

EXTRACELLULAR AND
INTERNAL
ENVIRONMENT

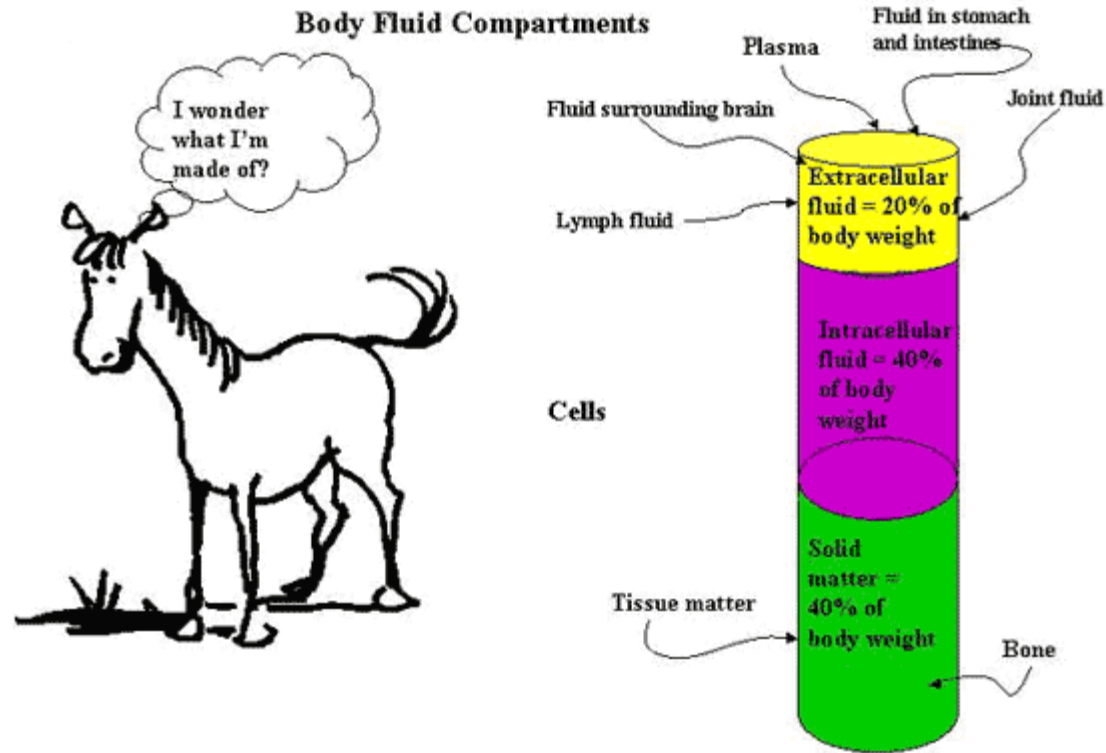
Learning Objectives

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 CELLUAR FLUID

28 L (ROUGHLY 2/3 OF

EXTRA CELLULAR FLUID

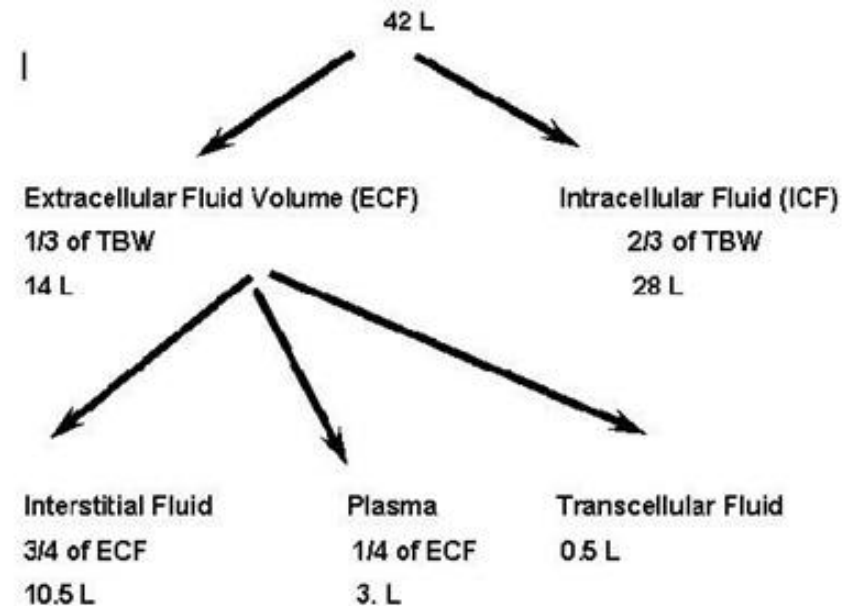
14 L (ROUGHLY 1/3 OF TBW)

