

**EXTRACELLULAR AND**

**INTERNAL**

**ENVIRONMENT**

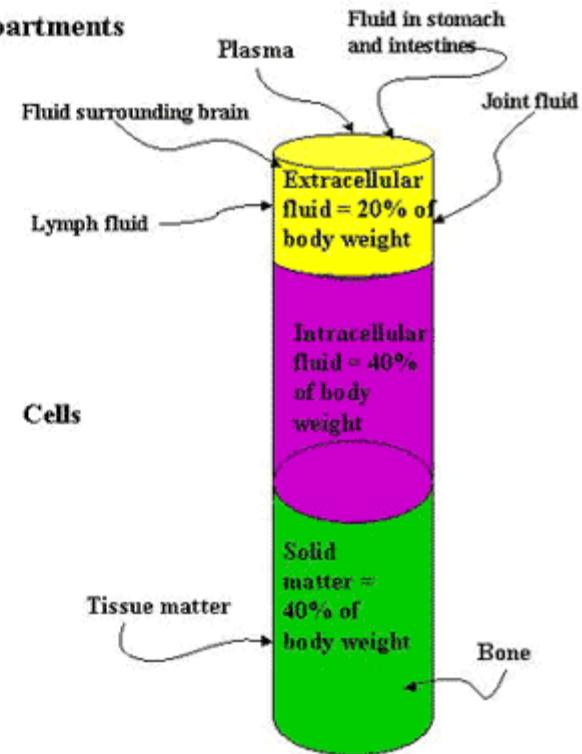
# Learning Objectives

At the end of the lecture the students should be able to:

- Define the extracellular and intracellular fluid.
- Describe origin of nutrients in the extracellular fluid.
- Explain removal of metabolic end products.
- Explain exchange of water ,nutrients, and other substances between the blood and interstitial fluid diffusion through the capillary membrane.
- Discuss the interstitium and interstitial fluid fluid imbalance edema.

# Body Fluids

- Water content of the body is divided into
- Intracellular compartment (67%)
  - Inside the cell
- Extracellular compartment (33%)
  - Outside the cell



