Body fluids

Asst.Prof. Dr. Ghaith Ali Jasim

PhD Pharmacology

MSc Physiology & Pharmacology

Body fluids

Water is by for the most abundant components of the body, constituting **55-60%** in young males and **45-50%** in young women of the total body weight (TBW) (lower level in fat, upper level in thin, 80% in infants). This large variation in water content is primarily a function of variation in the amount of adipose tissue, thus, the percentage of body water will vary inversely with the body's fat content.

The total body water in males is larger than in females because the latter have a somewhat larger amount of subcutaneous fat. In both sexes, the percentage of body water decreases with age, which can be attributed primarily to an increase of adipose tissue.

- The body water is distributed into two major fluid compartments,
- **extracellular fluid (ECF),** which contains approximately 20% of TBW (30% in infants), and **intracellular fluid (ICF)**, which contains approximately 40% of the TBW.

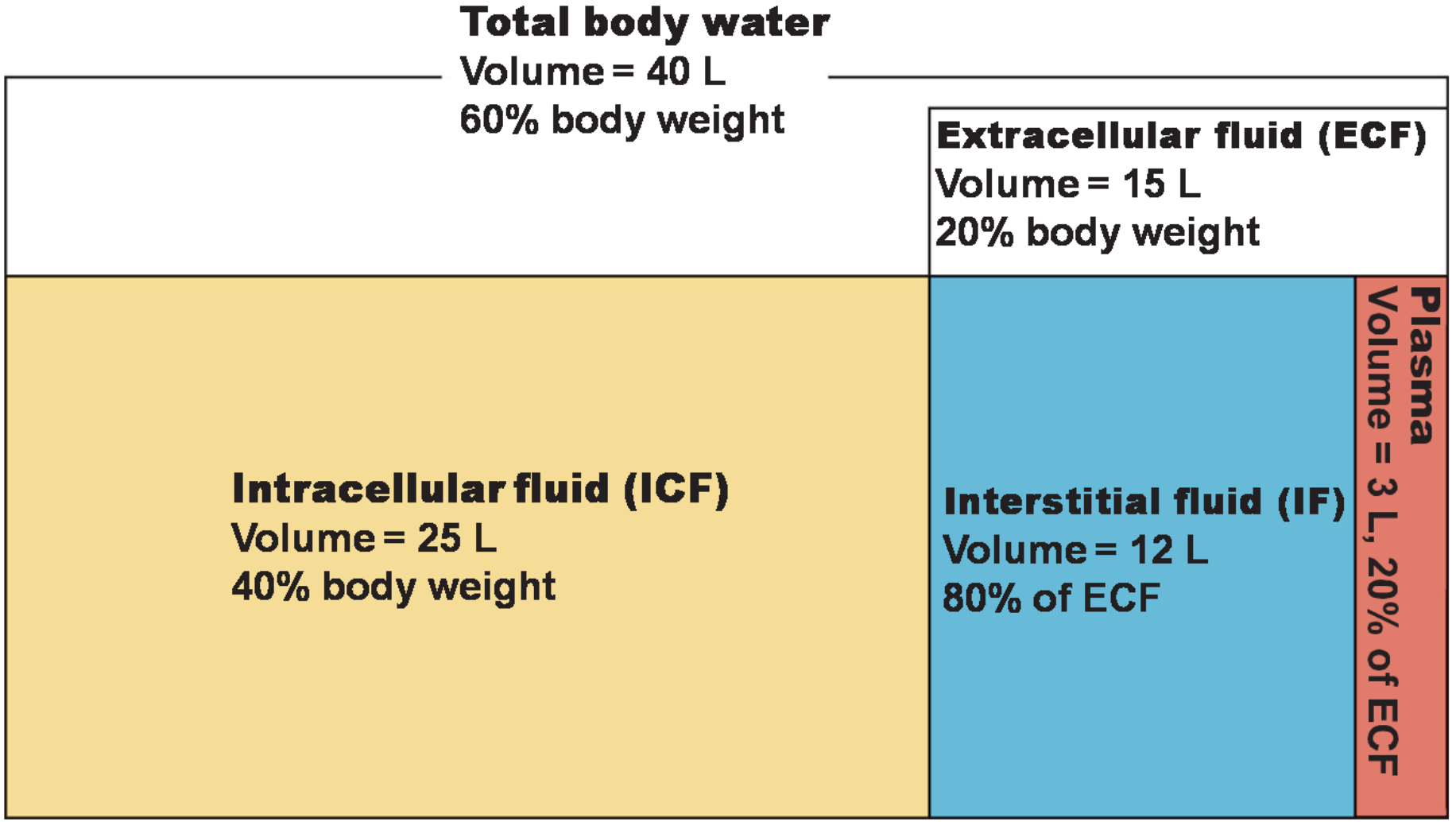
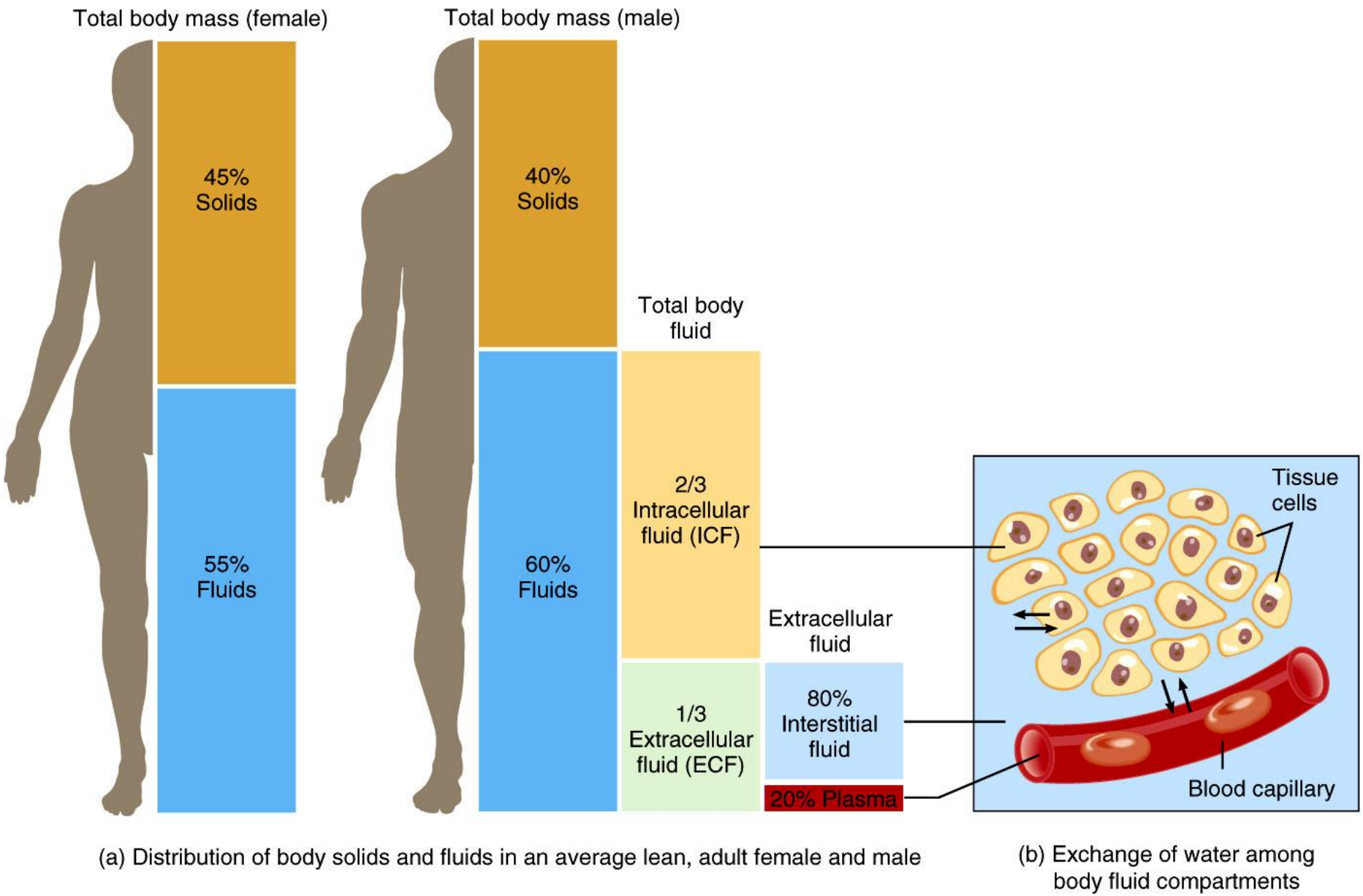

Total body water
Volume = 40 L
60% body weight
Extracellular fluid (ECF)
Volume = 15 L
20% body weight
Intracellular fluid (ICF)
Volume = 25 L
40% body weight
Interstitial fluid (IF)
Volume = 12 L
80% of ECF
Plasma
Volume = 3 L, 20% of ECF

Figure 25



(a) Distribution of body solids and fluids in an average lean, adult female and male

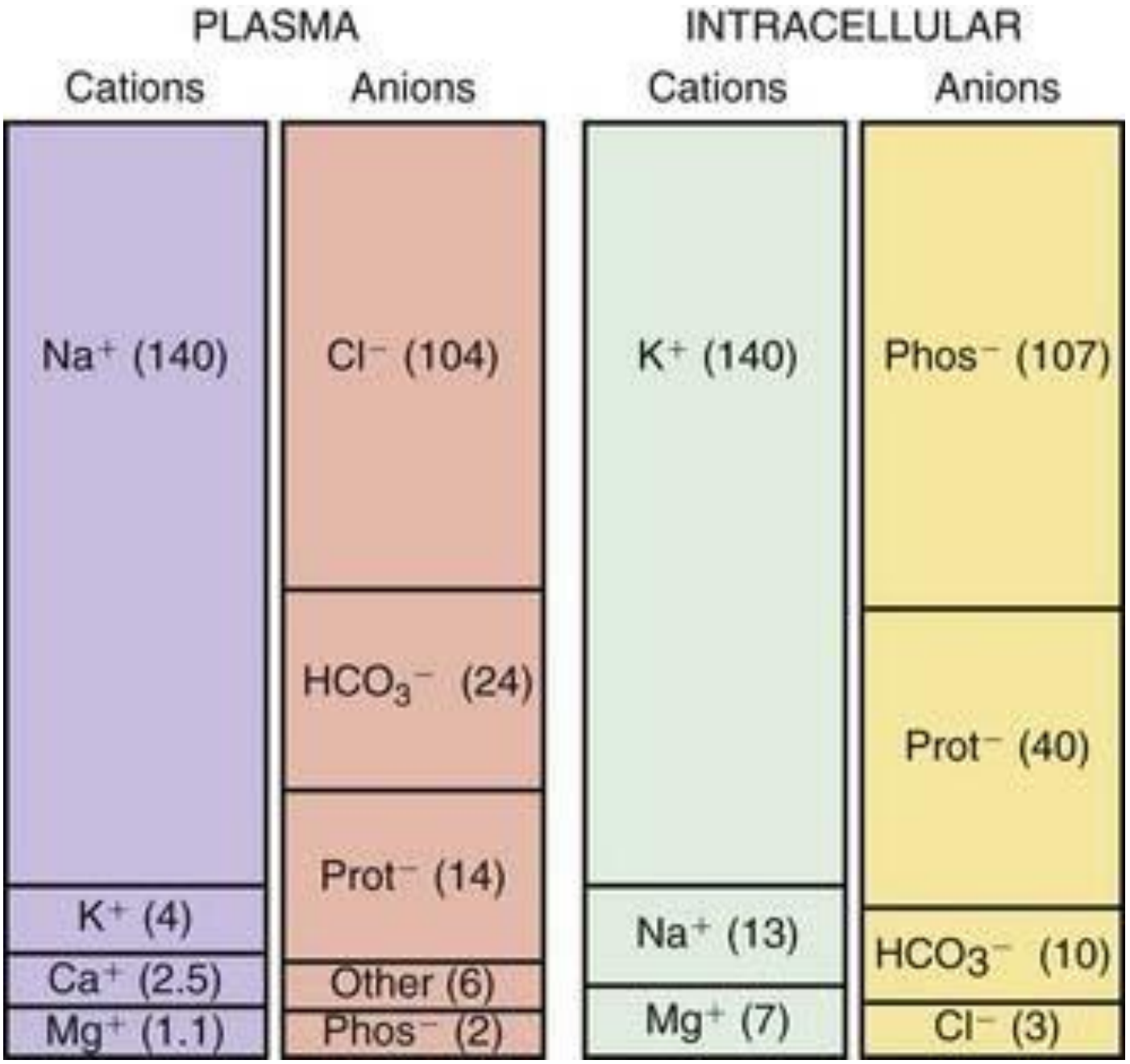
(b) Exchange of water among body fluid compartments

