

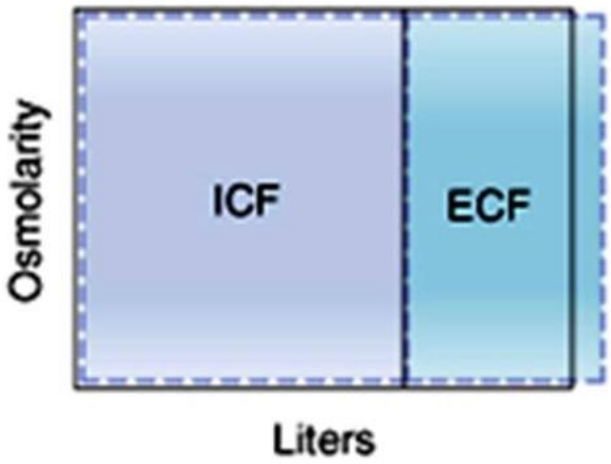


Ashur University
College of Medicine

Grade 2
Neuroscience

Physiology of body fluids

Lecture 2



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Objectives:

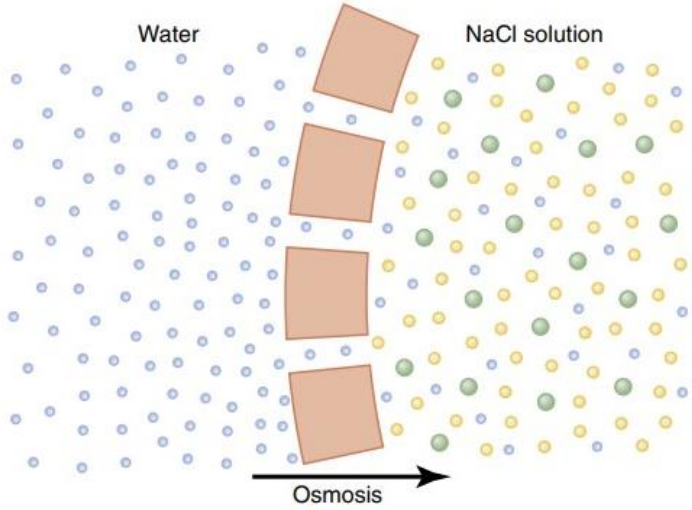
- Define Osmotic Pressure.
- Describe the Osmotic Equilibrium.
- Explain the Isotonic, Hypotonic, and Hypertonic Fluids.
- Explain the Effect of Adding Saline Solution to the Extracellular Fluid.
- Describe the fluids in potential spaces.

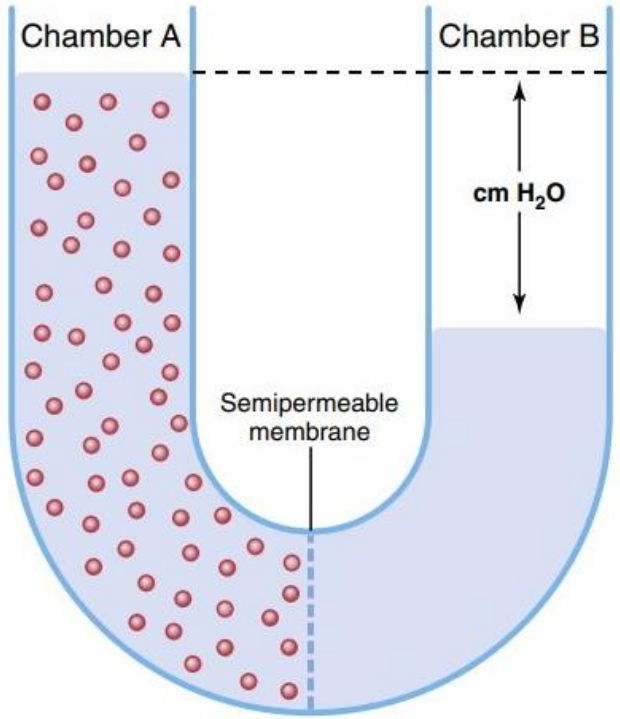
Osmotic Pressure

- **Osmosis** is the movement of water molecules from a region of higher concentration to a region of lower concentration through a semipermeable membrane.
- **Osmotic pressure** is the pressure required to stop water from diffusing through a membrane by osmosis.
- The **higher the osmotic pressure of a solution**, the **lower the water concentration** and the higher the solute concentration of the solution.
- **Example** : proper hydration of the blood molecules is an essential factor in the overall health.