**TOTAL VOLUME  
42 L**

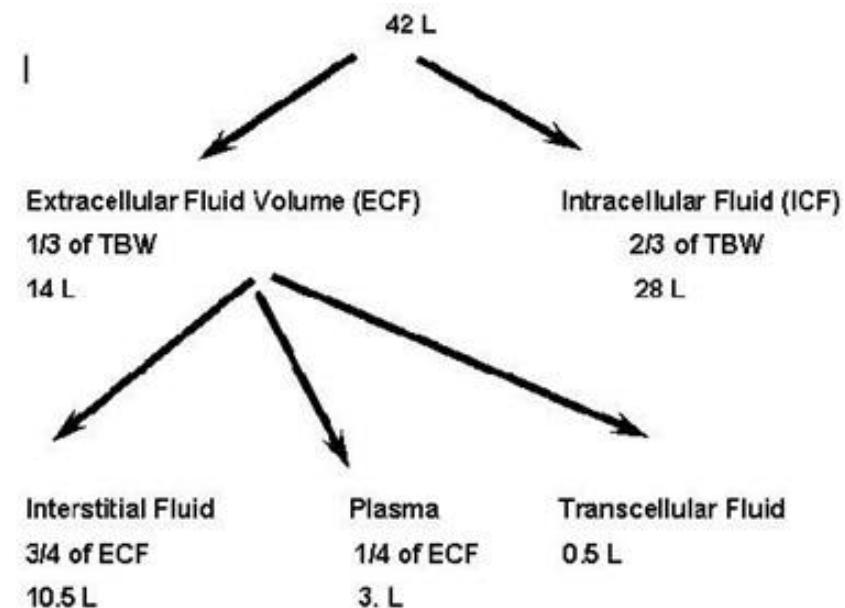
**INTRA CELLULAR FLUID  
28 L(ROUGHLY 2/3 OF**

**EXTRA CELLULAR FLUID  
14 L(ROUGHLY 1/3 OF TBW)**

**PLASMA  
4 L (ROUGHLY ¼ OF**

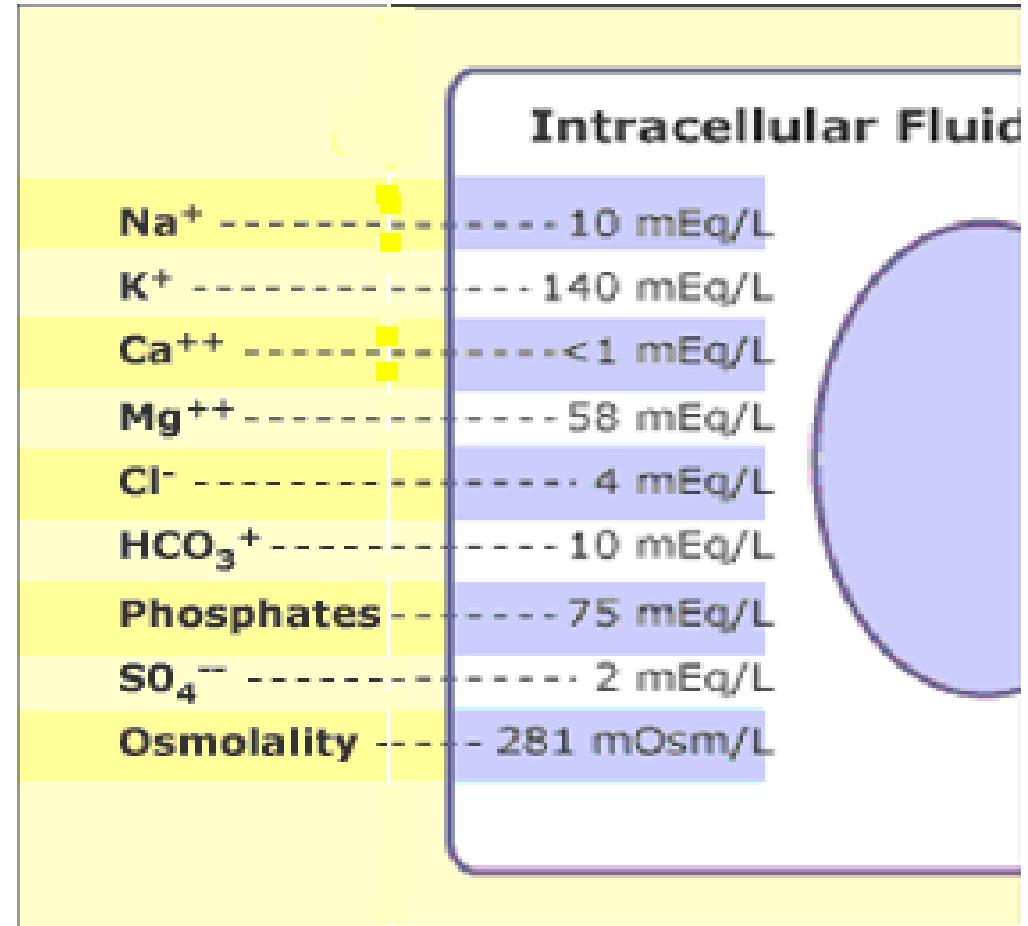
# Intracellular Fluid (ICF)

- **Intracellular Fluid (ICF)**
- **Cytosol** or **intracellular fluid (or cytoplasmic matrix)** is the liquid found inside cells.
- It is a complex mixture of substances dissolved in water. Although water forms the large majority of the cytosol
- Comprises 2/3 of the body's water.
- If body has 60% water, ICF is about 40% of your weight.



# Composition Of Intracellular Fluid

- The ICF consists of
- Potassium
- organic anions
- proteins etc. (Cellular Soup!).
  - The cell membranes and cellular metabolism control the constituents of this ICF.



# **Extracellular Fluid (ECF)**

- **Extracellular Fluid (ECF)**
- Denotes all body fluid outside of cells.
- It is the remaining 1/3 of your body's water.
- ECF is about 20% of the body weight.
- The ECF is primarily a NaCl and NaHCO<sub>3</sub> solution.