PLASMA

4 L (ROUGHLY 1/4 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.

Intracellular Fluid	
Na ⁺ -----	10 mEq/L
K ⁺ -----	140 mEq/L
Ca ⁺⁺ -----	<1 mEq/L
Mg ⁺⁺ -----	58 mEq/L
Cl ⁻ -----	4 mEq/L
HCO ₃ ⁺ -----	10 mEq/L
Phosphates -----	75 mEq/L
SO ₄ ⁼⁼ -----	2 mEq/L
Osmolality -----	281 mOsm/L

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 NaHCO₃ solution.

Body Fluid Distribution

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

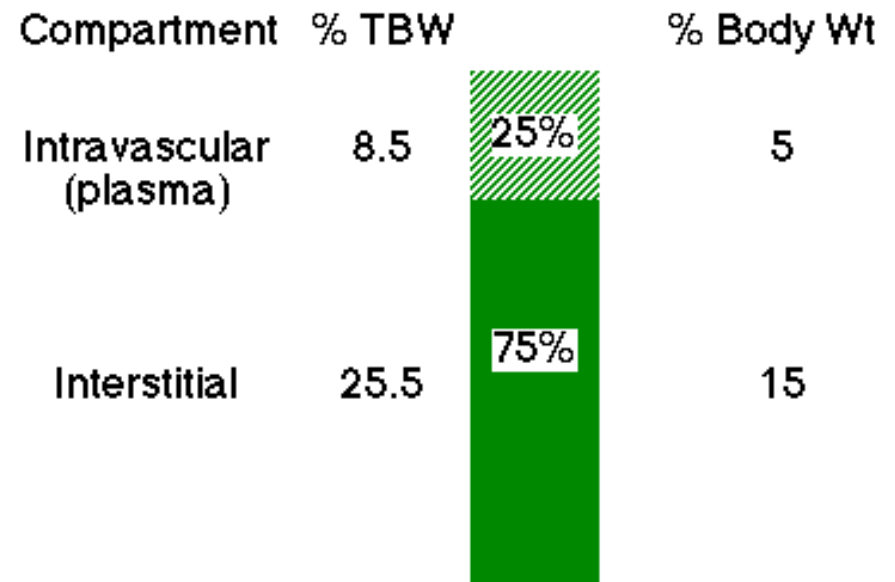
Composition Of Extracellular Fluid

- **Main Cations:**
- Sodium ($\text{Na}^+ = 136\text{-}145$ mEq/L)
- Potassium ($\text{K}^+ = 3,5\text{-}5,5$ mEq/L)
- Calcium ($\text{Ca}^{2+} = 8,4\text{-}10,5$ mEq/L)
- **Main Anions:**
- Chloride ($\text{Cl}^- = 99\text{-}109$ mEq/L)
- Hydrogen Carbonate (HCO_3^- 26 mM)
- It is poorer in proteins compared to intracellular fluid

Extracellular Fluid	
Na^+	142 mEq/L
K^+	4 mEq/L
Ca^{++}	5 mEq/L
Mg^{++}	3 mEq/L
Cl^-	103 mEq/L
HCO_3^+	28 mEq/L
Phosphates	4 mEq/L
SO_4^{--}	1 mEq/L
Osmolality	281 mOsm/L