Hypertonic solution of our blood is when our cells **do not have enough hydration**.

Hypotonic is the opposite, and it means we **have too much hydration in the cells.**





Relation Between Osmotic Pressure and Osmolarity

- The **osmotic pressure** of a solution is **directly proportional** to the concentration of osmotically **active particles in that solution**.
- The **osmotic pressure** of a solution is **proportional to its osmolarity**.
- The net movement of water into or out of cells is dictated by the osmotic pressure gradient. **Osmotic pressure causes water molecules from an area of lower osmolality (higher water concentration) to move to an area of higher osmolality (lower water concentration)** until the osmolalities of the compartments are equal.
- **Osmolality increases when the body is dehydrated and**

  decreases when there is too much fluid in the blood.

The body has a unique way to control osmolality. When **osmolality increases**, it triggers **the body to make AntiDiuretic Hormone (ADH), also called**

Arginine VasoPressin (AVP).

Osmolarity of the Body Fluids

Normal plasma osmolarity values range **from 275 to 295 mOsm/kg**

(275 to 295 mmol/kg).

Body fluid osmolarity is maintained constant within 1–2% at around **300 mOsm/L**.

The main compartments of body fluids are : **Intracellular** , extracellular fluid (**plasma** and **interstitial fluid**)

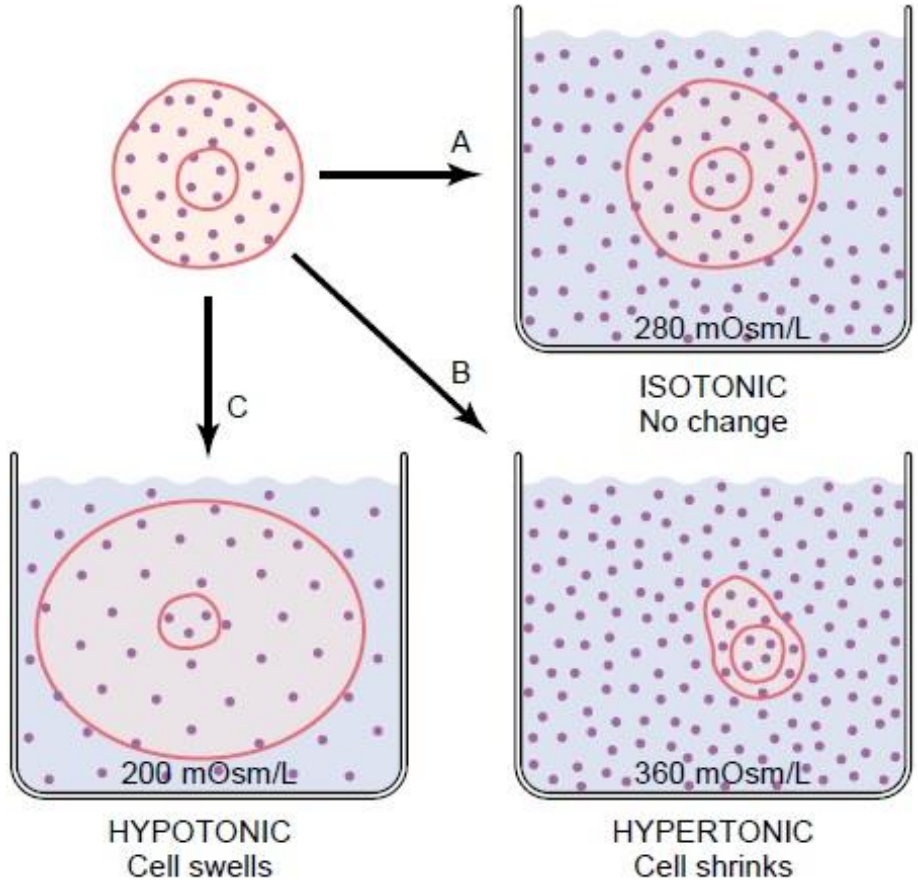
The total osmolarity of each of the three compartments is about 300 mOsm/L, with the **plasma** being about 1 mOsm/L greater than that of the **interstitial** and **intracellular fluids**. The slight difference between plasma and interstitial fluid is caused by the **osmotic effects of the plasma proteins**.