## **Body Fluid Distribution**

<b>Weight</b>	<b>70 Kg</b>	<b>100%</b>
<b>Body Water</b>	<b>42 L</b>	<b>60%</b>
<b>Intracellular Fluid (ICF)</b>	<b>28 L</b>	<b>40%</b>
<b>Extracellular Fluid (ECF)</b>	<b>14 L</b>	<b>20%</b>
<b>Plasma Volume (PV)</b>	<b>3.5 L</b>	<b>5%</b>

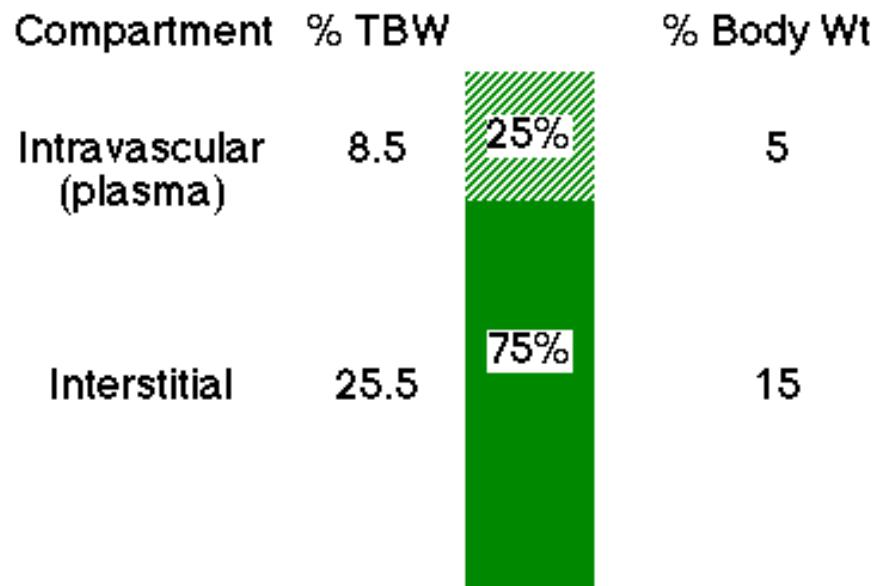
# Composition Of Extracellular Fluid

- **Main Cations:**
- Sodium ( $\text{Na}^+ = 136-145 \text{ mEq/L}$ )
- Potassium ( $\text{K}^+ = 3,5-5,5 \text{ mEq/L}$ )
- Calcium ( $\text{Ca}^{2+} = 8,4-10,5 \text{ mEq/L}$ )
- **Main Anions:**
- Chloride ( $\text{Cl}^- = 99-109 \text{ mEq/L}$ )
- Hydrogen Carbonate ( $\text{HCO}_3^- = 26 \text{ mM}$ )
- It is poorer in proteins compared to intracellular fluid

Extracellular Fluid	
$\text{Na}^+$	----- 142 mEq/L --
$\text{K}^+$	----- 4 mEq/L --
$\text{Ca}^{++}$	----- 5 mEq/L --
$\text{Mg}^{++}$	----- 3 mEq/L --
$\text{Cl}^-$	----- 103 mEq/L --
$\text{HCO}_3^+$	----- 28 mEq/L --
<b>Phosphates</b>	----- 4 mEq/L --
$\text{SO}_4^{--}$	----- 1 mEq/L --
<b>Osmolality</b>	----- 281 mOsm/L --

# Divisions Of ECF

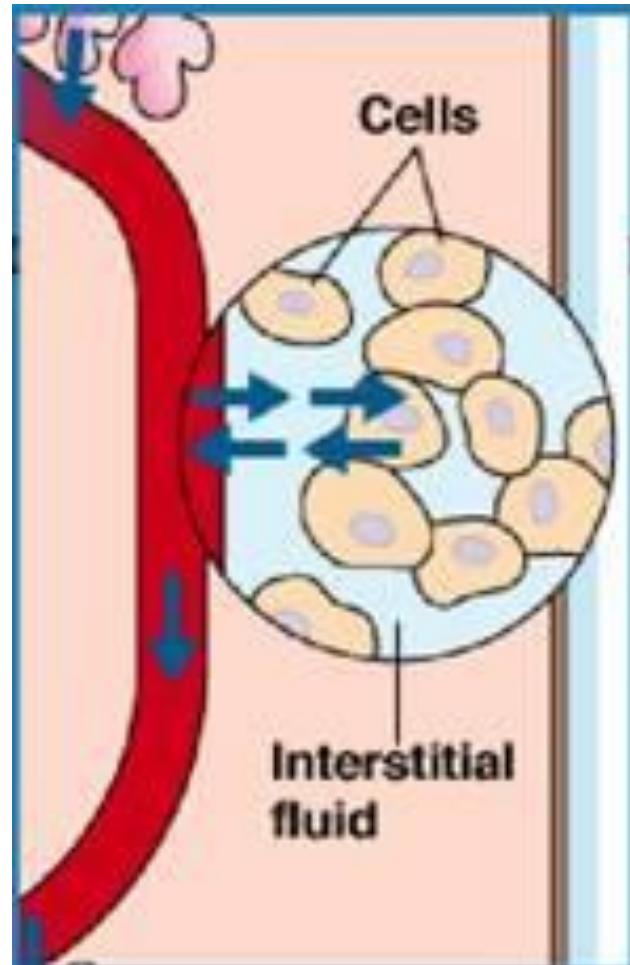
- The ECF is further subdivided into three sub-compartments:
- **Interstitial Fluid (ISF).**
- **Plasma.**
- **Transcellular fluid.**



