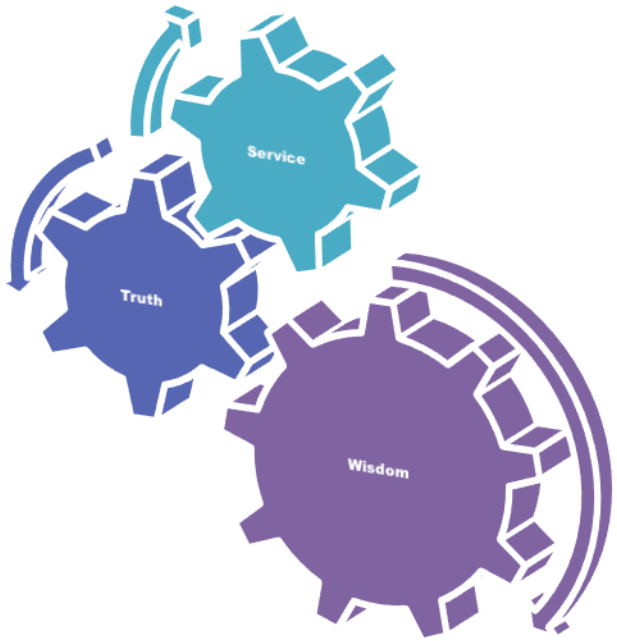

بسم الله الرحمن الرحيم

Motto Vision; The Dream/Tomorrow

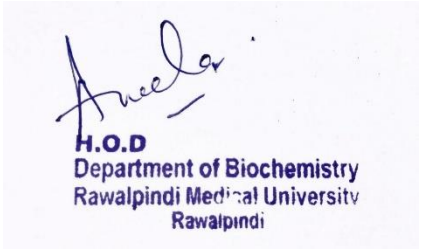


- To impart evidence based research oriented medical education
- To provide best possible patient care
- To inculcate the values of mutual respect and ethical practice of medicine

Foundation Module

1st Year MBBS(LGIS)

Physicochemical Properties-1



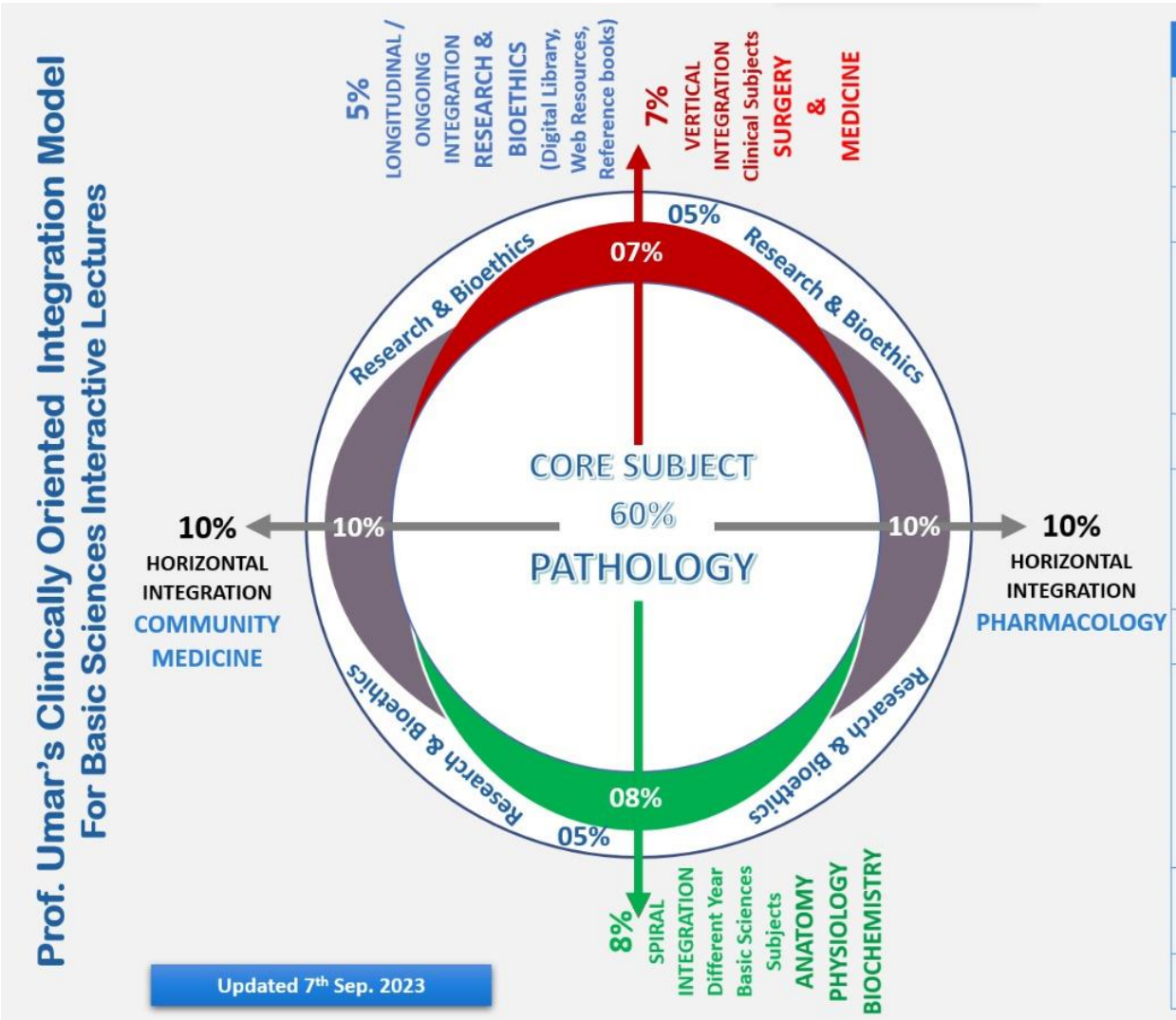
Presenter: Dr Nayab Ramzan

Deptt of Biochemistry

RMU

Date: 07-02-25

Professor Umar Model of Integrated Lecture



Model 3rd Year Pathology LGIS (≈30 slides)	
Core Subject – 60% (≈ 18-20 slides)	
Pathology (≈ 18-20 slides)	
Horizontal Integration – 20% (≈ 5-6 slides)	
Same Year Subjects	• Pharmacology (10%) (≈ 2-3 slides) • Community Medicine (10%) (≈ 2-3 slides)
Vertical Integration – 07% (≈ 2-3 slides)	
Clinical Subjects	• Medicine (3-5%) (≈ 1-2 slides) • Surgery (3-5%) (≈ 1-2 slides)
Spiral Integration – 08% (≈ 2-3 slides)	
Different Year Basic Sciences Subjects	• Anatomy (1-3%) (≈ 1-2 slides) • Physiology (1-3%) (≈ 1-2 slides) • Biochemistry (1-3%) (≈ 1-2 slides)
Longitudinal / Ongoing Integration – 05% (≈ 1-2 slides)	
Research & Bioethics (≈ 1-2 slides)	

