space
Cell


Interstitial Fluid (ISF)
75%
Blood Vessel
Interstitial Space
Cell
Plasma
25%
Blood Vessel
Interstitial Space
Cell

Blood Volume

- Blood contains both extracellular fluid (the fluid in plasma) and intracellular fluid (the fluid in the red blood cells).
- The blood volume is especially important in the control of cardiovascular dynamics. The average **blood volume** of adults is **about 7 per cent of body weight**, or **about 5 liters**. About **60 per cent of the blood is plasma** and **40 per cent is red blood cells**, but these percentages can vary considerably in different people, depending on gender, weight, and other factors.



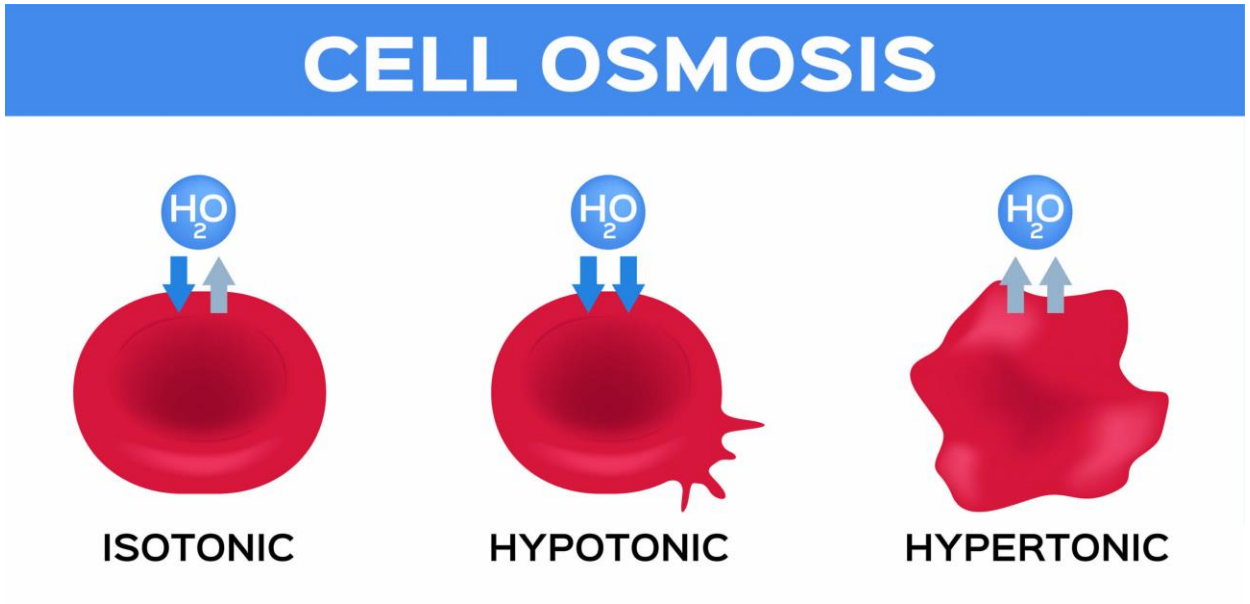
Regulation of Fluid Exchange and Osmotic Equilibrium Between Intracellular and Extracellular Fluid

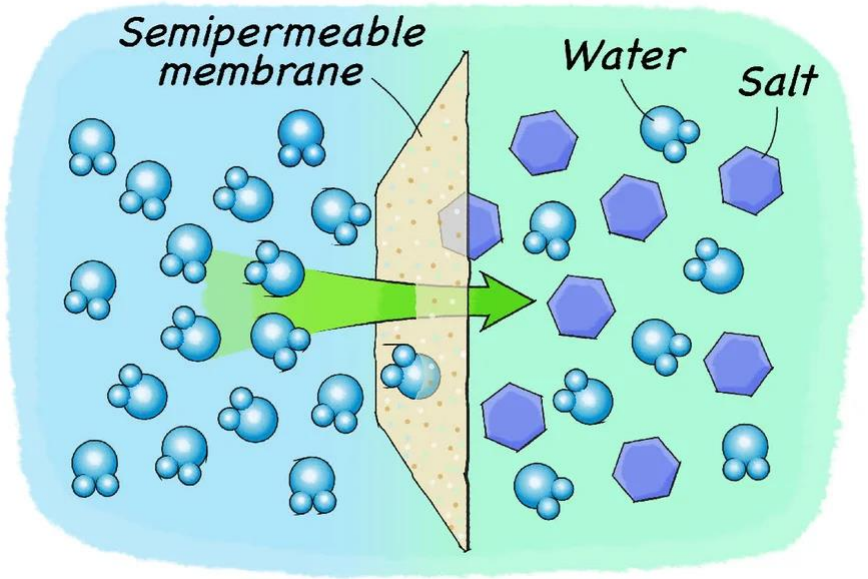
- The distribution of fluid between intracellular and extracellular compartments is determined mainly by the **osmotic effect of the smaller solutes** especially sodium, chloride, and other electrolytes— acting across the cell membrane. The reason for this is that the **cell membranes are highly permeable to water** but relatively impermeable to even small ions such as sodium and chloride. Therefore, **water moves across the cell membrane rapidly**, so that the **intracellular fluid remains isotonic** with the extracellular fluid.