- Maintaining ECF volume is critical to maintaining blood pressure
- ECF osmolarity is of primary importance in long-term regulation of ECF volume
  - ECF osmolarity maintained mainly by NaCl balance:
    - intake: 10.5g/d      output: 10g/d in urine

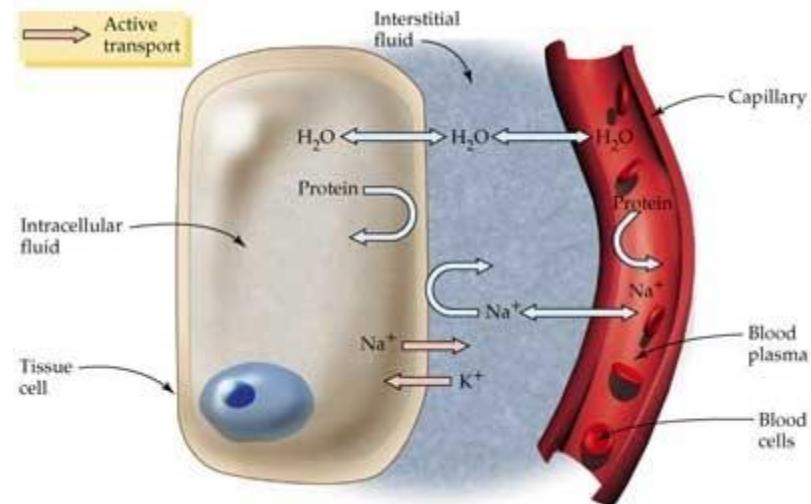
# Interstitial Fluid (ISF)

- **Interstitial Fluid (ISF)** surrounds the cells, but does not circulate.
- It is the main component of the extracellular fluid
- It comprises about 3/4 of the ECF.
- **Interstitial fluid** is found in the interstitial spaces, also known as the tissue spaces.