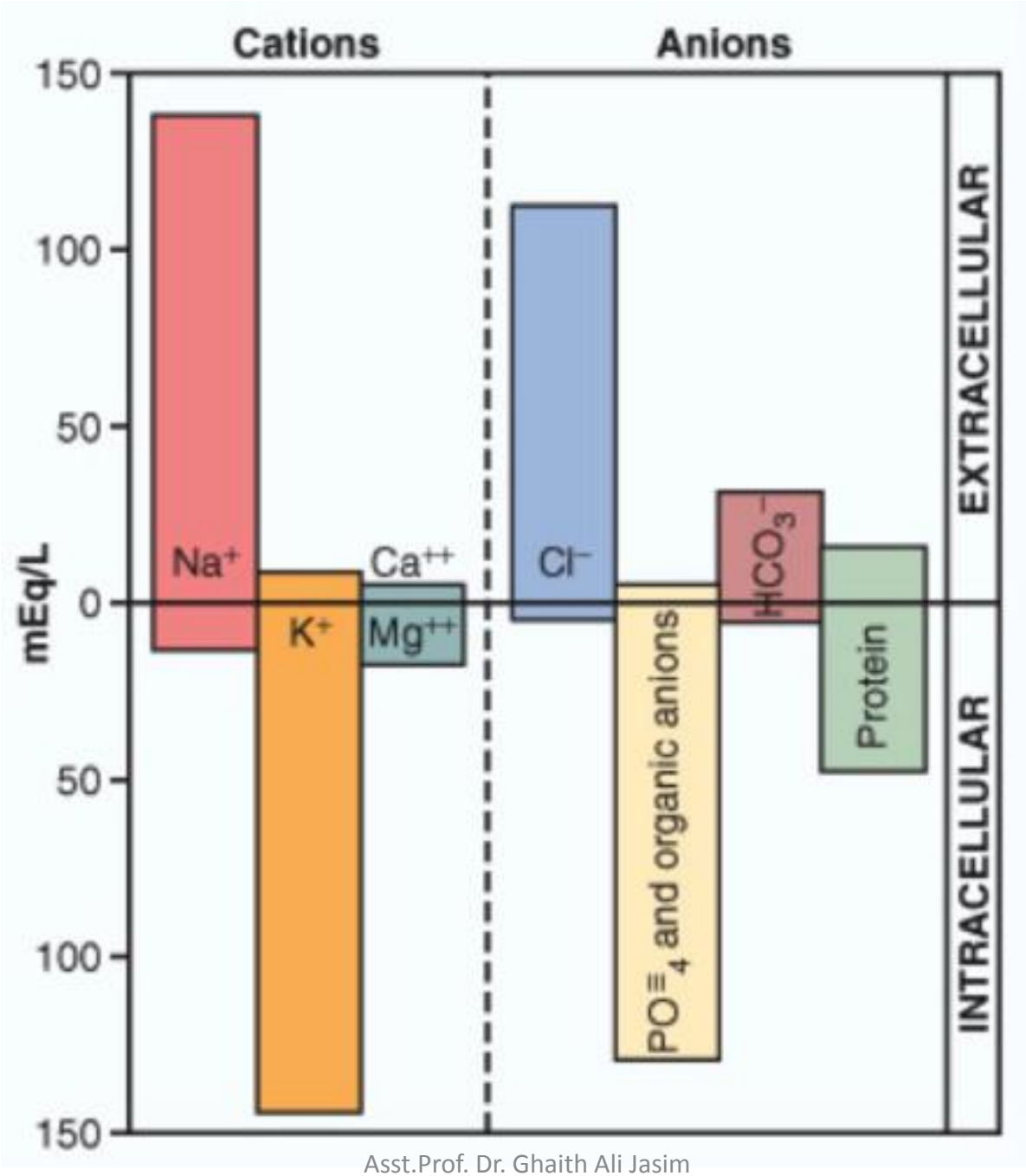
Figure 27.01 Tortora - PAP 12/e

Copyright © John Wiley and Sons, Inc. All rights reserved.

Extracellular fluid (20% of the TBW):

- **1. The interstitial fluid** (the fluids between cells and in lymphatic) which constitutes the major part in ECF compartment constitutes about 15% of the TBW.
- **2. Plasma** constitutes about 4% of the TBW.
- **3. Transcellular fluids** (include fluid in the gastrointestinal, billary, and urinary tracts, the intraocular and cerebrospinal fluids, and fluid in the serosal spaces, such as the pleural, peritoneal, and pericardial fluid) constitutes about 1% of the TBW.


PLASMA
Cations
Anions
INTRACELLULAR
Cations
Anions
Na+ (140)
K+ (4)
Ca+ (2.5)
Mg+ (1.1)
Cl− (104)
HCO3− (24)
Prot− (14)
Other (6)
Phos− (2)
K+ (140)
Na+ (13)
Mg+ (7)
Phos− (107)
Prot− (40)
HCO3− (10)
Cl− (3)


Cations
Anions
150
100
50
0
50
100
150
mEq/L
Na+
K+
Ca++
Mg++
Cl−
PO≡4 and organic anions
HCO3−
Protein
EXTRACELLULAR
INTRACELLULAR

Plasma and interstitial fluid:

These two major compartments of ECF have very similar composition, with Na^+ as the predominant cation and Cl^- and HCO_3^- as the predominant anions.

However an important difference between plasma and interstitial fluid is the larger concentration of proteins in the plasma.

This difference exists because the capillary endothelium is freely permeable to water and to small solutes (the so-called crystalloids), such as inorganic icons, glucose, and urea, but has limited permeability to larger solutes (colloidal particles), such as large proteins and lipids. Thus, interstitial fluid is an ultra filtrate of plasma.

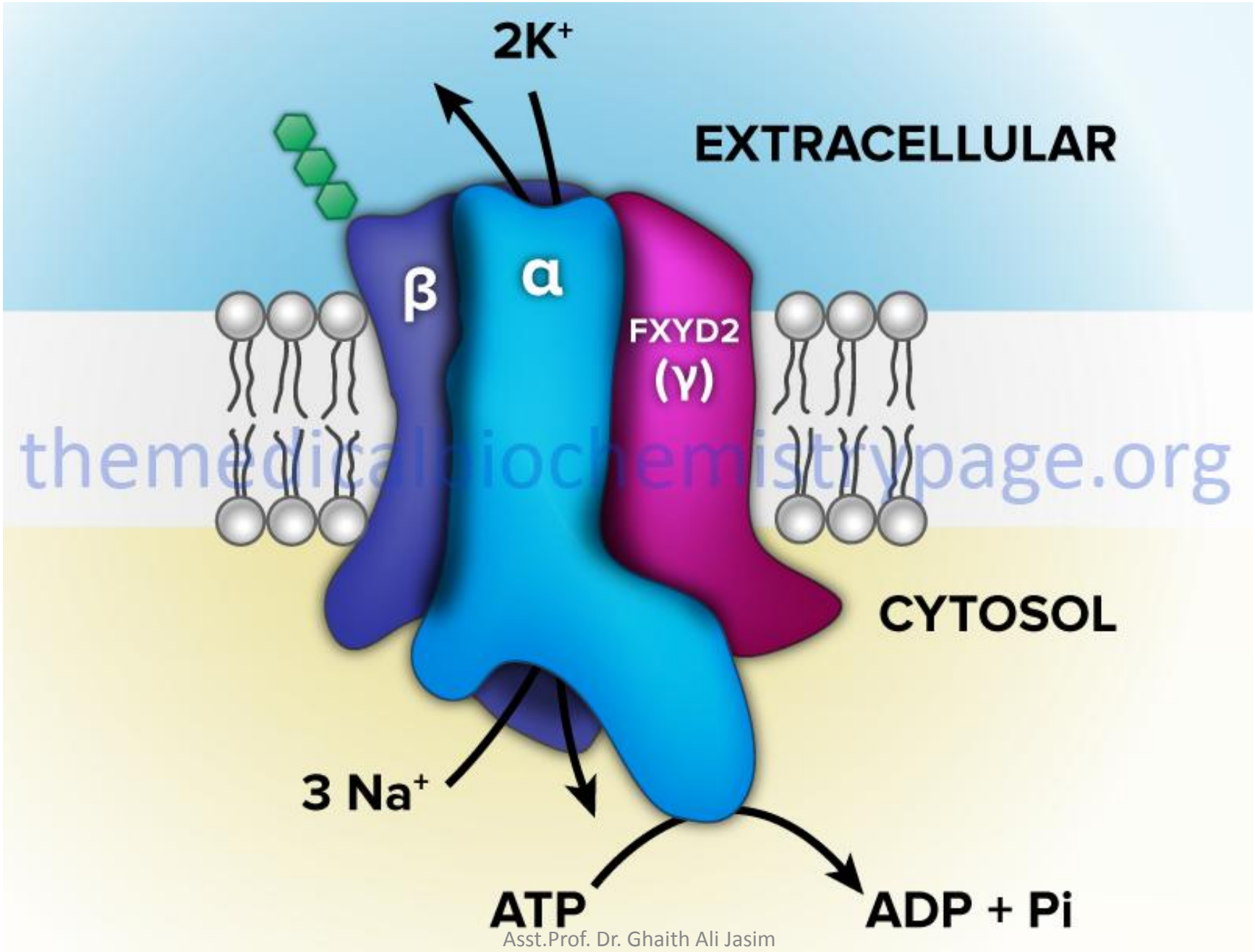
Intracellular fluid (40% of the TBW):

- Intracellular of fluid (ICF), in contrast to ECF, ICF contains relatively low concentration of Na^+, Cl^-, and HCO_3^-. Instead, the predominant cation in ICF is K^+ and Mg^{++}, while the predominant anions are organic phosphates (e.g. ATP, ADP, and AMP) and proteins.

- These striking composition differences between ICF and ECF can be attributed mainly to presence of the Na^+-K^+ ATPase pump in cell membranes which actively transports:

((3 sodium ions from & 2 potassium ions into cells))

thereby accounting for the high sodium ion and low potassium ion concentrations in ECF and the low sodium ion and high potassium ion concentration in ICF.



themedicalbiochemistrypage.org

Measurement of volume of the major fluid compartments:

The volume of water in each fluid compartment can be measured by the indicator dilution technique.

This technique is based on the relationship among the amount of a substance injected intravenously (A) in mg, the volume in which that substance is distributed (V) in liter (L), and the final concentration attained (C) in mg/L:

$$V = A / C$$

The volume measurement by the dilution technique requires that the introduced substance (the marker) be distributed evenly in the body fluid compartment being measured and should have four criteria:

- It is measurable.
- it remains in the compartment being measured.
- it does not alter water distribution in the compartment being measured.
- It is non toxic. For the plasma volume measurement.

- The first method employs substances that neither leave the vascular system nor penetrate the erythrocytes such as *Evans blue dye, radio iodinated gamma globulin and fibrinogen*.

