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REFLECTION OF FLUID MECHANICS ON BIO–MEDICAL ENGINEERING

[1]*Arunava Chandra Chandra, [2]Dr. Dhananjoy Saha, [3]Dr. Sampa Dhabal and [1]Dr. Dhrubo Jyoti Sen

[1]Department of Pharmaceutical Chemistry, School of Pharmacy, Techno India University, Salt–Lake City, Sector–V, EM–4, Kolkata–700091, West Bengal, India.
[2]Deputy Director of Technical Education, Directorate of Technical Education, Bikash Bhavan, Salt Lake City, Kolkata–700091, West Bengal, India.
[3]Forensic Scientist, Kolkata, West Bengal, India.

***Corresponding Author: Arunava Chandra Chandra**
Department of Pharmaceutical Chemistry, School of Pharmacy, Techno India University, Salt–Lake City, Sector–V, EM–4, Kolkata–700091, West Bengal, India.

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ABSTRACT
Era of science and Technology the two main Stream was evaluated first one is medical Science and Second is Engineering and Technology. Medical Science mainly biology and chemistry based and other side Engineering and Technology are the based–on physics and its laws but there were many similarities between physics and human biomedical engineering. In the growing age of Science and Technology we must be compare our human body with a mechanical device (like Robot) before we comparing this, we must have knowledge about human body and mechanical device and its own laws. Human body also made up with natural things and chemicals but mechanical device was made up with hard materials like metals plastic and other electrical and non–electrical particles. Our bodies have a particular circulatory system and central nervous system which is control everything in our body. In this article We have discussed about Liquids flowing System in human body. Our body is totally depended on liquids and minerals. Many properties of physics are followed by our body. There are two types of liquids are found in Human body 1. Blood and 2. Lymph. Blood is circulating in every human cell by a circulatory system which is based on a pump machine is called heart. Heart is found in our left chest. Before discussed about our circulatory system and it's biomedical significance. We focused on our main liquid 'Blood'. Blood is an alkaline liquid which is found in human and others animal and supply and transport of oxygen and nutrients cell to cell. Blood is also known as river of the life. Blood is contentions mainly two parts: 1. Plasma the fluid part and 2. The solid Part (blood cell, proteins, minerals). Blood is contained mainly types of cell RBC and WBC (White Blood Cell). 120 days long RBC if contain haemoglobin which is responsible for transportation of oxygen in cell to Cell. Other side WBC is responsible for the immune system in our body.

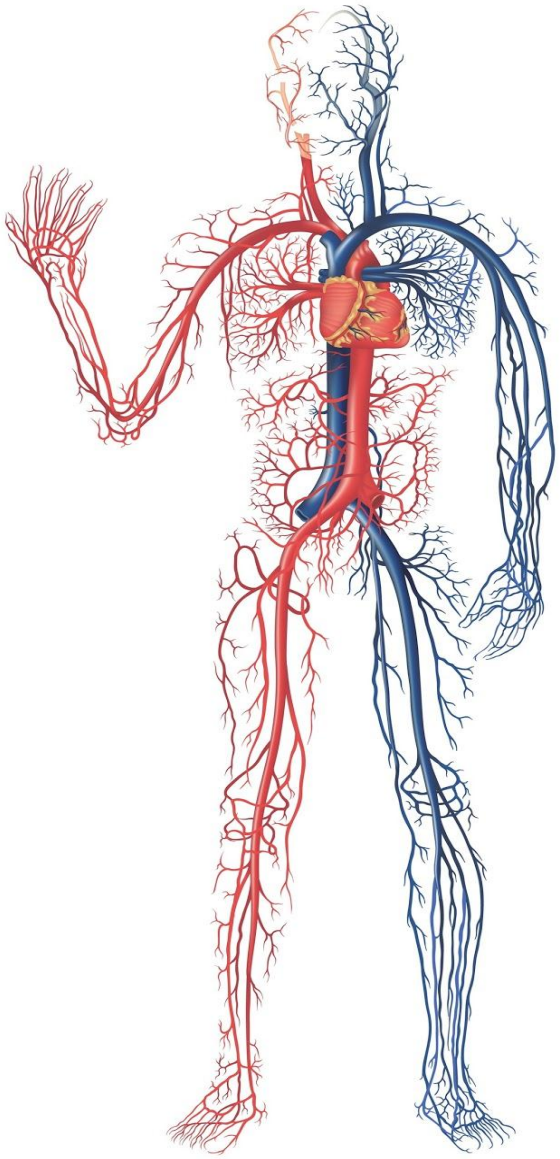
KEYWORDS: RBC, WBC, Platelets, Serum, Plasma.