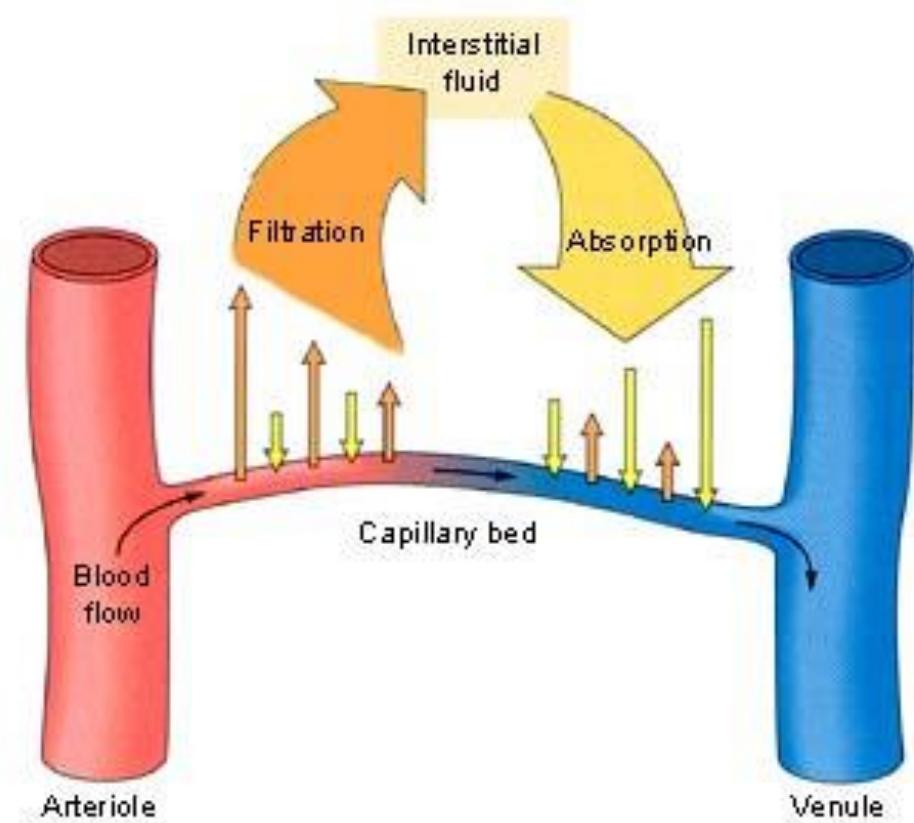
# Composition of interstitial fluid

- Interstitial fluid consists of:
  - Water solvent amino acids
  - Sugars
  - Fatty acids
  - Coenzymes
  - Hormones
  - Neurotransmitters
  - Salts
  - Waste products from the cells.
  - Lymph is considered a part of the interstitial fluid



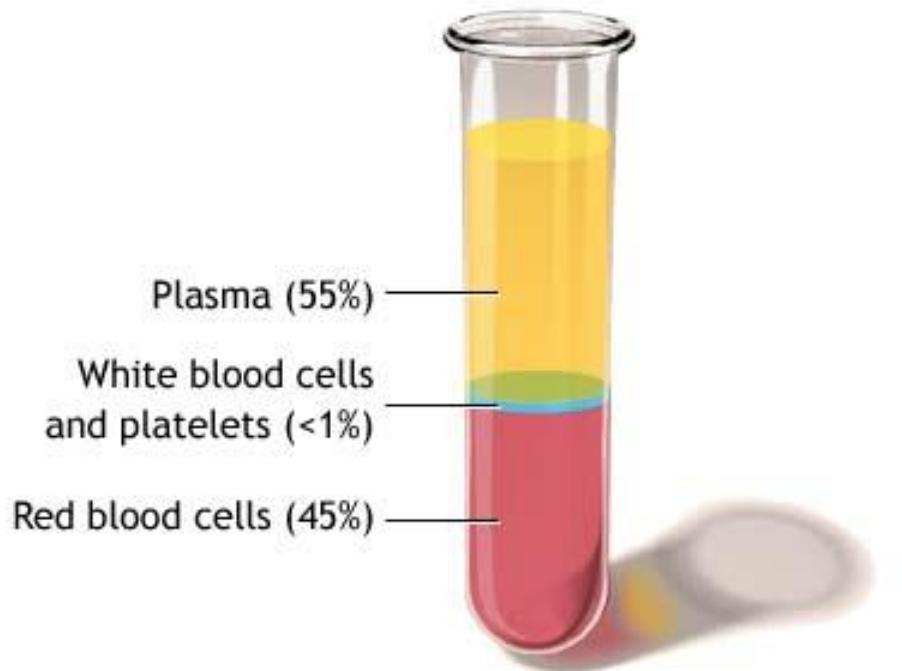
# Function Of Interstitial Fluid

- Intercellular communication.
  - Interstitial fluid bathes the cells of the tissues.
  - This provides a means of delivering materials to the cells, intercellular communication, as well as removal of metabolic waste.