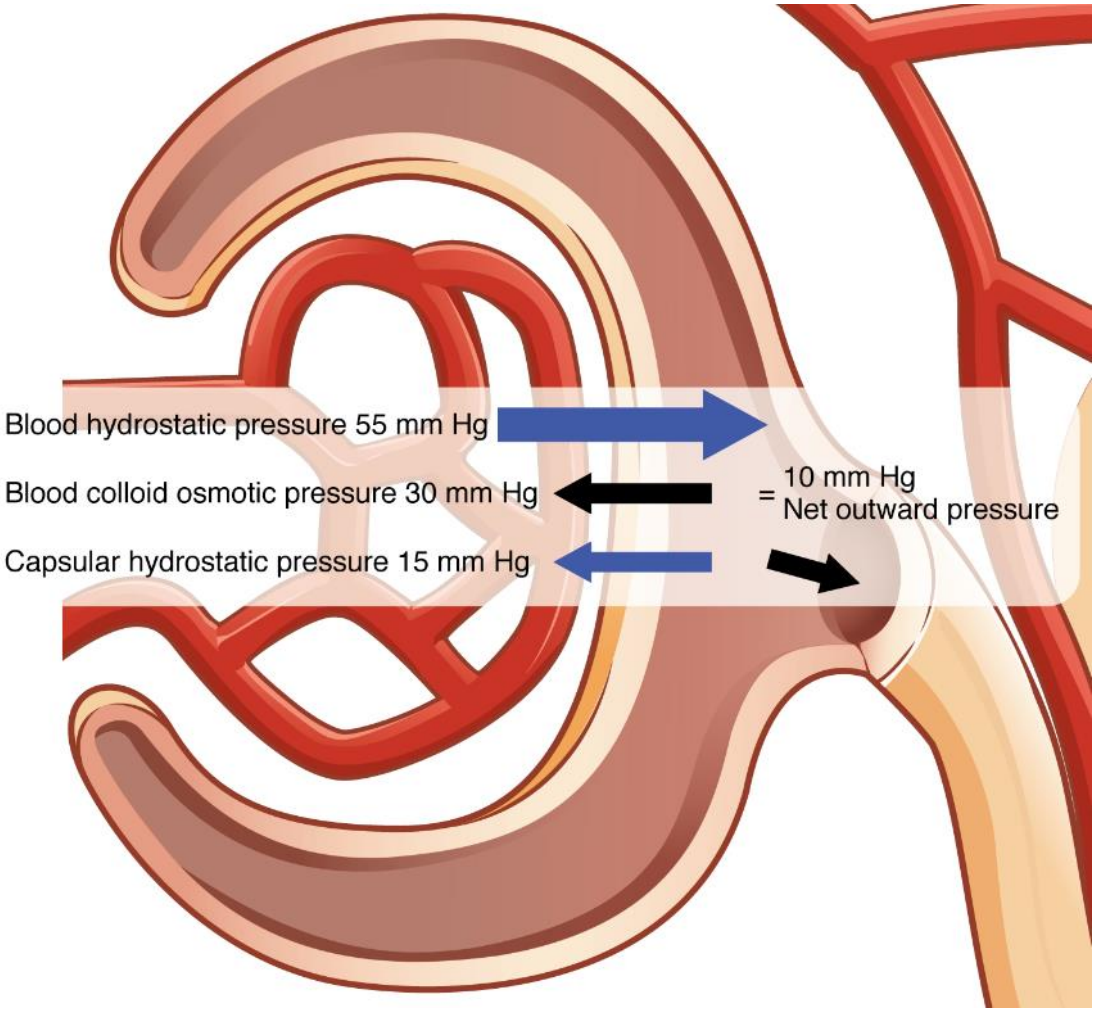
Learning Objectives

At the end of the lecture, students will be able to

1. Define Osmosis, Osmotic pressure and Oncotic Pressure
2. Discuss Biochemical Applications of Osmotic and Oncotic Pressures and methods to measure them.
3. Correlate physicochemical properties of cell with clinical conditions
4. Practice the principles of bioethics & apply strategic use of A.I in the related clinical aspects.
5. Read relevant research articles related to the Core Knowledge.

Importance of Osmotic Pressure

- **Drinking** water → blood is diluted → osmotic pressure is lowered → more **water passes from Blood to Tissues**
- **Kidneys -**At the same time Hydrostatic Pressure of water passing through **Kidneys** is increased → **More Dilute Urine is Excreted**.
- This **Continues** until the concentration of water in blood and tissues is **Returned To Normal Limits**.

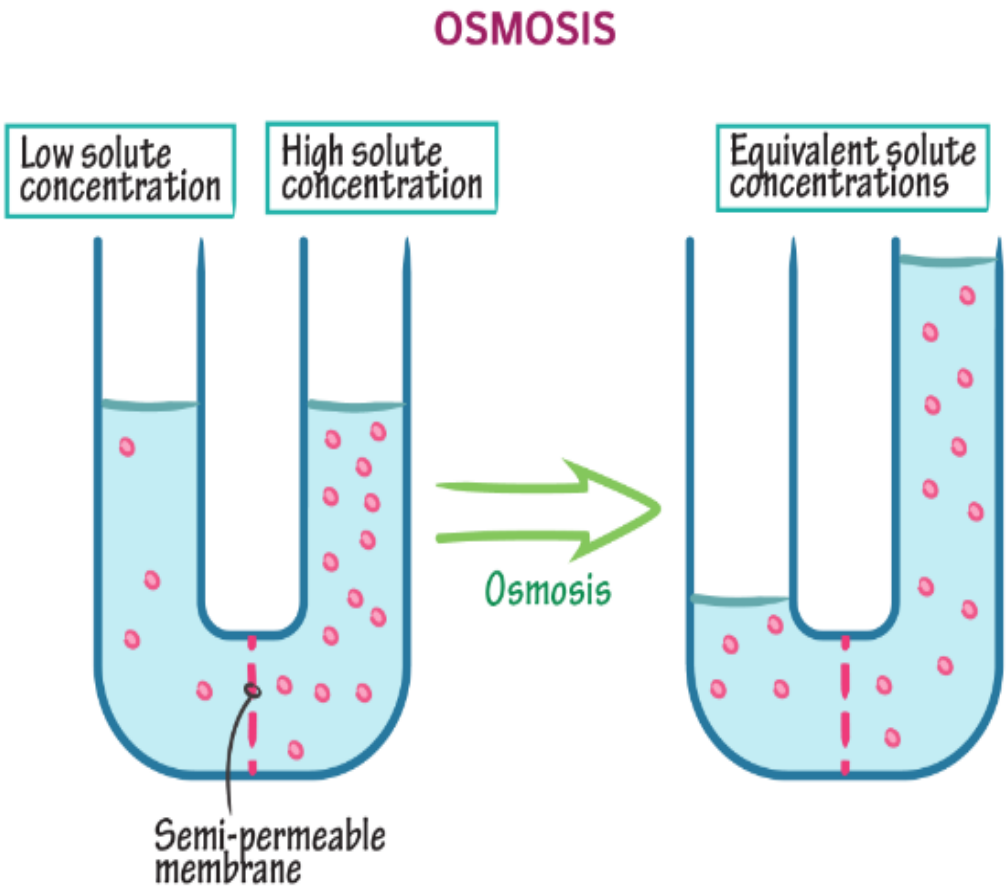


Osmosis

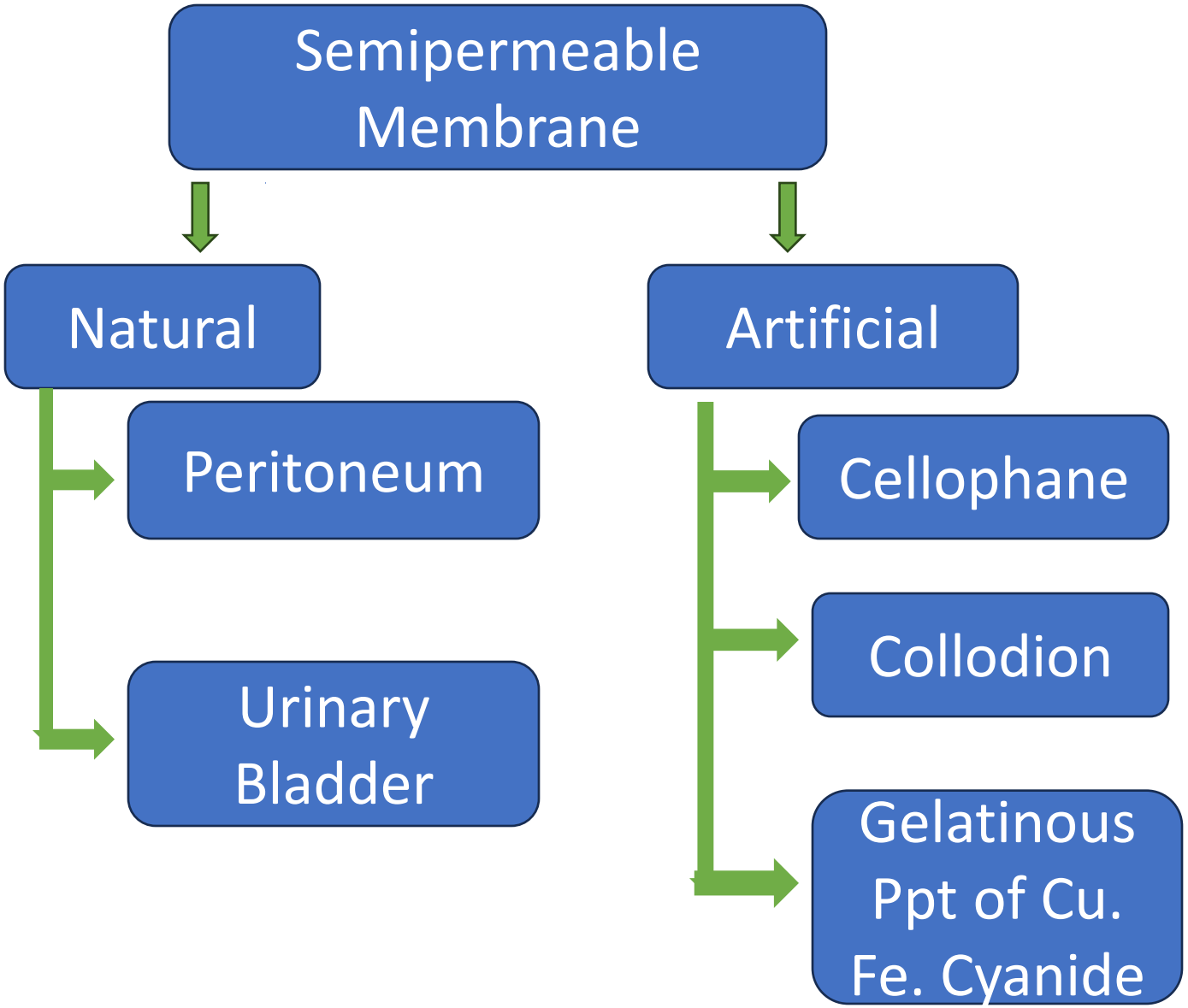
- **Osmosis**

➢ Derived from Greek word meaning "**push**"