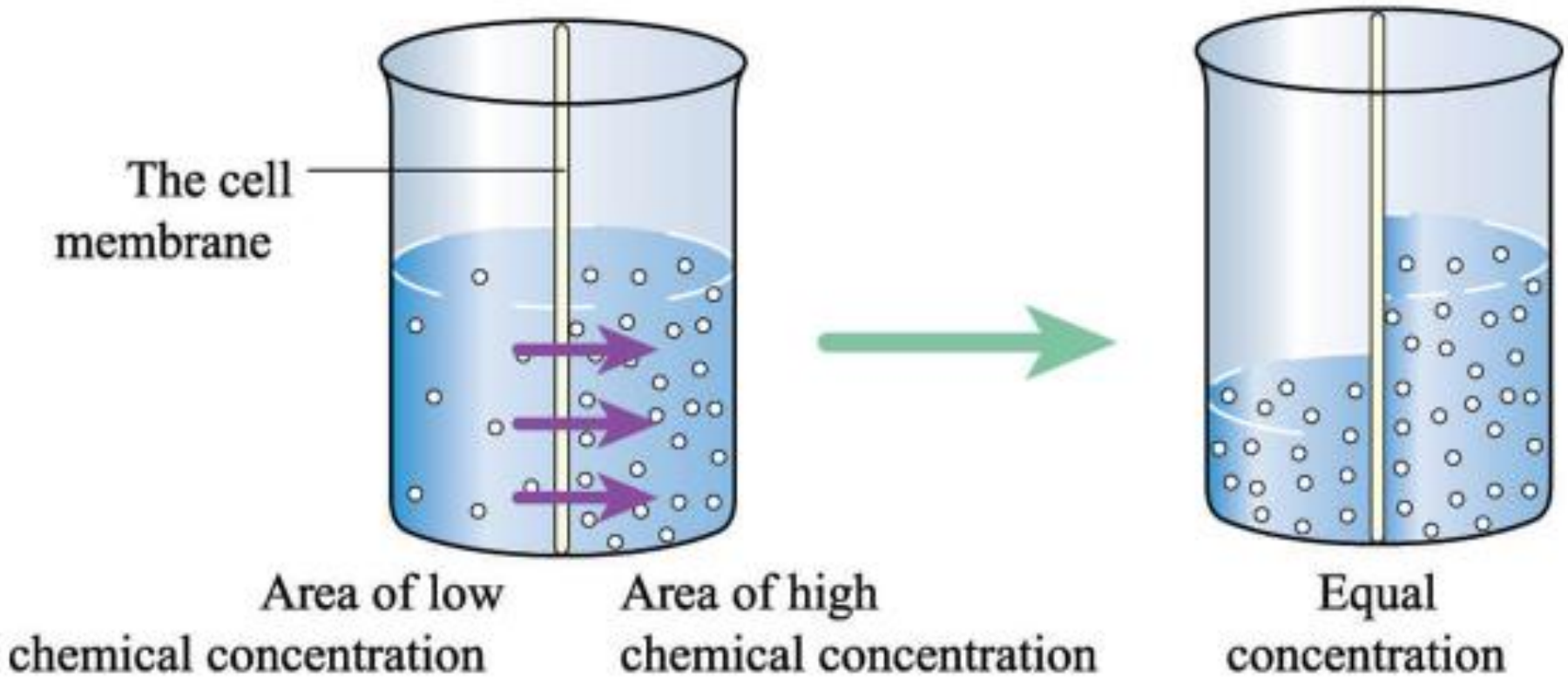
Basic Principles of Osmosis and Osmotic Pressure

- **Osmosis is the net diffusion of water across a selectively permeable membrane from a region of high water concentration to one that has a lower water concentration**.
- When a solute is added to pure water, this reduces the concentration of water in the mixture. Thus, the higher the solute concentration in a solution, the lower the water concentration.
- Further, **water diffuses** from a region of **low solute concentration (high water concentration)** to one with a **high solute concentration (low water concentration)**. Because cell membranes are relatively impermeable to most solutes but highly permeable to water (i.e., selectively permeable), whenever there is a higher concentration of solute on one side of the cell membrane, water diffuses across the membrane toward the region of higher solute concentration.