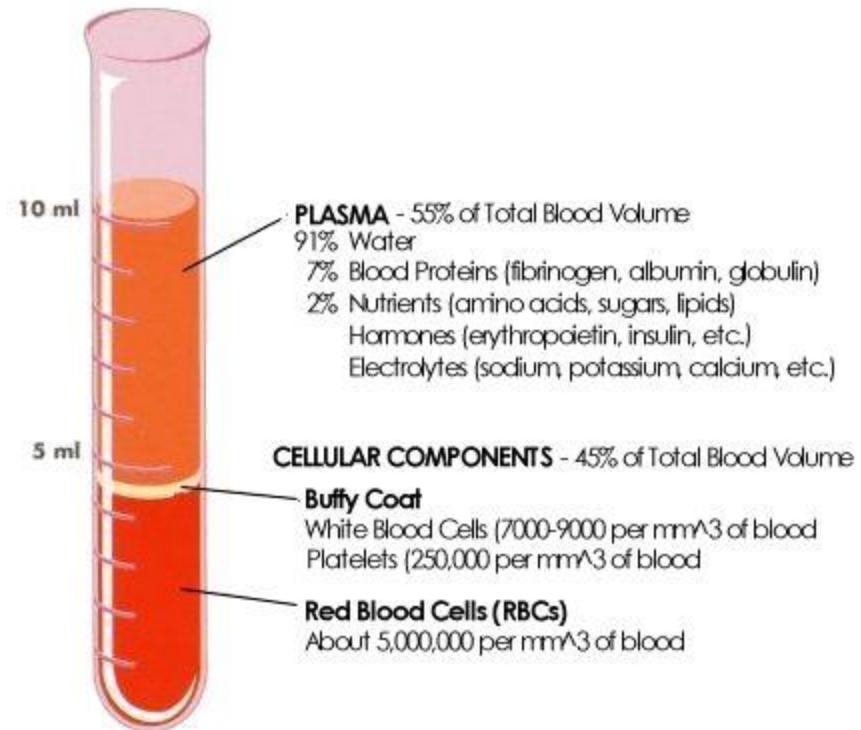
# Plasma

- **Plasma**
- It is the yellow liquid component of blood in which the blood cells in whole blood are normally suspended
- 55% of the total blood volume.
- It is the **intravascular fluid** part of extracellular fluid (all body fluid outside of cells)
- It makes up about 1/4 of the ECF.



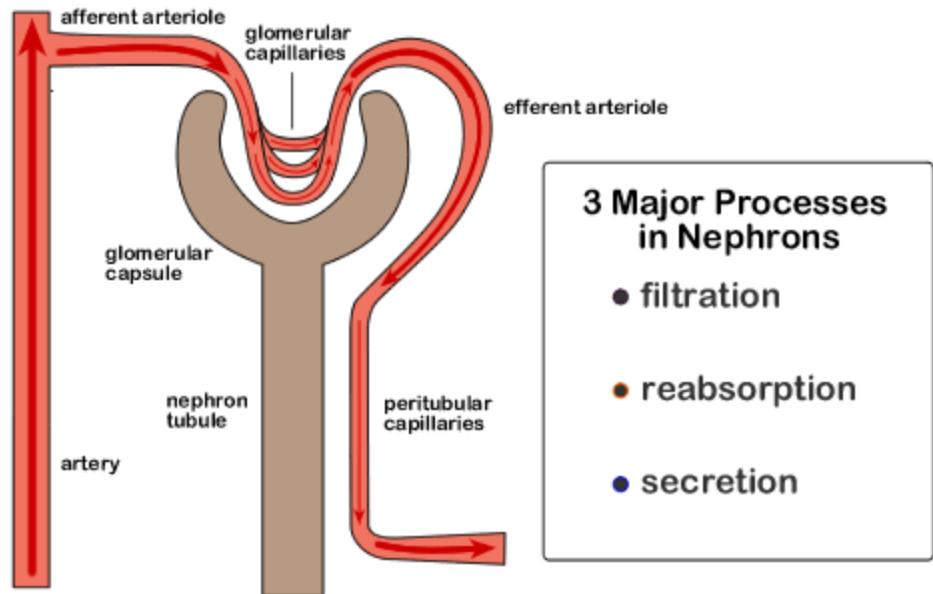
# Composition Of Plasma

- It is mostly water (90% by volume) and contains
- Dissolved proteins
- Glucose
- Clotting factors
- Mineral ions
- Hormones
- Carbon dioxide.



# Function Of Plasma

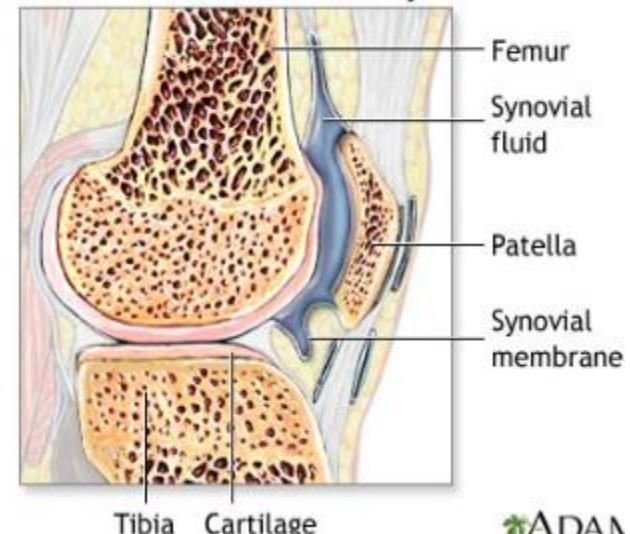
- Plasma being the main medium for excretory product transportation.
- **Blood serum** is blood plasma without fibrinogen or the other clotting factors (i.e., whole blood minus both the cells *and* the clotting factors).



