Surface tension and Viscosity

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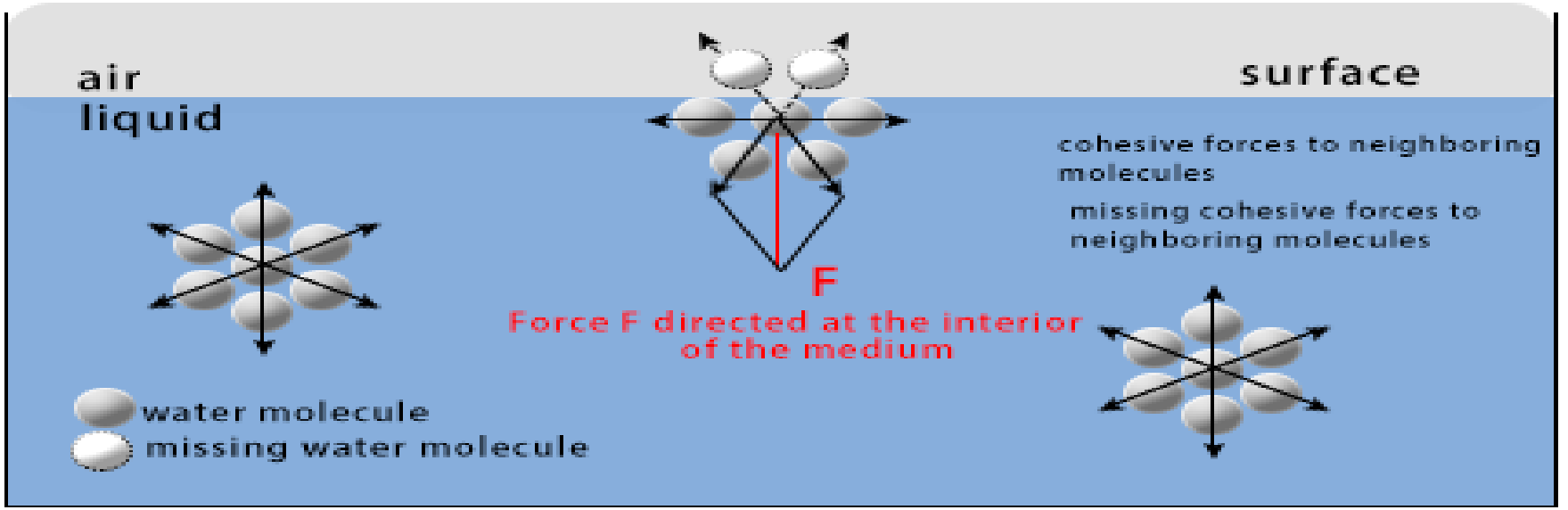
Learning Objectives

- Definition of surface tension
- Explanation
- Factors affecting surface tension
- Importance of Surface tension in our body
- Surfactant
- Definition of viscosity
- Causes of viscosity
- Factors affecting viscosity
- Importance of viscosity in our body

SURFACE TENSION

Definition

- Surface tension could be defined as the property of the surface of a liquid that allows it to resist an external force, due to the cohesive nature of the water molecules.
- This is the force which causes a liquid to assume the form of a spherical drop in which it has the smallest surface area for a given volume.