➢ Process by which a **Solvent** (water) passes from a dilute solution to a more concentrated solution when both are separated by a **Semi Permeable Membrane** (this membrane allows water to diffuse but not the solute)



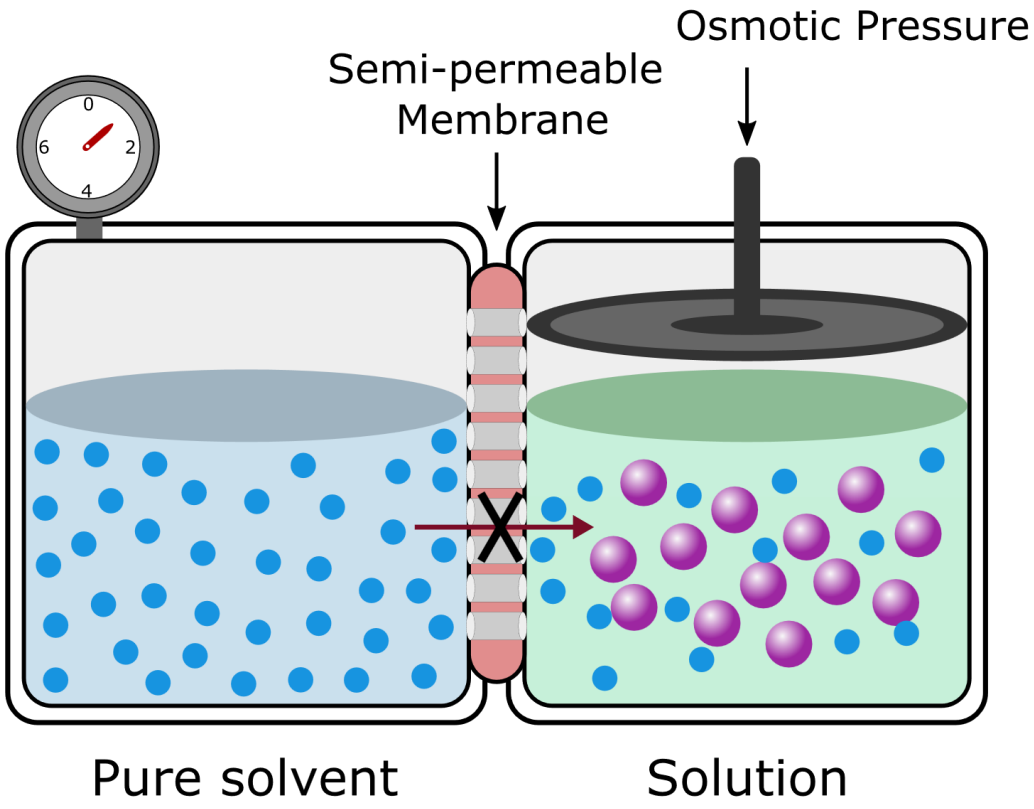
Types of Semipermeable Membranes



Osmotic Pressure

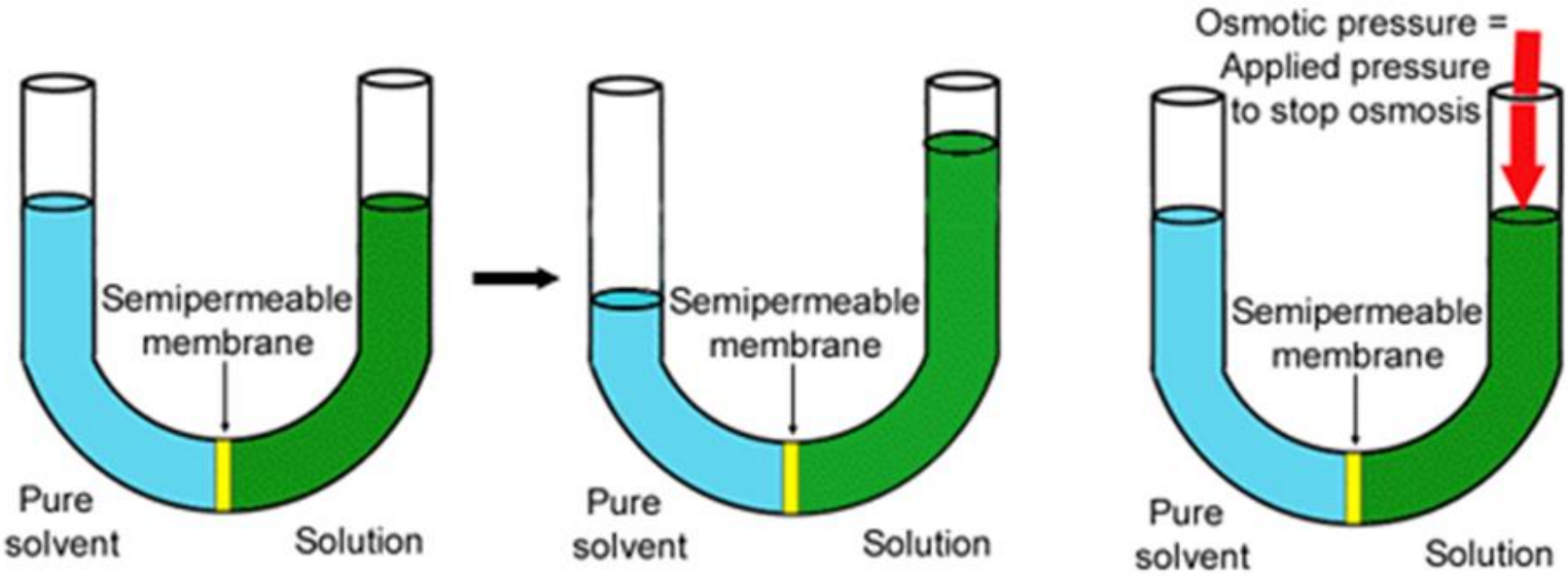
- Defined as

➢The Equivalent of **Excess Of Pressure** which must be applied to the concentrated solution in order to **Prevent the Passage of the Solvent** into it through a **Semi Permeable Membrane** separating the two i.e. Solution and Solvent



Osmotic Pressure

The minimum pressure that stops the osmosis is equal to the osmotic pressure of the solution



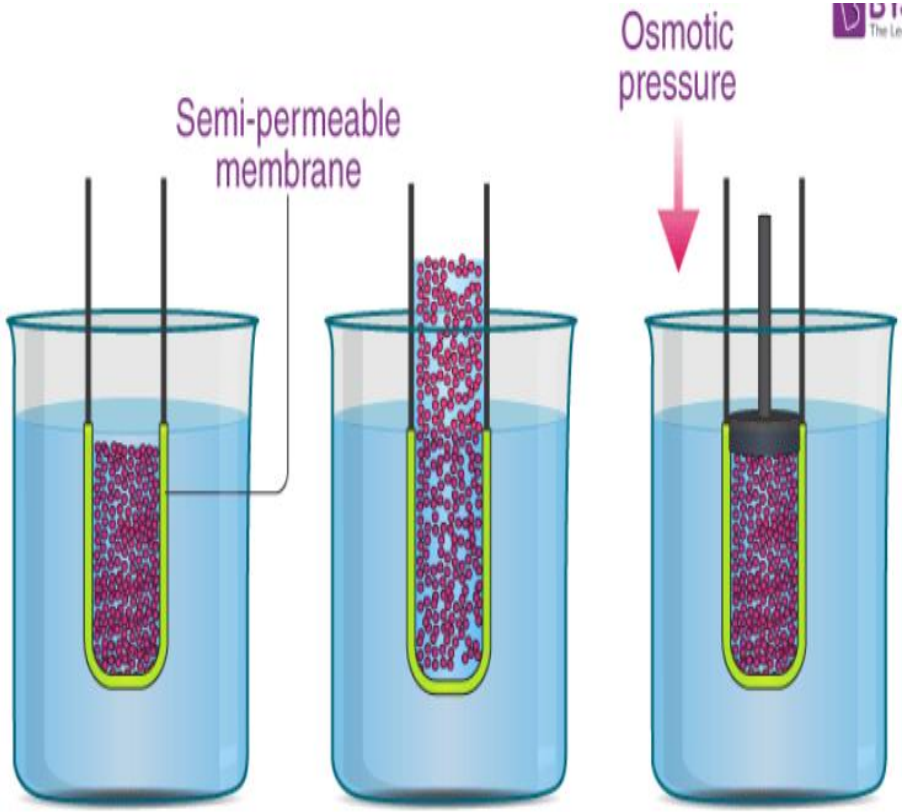
Osmotic Pressure

- Example - An unglazed pottery jar is taken, pores in its wall are coated with precipitate of **Copper Ferrocyanide** so as to make it as a Semi Permeable Membrane.