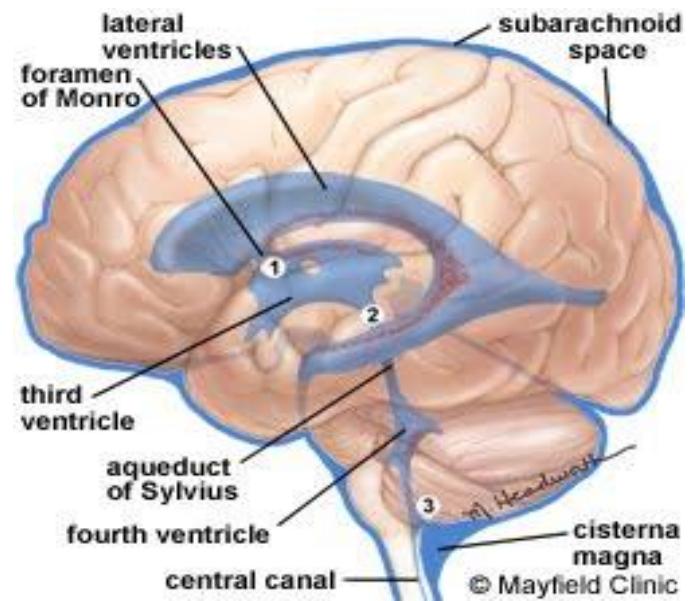
# Transcellular Fluid

- **Transcellular fluid** is the portion of total body water contained within epithelial lined spaces.
- Smallest compartment.
- It is about 2.5% of the total body water.
- Examples
  - Cerebrospinal fluid
  - Ocular fluid
  - Joint fluid
  - Bladder urine

Cut-section view of normal knee joint



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# **Composition Of Transcellular Fluid**

- Due to the varying locations of transcellular fluid, the composition changes dramatically.
- Some of the electrolytes present are:
  - Sodium ions.
  - Chloride ions.
  - Bicarbonate ions.

## Concentrations of ions

concentration in mM/l			
	plasma	inter-stitial	intra-cellular
Na <sup>+</sup>	140	145	10
K <sup>+</sup>	4	4	160
Ca <sup>2+</sup>	2	2	10 <sup>-4</sup>
Cl <sup>-</sup>	100	115	3
HCO <sub>3</sub> <sup>-</sup>	28	30	10
Protein	16	10	55