- Thus, if a solute such as **sodium chloride is added to the extracellular fluid**, **water rapidly diffuses from the cells through the cell membranes into the extracellular fluid until the water concentration on both sides of the membrane becomes equal**. Conversely, if a solute such as sodium chloride is removed from the extracellular fluid, water diffuses from the extracellular fluid through the cell membranes and into the cells.
- **The rate of diffusion of water is called the rate of osmosis.**






The cell membrane
Area of low chemical concentration
Area of high chemical concentration
Equal concentration

Relation Between Moles and Osmoles

- Because the water concentration of a solution depends on the number of solute particles in the solution, a concentration term is needed to describe the total concentration of solute particles, regardless of their exact composition. The total number of particles in a solution is measured in **osmoles**. One osmole (osm) is equal to 1 mole (mol) (6.02 × 1023) of solute particles.
- Therefore, a solution containing **1 mole of glucose** in each liter has a concentration of **1 osm/L**. If a molecule dissociates into two ions (giving two particles), such as sodium chloride ionizing to give **chloride and sodium** ions, then a solution containing **1 mol/L** will have an osmolar concentration of **2 osm/L**.

- Likewise, a solution that contains **1 mole of a molecule** that dissociates into **three ions**, such as **sodium sulfate (Na2 SO4),** will contain **3 osm/L**.
- Thus, the term **osmole refers to the number of osmotically active particles in a solution rather than to the molar concentration.**
- In general, the osmole is too large a unit for expressing osmotic activity of solutes in the body fluids. The term **milliosmole (mOsm),** which equals 1/1000 osmole, is commonly used.

Osmolality and Osmolarity

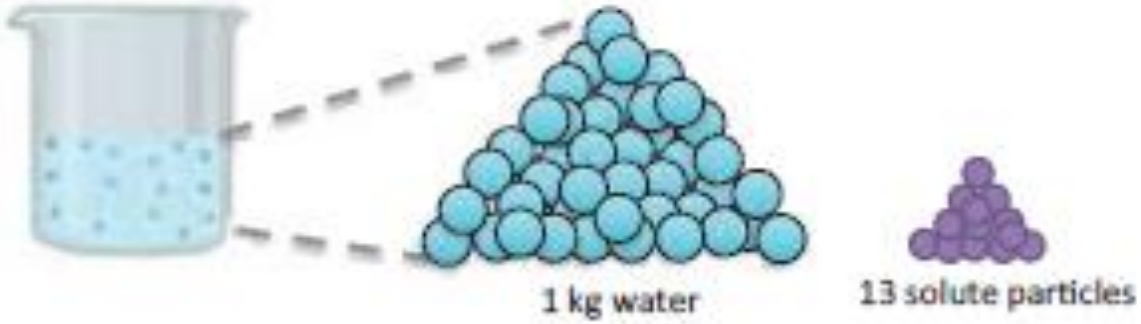
- **The osmolal concentration of a solution is called osmolality when the concentration is expressed as osmoles per kilogram of water; it is called osmolarity when it is expressed as osmoles per liter of solution**.

  In most cases, it is easier to express body fluid quantities in liters of fluid rather than in kilograms of water.

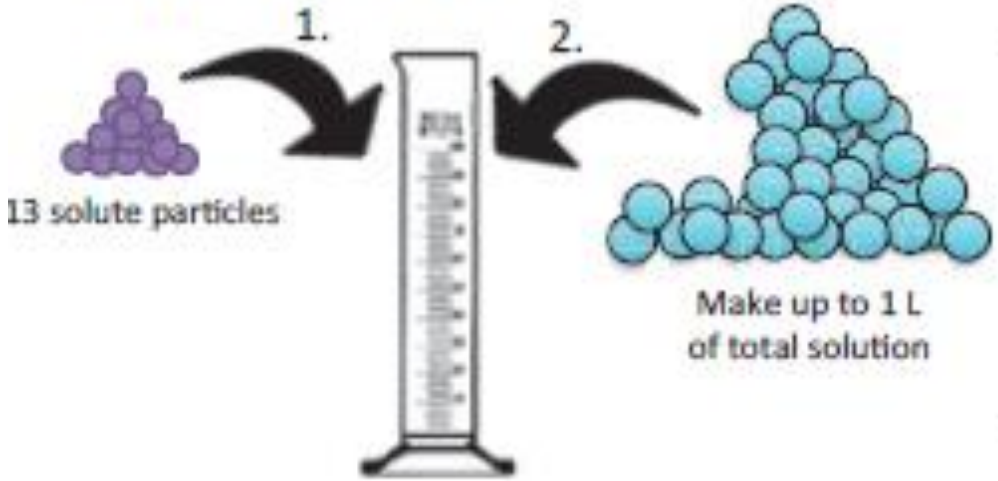
  Plasma osmolality reflects a person's state of hydration.