Divisions Of ECF

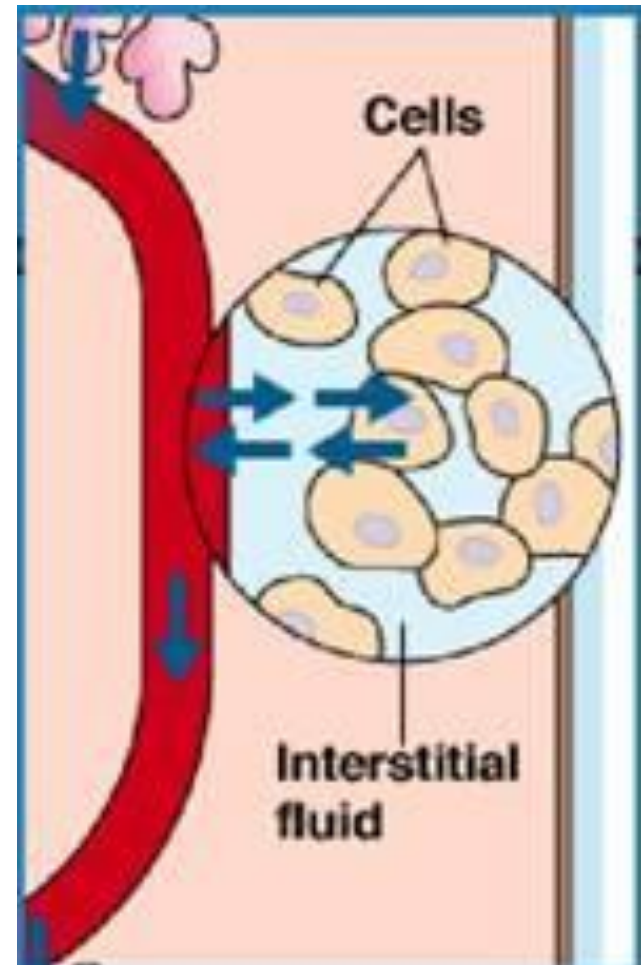
- The ECF is further subdivided into three sub-compartments:
- **Interstitial Fluid (ISF).**
- **Plasma.**
- **Transcellular fluid.**



- **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**

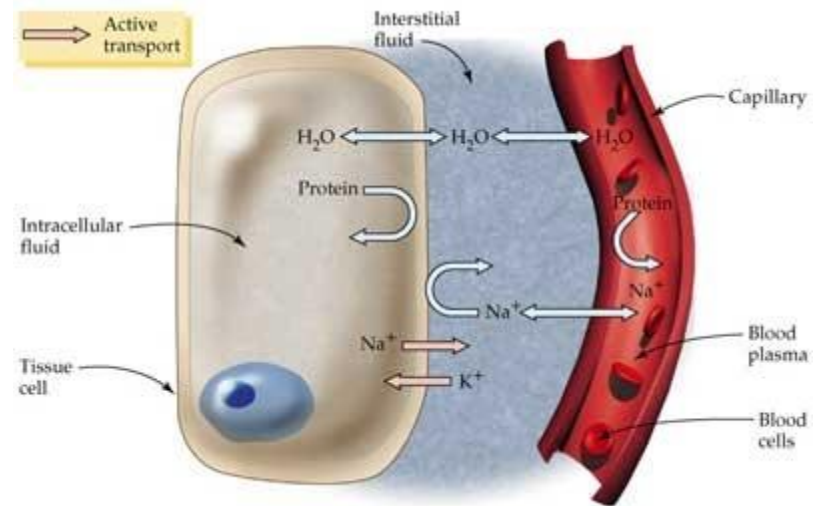
Interstitial Fluid (ISF)

- **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.