- Some Solute (sugar) dissolved in water is placed in the jar.

- The jar is then placed in a beaker of water. Water will start rising in the tube and after sometime it will reach a maximum level - **Osmosis**

- **On Application of Pressure** - At Equilibrium the hydrostatic pressure of the solution is sufficient to prevent entry of more water into it - this **process of pressure production by process of osmosis** is called **Osmotic Pressure**



Colloidal State

- **Crystalloids**

➢Substances which in solution can **freely pass through the Semi-Permeable Membrane** e.g **Sugar**, **Urea**, **NaCl**.

➢Subs that **Dissociate into ions** when dissolved in water.

- **Colloids**

➢Greek : glue-like

➢Substances that are **retained by the Semi-Permeable Membrane**, e.g. Gum, Gelatin, **Albumin**.

➢Subs that **DO NOT Dissociate into ions** when dissolved in water

- **Colloidal State** Characterized by the particle size of **1 to 100 nm**.

➢When particle size is **< 1nm**, it is a **True Solution**.

➢When particle size is **> 100nm**, the matter exists as a **Precipitate**.

➢Thus the **Colloidal State** is an **Intermediate** between **True Solution** and **Precipitate**

Colloidal State

- **Phases of Colloids**

➢ **Dispersed Phase** → Internal phase – **Colloidal Particles**

➢ **Dispersion Medium** → External phase – **Medium** in which colloidal particles are suspended

- **Classification of Colloids**

➢ **Lyophobic** (Greek: **Solvent-Hating**): No affinity towards dispersion medium. (Hydrophobic, when water is the solvent) e.g, **Unconjugated Bilirubin**.

➢ **Lyophilic** (Greek: **Solvent-Loving**): distinct affinity towards dispersion medium. (Hydrophilic, when the solvent is water) e.g, **Protein** & **Bile Salts**.

Oncotic Pressure

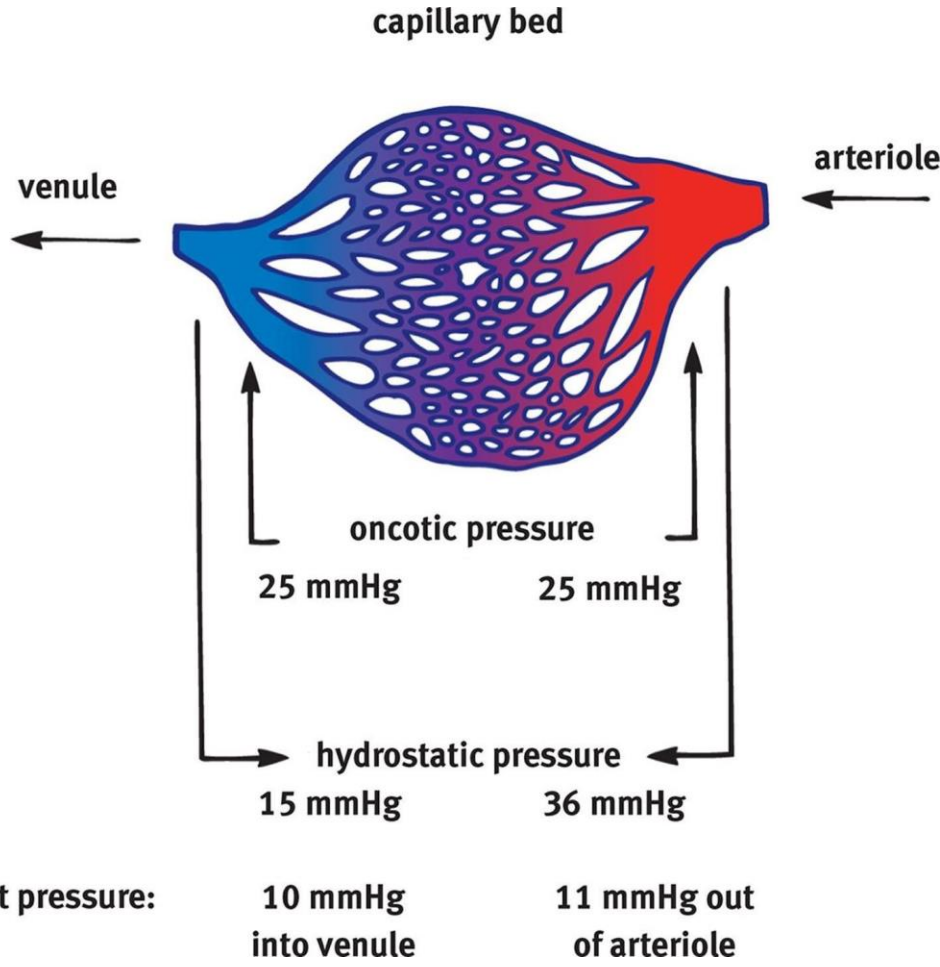
- Chief colloids of plasma - **Plasma Proteins** form a colloidal solution.

- **Oncotic Pressure OR Colloid Osmotic Pressure** - **Osmotic Pressure exerted by Plasma Proteins**, notably **Albumin**, in a blood vessel's plasma.

- **25-30 mm Hg -** negligible compared to that of Plasma Crystalloids (about 5000 mm Hg).

- The **Main Force that usually tends to <u>Pull</u> water into the circulatory system**

- **Opposing force** to **Hydrostatic pressure.**



Osmotic Pressure & Hydrostatic Pressure

➢Hydrostatic Pressure -

- Pressure of any **fluid enclosed** in a space
- It forces fluid out of the solution.

➢Osmotic pressure

- Draws fluid back into the solution

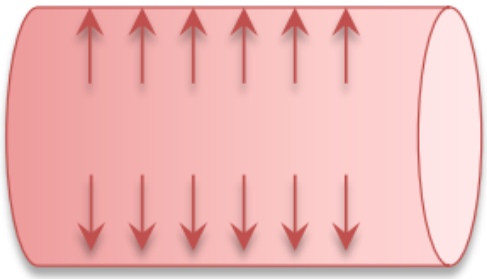
Hydrostatic pressure P

The pressure exerted by blood (water) on the walls of the blood vessel.

Colloid osmotic(oncotic) pressureπ

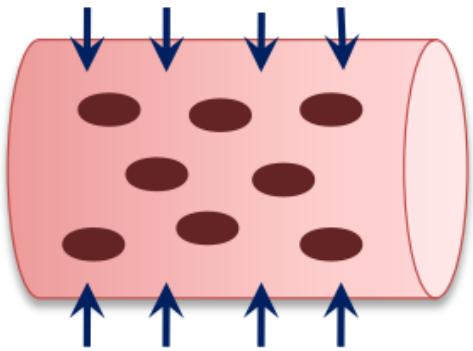
The osmotic pressure created by the non-diffusible plasma proteins inside the blood vessel.