- The second method is based on the fact that the radioisotopes of phosphorus (^{32}P), iron ($^{55.59}Fe$), and chromium (^{51}Cr) penetrate and bind to erythrocytes. The tagged cells are injected intravenously, and their volume of distribution is measured. Then, the plasma volume can be calculated from the measured erythrocyte volume and haematocrit.

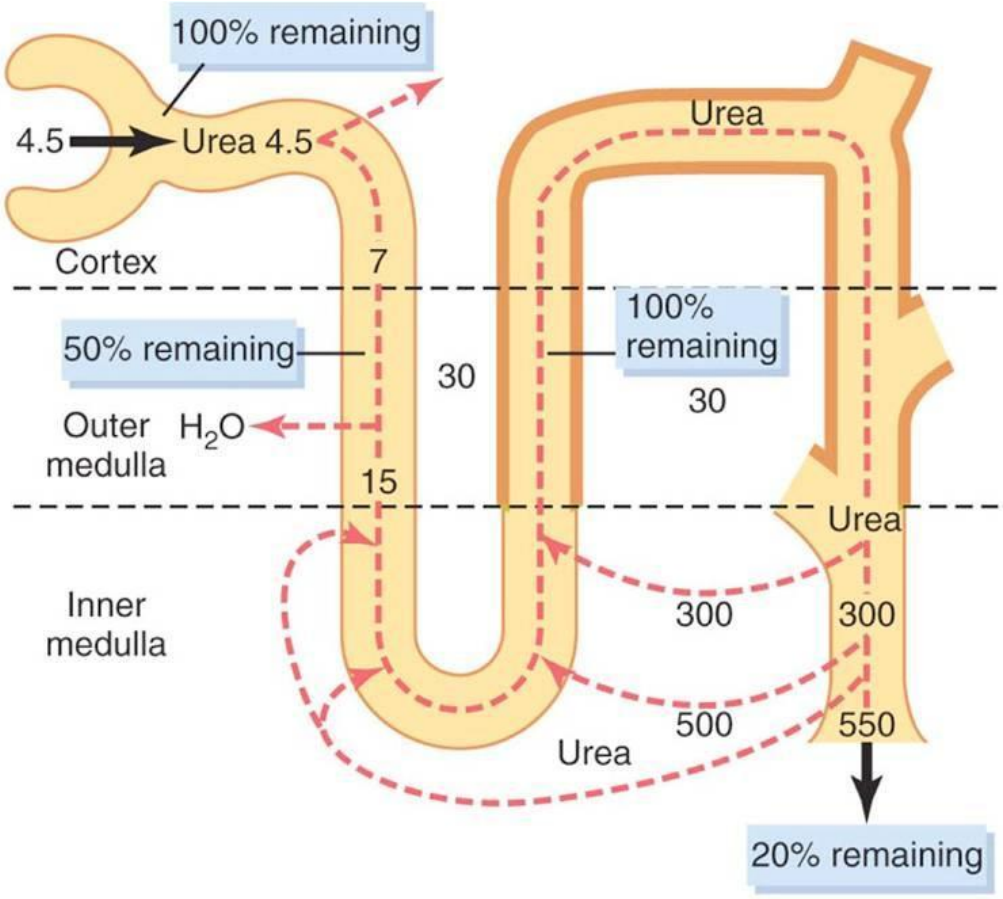
- The interstitial fluid volume cannot be measured directly, because no substance is distributed exclusively within this compartment.
- To measure the interstitial fluid volume, the capillary membranes must be permeable to a substance injected intravenously, which becomes distributed throughout the ECF and not exclusively in the interstitium.

- *Therefore, the interstitial fluid volume is determined as the difference between ECF volume and plasma volume.* Intracellular fluid volume also cannot be measured directly by dilution, because no substance is confined exclusively to this compartment after intravenous injection of a marker substance.
- *intracellular fluid volume is obtained by subtracting the ECF volume from the total body water.*

Osmosis, Osmolarity and osmotic pressure of the body fluids:

Osmosis is the flow of water (solvent) molecules across a semipermeable membrane (through channel proteins, especially those called **aquaporins**) into a region in which there is a high concentration of a solute to which the membrane is impermeable. Cells can regulate the rate of osmosis by adding aquaporins to the plasma membrane or removing them.

Certain cells of the kidneys, for example, install or take away aquaporins to regulate the rate of water loss from the body in the urine



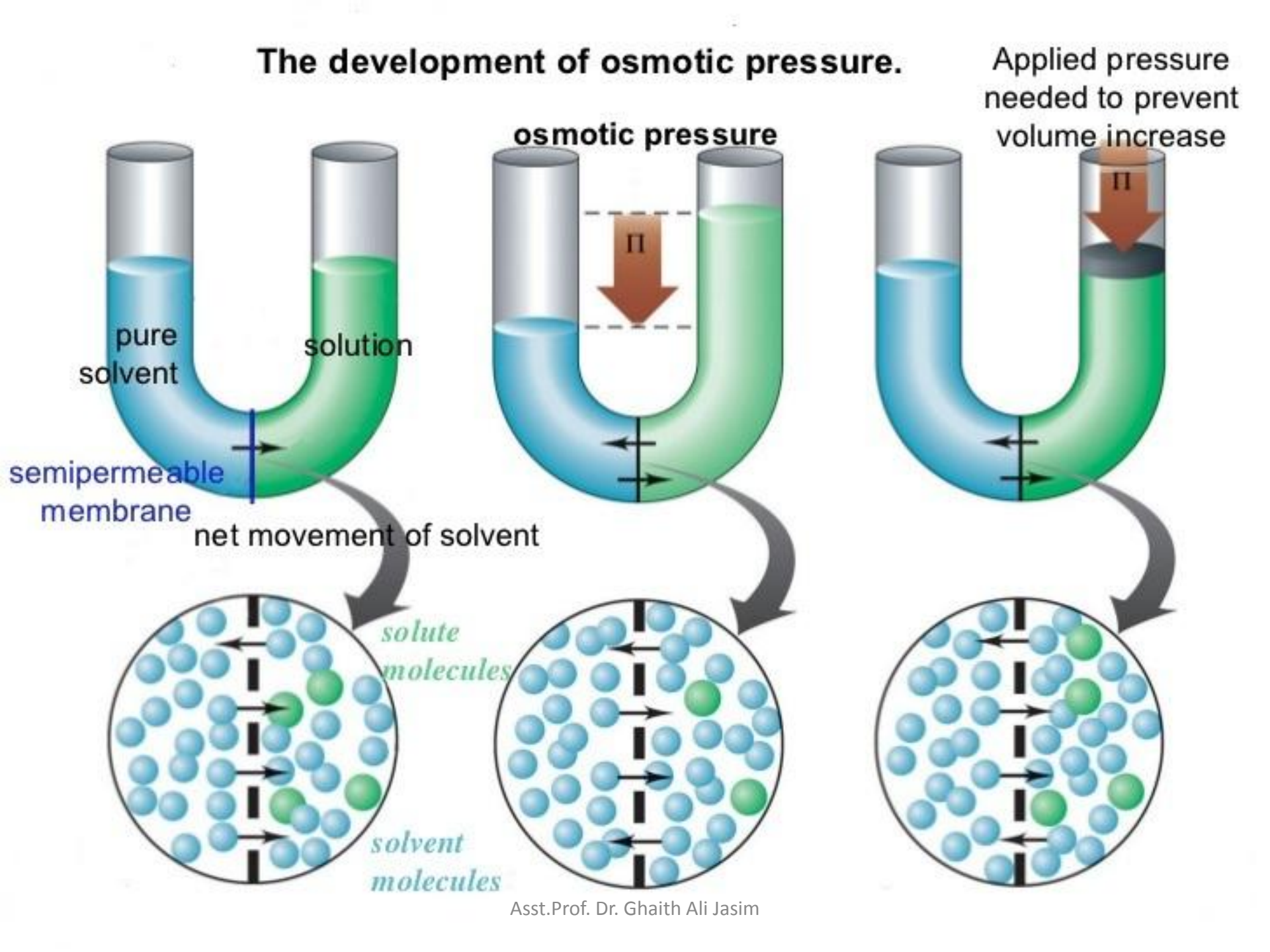
Hall: Guyton and Hall Textbook of Medical Physiology, 12th Edition
Copyright © 2011 by Saunders, an imprint of Elsevier, Inc. All rights reserved.

The **osmolarity** is the concentration of osmotically active particles (the particles which attact water to it) in a solution.

Osmolarity of any fluid is determined by the number of moles per liter (the concentration) and by the numbers of osmotically active particles released into solution when the solute is dissolved.

Osmolarity (concentration of particles, osm/L)

= Concentration (mol/L) x Number of particles released into solution when the solute is dissolved in solution.


The development of osmotic pressure.
osmotic pressure
Applied pressure needed to prevent volume increase
Π
Π
pure solvent
solution
semipermeable membrane
net movement of solvent
solute molecules
solvent molecules

Therefore, osmolality of the plasma and ECF is mainly due to sodium ions, chloride ions, bicarbonate ions, and to less extent due to other ions, urea, glucose, and proteins.

The osmolality of the ICF is mainly due to potassium ions, magnesium ions, organic phosphates, proteins and other nitrogen containing solutes.

- **In spite of the differences in composition, these fluids have essentially identical total osmolalities**

- **The** osmotic pressure **is an attractive force of the solute particles that drives water molecules to move from solution 2 to solution 1 as a result of the presence of solute in solution 1. Consequently, the osmotic pressure difference across the membrane causes water to flow from solution 2 (which has no solute and the lower osmotic pressure) to solution 1 (which has the solute and the higher osmotic pressure).**

- In spite of the differences in composition of the body fluids, they have essentially identical total osmolalities of about of about **290-300 mosmo1/ kg H_2O**.
- This is because the capillary endothelium and cell membranes are freely permeable to water, allowing the plasma, interstitial fluid, and ICF to be isomostic.

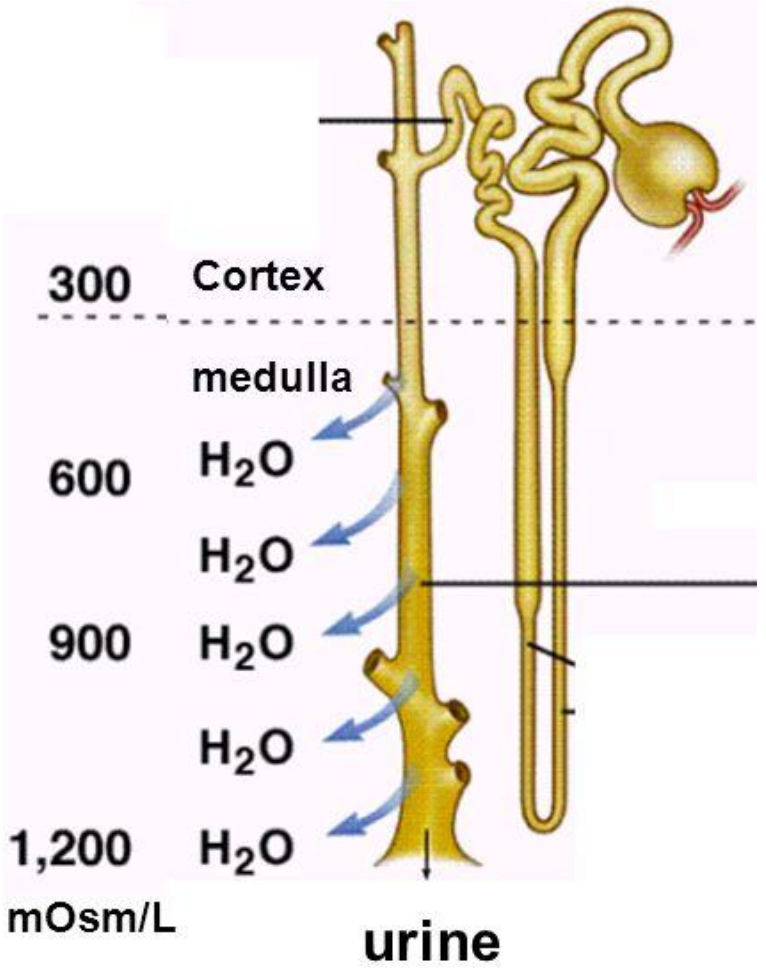
- It should be noted that the isosmolality principals applies primarily to the main body fluid compartments. Other body fluids can differ significantly from 290 mosmol/kg H_2O, including the peritubular interstitial fluid of the renal medulla (as much as 1200 mosmol / Kg H_2O) and certain transcellular fluids such as urine whose osmolality can very from 70 mosmol/ Kg H_2O to 1200 mosmol/ Kg H_2O.