Osmotic Equilibrium Is Maintained Between Intracellular and Extracellular Fluids

- If a cell is placed in a **solution of impermeant solutes having an osmolarity of 282 mOsm/L**, the cells will not shrink or swell because the **water concentration in the intracellular and extracellular fluids is equal** and the solutes cannot enter or leave the cell.
- Examples of **isotonic solutions** include a

  0.9 per cent solution of sodium chloride

  or a **5 per cent glucose solution.**



Osmotic Equilibrium Between Intracellular and Extracellular Fluids Is Rapidly Attained

The transfer of fluid across the cell membrane occurs so rapidly that any differences in osmolarities between these two compartments are usually corrected within seconds or, at the most, minutes.

This rapid movement of water across the cell membrane does not mean that complete equilibrium occurs between the intracellular and extracellular compartments throughout the whole body within the same short period. The reason for this is that **fluid usually enters the body through the gut** and must be transported by the **blood** to **all tissues** before complete osmotic equilibrium can occur. **It usually takes about 30 minutes to achieve osmotic equilibrium everywhere in the body after drinking water.**



Fluids used in clinical practice: (Isotonic, Hypotonic, and Hypertonic Fluids)

Isotonic Fluid:

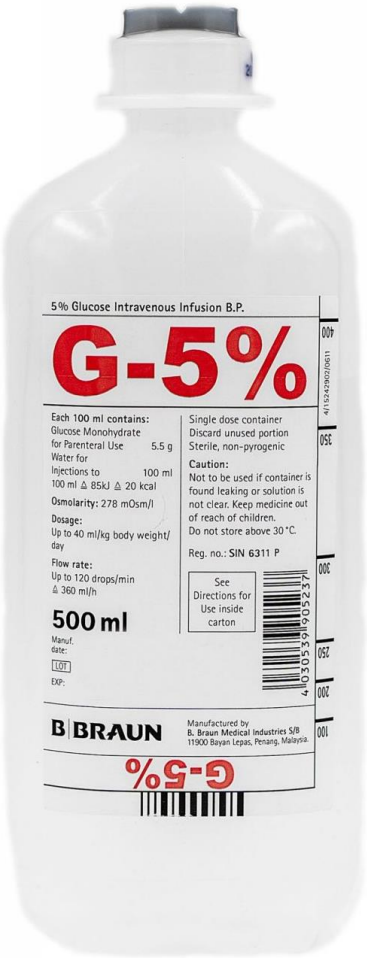
Examples of isotonic solutions include a

0.9 per cent solution of sodium chloride (Normal Saline) or a

5 per cent glucose solution

These solutions are important in clinical medicine because they can be infused into the blood without the danger of upsetting osmotic equilibrium.





Hypotonic fluid

If a cell is placed into a **hypotonic solution** that has a lower concentration of impermeant solutes (less than 282 mOsm/L), **water will diffuse into the cell**, causing it to swell. Water will continue to diffuse into the cell, diluting the intracellular fluid while also concentrating the extracellular fluid until both solutions have about the same osmolarity. **Solutions of sodium chloride with a concentration of less than 0.9 per cent (e.g. 0.45%) are hypotonic and cause cells to swell.**