# REGULATION OF FLUID

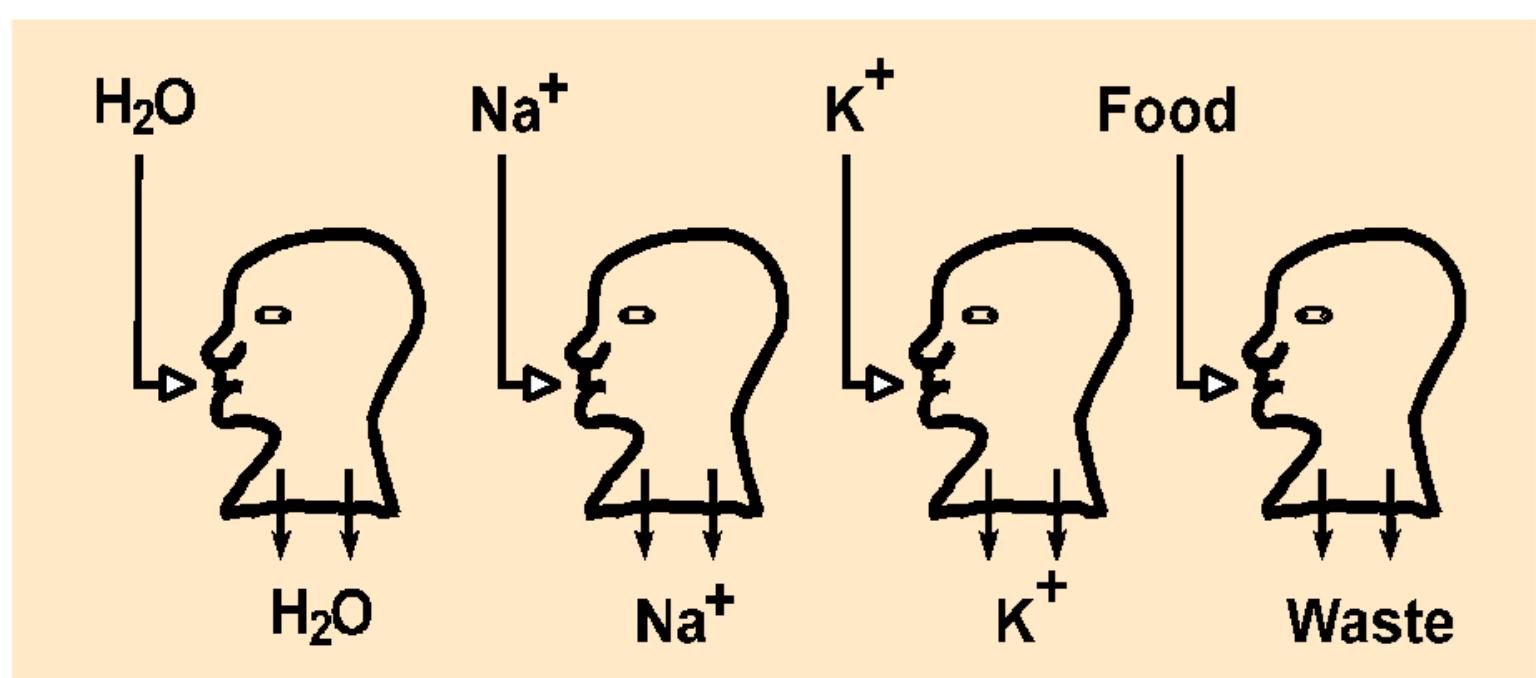
- Body Fluids and Fluid Compartments
- 

Why do we care about this?

✓ ECF volume

✓ Osmolarity

# The Body as an Open System



# **Electrolyte ( $\text{Na}^+$ , $\text{K}^+$ , $\text{Ca}^{++}$ ) Steady State**

- Amount Ingested = Amount Excreted.
- Normal entry: Mainly ingestion in food.
- Clinical entry: Can include parenteral administration.

# **Electrolyte losses**

- Renal excretion
- Stool losses
- Sweating
- Abnormal routes: e.g.. vomit and diarrhea

# Net Osmotic Force Development

- Semipermeable membrane
- Movement of some solute obstructed
- $\text{H}_2\text{O}$  (solvent) crosses freely
- **End point:**
  - Water moves until solute concentration on both sides of the membrane is equal
  - OR, an opposing force prevents further movement

# Osmotic Concentration

- Proportional to the number of osmotic particles formed:  $\text{Osm/L} = \text{moles} \times n$  (n, # of particles in solution) e.g. 1 M NaCl = 2 M Glu in Osm/L
- Assuming complete dissociation:
  - 1 mole of NaCl forms a \_\_\_\_\_ osmolar solution in 1L
  - 1 mole of CaCl<sub>2</sub> forms a \_\_\_\_\_ osmolar solution in 1L
- Physiological concentrations:
  - milliOsmolar units most appropriate
  - 1 mOSM = \_\_\_\_\_ osmoles/L

# Principles of Body Water Distribution

- Body control systems regulate ingestion and excretion:
  - constant total body water
  - constant total body osmolarity
- Osmolarity is identical in all body fluid compartments (steady state conditions)
  - Body water will redistribute itself as necessary to accomplish this

# Intra-ECF Water Redistribution Plasma vs. Interstitium

- Balance of Starling Forces acting across the capillary membrane
  - osmotic forces
  - hydrostatic forces

# **Primary Disturbance: Increased ECF Osmolarity**

- Water moves out of cells
  - ICF Volume ? Increased or decreases
  - ICF Osmolarity? Increased or decreases

# Primary Disturbance: Decreased ECF Osmolarity

- Water moves into the cells
  - ICF Volume ? Increased or decreases
  - ICF Osmolarity ? Increased or decreases

# **Exchange b/w interstitial fluid and Plasma**

- If Oncotic pressure changes. For eg. If decreases, it will leads to edema.
- Edema is define as, .....
- Solute responsible for maintaining oncotic pressure in plasma is .....?