1. Driving force

The ***high osmolarity*** of extracellular fluid generated by ***NaCl*** and ***urea***, provides the driving force for water reabsorption.

2. Regulation

The medullary portion of the CD is ***not permeable to NaCl but permeable to water***, depending on ADH.



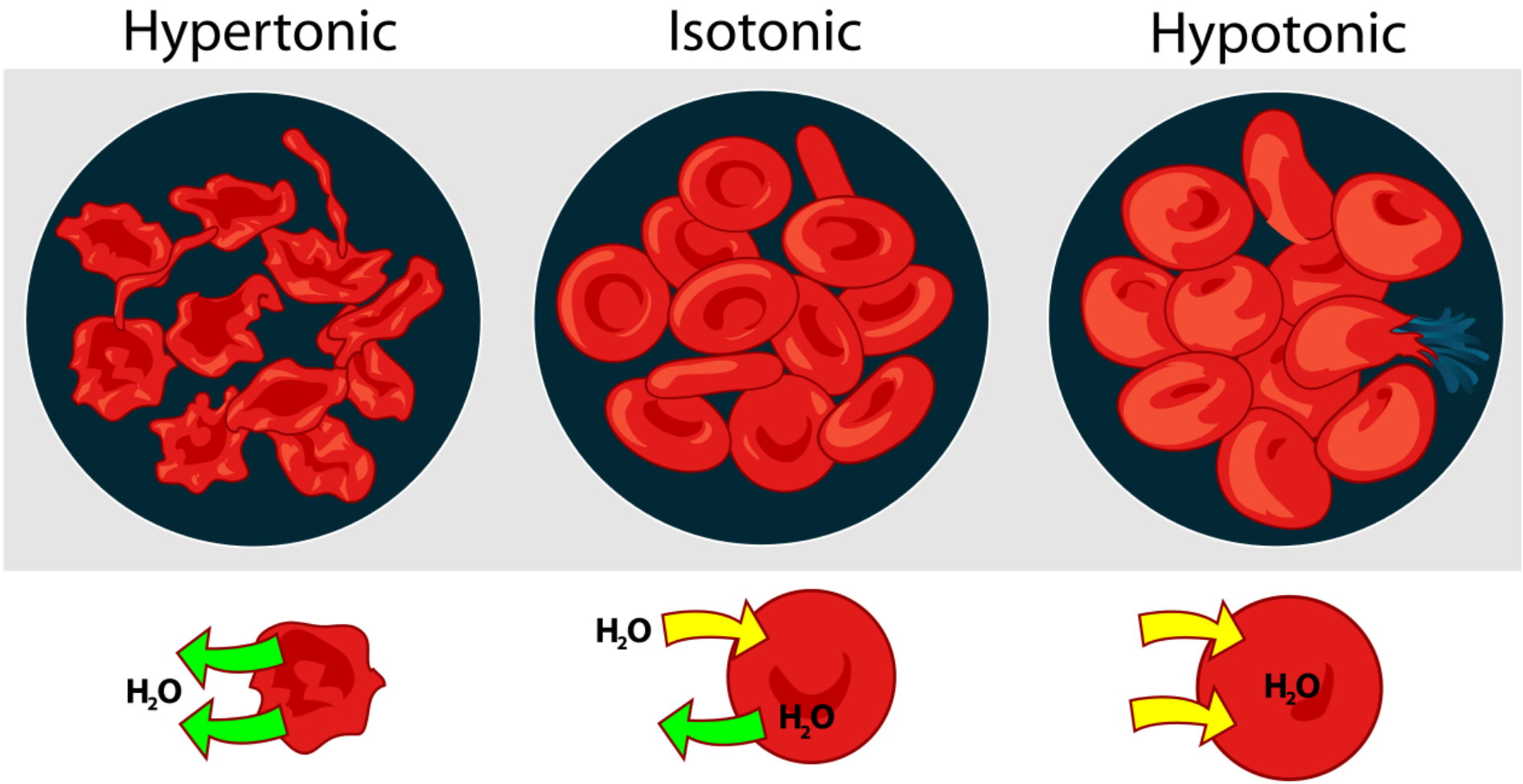
Tonicity

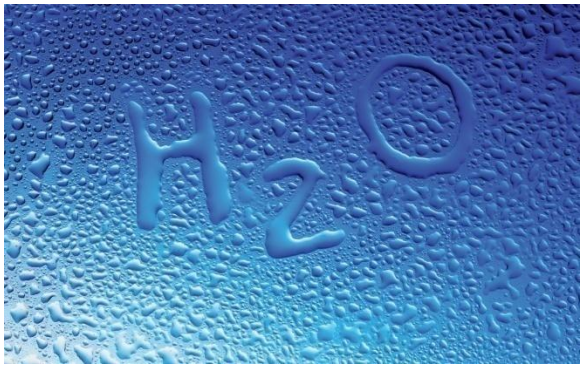
- The term **tonicity** is used to describe the effective osmotic pressure solution relative to plasma in which the normal body cells can be placed without causing either swelling or shrinking.

A solution with effective osmotic pressure as plasma is said to be **isotonic** which corresponds to 0.9 % solution of NaCl or a 5% glucose solution.

Those solutions with greater pressure are **hypertonic** in which the normal body cells shrink when they are placed in it.

Those solutions with lesser pressure are **hypotonic** in which the normal body cells swell when they are placed in it.


Hypertonic
Isotonic
Hypotonic
H_2O
H_2O
H_2O
H_2O



If water is added to the extracellular fluid by injection into the blood stream, by injection beneath the skin, or by ingesting water followed by absorption from gastrointestinal tract into the blood, the water dilutes the extracelluar fluids, causing it to become hypotonic with respect to the interstitial and to the intracellular fluids.

Osmosis begins immediately at the capillary and cells membranes, with large amounts of water passing to the interstitial and to the interiors of the cells, within a few minutes the water becomes distributed almost evenly amongst all the extracelluar and intracellular fluid compartments, and all compartments will have the same osmolalities (i.e. the same tonicity).

- Excess water intake and dilution of extracelluar fluid called overhydration *or water intoxication*.



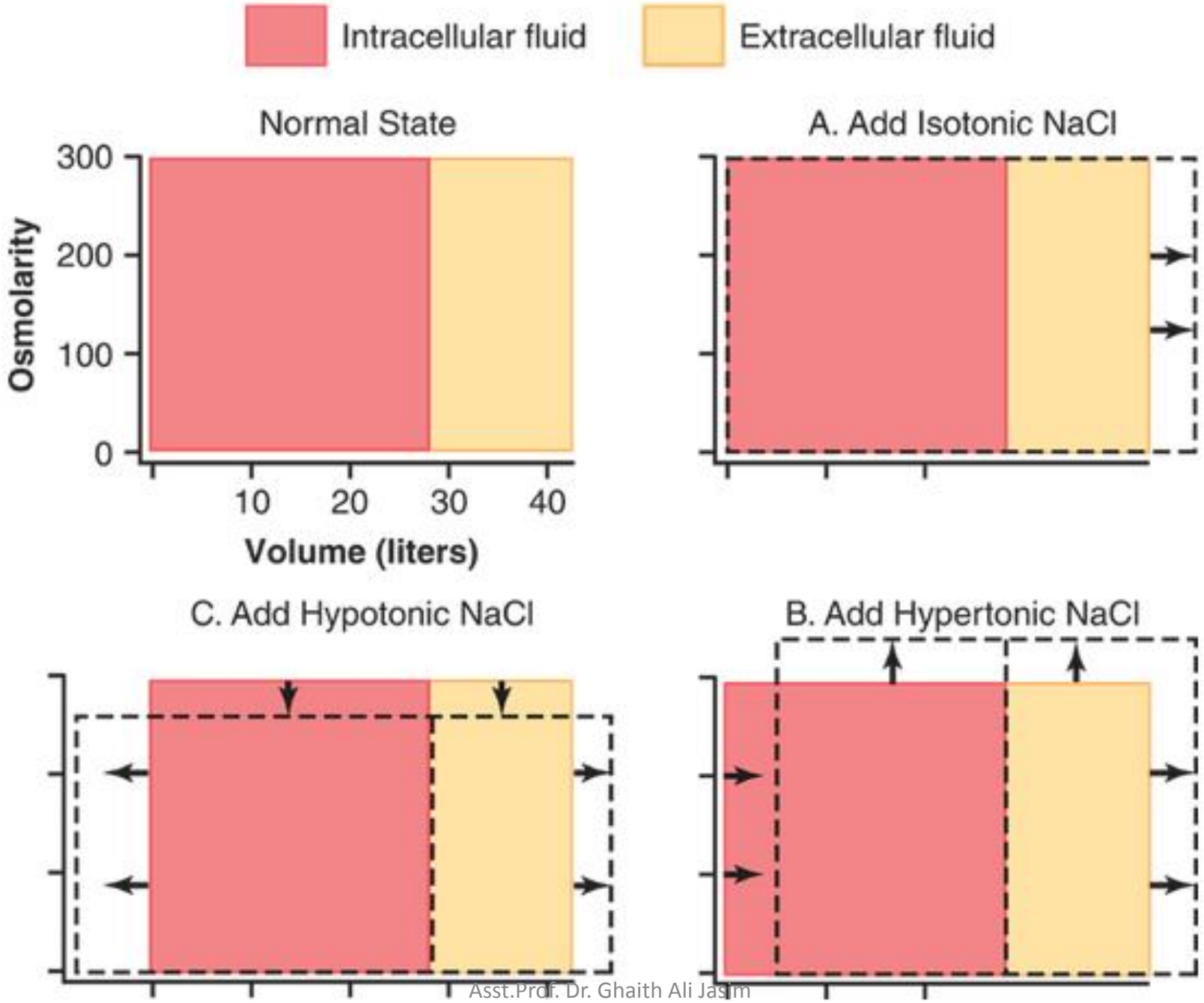


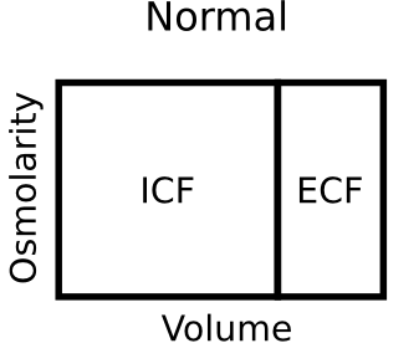
If water is lost from the body by evaporation from the skin, evaporation from the lungs, or excretion of a very dilutes urine as in diabetes insipidus, or loss in feces as in diarrhea.

- the water will leave the extracellular fluid compartment causing this compartment to have a hypertonic fluid in respect to the fluids in the intracellular compartments.