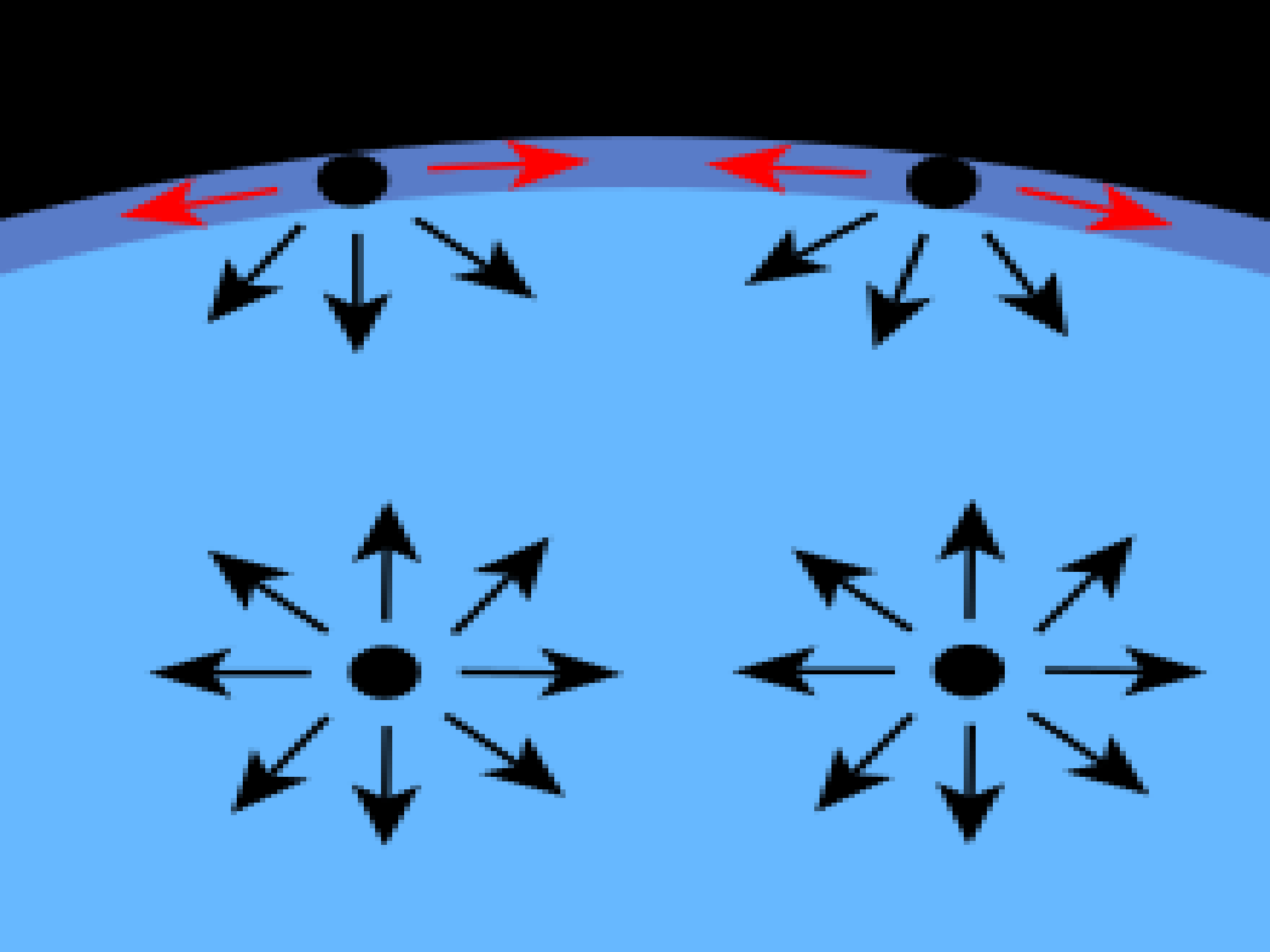


SURFACE TENSION

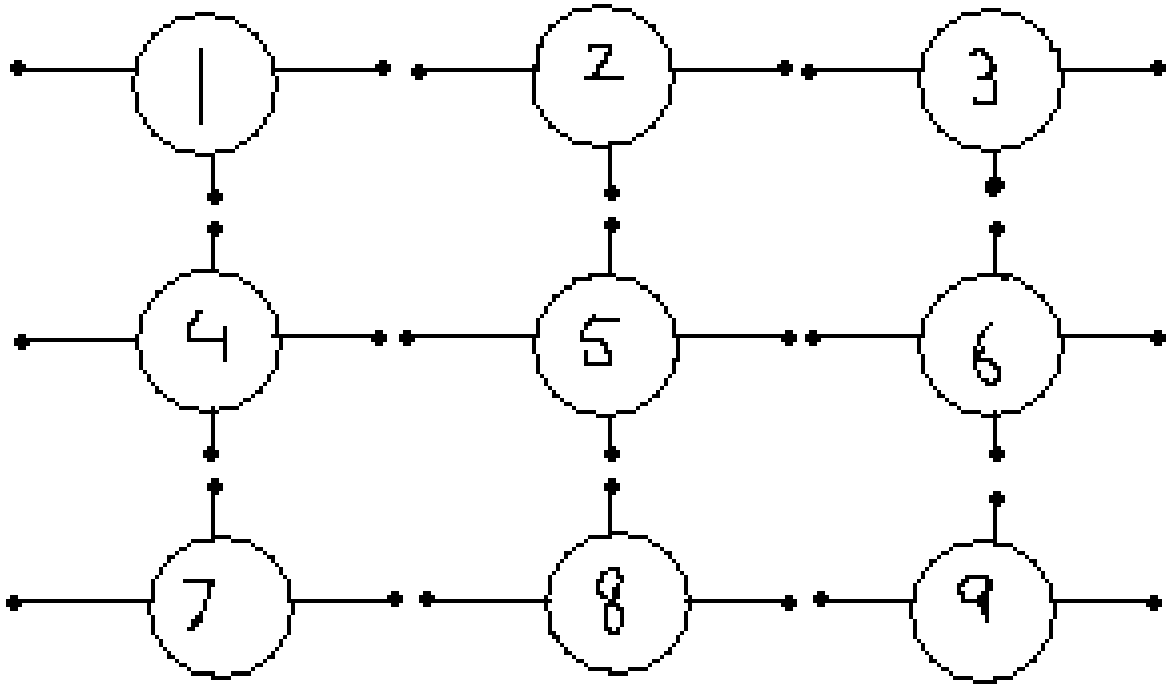
- It is the force acting perpendicularly inwards on the surface layer of a liquid to pull its surface molecules towards the interior of the fluid. It keeps the surface like a stretched membrane.

- molecules in the bulk liquid are surrounded in all directions by other molecules for which they have an equal attraction.

- molecules at the surface (i.e., at the liquid–air interface) can only develop attractive cohesive forces with other liquid molecules that are situated below and adjacent to them. They can develop adhesive forces of attraction with the molecules constituting the other phase involved in the interface, although, in the case of the liquid–gas interface, this adhesive force of attraction is small.



- In figure molecules 4 to 9 are attracted equally to all side and thus free to move in any direction , but molecules 1 to 3 do not have any molecules above them and so pulled downwards and side wards and the layer of the surface molecules is thus stretched .



Surface tension

- The net effect is that the molecules at the surface of the liquid experience an inward force toward the bulk.
- Such a force pulls the molecules of the interface together and, as a result, contracts the surface, resulting in a *surface tension*.

Formula

Surface Tension, Equation

- The surface tension is defined as the ratio of the magnitude of the surface tension force to the length along which the force acts:

$$\gamma = \frac{F}{L}$$

- SI units are N/m