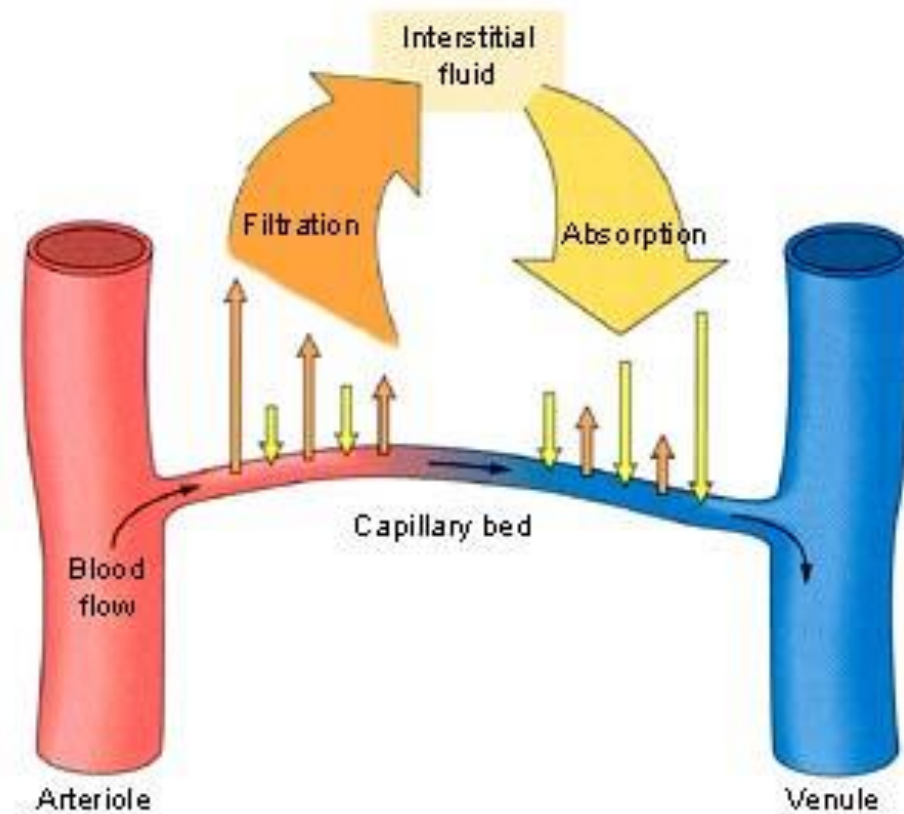
Composition of interstitial fluid

- 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



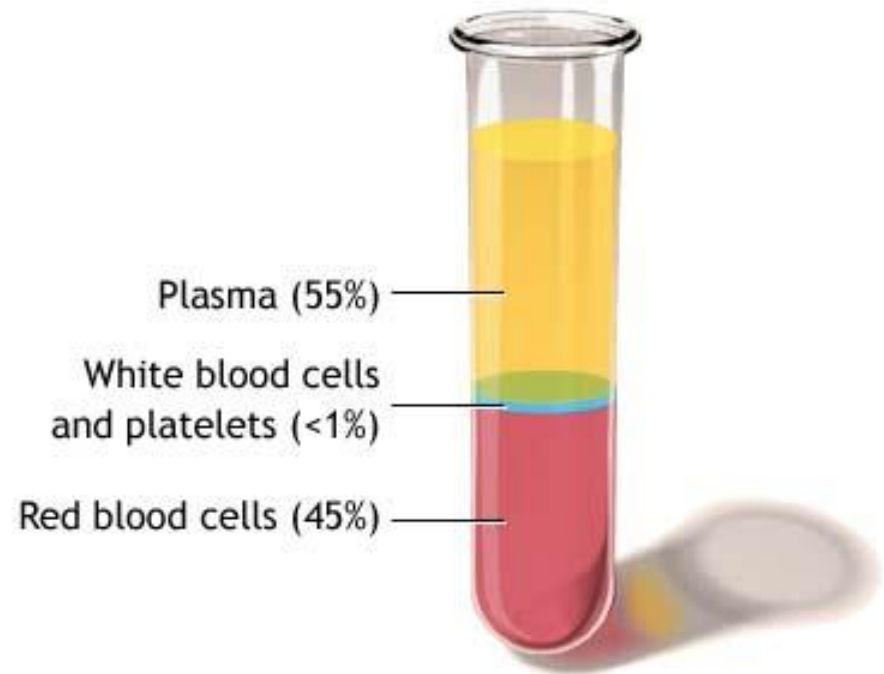
Function Of Interstitial Fluid

- 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.