- Osmosis begins immediately at the cell membrane with water passing to the interstitium and plasma and distributed uniformly between the three compartments, so that all the three compartments will have the same osmolalities. The overall effect is called *dehydration.*

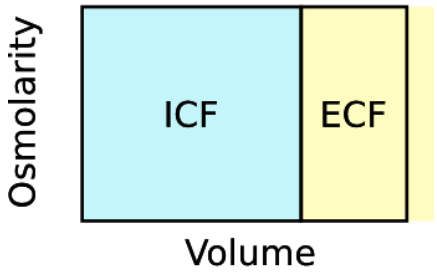



Intracellular fluid
Extracellular fluid
Normal State
A. Add Isotonic NaCl
Osmolarity
300
200
100
0
10
20
30
40
Volume (liters)
C. Add Hypotonic NaCl
B. Add Hypertonic NaCl

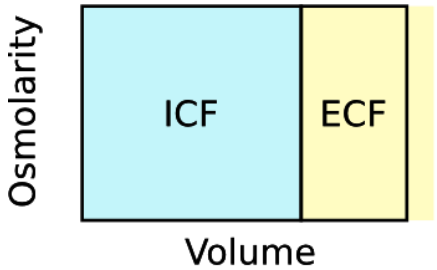


Isotonic Saline Infusion

Isoosmotic Volume-addition to ECF

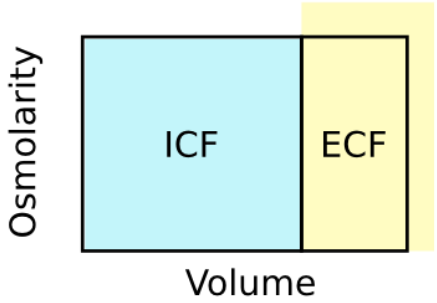


Water flow: None

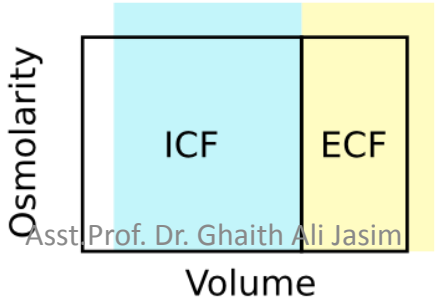


Hypertonic Saline Infusion

Hyperosmotic Volume-addition to ECF

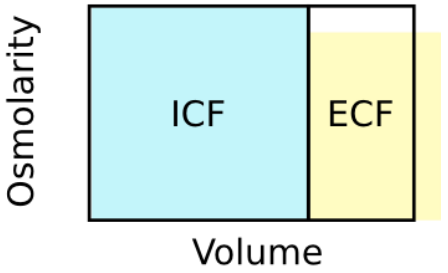


Water flow: ICF → ECF

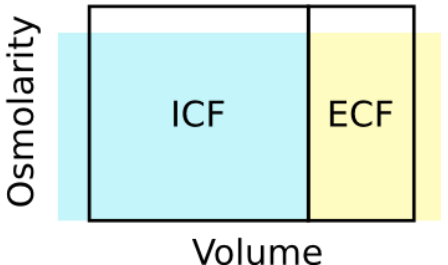


Glucose Infusion

Hyposomotic Volume-addition to ECF



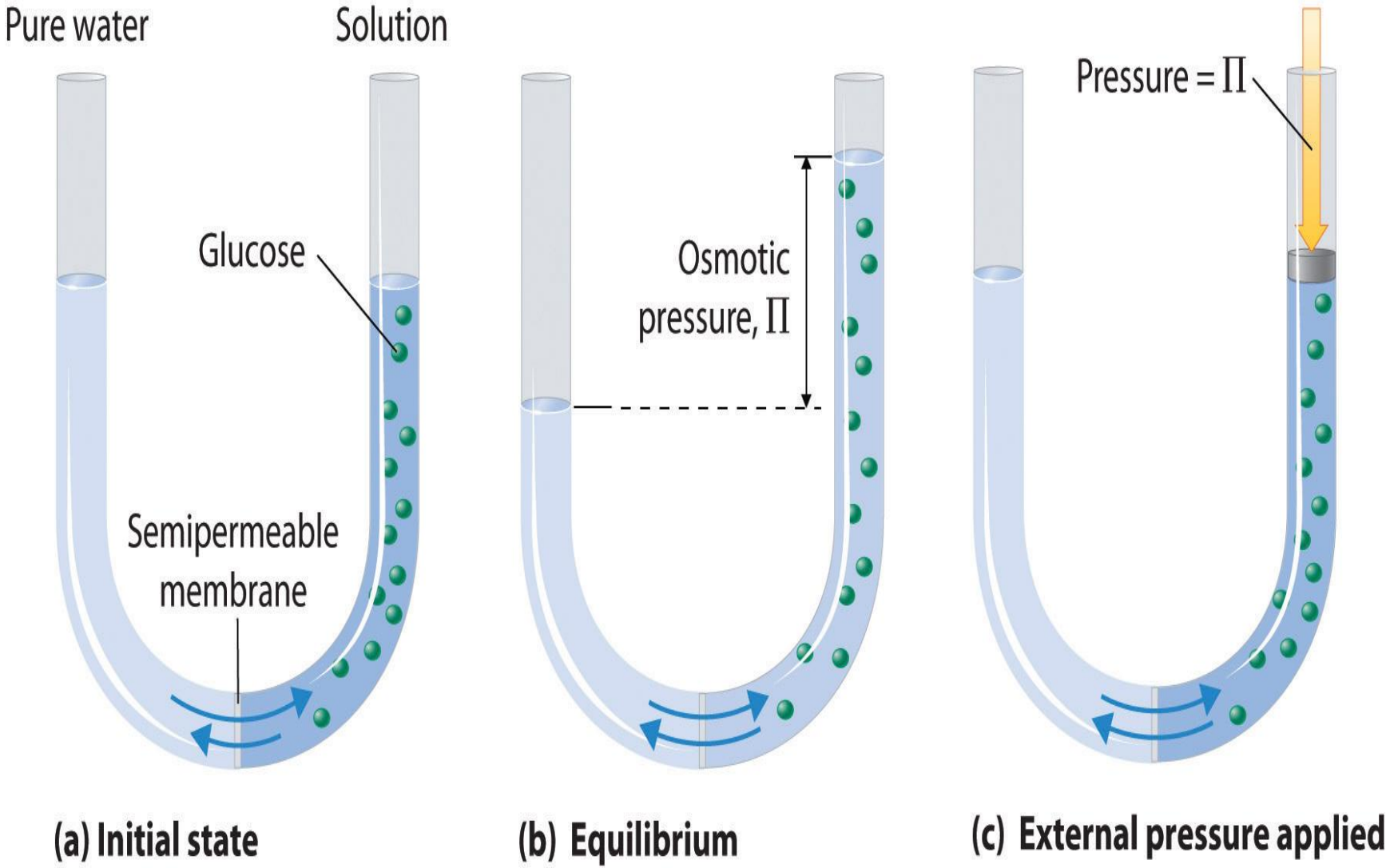
Water flow: ECF → ICF

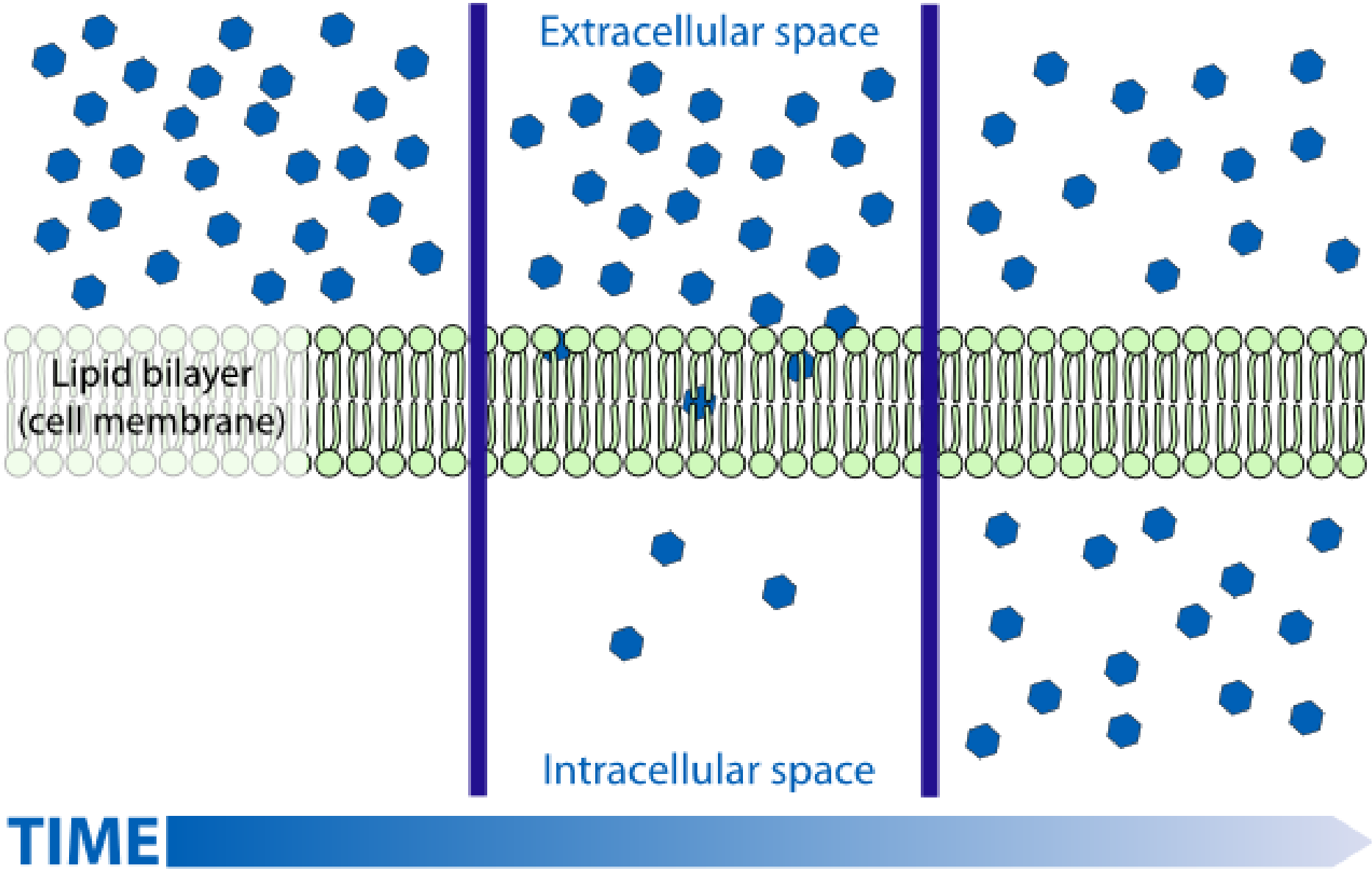


Asst. Prof. Dr. Ghaith Ali Jasim

Forces producing movement of substances between Compartments

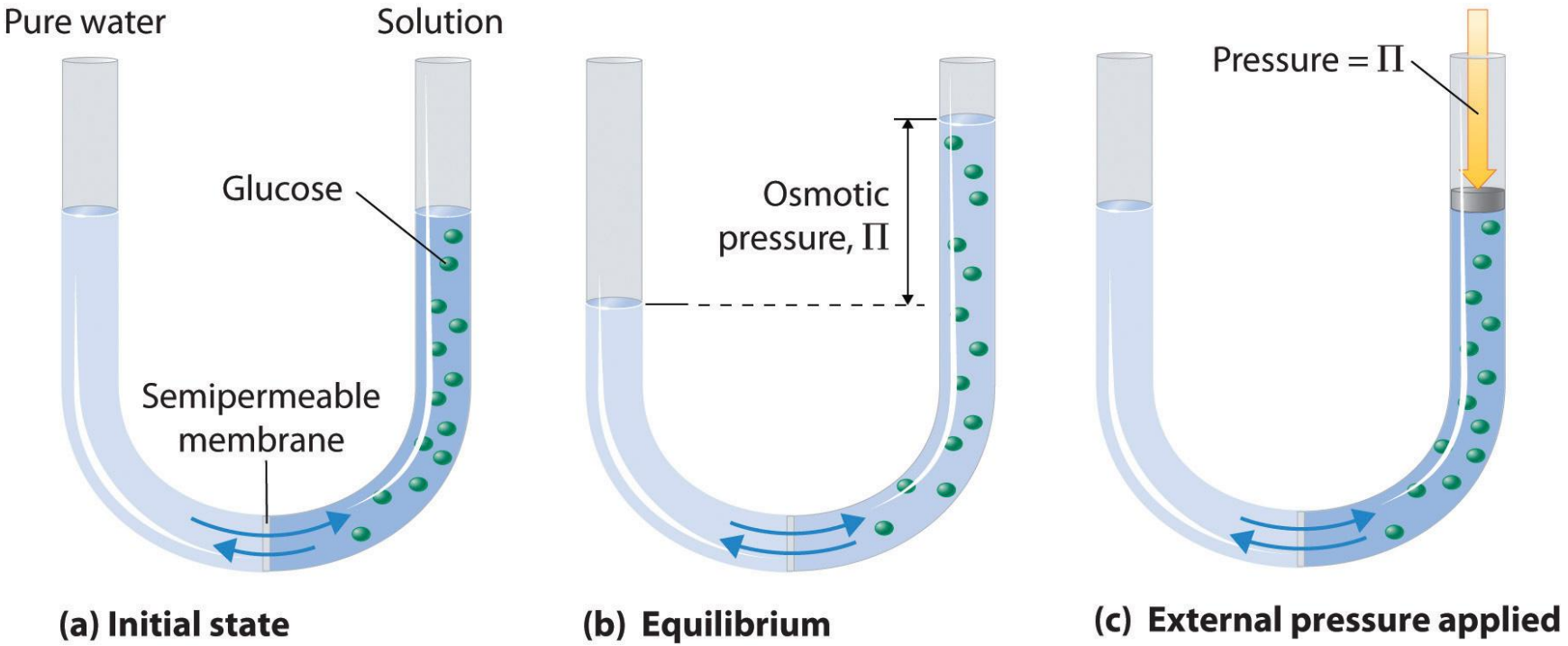
- **[1] Simple diffusion:** In which the molecules or ions tend to spread from regions to another regions through the **membrane lipid bilayer** (for lipid soluble substances such as oxygen, nitrogen, CO_2, and alcohol) or through **cell membrane pore** (Nonspecific "holes" in the lipid bilayer and include movement through the hydrophilic centers of protein complexes) or **protein channel** (for water and water soluble substances such as ions and glucose) until the concentration is uniform across the membrane.
- It does nor require metabolic energy and therefore, it is passive.


Pure water
Solution
Glucose
Semipermeable membrane
(a) Initial state
Osmotic pressure, Π
(b) Equilibrium
Pressure = Π
(c) External pressure applied


Extracellular space
Lipid bilayer
(cell membrane)
Intracellular space
TIME

Diffusion from one region to another is affected by:

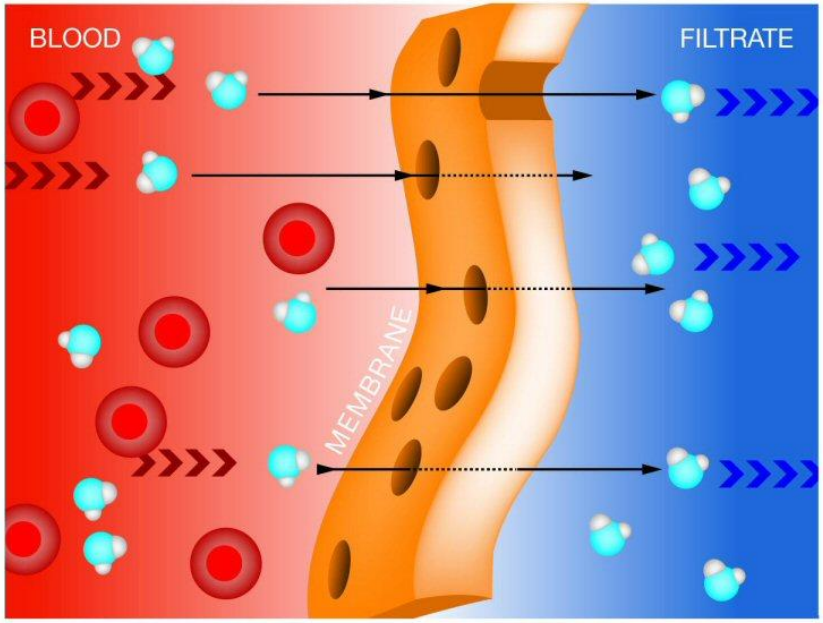
- ***(a)*** *the concentration gradient*
- ***(b)*** *the electrical gradient. Whenever there is a difference potential between 2 regions, positively charged ions move along this electrical gradient to the more negative charged region, negatively charged ions move in the opposite direction.*