- In terms of energy, any equilibrium configuration of an object is one in which the energy is a minimum

Factors affecting surface tension

- **Nature of liquid/force of attraction**: is due to intra molecular attraction of molecules,water having strong H.bonding have more surface tension,ether having weak dipole-dipole forces have weak surface tension between its molecules.
- **Temperature**:Inverse relation i.e increase in T, decreases surface tension and vice versa.The surface tension of water at 0°C is 75.6, at 20°C it is 72.8, and at 75°C it is 63.5 dynes/cm.
- **Purity of liquid**: impurities present in the liquid.
- **Presence of surfactant**:presence of surfactants lowers surface tension.Surfactants may be detergents, emulsifiers .

Role in human body

- Human biological fluids such as serum, urine, gastric juice, amniotic fluid, digestive, urinary and reproductive tracts, endocrine glands and alveolar lining fluid contain numerous surfactants, proteins, and lipids. These low and high-molecular weight surfactants are the common materials in various tissues of the body which control surface tension of human interfaces. The physicochemical processes that take place in these interfaces are of fundamental importance for various tissues and the vital function of body organs.
- Pathological features of diseases vary in the nature and the magnitude. Despite this diversity, the common feature of various disorders underlies the physicochemical and biochemical factors such as surface tension. Changes in the surface tension behavior of human biological fluid are characteristic for some diseases.