Osmolarity vs osmolality

Osmolality is the number of osmotically active particles *per unit weight of solvent*. The units are milli Osmoles/kg of solvent (eg water). This determines the osmotic pressure exerted by a solution across a membrane.



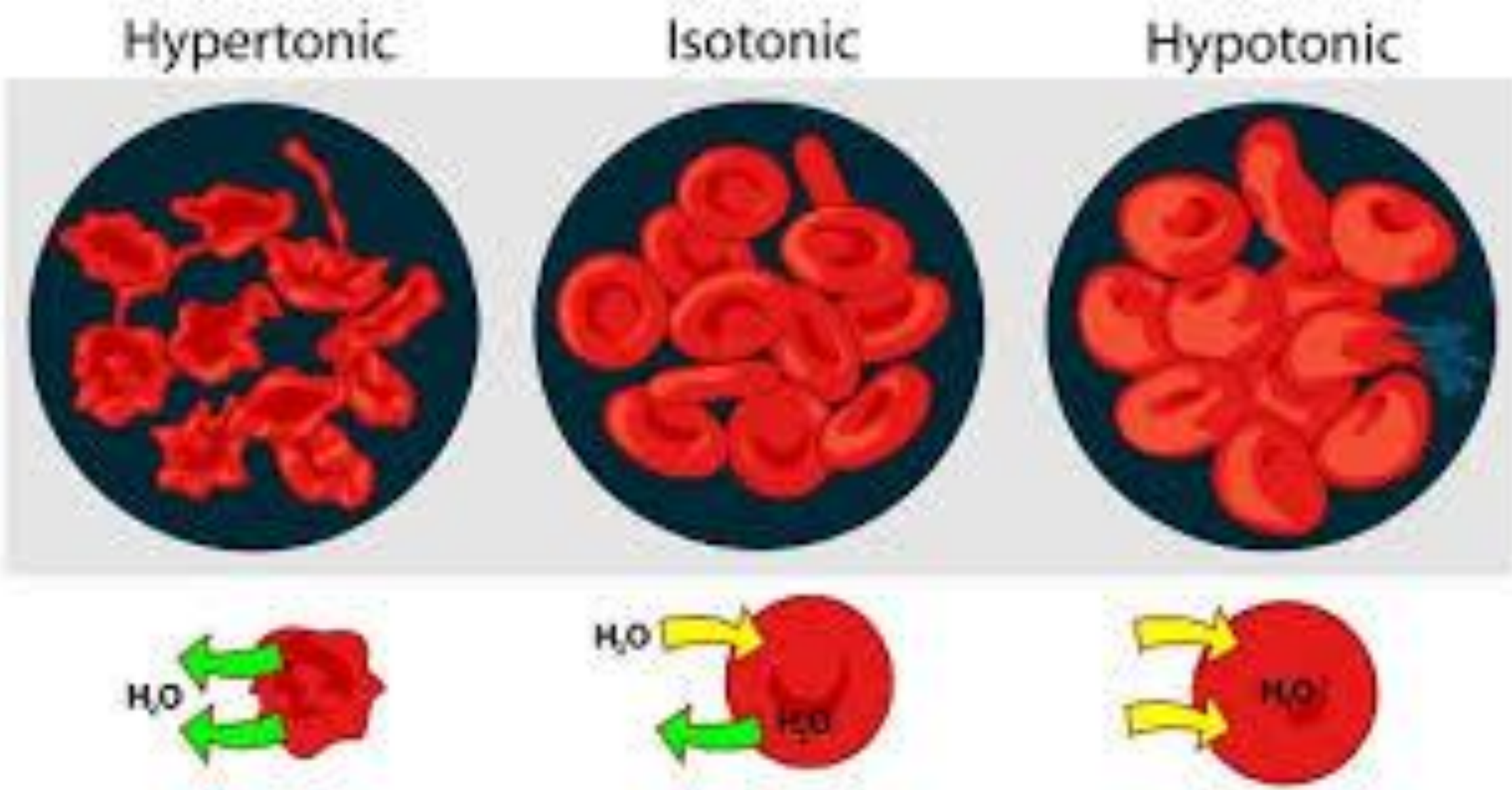
Osmolarity is the number of osmotically active particles *per litre of **total** solution*.
Its units are mOsmol/L.



A molal solution is approx. equal to a molar solution.

Although osmolality and osmolarity differ, the former being an expression of osmotic activity per weight (kg) and the latter per volume (L) of solution, for clinical purposes they are similar.

Osmolality has largely replaced osmolarity.


Hypertonic
Isotonic
Hypotonic
H2O
H2O
H2O
H2O


THANK YOU