INTRODUCTION
In many times ago, the life was found by our nature, and it's made human Bing the most intelligent species in the world. Human body is not only described in our anatomy and physiology, it also belongs seen a systemic and design architecture engineering which is built by our nature. In 19th century v are going to discuss and compare our human body with our engineering and Technology. Science is differentiating between many streams like biological stream Technology physics biochemistry and engineering also. We are particularly gone to found the particular similarities human body with our mechanical Technology and engineering. How our Body does work not only as a biological process also be an engineering process. we think that its mostly helpful for our future generation to compare our human body with a mechanical device.[1]

Basic: Human body looks like a liquid Fill–up and drainage system, this fluid is transport through a natural Pipelines which is made up by epithelial Cells These are called Arteries. Here we discuss about The Properties of Blood and how it's flows in the body and our mechanical pump (Heart) and How its flows the blood in contrast of the force and gravity. This Phenomenon is called Human Circulatory System. This Process is random and Works by its Own Redeem and follow its own Law's.

Circulatory System in body: The Two major Circulatory System in Body is:
1. Blood Circulatory System And 2. Lymphatic System.
Others Fluids Like Hormones & endocrine and Enzyme and Enzymatic Systems.

Blood Circulatory System: The Circulatory system is the most important system in our body. Without the Circulatory System we can't imagine Our existence as a



Figure–1: Human circulatory system.