- ***(c)*** *the thickness of the boundary*
- ***(d)*** *the cross sectional area of the boundary across which diffusion is tacking place.*

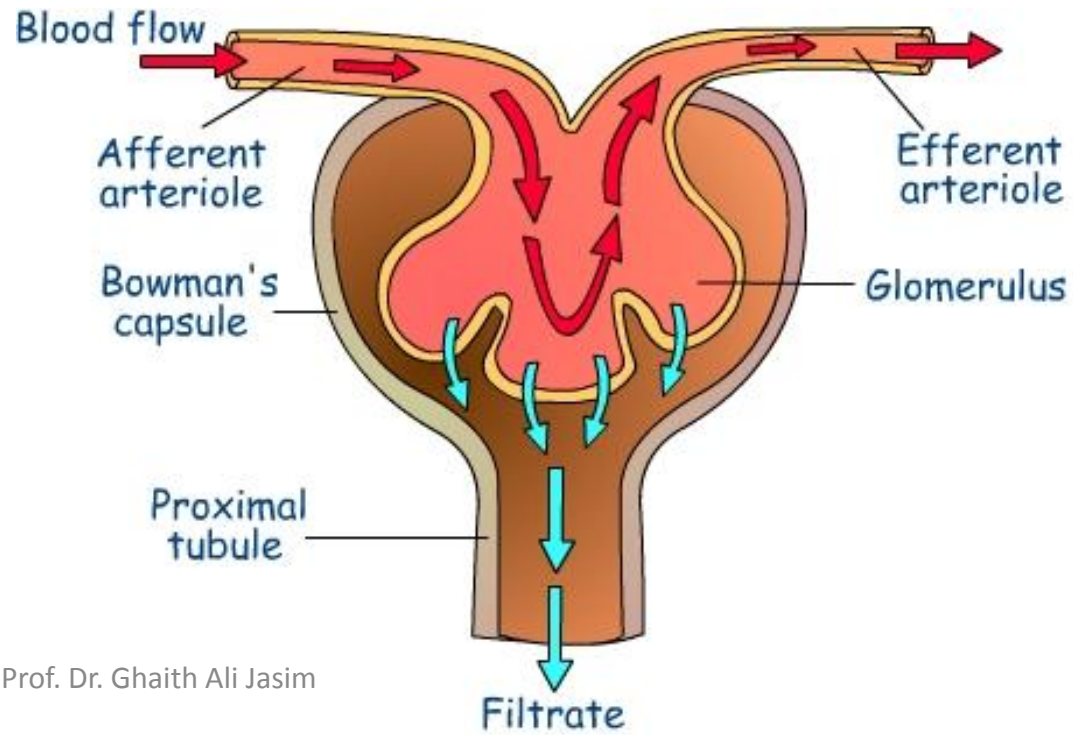

Pure water
Solution
Glucose
Semipermeable membrane
(a) Initial state
Osmotic pressure, Π
(b) Equilibrium
Pressure = Π
(c) External pressure applied

- ***(e)*** *Temperature. Diffusion is driven by the kinetic energy of the particles, and temperature is a measure of that kinetic energy. The warmer a substance is, the more rapidly its particles diffuse. This is why sugar diffuses more quickly through hot tea than through iced tea.*
- ***(f)*** *Membrane permeability. Diffusion through a membrane depends on how permeable it is to the particles. Cells can adjust their permeability to such a substance by adding channel proteins to the membrane or taking them away. Kidney tubules, for example, do this as a way of controlling the amount of water eliminated from the body*

- **[2] Solvent Drag:** When solvent is moving in one direction across the cell membrane, the solvent tends to drag along some molecules of solute. This force is called solvent drag. In most situations in the body, its effects are very small.

- **[3] Filtration:** Filtration is the process by which fluid forced through an epithelial layer or other barrier due to a difference in hydrostatic pressure on the two sides. Filtration is affected by :
- ***(a)*** *the pressure gradient across the membrane,*
- ***(b)*** *the surface area of the membrane,*
- ***(c)*** *the diameter of the membrane pores,*
- ***(d)*** *the size of the filtered molecules.*

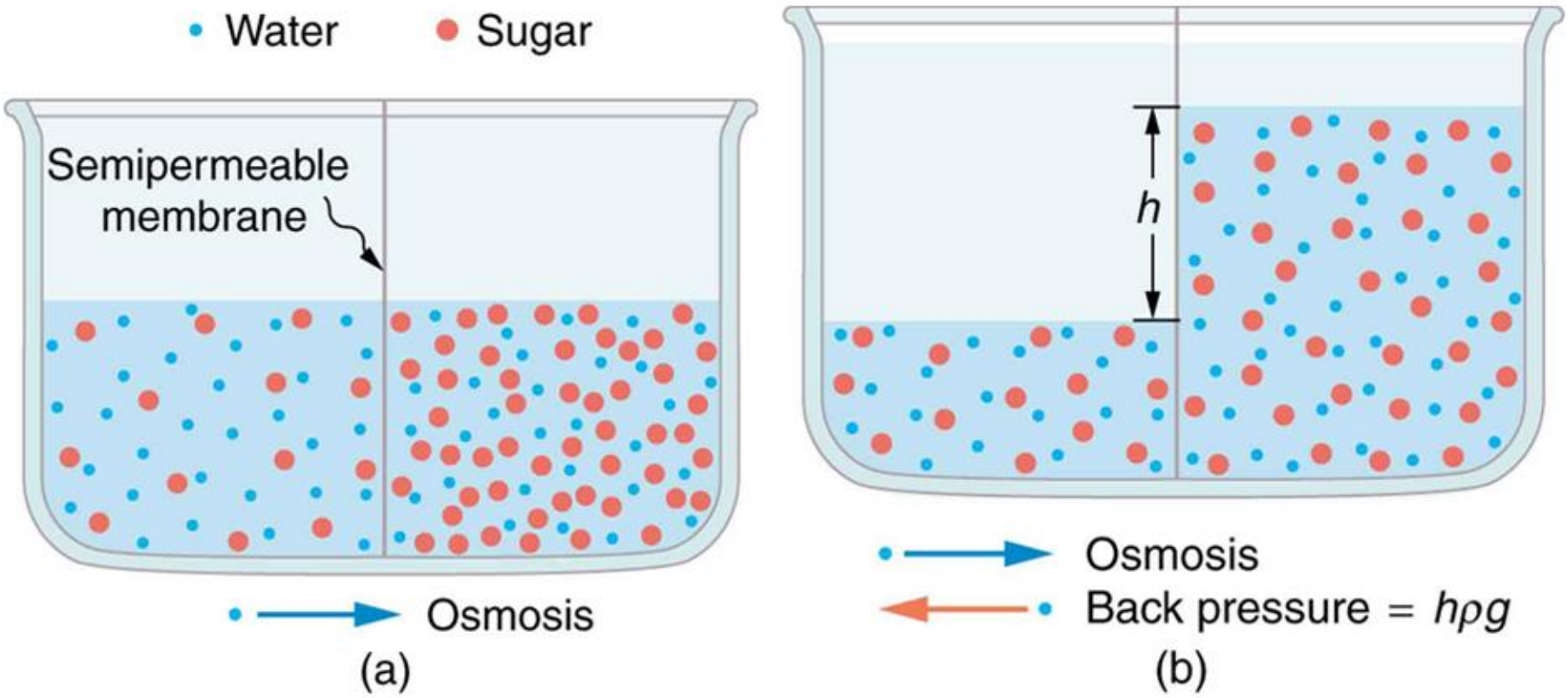

BLOOD
FILTRATE
MEMBRANE
Water molecules
Blood cells
Positive pressure
Negative pressure


Blood flow
Afferent arteriole
Efferent arteriole
Bowman's capsule
Glomerulus
Proximal tubule
Filtrate

In physiology, the most important case of filtration is seen in the blood capillaries, where blood pressure forces fluid through gaps in the capillary wall. This is how water, salts, nutrients, and other solutes are transferred from the bloodstream to the tissue fluid and how the kidneys filter wastes from the blood. Capillaries hold back larger particles such as blood cells and proteins.