Role in human body

- **Chronic bronchitis**

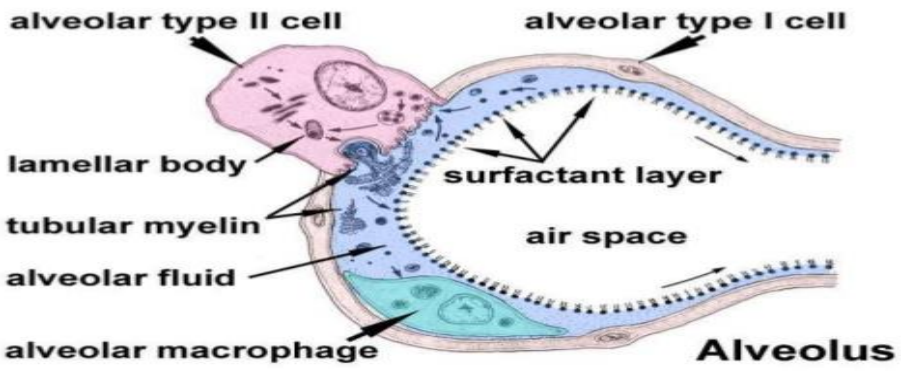
Chronic bronchitis is caused by the excess mucus production or hypertrophy of the mucous gland which causes thickening of the bronchial mucosa. An increase in the mucus secretion dilutes the surfactant and increases the surface tension of surfactant lining of the lung airways and causes narrowing and obstruction of the airway.

- **Respiratory distress syndrome and hyaline membrane disease**

Hyaline membrane disease (HMD), more commonly known as the neonatal respiratory distress syndrome (RDS). The disease is caused by lung immaturity and surfactant deficiency in the alveolar space.

Surface tension in Alveoli SURFACTANTS

- Phospholipid produced by alveolar type II cells.
- Lowers surface tension.
  - Reduces attractive forces of hydrogen bonding by becoming interspersed between H_20 molecules.
- As alveoli radius decreases, surfactant's ability to lower surface tension increases.



SURFACTANTS

- Molecules and ions that are absorbed at the interface is termed as ***Surfactants***

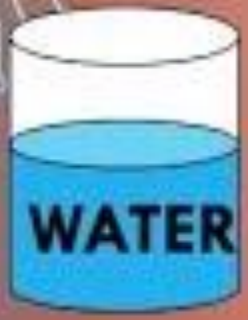
- Surfactants have two distinct regions in their chemical structure, one of which is water-liking or ***Hydrophilic*** and the other of which is water-hating or ***Hydrophobic***.

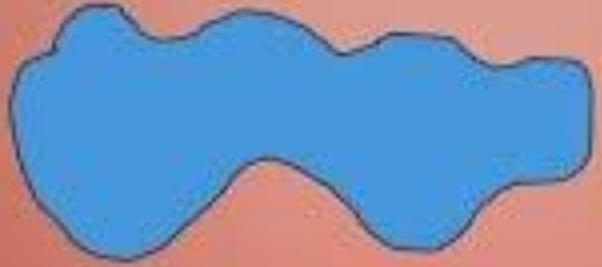
- These molecules are referred to **as** ***Amphiphilic*** *or* ***Amphipathic*** molecules or simply as ***Surfactants*** or ***Surface active agents***.