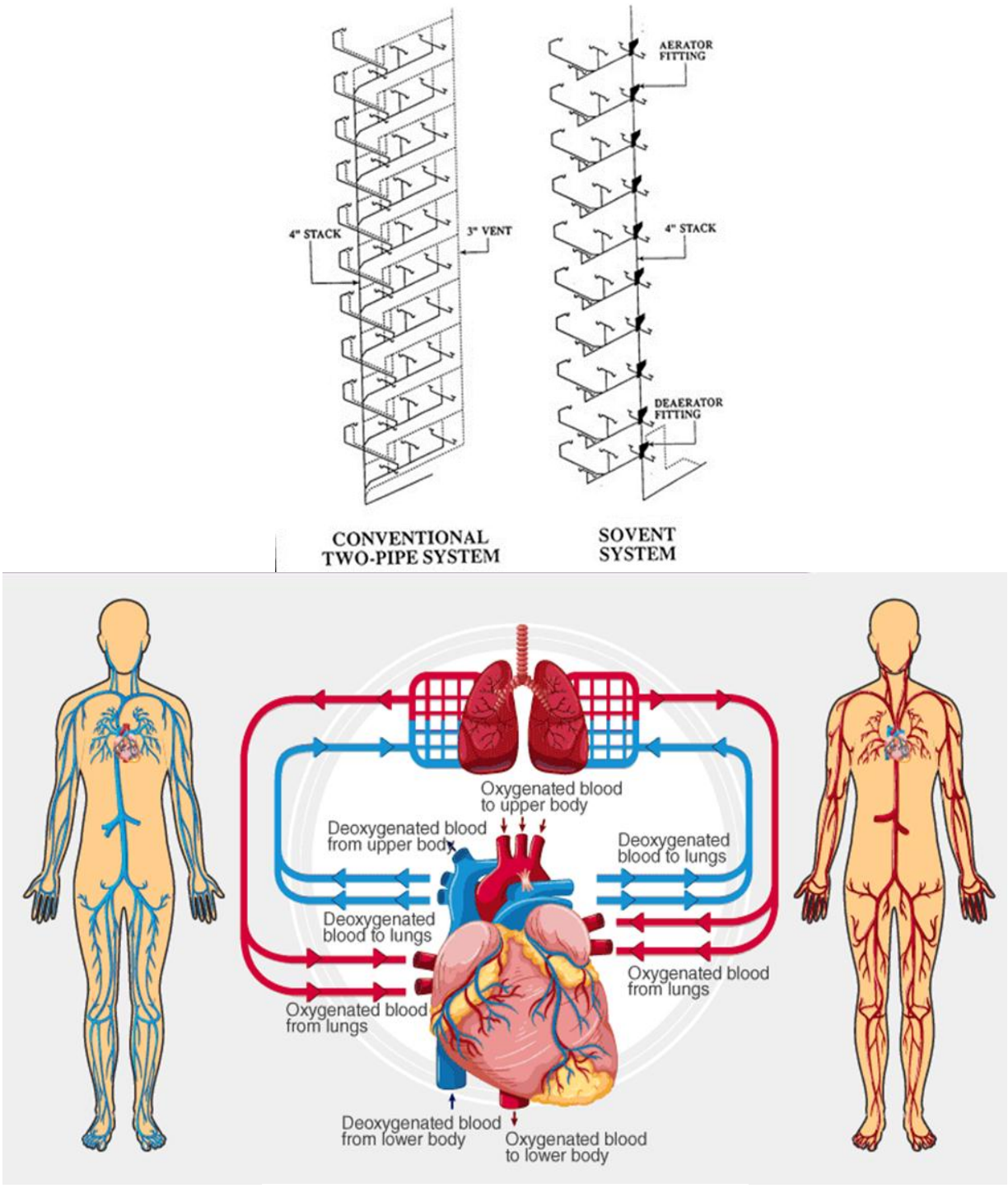
Human. The main organ of the circulatory system is the heart, which is responsible for pumping oxygenated blood throughout the body. Without the heart, a human cannot live. Other parts of the circulatory system include the blood and blood vessels, such as arteries and veins. Arteries are responsible for carrying blood away from the heart, and veins are responsible for carrying blood toward the heart.

Capillaries are also blood vessels; they are the structures that connect arteries to veins throughout the body. The blood itself has many different types of cells that help the body function, such as red blood cells, white blood cells and platelets. Red blood cells are transporters of oxygen and carbon dioxide, and white blood cells serve to protect the body against harmful germs and disease. Platelets are thick blood cells that stop the body from bleeding when there is an injury, such as a cut or a wound. Plasma is the liquid part of blood that transports the blood cells throughout the body.

Blood is the "river of life" that surges within us. It transports everything that must be carried from one place to another within the body– nutrients, wastes (headed for elimination from the body) and body heat through blood vessels. Long before modern medicine, blood was viewed as magical, because when it drained from the body, life departed as well.