(especially albumin)



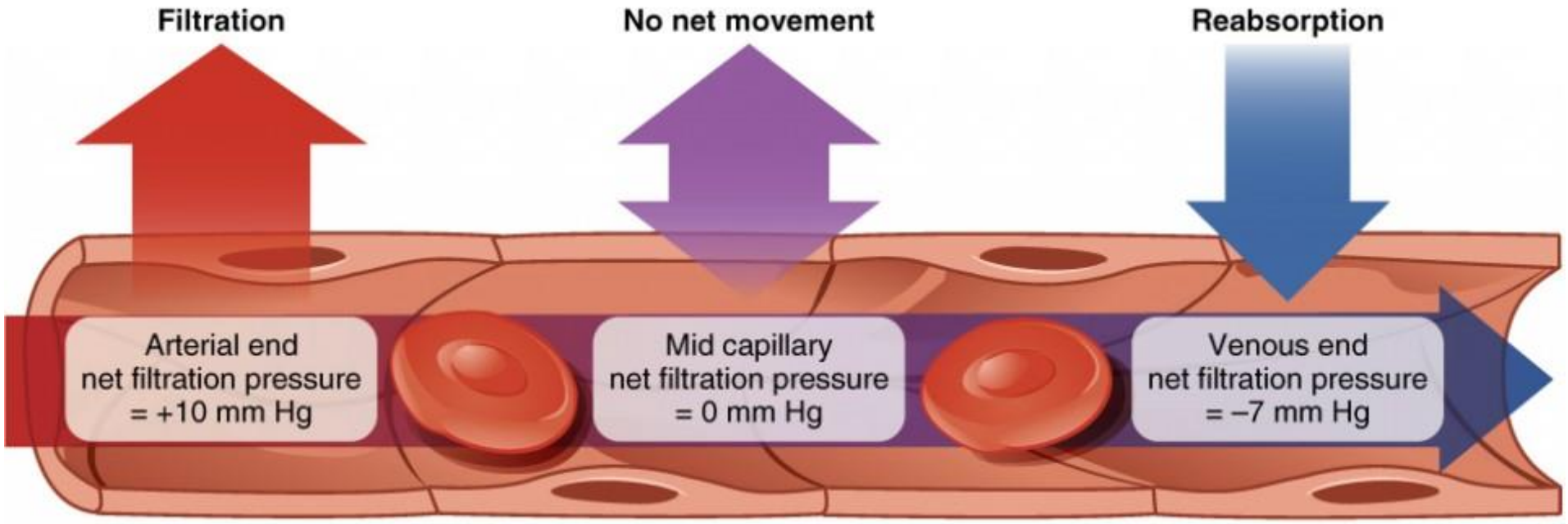
Pushes fluid OUTSIDE

In order to counteract and stop the osmotic inflow into a solution, it **Equals the Difference between the Hydrostatic Pressure on both sides**



Pulls fluid INSIDE

Osmotic Pressure & Hydrostatic Pressure



Fluid exits capillary since capillary hydrostatic pressure (35 mm Hg) is greater than blood colloidal osmotic pressure (25 mm Hg)

No net movement of fluid since capillary hydrostatic pressure (25 mm Hg) = blood colloidal osmotic pressure (25 mm Hg)

Fluid re-enters capillary since capillary hydrostatic pressure (18 mm Hg) is less than blood colloidal osmotic pressure (25 mm Hg)

Laws of Osmotic Pressure

1. Osmotic Pressure - Directly Proportional to Absolute Temperature.

2. Osmotic Pressure - Directly Proportional to conc (number) of solute molecules/Ions

- **LMW substances** (NaCl, Glucose) will have **more number of molecules per unit mass** compared to HMW substances (Albumin, Globulin).
- Exhibit **Greater** osmotic pressure.
- **1% NaCl** sol will have **Double Osmotic Pressure** than **0.5% NaCl**.
- **Ionizable Compounds** the total OP is equivalent to the **sum** of the **Individual Pressure** exerted by each ion.
- **1molar solution of NaCl** will exert **Double the OP** as compared to **1molar solution of Glucose**.
- This is because **NaCl Ionizes while glucose is non-ionizable**

Strength of Solutions

- **Molarity (M)**

➢Defined as the number of moles of solute per liter solution.

e.g, NaCl has a molecular weight of 58.5.

➢To get **1molar (1M)** or **one mole solution** of NaCl, one gram molecular weight **58.5 g** of it should be dissolved in the solvent (H2O) to make a **final total volume of 1 liter**.

- **Molality**
- Represents the number of moles of solute per 1000 g of solvent.
- **One molal solution** can be prepared by dissolving **1 mole of Solute in 1000 g of Solvent**.

Osmotic Pressure Vs Oncotic Pressure

Osmotic pressure is the pressure needed to stop the net movement of water across a permeable membrane which separates the solvent and solution.	Oncotic pressure is the contribution made to total osmolality by colloids.
Osmotic pressure is measured by osmometer.	Oncotic pressure is measured by oncometer.
The number of solutes or particles and the degree of ionization determine the osmotic pressure.	Oncotic pressure is determined by the number of colloids in a solution.

Unit of Osmotic Pressure

- **Osmole** - Unit of Osmotic Pressure.

- **1 Osmole** is the number of molecules in gram molecular weight of undissociated solute.

- **1 Osmole** equals to **22.4 atmospheres or 17024 mm Hg,** this unit is too large for use in biology therefore **milliosmole** **i.e. 1/1000 of Osmole or about 17mm Hg** is used**.**

- **OP of Plasma is 280- 300 milliosmole/litre**

Tonicity

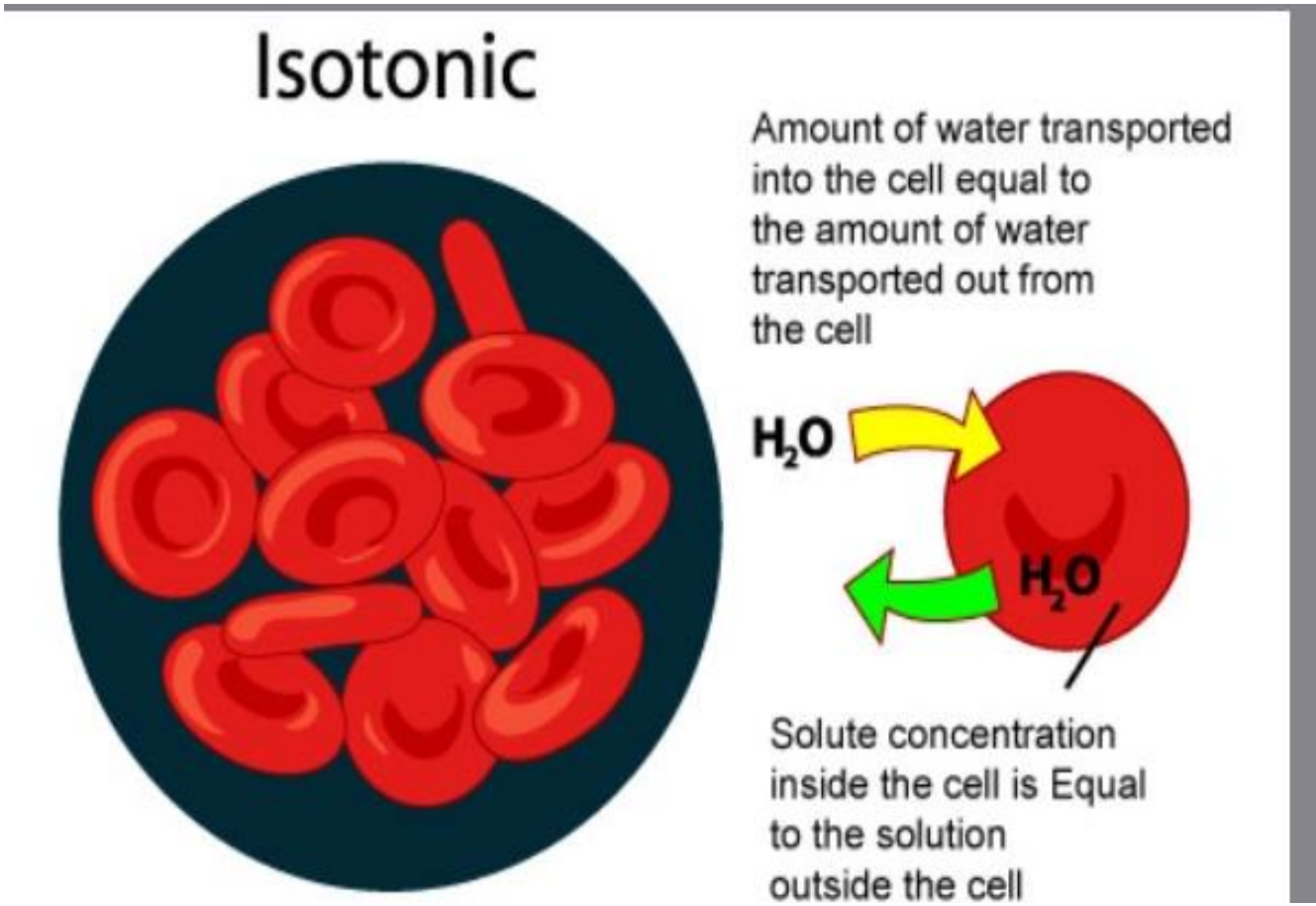
General terms

- Iso – osmotic
- Isotonic – (0.9% NaCl)
- Hypertonic (greater than 0.9% NaCl)
- Hypotonic (less than 0.9% NaCl)

- These laws of osmotic pressure hold good only for dilute solutions, appropriate corrections must be made for concentrated solutions.