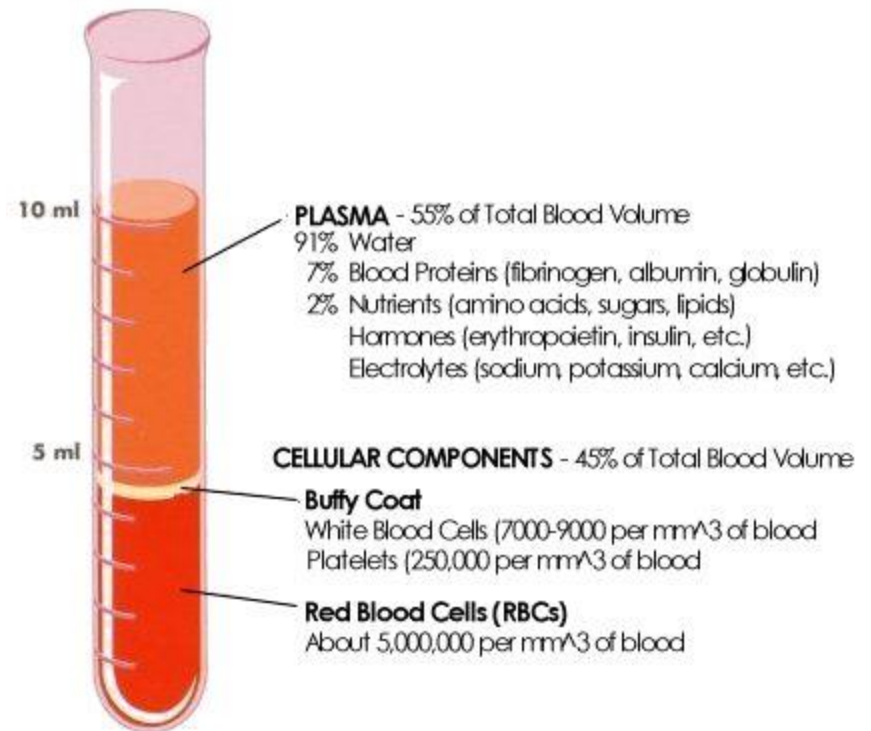
Plasma

- **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

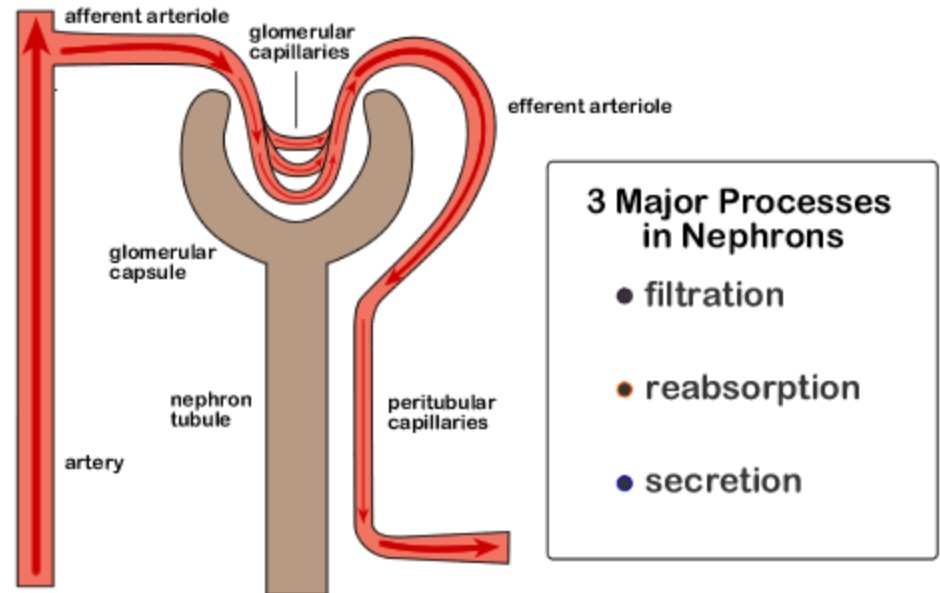
- It is mostly water (90% by volume) and contains
- Dissolved proteins
- Glucose
- Clotting factors
- Mineral ions
- Hormones
- Carbon dioxide.



Function Of Plasma