The Main Functions of Blood

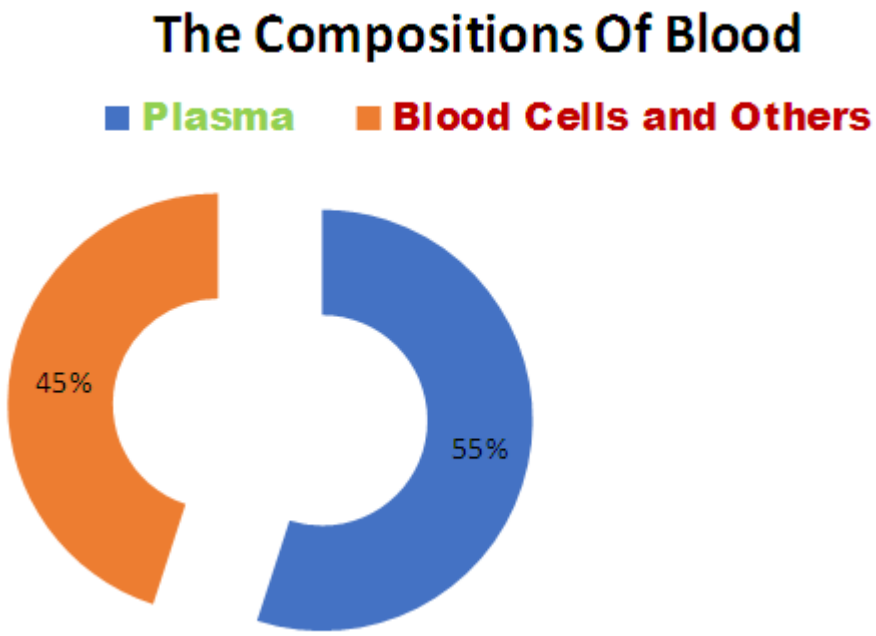
1. **Carrier of gases, nutrients, and waste products.** Oxygen enters blood in the lungs and is transported to cells. Carbon dioxide, produced by cells, is transported in the blood to the lungs, from which it is expelled. Ingested nutrients, ions, and water are carried by the blood from the digestive tract to cells, and the waste products of the cells are moved to the kidneys for elimination.
2. **Clot formation.** Clotting proteins help stem blood loss when a blood vessel is injured.
3. **Transport of processed molecules.** Most substances are produced in one part of the body and transported in the blood to another part.
4. **Protection against foreign substances.** Antibodies help protect the body from pathogens.
5. **Transport of regulatory molecules.** Various hormones and enzymes that regulate body processes are carried from one part of the body to another within the blood.
6. **Maintenance of body temperature.** Warm blood is transported from the inside to the surface of the body, where heat is released from the blood.
7. **pH and osmosis regulation.** Albumin is also an important blood buffer and contributes to the osmotic pressure of blood, which acts to keep water in the blood stream.

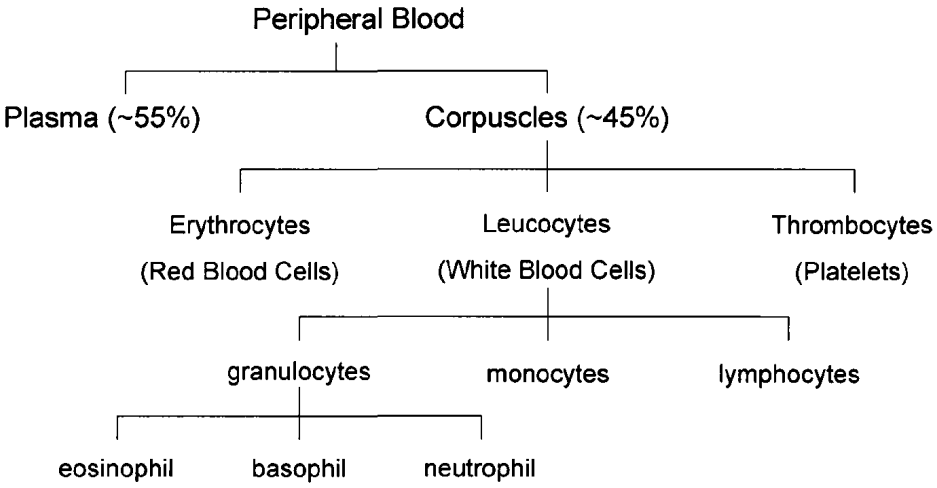


Figure–2: Circulation of blood: the fluid mechanics.

Plasma: Plasma, which is approximately 90 percent water, is the liquid part of the blood.

- **Dissolved substances.** Examples of dissolved substances include nutrients, salts (electrolytes), respiratory gases, hormones, plasma proteins, and various wastes and products of cell metabolism.
- **Plasma proteins.** Plasma proteins are the most abundant solutes in plasma; except for antibodies and protein–based hormones, most plasma proteins are made by the liver.[2]
- **Composition.** The composition of plasma varies continuously as cells remove or add substances to the blood; assuming a healthy diet, however, the composition of plasma is kept relatively constant by various homeostatic mechanisms of the body.