SURFACTANTS

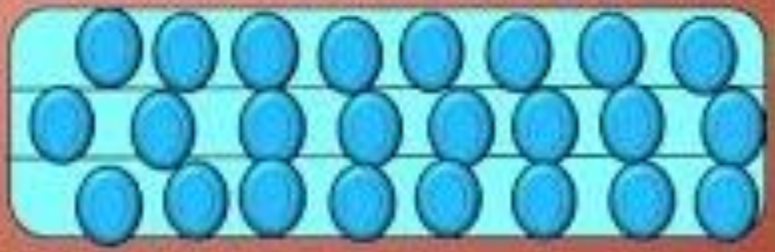
Before	Shampooing	Mode of Action	Rinse
			
Skin	Skin	Skin	Skin
Oil and dirt are attached to the skin and hair	The surfactant lowers the surface tension of the water	The surfactant creates micelles around the dirt and oil that are removed from the skin and hair	The micelles with the oil, dirt and surfactant are eliminated with the water during rinse

VISCOSITY



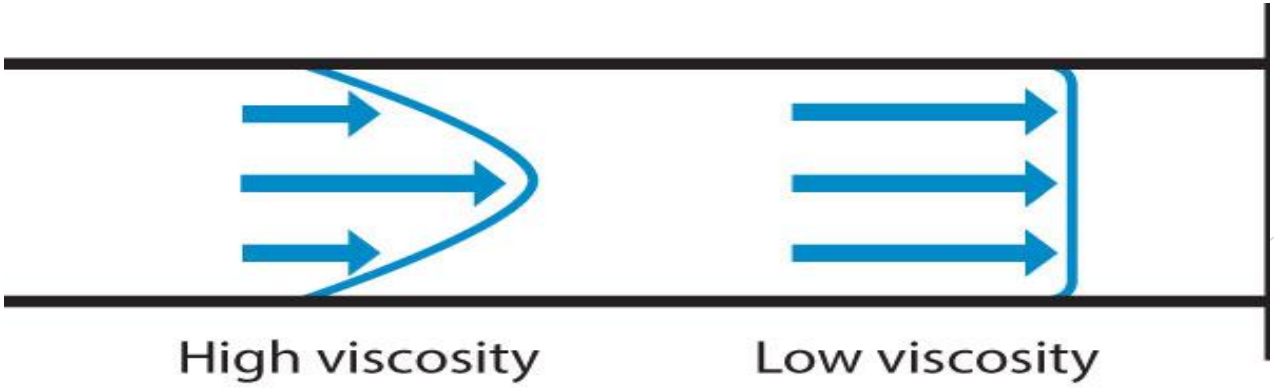


parallel layers of fluids



VISCOSITY:

- Viscosity is the quantitative measure of a fluid resistance to flow.
- It is defined as the internal friction of fluid to move.



Viscosity

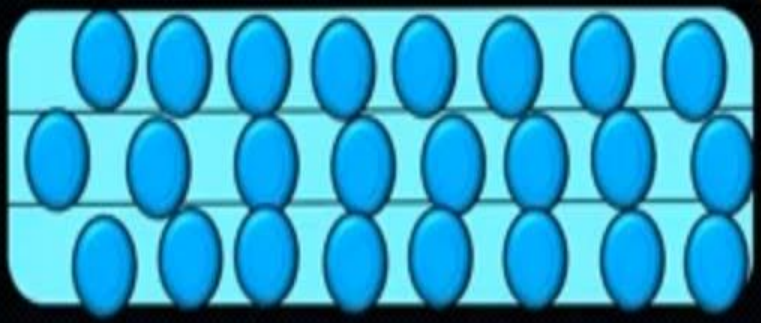
- Viscosity is the internal resistance of fluid to the free flow of a liquid. It is due to the frictional forces between the fluid layers moving over each other at different velocities
- Water will flow over a glass plate much faster than honey therefore water is said to have more fluidity and less viscosity than honey.
- The rate of flow of a liquid is inversely proportional to its viscosity . If the viscosity of the fluid is less, greater will be its fluidity and vice versa.

VISCOSITY

- Viscosity is the internal property of fluid
- It is the frictional forces resulting due to the interaction between the layers of molecules.

↑ interaction between liquid molecules = ↑ viscosity

↓ interaction between liquid molecules = ↓ viscosity



layer 1
layer 2
layer 3

parallel layers of fluids

CAUSES OF VISCOSITY

- **Attraction among molecules**: cohesive forces between the molecules in liquid & molecular collision in gases.
- **Asymmetry in molecular structure**: viscosity is greater with larger molecules than smaller molecules & with elongated than with rounded molecules.