- **[4] Osmosis.**

- **[5] Nonionic diffusion:** Some weak acids and bases are quite soluble in cell membranes in the undissociated form, whereas in the ionic from they cross membranes with difficulty. Consequently, if molecules of the undissociated substances diffuse from one side of the membrane to the other and then dissociate, they are effectively moved from one side of the membrane to another.


Water
Sugar
Semipermeable membrane
Osmosis
(a)
h
Osmosis
Back pressure = hρg
(b)

- **[6] Carrier-mediated transport:** It is the transport of substances across the cell membrane mediated by a carrier protein. This type of transport is characterized by the following:

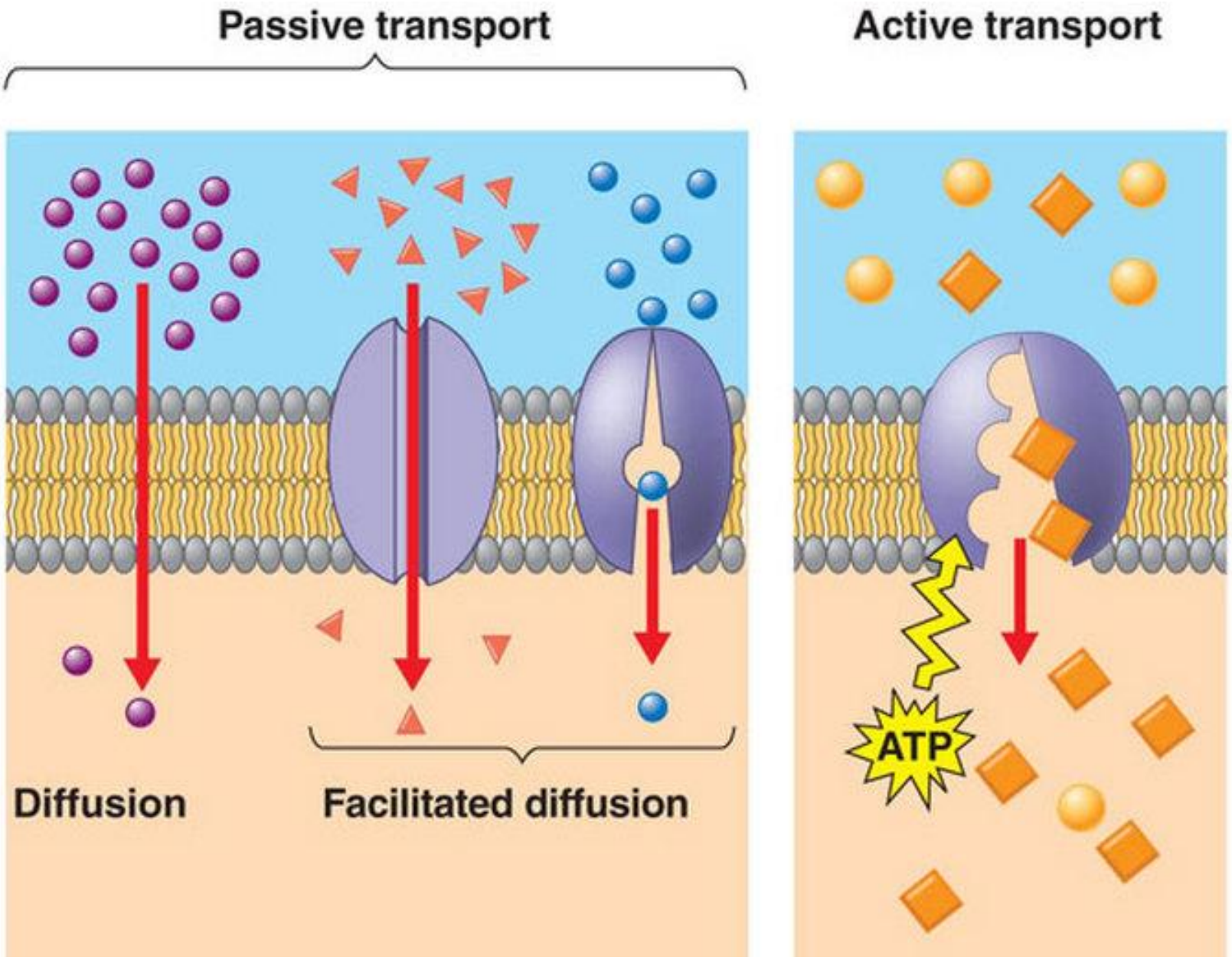
Carrier-mediated transports are of two main types:

[A] Facilitated diffusion: When the carrier-mediated transport occurs according to electrochemical gradient and the energy is not required (passive), the process is called facilitated diffusion. It is also called a **uniport transport**. Example of facilitated diffusion is glucose transport in muscle and adipose cells is carrier-mediated, according to the electrochemical gradient, and is inhibited by sugars such as galactose.

[B] Active transport: When the carrier-mdiated transport occurs against electrochemical gradient, the process requires energy and is referred to as active transport.

- **(i) Primary active transport:** In which high energy phosphate compound, ATP, provides directly the energy required for the transport process. Such a transport are Na-K-ATPase pump, H-ATPase pump (proton pump), and Ca-ATPase pump.

- **(ii) Secondary active transport:** In which the transport of one substances (e.g. Na^+) accodrding to electrochemical gradient provides the energy to transport another substance against its electrochemical gradient. The metabolic energy is not provided directly, but indirectly from the Na^+ gradient, which is maintained across cell membranes by Na^+-K^+ ATPase pump. Thus, inhibition of Na^+-K^+ ATPase pump will decrease transport of Na^+ out of cell, decrease the transmembrane Na^+ gradient, and eventually inhibit secondary active transport.


Passive transport
Active transport
Diffusion
Facilitated diffusion
ATP

The direction of the carrier-mediated transport is:

[a] Uniport transport: If one transported substance is moving in one direction and without an associated transport of another substance (as in the facilitated diffusion of glucose).

[b] Co-transport or **symport:** If two or more of the transported substances are moving in the same direction (as Na co-transport of glucose and amino acids, Na-K-2Cl co-transport).

[c] Counter-transport or **antiport:** If two or more of the transported substances are moving in the opposite direction (as Na-Ca counter-transport and Na-H counter transport).

- **7. Transport of proteins and other large molecules:** This may occur through **endocytosis** and **exocytosis** processes**.**

The primary factors (Starling forces) that determine fluid movement through the capillary mabrane

- **[1] The capillary hydrostatic pressure,** which tends to move or to filter the fluid outward through the capillary membrane. The capillary pressure at the arteriolar end is about **35 mm Hg** and it is about **15 mm Hg** at the venous side (except in glomerular capillaries, where it is higher and nearly constant of about 50-60 mm Hg). The filtration is greater at the arteriolar side than at the venous side.

- **[2] The interstitial fluid hydrostatic pressure,** which tends to move fluid outward through the capillary membrane when interstitial fluid pressure is negative. It is about **– 4 to – 5 mm Hg**. The interstitial pressure can be affected by lymphatic drainage and by the tissue tension. If the lymphatic drainage is blocked, the interstitial fluid pressure is increased.

- **[3] The plasma colloid osmotic pressure,** which tends to cause osmosis of fluid inward through the membrane. The colloid osmotic (oncotic) pressure of normal human plasma averages approximately **25 mm Hg** mainly is caused by the dissolved protein (60-80 g/1). About 75% of the total colloid osmotic pressure of the plasma result from the albumin fraction, 25% from globulin, and almost non from the fibrinogen.

- **[4] The interstitial fluid colloid osmotic pressure** due to protein (1g/l) which tends to cause osmosis of fluid outward through the membrane. It is about **1 mm Hg.**

- **[5] Capillary permeability:** The capillary is completely permeable to small molecules and water, but is normally only slightly permeable to plasma protein. This permeability to colloids may be increased by a number of factors such as certain poisons, oxygen lack and bacterial toxins.

Intake versus output of water:

Most of the daily intake of water enters by the oral route. Approximately:

* **2250 ml** is in the form of pure water, some other beverage, and in the food that is eaten.
* **350 ml** is also synthesized in the body due to body metabolism.

The normal intake of fluid, including the synthesized in the body, average about **2600 ml per day**.

The daily loss of water normally, at an atmospheric temperature of about 20^{o} C, approximately:

- **1500 ml** is lost in the urine (500-700 ml. is obligatory, meaning it is essential to urinate at least 500 - 700 ml of urine per day to get rid of wastes).
- **200 ml** is lost in the sweat.
- **100 ml** in the feces.
- **800 ml** is lost by diffusion through the skin and respiratory tract.
- Therefore, the normal total output of water averages about **2600 ml per day**.

- Loss of water by diffusion through the skin and by evaporation from the respiratory tract is known as **insensible water loss** because we do not know that we are actually losing water at the time that it is leaving the body.
- The diffusion of water through the skin occurs when water molecules themselves actually diffuse through the cells of the skin.
- Fortunately, the cholesterol–filled cornified layer of the skin acts as a protector against still much greater loss of water by diffusion.
- When cornified layer becomes denuded, as after extensive burns, the rate of evaporation can increase to as much as 3 to 5 liters each day.

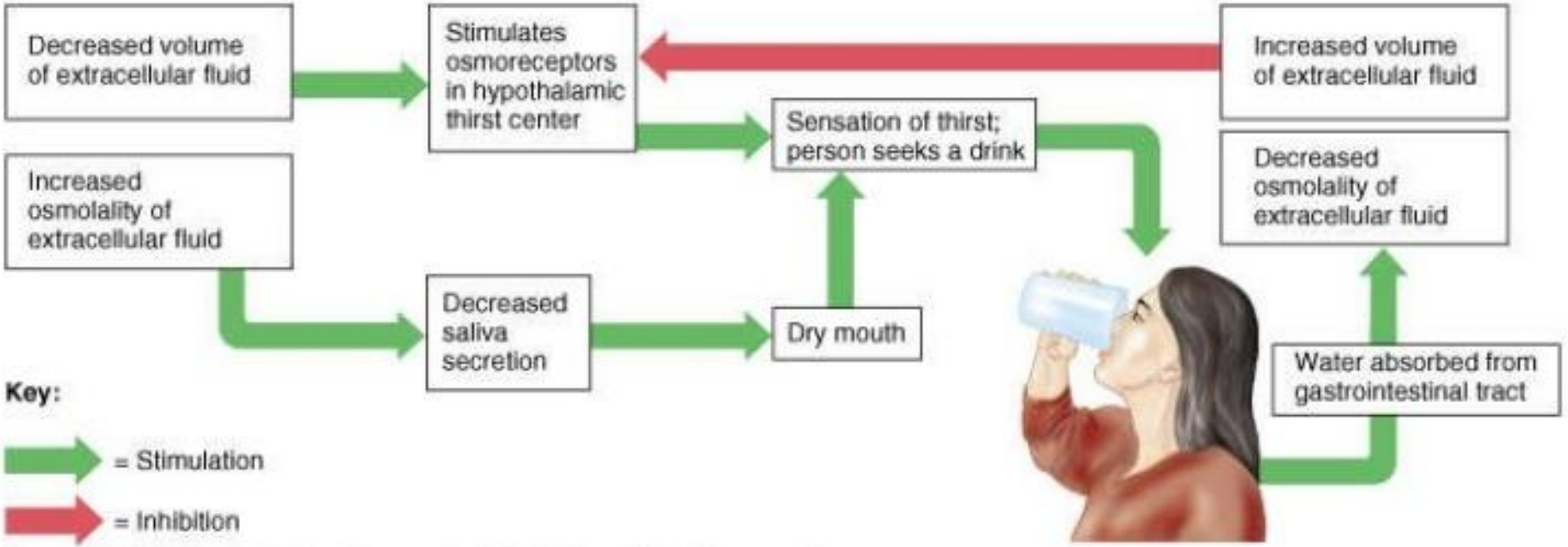
- In very hot weather, water loss in sweat is increased to as much as 1.5 to 2 liters an hour, which obviously can rapidly deplete the body fluids.
- Exercise increases the loss of water in two ways: First, it increases the rate of respiration, which promotes increased water loss through the respiratory tract in proportion to the increased ventilatory rate. Second, and much more important, exercise increases the body heat and consequentially is likely to result in exercise sweating.