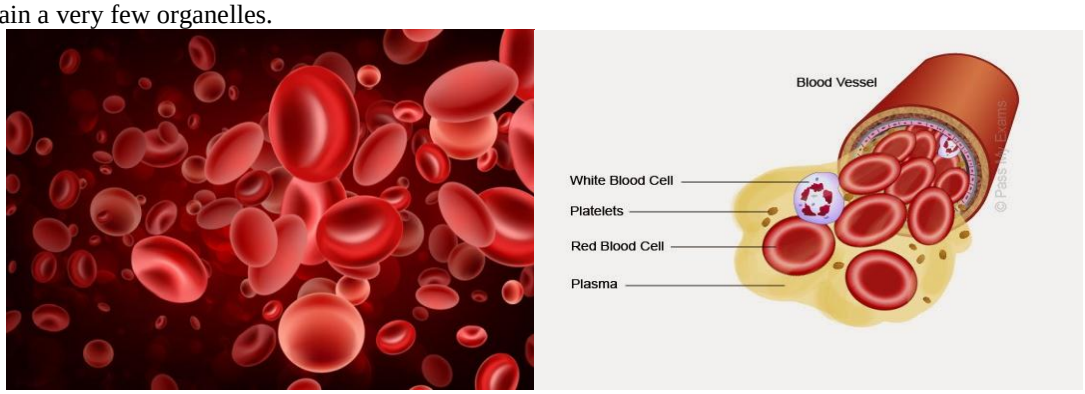




Blood Cells and Others

Erythrocytes (RBC)

- **Anucleate.** RBCs differ from other blood cells because they are anucleate, that is, they lack a nucleus; they also contain a very few organelles.



Figure–3: Flow of blood.

- **Haemoglobin.** Haemoglobin, an iron bearing protein, transports the bulk of oxygen that is carried in the blood.
- **Microscopic appearance.** Erythrocytes are small, flexible cells shaped like biconcave discs–flattened discs with depressed centers on both sides; they look like miniature doughnuts when viewed with a microscope.
- **Number of RBCs.** There are normally about **5 million cells** per cubic millimeter of blood; RBCs outnumber WBCs by about 1000 to 1 and are the major factor contributing to blood viscosity.
- **Normal blood.** Clinically, normal blood contains **12–18 grams** of hemoglobin per 100 milliliters (ml); the hemoglobin content is slightly higher in men (13–18 g/dl) than in women (12–16 g/dl).

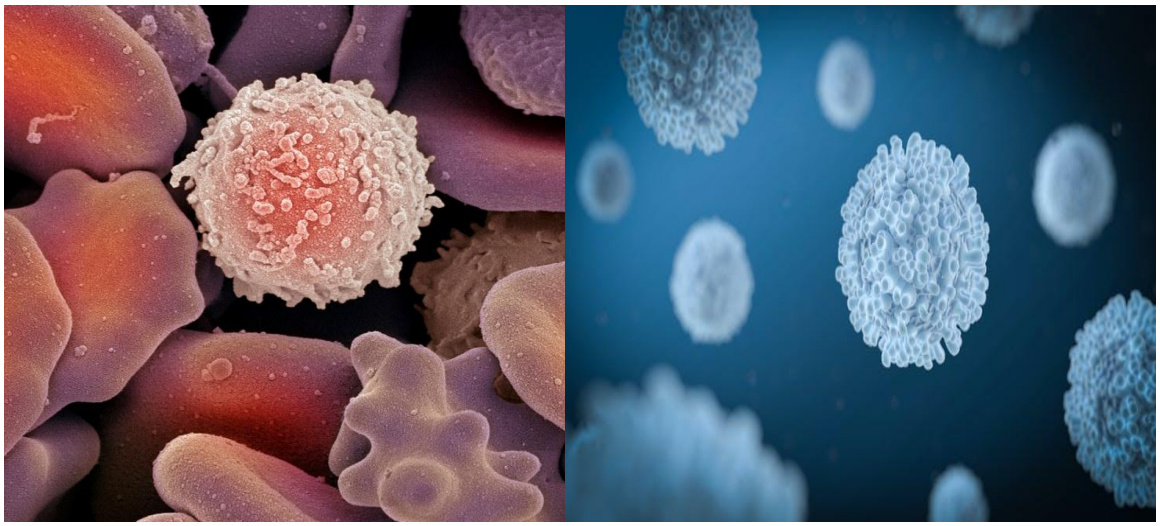
Erythrocytes, or red blood cells, function primarily to ferry oxygen in blood to all cells of the body.[3]