Hypertonic fluid

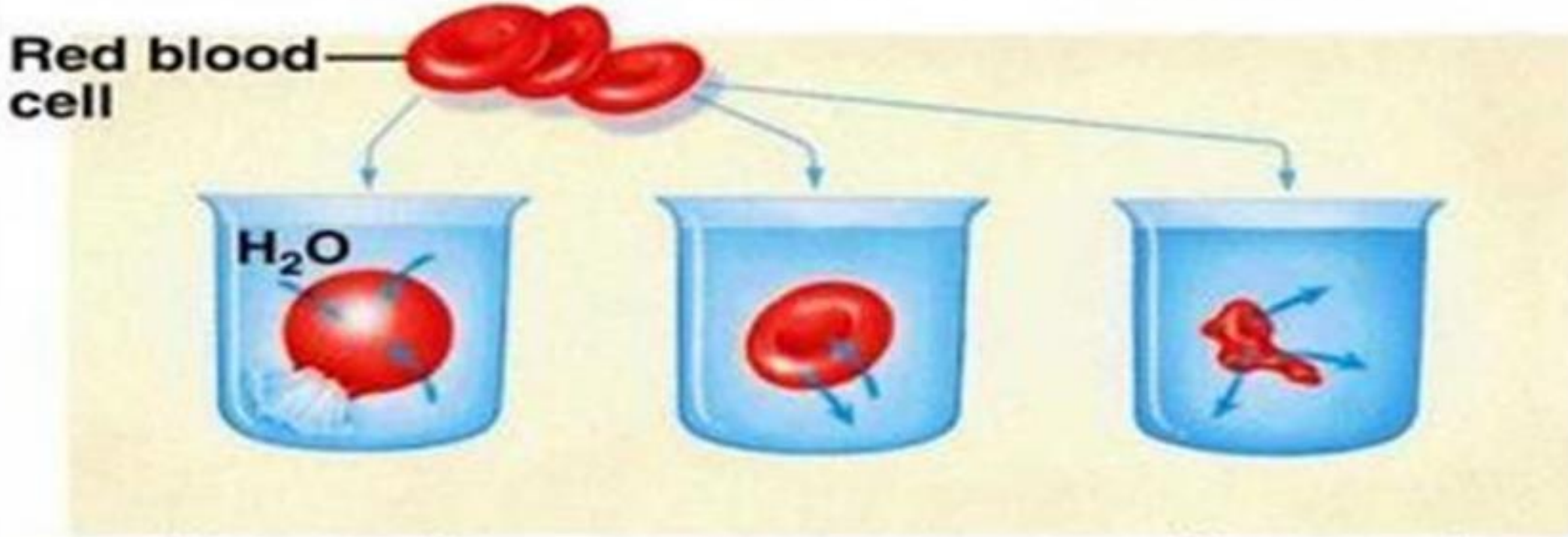
If a cell is placed in a **hypertonic solution** having a higher concentration of impermeant solutes, **water will flow out of the cell into the extracellular fluid**, concentrating the intracellular fluid and diluting the extracellular fluid. In this case, the **cell will shrink until the two concentrations become equal**. Sodium chloride solutions of greater than 0.9 per cent are hypertonic .(e.g. 3% NaCl)





Cell Transport

Effects of Hypotonic, Isotonic, and Hypertonic Solutions on Red Blood Cells



Isosmotic, Hyperosmotic, and Hypo-osmotic Fluids

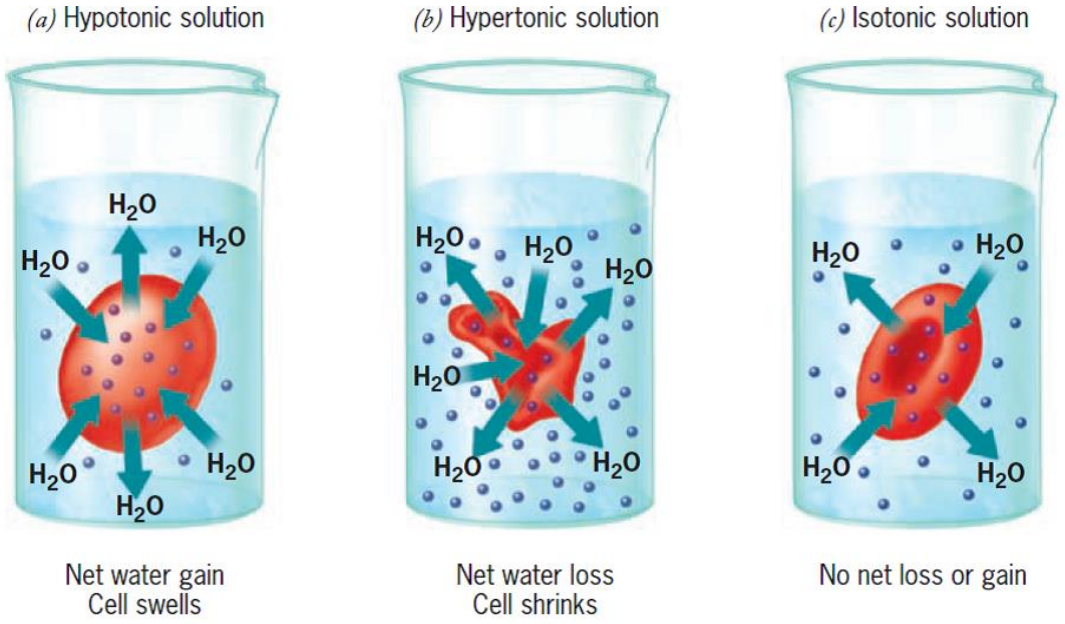
The terms **isotonic, hypotonic, and hypertonic** refer to whether solutions will cause a change in cell volume. The tonicity of solutions depends on the concentration of impermeant solutes. Some solutes, however, can permeate the cell membrane. **Solutions with an osmolarity the same as the cell are called isosmotic**, regardless of whether the solute can penetrate the cell membrane. The terms hyperosmotic and hypo-osmotic refer to solutions that have a higher or lower osmolarity,

respectively, compared with the

normal extracellular fluid,

without regard for whether

the solute permeates the cell membrane.