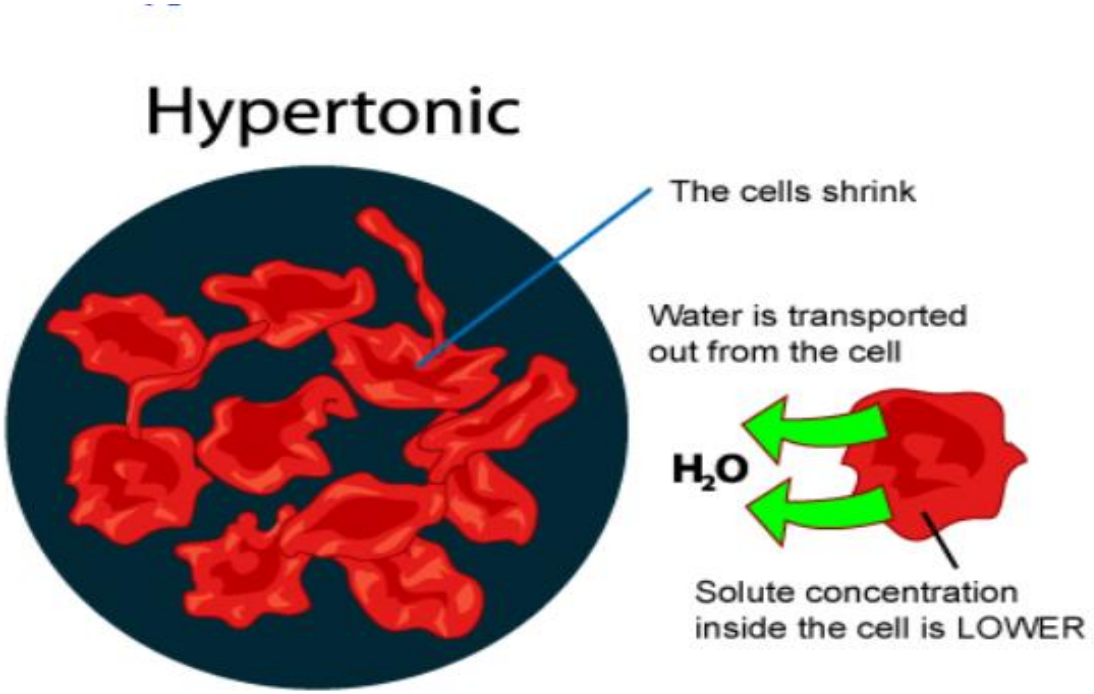
Red Blood Cells and Fragility

- When RBC,s are suspended in an isotonic (0.9% NaCl) solution , the cell volume remains unchanged and they are intact.



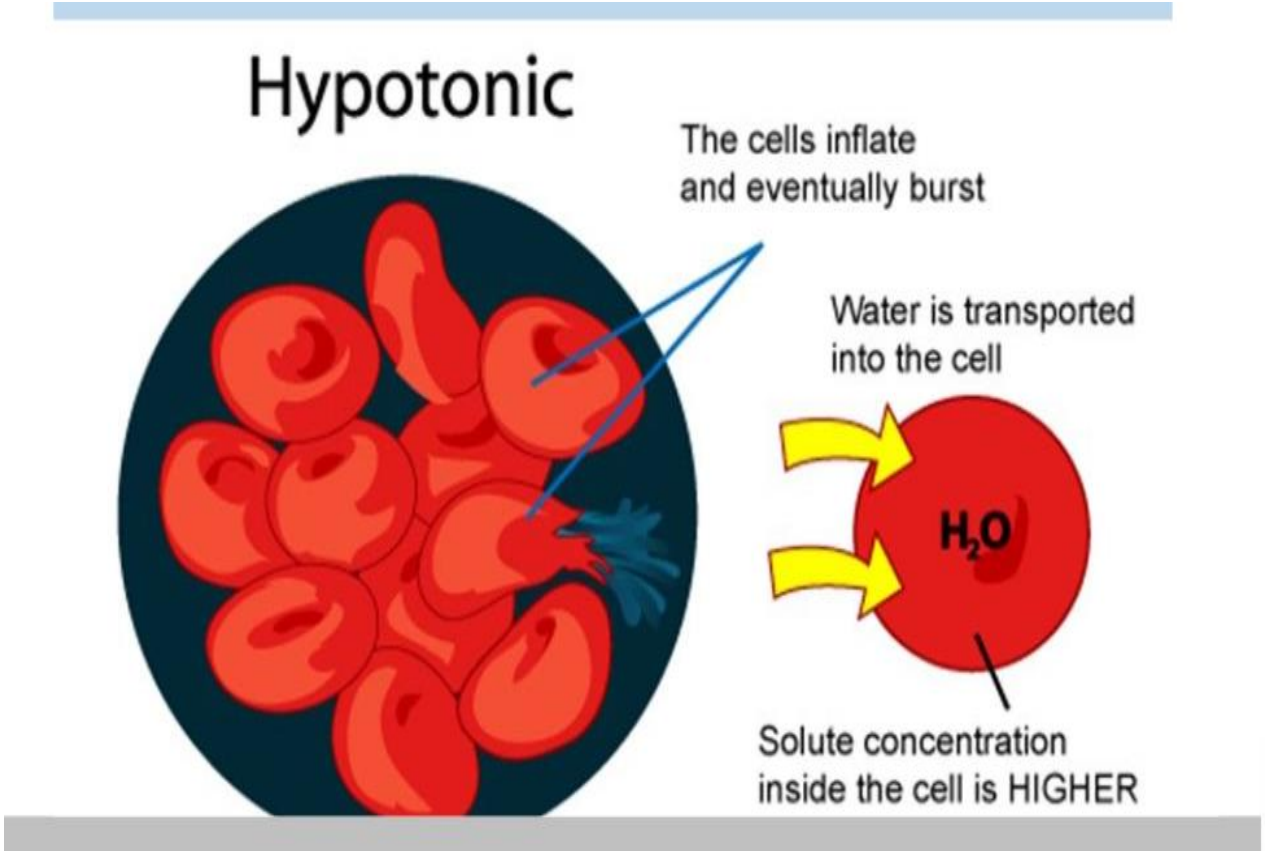
Red Blood Cells and Fragility

In hypertonic solution (eg 1.5% NaCl) water flows out of RBC and the cytoplasm shrinks, a phenomenon known as crenation.



Red Blood Cells and Fragility

- On the other hand, when the RBC are kept in a hypotonic solution (eg 0.4% NaCl), the cells bulge due to entry of water in them which often causes rupture of plasma membrane of RBC (hemolysis).



Methods to Measure Osmotic Pressure

1. Pfeffer's Method

- Semipermeable membrane formed by layers of precipitates of **Copper Ferrocyanide** on the walls of the **Porous cup E** which is connected to a **Manometer B**.
- The **Manometer B -** filled with **Hg** and **Nitrogen Gas** & closed at its upper end.
- The **Porous Cup E -** filled through the **Tube D** with the solution under investigation and sealed.
- The porous cup E is placed in **Distilled Water Jar A** at constant temperature.
- The solvent passes through the **Semipermeable Membrane** into the **Cup E**
- Pressure inside the **Cup E** increases → **Rise In The Level of Hg** in the **Manometer B**.
- At Equilibrium → level of **Hg stops rising** and the **reading on the manometer is the direct measure** of **Osmotic Pressure** of the solution under investigation.

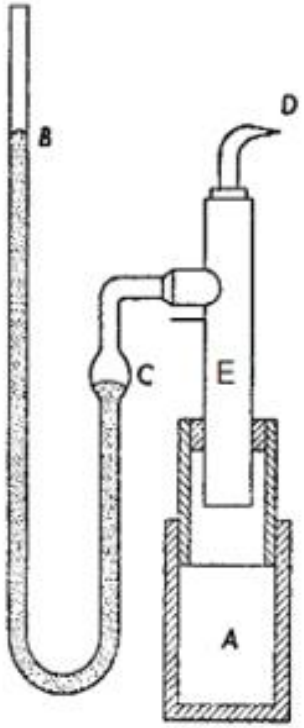


Fig.12.9. Pfeffer's osmotic pressure apparatus.

A= Jar containing water. B= Manometer for recording OP E= Porous cup containing solution for measuring of OP. D= Tube through which the solution under test is filled

Methods to Measure Osmotic Pressure

2. Freezing Point Determination Method

- One osmole osmotic pressure produces a **Decrease Of 1.86°C** in the freezing point.
- This property is used for measurement of osmotic pressure and is **More Accurate** than the Pfeffer's method.
- A special apparatus is used for determination of **freezing point of the Solution** under investigation and **Compared** with the **freezing point of the Pure Solvent**.