Plasma being the main medium for excretory product transportation.

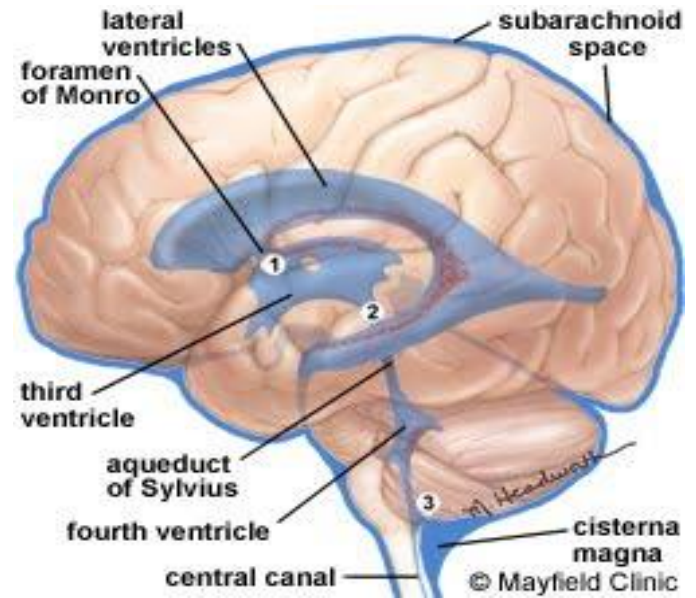
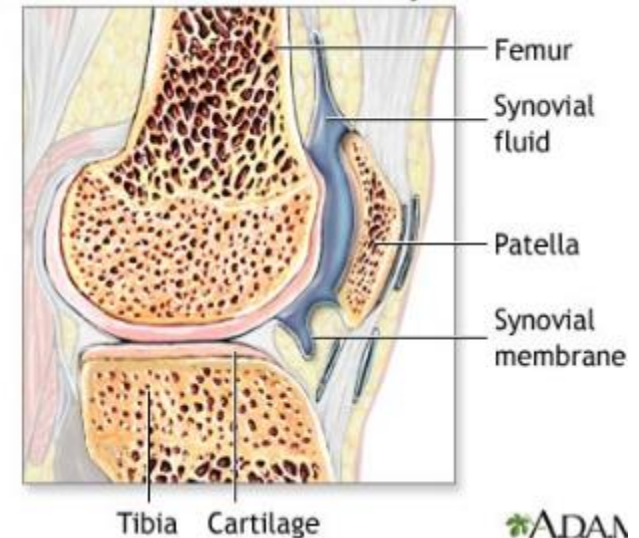
- **Blood serum** is blood plasma without fibrinogen or the other clotting factors (i.e., whole blood minus both the cells *and* the clotting factors).