Volume and Osmolality of Extracellular and Intracellular Fluids in Abnormal States

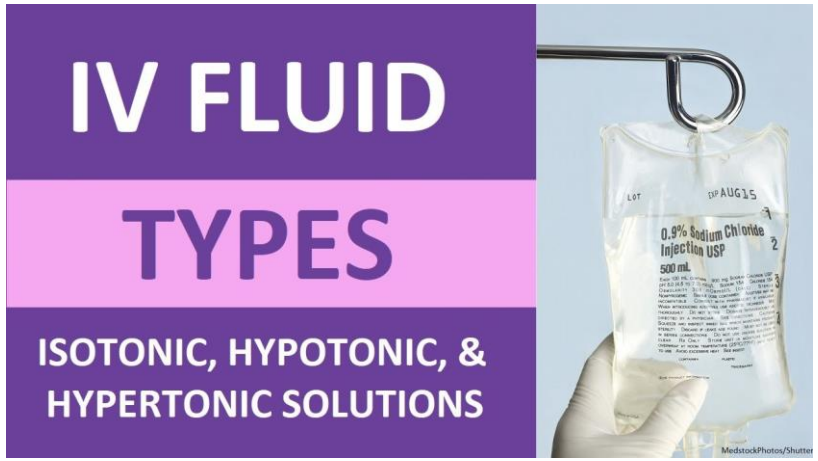
Some of the **different factors** that can cause extracellular and intracellular volumes to change markedly are:

- **Excessive ingestion of water,**
- **Dehydration,**
- **Intravenous infusion of different types of solutions,**
- **Loss of large amounts of fluid from the gastrointestinal tract**, and
- **Loss of abnormal amounts of fluid by sweating or through the kidneys**.

One can calculate both the changes in intracellular and extracellular fluid volumes and the types of therapy that should be instituted if the **following basic principles are kept in mind:**

1- Water moves rapidly across cell membranes; therefore, the osmolarities of intracellular and extracellular fluids remain almost exactly equal to each other except for a few minutes after a change in one of the compartments.

2- Cell membranes are almost completely impermeable to many solutes; such as sodium and chloride, therefore, the number of osmoles in the extracellular or intracellular fluid generally remains constant unless solutes are added to or lost from the extracellular compartment.





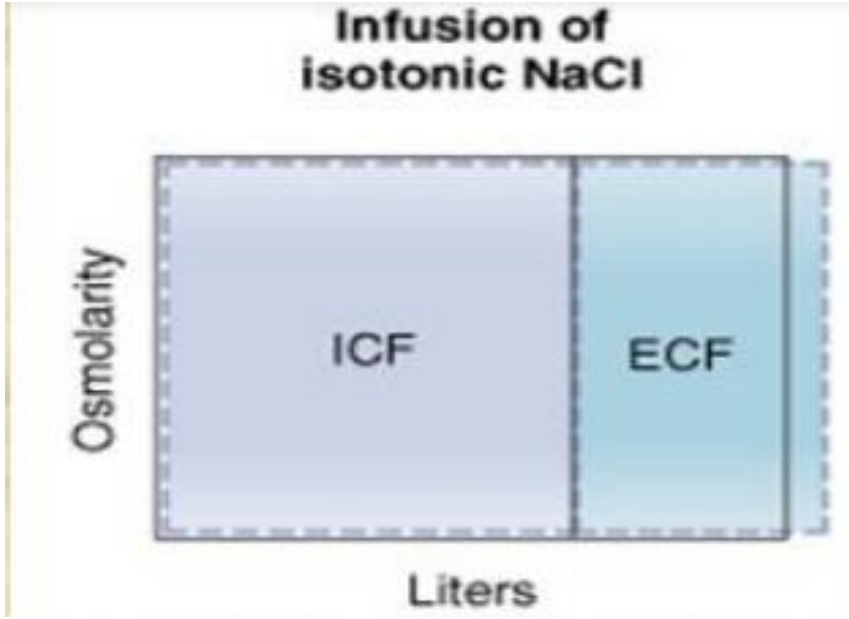
Effect of Adding Saline Solution to the Extracellular Fluid

- If **isotonic** saline is added to the extracellular fluid compartment, the **osmolarity of the extracellular fluid does not change**. The main effect is **an increase in extracellular fluid volume**. The sodium and chloride largely remain in the extracellular fluid because the cell membrane behaves as though it were virtually impermeable to the sodium chloride.