3. Elevation of Boiling Point and Depression Of Vapor Density

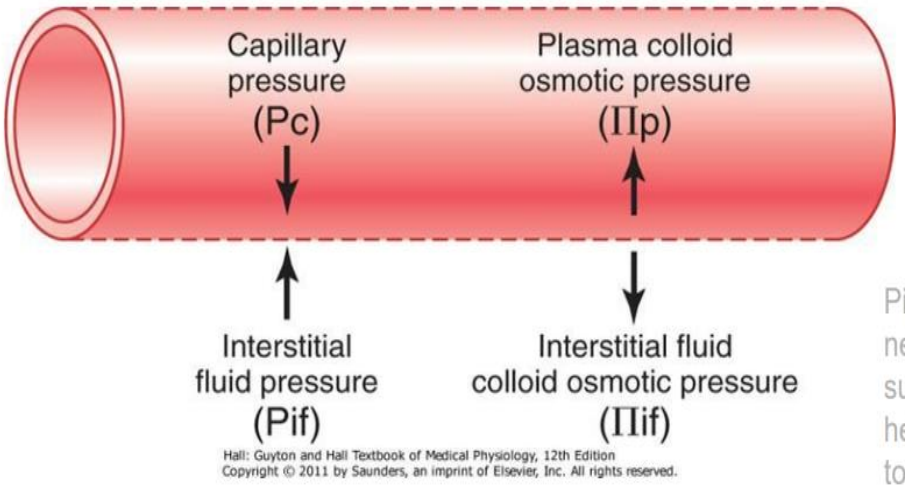
- Also be used in determination of osmotic pressure of the solution.

Importance of Osmotic Pressure

Physiological Aspect of Osmotic Pressure

Fluid balance and blood volume:

The fluid balance of the different compartments of the body is maintained due to osmosis. Further, osmosis significantly contributes to the regulation of the blood volume and urine excretion.



Pif=lower than atm (sc
negative) causing a lig
suction in tissues that
helps hold tissues
together

Four primary forces determine whether fluid moves in or out of blood "Starling forces":

capillary **"hydrostatic "** pressure ⟶ out of blood.

IF **"hydrostatic"** pressure ⟶ into blood.

. Plasma **"colloid osmotic "** pressure ➔ into blood

IF **"colloid osmotic "** pressure ⟶ out of blood.

Arteriolar end: Hydrostatic pressure > Oncotic pressure⇒ Fluid passes into interstitium

Venule end: Oncotic pressure > Hydrostatic pressure⇒ Fluid returns capillary bed

Importance of Osmotic Pressure

1. Red blood cells and fragility

- When RBC,s are suspended in an isotonic (0.9% NaCl) solution , the cell volume remains unchanged and they are **intact.**

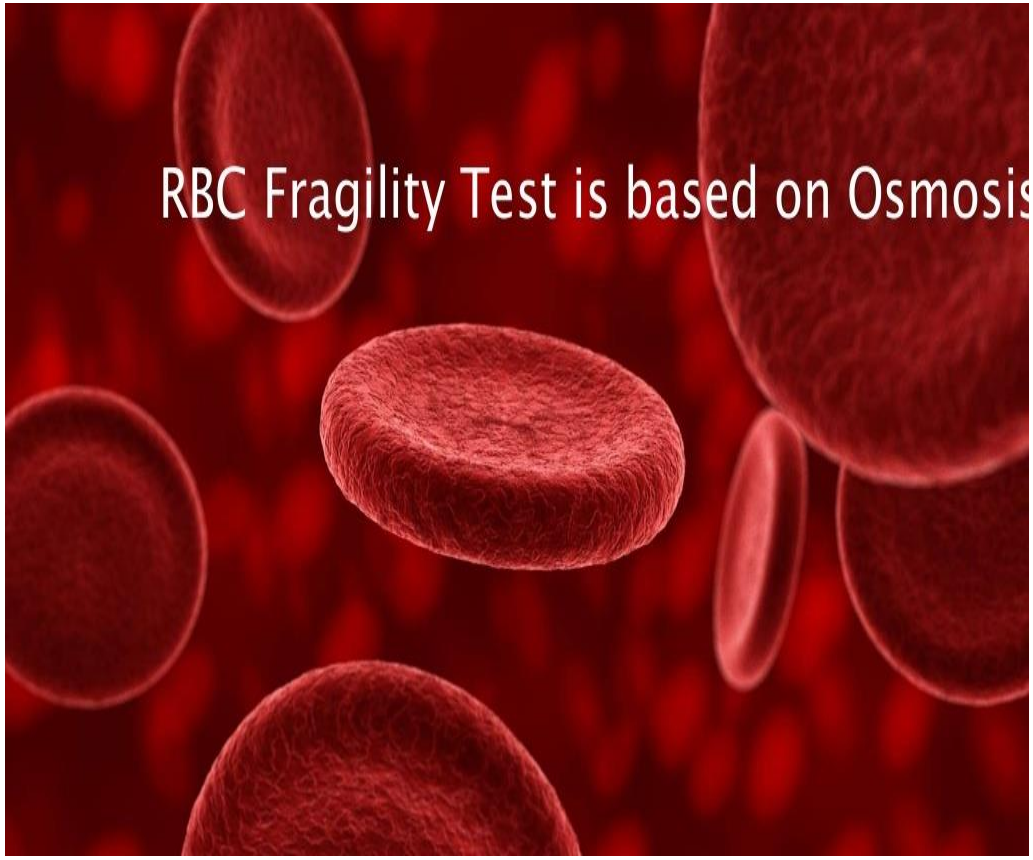
- In hypertonic solution (eg 1.5% NaCl) water flows out of RBC and the cytoplasm shrinks, a phenomenon known as **crenation.**

- On the other hand, when the RBC are kept in a hypotonic solution (eg 0.4% NaCl), the cells bulge due to entry of water in them which often causes **rupture** of plasma membrane of RBC **(hemolysis).**

Applications of Osmotic/Oncotic Pressure

1. Osmotic Fragility Test for RBCs

- Employed in lab for diagnostic purposes
- **Increased Fragility** of RBCs - observed in **Haemolytic Jaundice**
- **Decreased Fragility** of RBCs - seen in certain **Anaemias**



Applications of Osmotic/Oncotic Pressure

2. TRANSFUSION: Isotonic solution of NaCl 0.9% or glucose 5% or a suitable combination of these two is commonly used in I/V (intravenous) transfusion in hospitals for the treatment of dehydration, burns, etc.

3. ACTION OF PURGATIVES: The mechanism of action of purgatives is mainly due to osmotic phenomenon, Epsom (MgSO4. 7h20) or Glauber's (Na2SO4. 10H2O). Salts withdraw water from the body, besides preventing the intestinal water absorption.

4. OSMOTIC DIURESIS:

High blood glucose concentration causes osmotic diuresis resulting in loss of water, electrolytes and glucose in the urine. This is the basis of polyuria observed in diabetes mellitus.

Diuresis can be observed by administering compounds (eg mannitol) which are filtered but not reabsorbed by renal tubules

Applications of Osmotic/Oncotic Pressure

5. OEDEMA DUE TO HYPOALBUMINEMIA: Disorders such as KWASHIORKOR AND GLOMERONEPHRITIS are associated with low plasma albumin concentration and edema. Oedema is caused by reduced oncotic pressure of plasma leading to accumulation of excess fluid in tissue spaces.

6. **CEREBRAL OEDEMA:** Hypertonic solutions of salts (NaCl, MgSO4) are in use to reduce the volume of brain or the pressure of CSF.

7. IRRIGATION OF WOUNDS: Isotonic solutions are used for washing wounds. The pain experienced by the direct addition of salt or sugar to wound is due to osmotic removal of water.

Management of

Role of family Medicine in patients with **Kwashiorkar** (**Edematous Malnutrition**):

- **Diagnosis & Monitoring**– Clinical assessment, Proper investigations - **Serum Total Proteins/Albumin,** Anemia - Close follow-up

- **Education & Dietary Guidance** –

- Condition of **Protein Energy Malnutrition** in infants & children, Education of Parents esp Mother
- **Regular Diet** - Initially light digestible, gradual increase according to patient response , approx. 150kcal/day
- High Protein diet, Seasonal Fruits & Vegetables .