Factors affecting viscosity:

1. **Temperature:**An increase in temperature decreases the viscosity of liquid. This is due to an increase in the kinetic energy of molecules for overcoming the resistance due to intermolecular attractions and also for breaking intermolecular H-bonds of associated liquid.
2. **Solute concentration**:Viscosity of a solution is directly proportional to the solute concentration. Suspended particles cause an increase in viscosity in proportion to the volume of suspended material.
3. **Density**: Viscosity of a liquid varies directly with its density.

IMPORTANCE OF VISCOSITY

- **Regulation of blood flow:** The viscosity of blood is largely due to the lyophilic colloidal system(mainly proteins) & due to the great proportion of suspended particles (RBCs).
- **Regulation of blood pressure**: it is directly proportional to viscosity. The viscosity of serum is1.4 to 1.8 times that of water.

Viscosity of blood

- Blood is a suspension of cells in plasma. Plasma is a water solution of salts and heavily hydrated macromolecules.
- The viscosity of blood thus depends on the viscosity of the plasma, in combination with the hematocrit (The hematocrit or packed cell volume (PCV) or erythrocyte volume fraction (EVF) is the volume percentage (%) of red blood cells in blood. It is normally about 45% for men and 40% for women)
- Blood cells behave as suspended particles and increase the viscosity of blood. Fibrinogen due to its asymmetry and high density imparts maximum viscosity to the blood
- Globulins have greater influence than albumin

Effect of Erythrocytes on viscosity of blood

- Deformability of Erythrocytes
- Haematocrit

Deformability of Erythrocytes

- Erythrocyte deformability refers to the cellular properties of erythrocytes which determine the degree of shape change under a given level of applied force
- Erythrocytes change their shape extensively under the influence of applied forces in fluid flow or while passing through microcirculation.
- The extent and geometry of this shape change is determined by both the mechanical properties of erythrocytes, the magnitude of the applied forces and the orientation of erythrocytes with the applied forces

Deformability and viscosity

- Erythrocyte deformability is an important determinant of blood viscosity, hence blood flow resistance in the vascular system.
- Deformability of erythrocytes affects viscosity of blood in small vessels where erythrocytes are forced to pass through blood vessels with diameters smaller than their size.
- In sickle cell anaemia, deformability of erythrocytes is reduced thereby increasing viscosity of blood.

Effect of hematocrit on viscosity

- Viscosity of blood also varies with changing haematocrit.
- When the haematocrit rises, the friction between the successive layers of blood increases. Hence with increasing haematocrit the viscosity of the blood rises.

Effect of temperature on blood viscosity

- This is due to the presence of thermoproteins, which show physical change s at temperatures below or above 37 °C
- Cryglobulin operates at temperatures below 37 °C forming reversible or irreversible precipitates, gels or crystals.
- Pyroglobulin gets precipitated at 56 °C.
- Bence-Jones proteins gets precipitated at 40 °C
- At 0 °C, the viscosity of blood is increased up to three times. This reduces the circulation in the tissues exposed to cold.

Effect of Inflammation and disease conditions on Viscosity of Blood

- Inflammation causes loss of plasma into the tissues. This leads to slowing of blood flow, disturbance in the axial flow and increase in viscosity.
- Blood viscosity is increased in diabetes mellitus, multiple myeloma, jaundice, leukaemia, asphyxia, vomiting and diarrhea.

Viscosity of Synovial fluid

- Synovial fluid is highly viscous. Its viscosity varies from 50 to 200 times that of water. Its viscosity is due to the presence of hyaluronic acid.
- Viscosity of Synovial fluid reflects its hyaluronic acid content.
- In inflammatory effusions such as rheumatoid arthritis etc , the viscosity of synovial fluid is markedly decreased (down to water like) indicating the presence of a thin watery fluid containing degraded small molecular hyaluronidase particles.

THANKS