Infusion of isotonic NaCl

1-Increase in ECF volume

2-No change in osmolarity





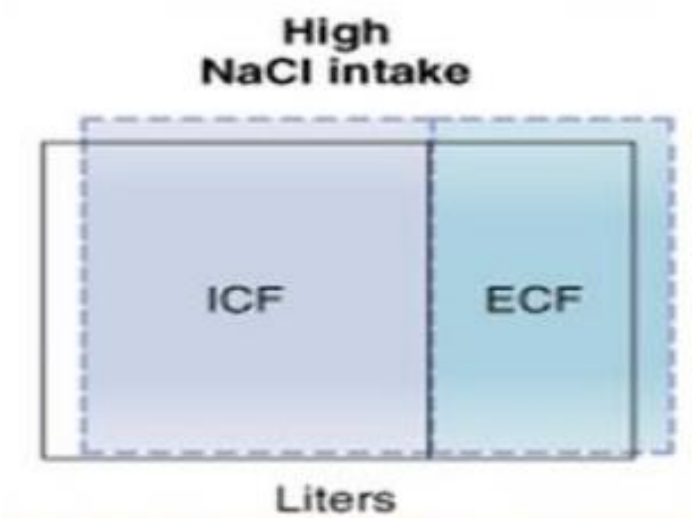
- If a **hypertonic** solution is added to the extracellular fluid, the **extracellular osmolarity increases** and causes osmosis of water out of the cells and into the extracellular compartment. Again, almost all the added sodium chloride remains in the extracellular compartment, and fluid diffuses from the cells into the extracellular space to achieve osmotic equilibrium. The net effect is an increase in extracellular volume (greater than the volume of fluid added), a decrease in intracellular volume, and a rise in osmolarity in both compartments.

Infusion of Hypertonic NaCl

↑ osmolarity in both (ICF and ECF)

↓ volume of ICF

↑ volume of ECF



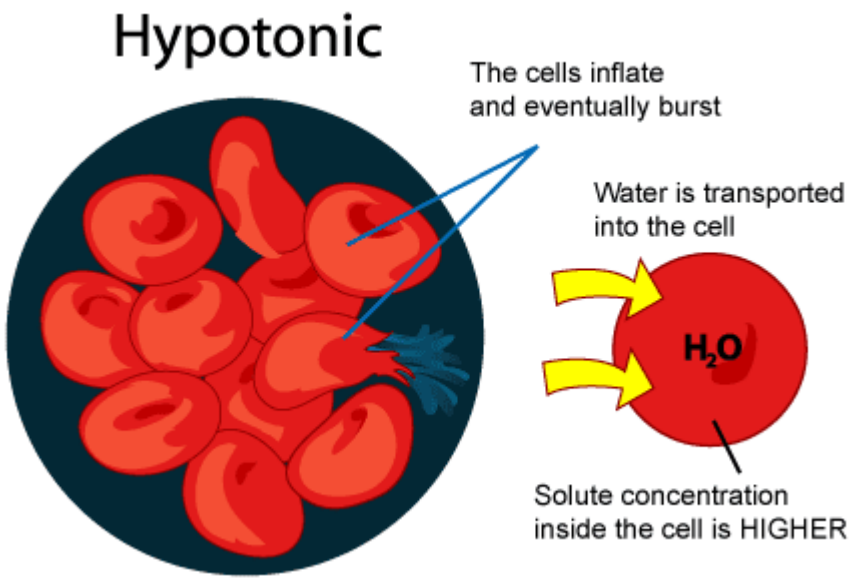


- If a **hypotonic solution is added to the extracellular fluid**, the **osmolarity of the extracellular fluid decreases**, and some of the extracellular water diffuses into the cells until the intracellular and extracellular compartments have the same osmolarity. Both the **intracellular and extracellular volumes are increased** by the addition of hypotonic fluid, although the intracellular volume increases to a greater extent.

Infusion of hypotonic NaCl

↑ volume (ICF and ECF)

↓ osmolarity (ICF and ECF)



Glucose and Other Solutions Administered for Nutritive Purpose

Several types of solutions are administered intravenously to provide nutrition to people who cannot otherwise ingest adequate amounts of nutrition. Glucose solutions are widely used; amino acid and homogenized fat solutions are used to a lesser extent.