Adjustment of water balance:

- Under normal conditions the osmolality of the body fluids is regulated extremely tightly to within about ± 2% of the mean plasma osmolality of 290 mosmol/kg H_2O. This is achieved by adjustment of water intake by means of the **thirst center** and by urinary output by means of **kidney**.

[1] Thirst center: It is located in the hypothalamus of the brain. Stimulation of the thirst center can be achieved by **osmoreceptor areas** located also in the hypothalamus.

- An increase in the electrolytes concentration inside the neurons of osmoreceptor areas or in the allied areas of hypothalamus (as a result of increase ECF osmolarity) stimulates thirst center and the subject developed an intense desire to drink water until the electrolyte concentration of the osmoreceptors center neurons return to normal.

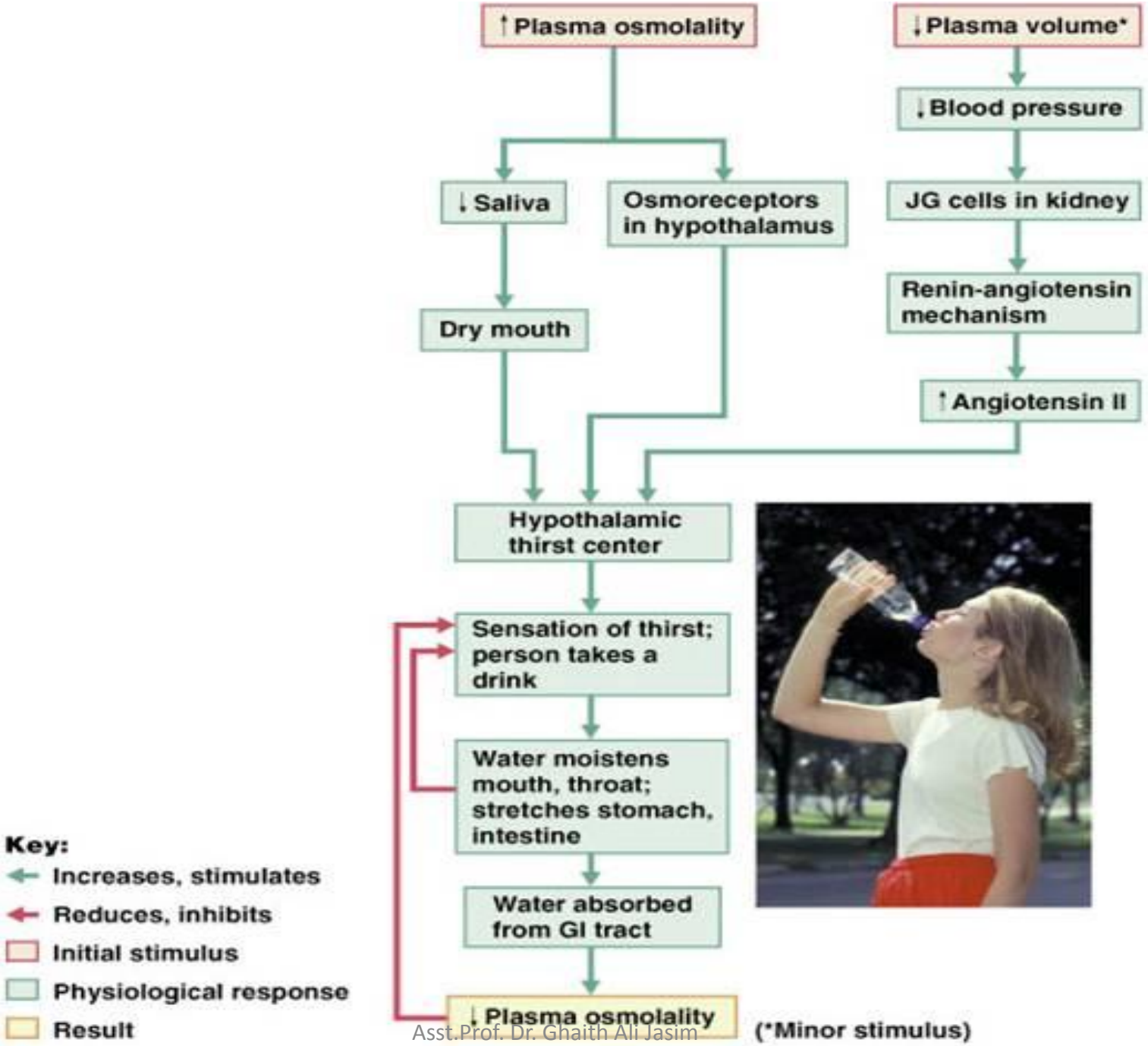


Copyright © 2001 Benjamin Cummings, an imprint of Addison Wesley Longman, Inc.

An increase of 2 – 3% in plasma osmolality triggers the thirst center of the hypothalamus.
Secondarily, a 10 – 15% drop in blood volume also triggers thirst. This is a significantly weaker stimulus.

The Thirst Mechanism

- It should be noted that if the plasma osmolality is raised by the presence of a substance such as urea, which rapidly equilibrates between the ECF and ICF, the osmoreceptors and consequently the thirst center are not simulated.
- The thirst center can be stimulated also by a **decrease in ECF volume**, by a pathway which is independent of the osmolality of the plasma. The effect of ECF volume depletion on thirst center is mediated in part via renin–angiotensin system in which angiotensin II acts on a specialized receptor area in hypothalamus to stimulate the neural areas concerned with thirst.



Asst.Prof. Dr. Ghaith Ali Jasim

**The result of the stimulation of thirst center and other osmoreceptor areas of the hypothalamus (supraoptic, paraventricular and suprachiasmatic nuclei of the hypothalamus) are:

- *(A) the creation the sensation of thirst and the desire to drink water.*

- *(B) the stimulation of the hypothalamus to secrete ADH (antidiuretic hormone, vasopressin) through the posterior pituitary gland. This hormone is absorbed into the blood and acts on the collecting ducts of the kidneys to cause massive reabsorption of water , thereby decreasing the loss of water into the urine.*

- **[2] Urinary output:** The kidney can adjust the urinary output through its autoregulatory mechanisms, through the activation of renin-angiotensin system, and through the effect of ADH on the kidney.

Clinical applications:

[A] Dehydration (volume contraction) states: They are of three types:

[1] Isomotic dehydration which is primarily caused by loss of isotonic fluid from ECF compartment. It can be caused by haemorrhage, plasma exudation through burned skin, and gastrointestinal fluid loss (as in vomiting and diarrhea). In this type of dehydration:

- ECF volume decreases while the osmolarity of the ECF is kept constant.
- Because osmolarity of ECF is unchanged, water does not shift between the ECF and ICF compartments.
- Therefore, the ICF volume and osmolarity do not change.
- The plasma protein concentration and haematocrit (Hct) are increased because the ECF volume is decreased.
- Arterial blood pressure is decreased.

[2] Hyperosmotic dehydration which is primarily caused by loss hypotonic fluid (water) from ECF compartment. It can be caused by diabetes insipidus, diabetes mellitus, alcoholism, administration of lithium salts (drugs), fever, and excessive evaporation from skin through heavy loss of sweat (which is hypotonic). In this type of dehydration:

- ECF volume decreases while the osmolarity of ECF is increased.
- Because osmolarity of ECF is decreased, water shifts from ICF to the ECF.
- As a result of this shift, ICF volume decreases while ICF osmolarity increases until it equals the ECF osmolarity.
- **The plasma protein concentration is increased while the haematocrit (Hct) remains unchanged because water shifts out of the RBCs, decreasing their volume and offsetting the concentrating effect of the decreased ECF volume.**

[3] Hyposmotic dehydration: This is primarily caused by loss of hypertonic fluid from ECF compartment. It can be caused by renal loss of NaCl because of adrenal insufficiency as in Addison's disease. In this type of dehydration:

- The osmolarity of ECF decreases.
- Consequently, water shifts from ECF to ICF.
- As a result of this shift, ECF volume is decreased while the ICF volume is increased with ICF osmolarity equals ECF osmolarity.
- **Plasma protein concentration increases because of the decrease in ECF volume. Haematocrit (Hct) increases because of the decreased ECF volume and because of RBCs swell as a result of water entry.**

[B] Overhydration (volume expansion) states: They are of three types:

[1] Isosmotic overhydration which is primarily caused by addition of isotonic fluid to the ECF compartment. It can be caused by any condition that is responsible to cause edema and also can be caused by oral or parenteral administration of large volume of isotonic NaCl (150 mmol/L). In this type of overhydration:

- The ECF volume is increased while the osmolality of the ECF is kept constant. Because osmolarity of ECF is unchanged, water does not shift between the ECF and ICF compartments.
- Therefore, the ICF volume and osmolarity do not change.
- The plasma protein concentration and haematocrit (Hct) are decreased because the ECF volume is increased.
- **Arterial blood pressure is increased.**

[2] Hyperosmotic overhydration which is primarily caused by addition of hypertonic fluid to the ECF compartment. It can be caused by oral or parenteral intake of large amounts of hypertonic fluid. In this type of overhydration:

- The ECF osmolarity is increased.
- Consequently, water shifts from ICF to ECF.
- As a result of this shift, ECF volume is increased while the ICF volume is decreased with ICF osmolarity equals ECF osmolarity.
- The plasma protein concentration and haematocrit (Hct) are decreased because of the increase in ECF volume.

[3] Hyposmotic overhydration which is primarily caused by addition of hypotonic fluid to the ECF compartment. It is caused by ingestion of a large volume of water or renal retention of water due to the syndrome of inappropriate antidiuretic hormone secretion (SIADH). In this type of overhydration:

- The volume of ECF increases because of water retention while ECF osmolarity is decreased.
- Consequently, water shifts from ECF to ICF.
- As a result of this shift, ICF volume increases and ICF osmolarity decreases until it equals ECF osmolarity.
- The plasma protein concentration decreases because of the increase in ECF volume. Haematocrit remains unchanged because water shifts into the RBCs, increasing their volume and offsetting the diluting effect of the gain of ECF volume.

Changes in volume and osmolarity of body fluids							
Type	**ECF volume**	**ECF osmolarity**	**ICF volume**	**ICF osmolarity**	**Plasma protein concentration**	**Hct**	**ECF [Na]**
Isosmotic dehydration	↓	=	=	=	↑	↑	=
Hyperosmotic dehydration	↓	↑	↓	↑	↑	=	↑
Hyposmotic dehydration	↓	↓	↑	↓	↑	↑	↓
Isosmotic overhydration	↑	=	=	=	↓	↓	=
Hyperosmotic overhydration	↑	↑	↓	↑	↓	↓	↑
Hyposmotic overhydration	↑	↓	↑	↓	↓	=	↓

= No change

Asst.Prof. Dr. Ghaith Ali Jasim


who
when
why
how
which
where
what