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



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 ⁺	140	145	10
K ⁺	4	4	160
Ca ²⁺	2	2	10 ⁻⁴
Cl ⁻	100	115	3
HCO ₃ ⁻	28	30	10
Protein	16	10	55

REGULATION OF FLUID

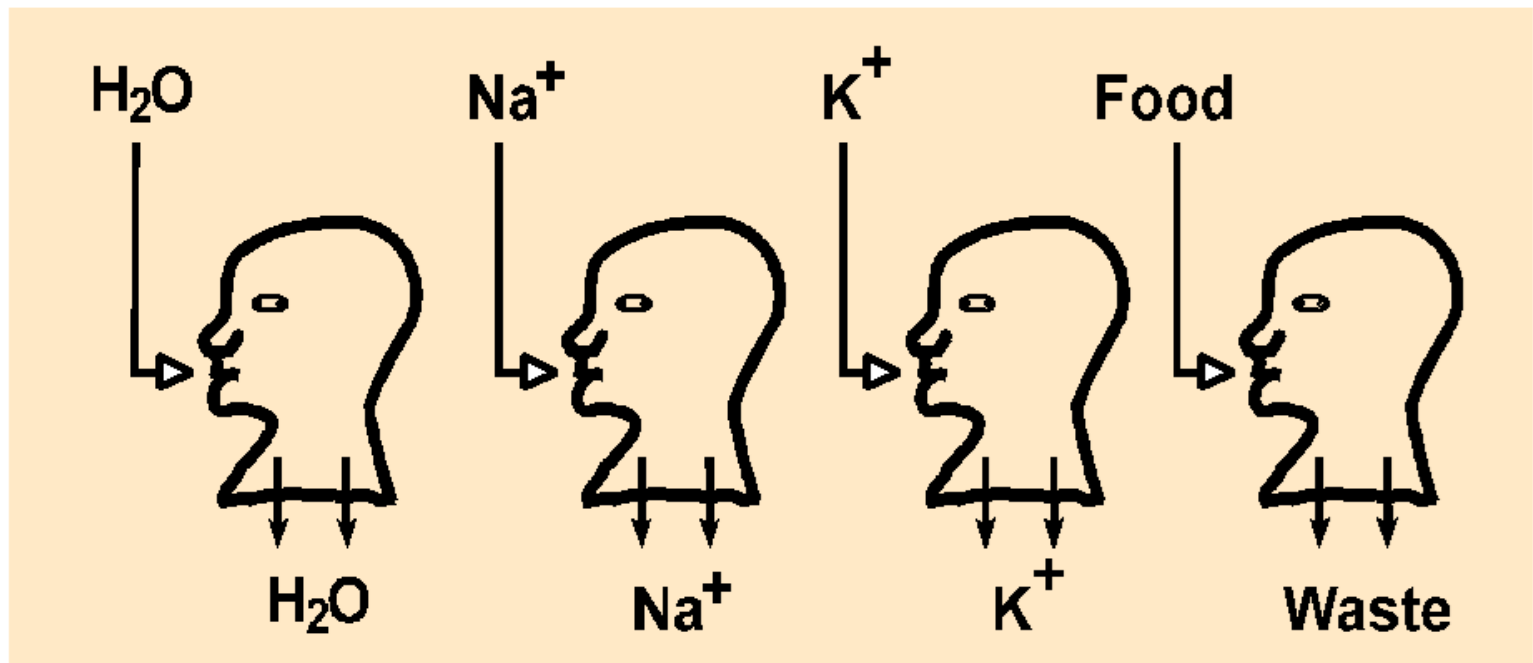
- Body Fluids and Fluid Compartments
-

Why do we care about this?

✓ ECF volume

✓ Osmolarity

The Body as an Open System



Electrolyte (Na^+ , K^+ , 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
- H₂O (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:
 - 1mole of NaCl forms a ___ osmolar solution in 1L
 - 1mole of CaCl_2 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 resposible for maintaining oncotic pressure in plasma is?