A **5% glucose solution**, which is nearly isosmotic, is often used to treat dehydration. Because the solution is isosmotic, it can be infused intravenously without causing red blood cell swelling.

Infusion of a **5% glucose solution reduces extracellular fluid osmolarity** and therefore helps correct the increase in extracellular fluid osmolarity associated with dehydration.



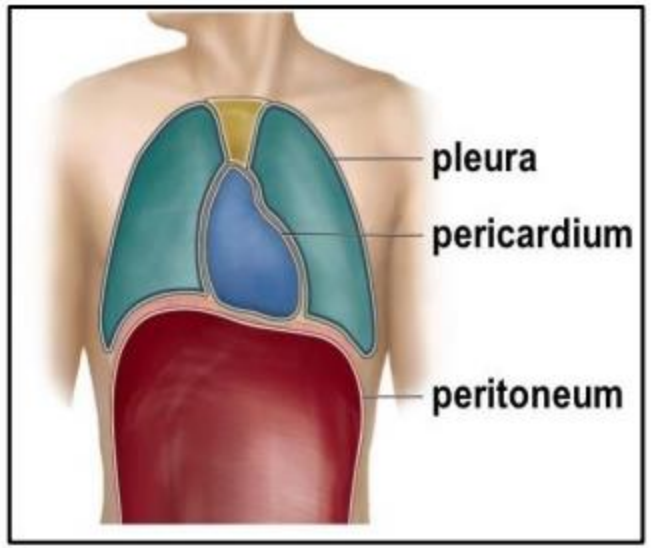
Infusion of a 5% glucose

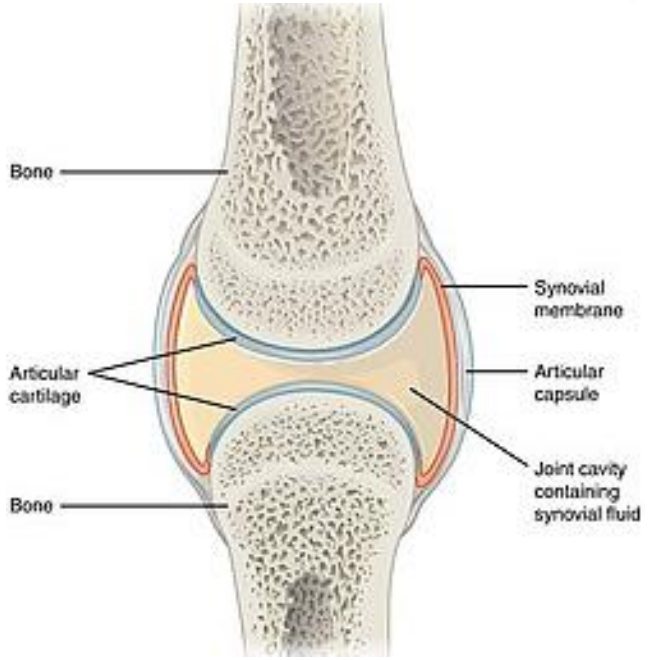
1- ↑ in ECF volume

2- ↓ ECF osmolarity

FLUIDS IN POTENTIAL SPACES OF THE BODY

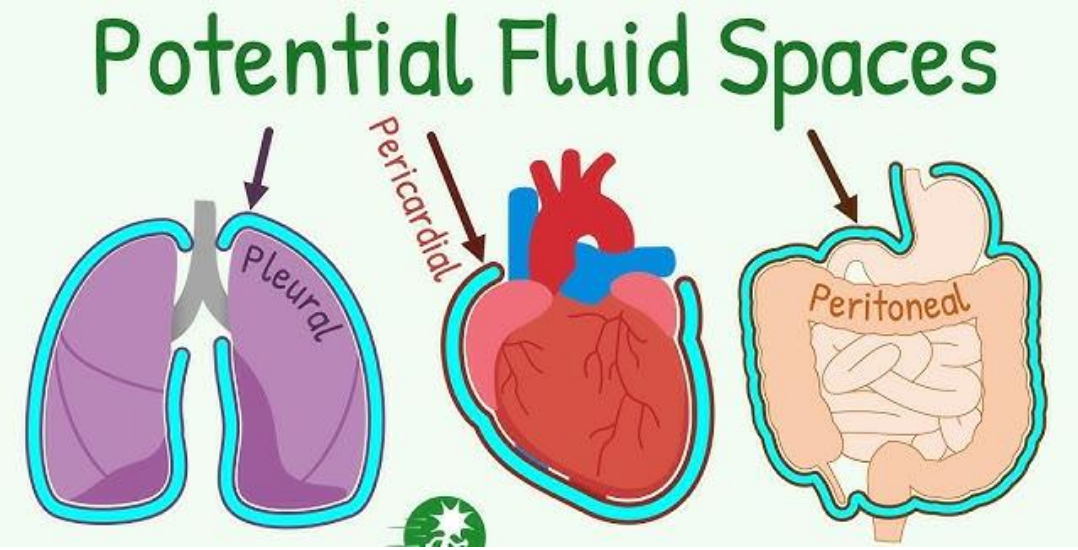
- Some **examples of potential spaces are** the **pleural**, **pericardial**, **peritoneal**, and **synovial cavities**, including both the joint cavities and the bursae. Virtually all these potential spaces have **surfaces that almost touch each other, with only a thin layer of fluid in between, and the surfaces slide over each other**. To facilitate the sliding, a viscous proteinaceous fluid lubricates the surfaces.