- **Refer to Specialists –** Urgent referral of Serious patients with severe signs & symptoms to **Paediatrician**

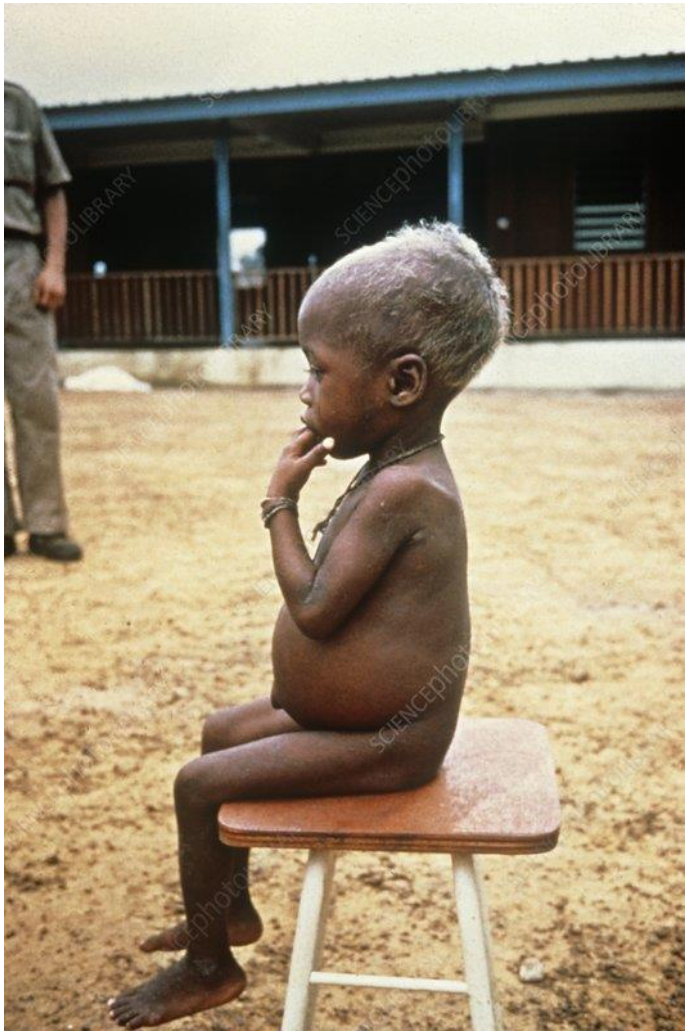
Role of AI in Managing Kwashiorkar

- **Personalized Nutrition –** Diet Optimization, Dietary Pattern Assessment

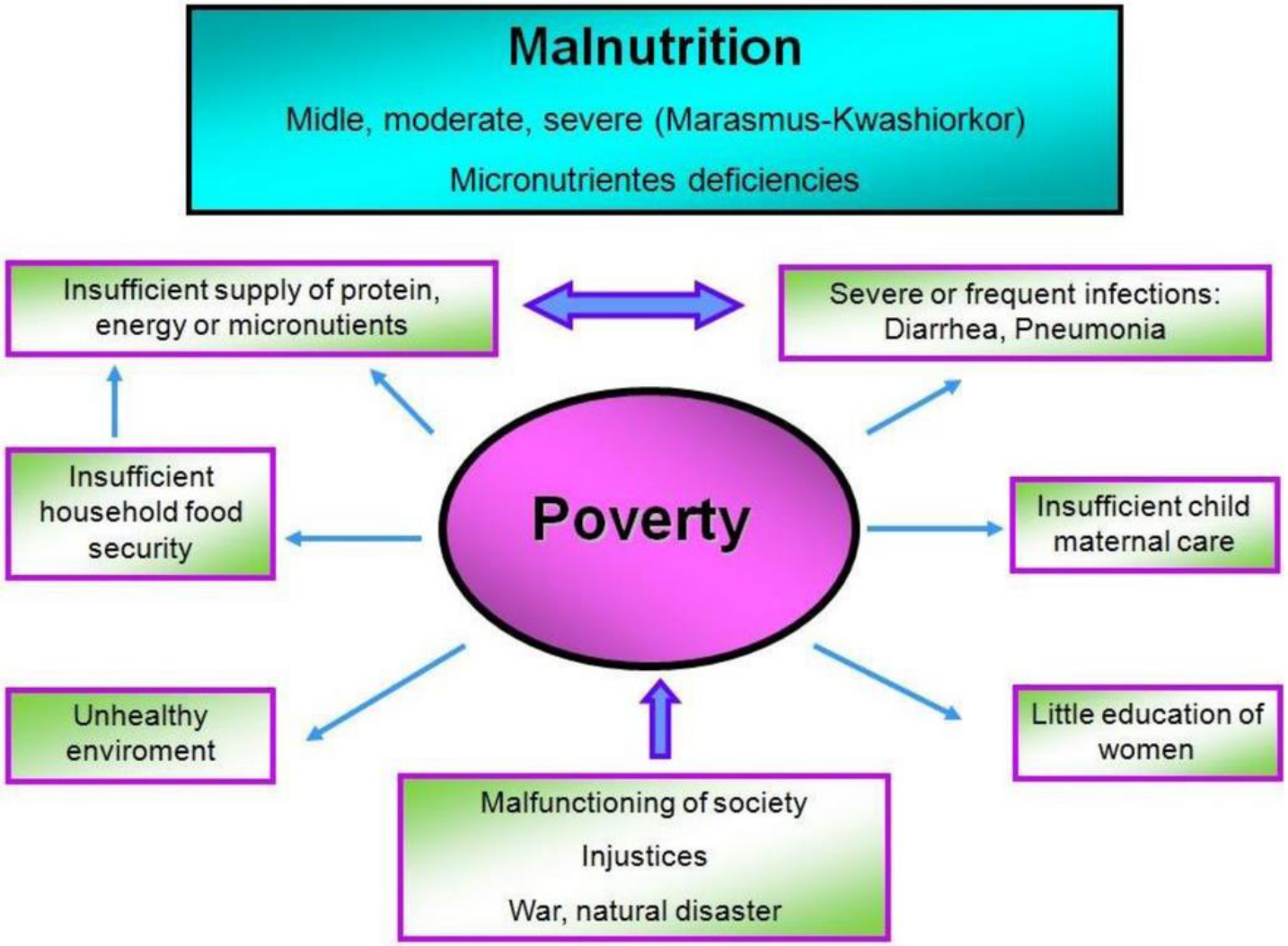
- **Diagnostic Tools** – Caused by a lack of protein in diet.
- Patients have an extremely emaciated appearance in all body parts except ankles, feet & belly which swell due to fluid retention.
- **AI may be able to judge a child's nutrition status & through photographs→ Diagnosis**

- **Food Recommendations –**
- Diet Planning & Advancement,
- Food Image Recognition by Robots

- **Prediction of Risk Factors –**
- Region of famine,
- Underlying Infections/Diseases,
- Pre-existing Immunity



Ethical Considerations



Suggested Research Articles

Link: https://www.researchgate.net/publication/341207755_Colloid_osmotic_pressure_of_contemporary_and_novel_transfusion_products

Journal Name: Vox Sanguinis

Title: Colloid osmotic pressure of contemporary and novel transfusion products

Author Name: Robert B. Klanderman, Joachim J. Bosboom

- Abstract

- Background and Objectives Colloid osmotic pressure (COP) is a principal determinant of intravascular fluid homeostasis and a pillar of fluid therapy and transfusion. Transfusion-associated circulatory overload (TACO) is a leading complication of transfusion, and COP could be responsible for recruiting additional fluid. Study objective was to measure COP of blood products as well as investigate the effects of product concentration and storage lesion on COP. Materials and Methods Three units of each product were sampled longitudinally. COP was measured directly as well as the determinants thereof albumin and total protein. Conventional blood products, that is red blood cell (RBC), fresh-frozen plasma (FFP) and platelet concentrates (PLTs), were compared with their concentrated counterparts: volume-reduced RBCs, hyperconcentrated PLTs, and fully and partially reconstituted lyophilized plasma (prLP). Fresh and maximally stored products were measured to determine changes in protein and COP. We calculated potential volume load (PVL) to estimate volume recruited using albumin's water binding per product. Results Colloid osmotic pressure varies widely between conventional products (RBCs, 1·9; PLTs, 7·5; and FFP, 20·1 mmHg); however, all are hypooncotic compared with human plasma COP (25·4 mmHg). Storage lesion did not increase COP. Concentrating RBCs and PLTs did not increase COP; only prLP showed a supraphysiological COP of 47·3 mm Hg. The PVL of concentrated products was lower than conventional products. Conclusion Colloid osmotic pressure of conventional products was low. Therefore, third-space fluid recruitment is an unlikely mechanism in TACO. Concentrated products had a lower calculated fluid load and may prevent TACO. Finally, storage did not significantly increase oncotic pressure of blood products.

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6. A page will appear showing the resources of the institution
7. Journals and Researches will appear
8. You can find a Journal by clicking on JOURNALS AND DATABASE and enter a keyword to search for your desired journal.

Learning Resources

- Essentials of Medical Biochemistry by Mushtaq Ahmed. Ninth edition, Vol 1, chapter 2, pages 24, 30, 31, 46.
- Guyton and Hall Textbook of Medical Physiology by John E. Hall, Michael E. Hall. Fourteenth edition.
- Harper's Illustrated Biochemistry 32nd Edition
- Google Scholar
- Google Images


Thank You!