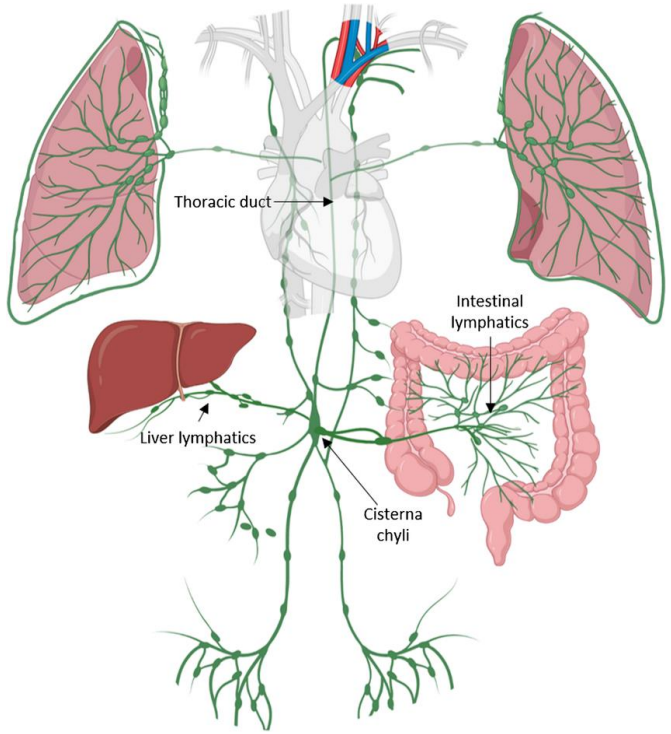
Fluid Is Exchanged Between Capillaries and Potential Spaces :

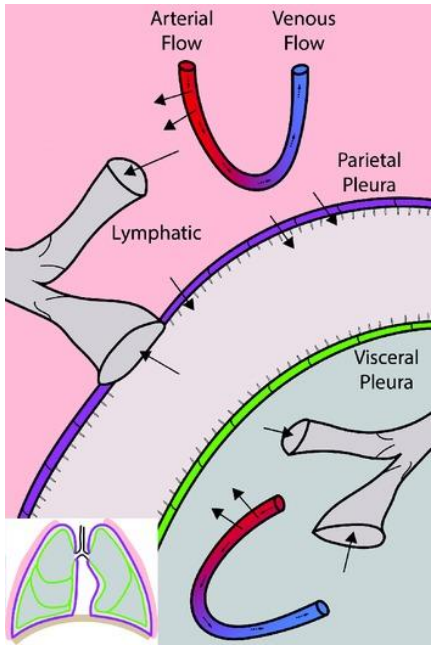
The surface membrane of a potential space usually does not offer significant resistance to the passage of fluids, electrolytes, or even proteins, which all move back and forth between the space and interstitial fluid in the surrounding tissue with relative ease. Therefore, each potential space is in reality a large tissue space. Consequently, **fluid in the capillaries** adjacent to the potential space diffuses not only into the interstitial fluid but also into the potential space.



Lymphatic Vessels Drain Protein From the Potential Spaces:

Proteins collect in the potential spaces because of leakage out of the capillaries, similar to the collection of protein in the interstitial spaces throughout the body. **The protein must be removed through lymphatics or other channels and returned to the circulation**. **Each potential space is directly or indirectly connected with lymph vessels**. In some cases, such as the pleural cavity and peritoneal cavity, large lymph vessels arise directly from the cavity itself.






Thank you