Leukocytes (WBC)

- **Number of WBCs.** On average, there are **4,000 to 11,000 WBC/mm^3**, and they account for less than 1 percent of total body volume.
- **Body defense.** Leukocytes form a protective, movable army that helps defend the body against damage by bacteria, viruses, parasites, and tumor cells.
- **Diapedesis.** White blood cells are able to slip into and out of the blood vessels– a process called diapedesis.
- **Positive chemotaxis.** In addition, WBCs can locate areas of tissue damage and infection in the body by responding to certain chemicals that diffuse from the damaged cells; this capability is called positive chemotaxis.

Ameboid motion. Once they have "caught the scent", the WBCs move through the tissue spaces by ameboid motion (they form flowing cytoplasmic extensions that help move them along).

- **Leukocytosis.** A total WBC count above 11, 000 cells/mm^3 is referred to as leukocytosis.



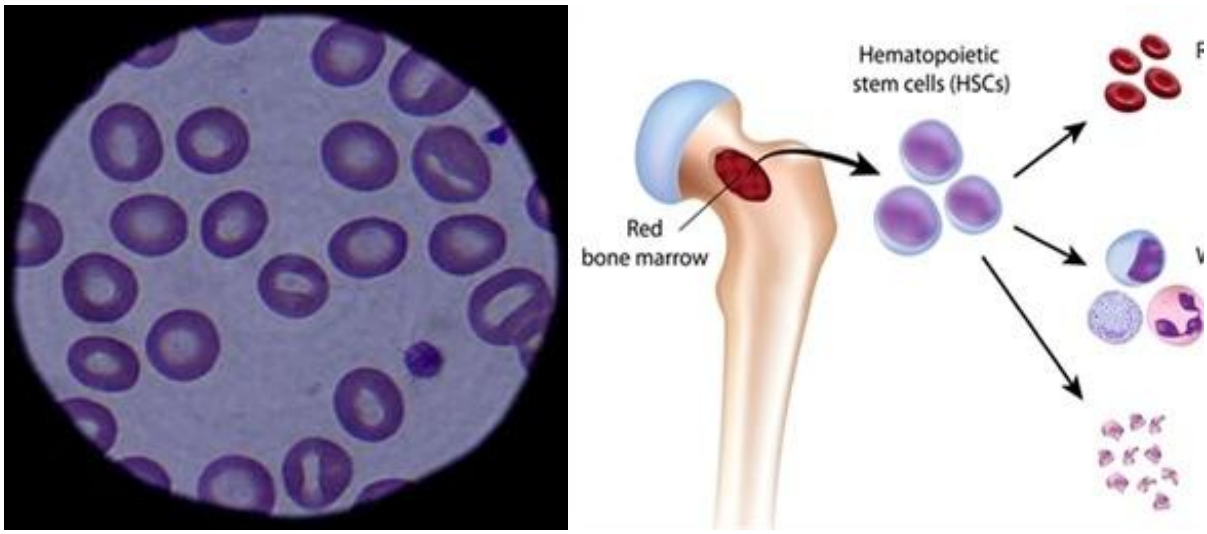
Figure–4: Blood cells.

- **Leukopenia.** The opposite condition, leukopenia, is an abnormally low WBC count.
- **Granulocytes.** Granulocytes are granule–containing WBCs; they have lobed nuclei, which typically consist of several rounded nuclear areas connected by thin strands of nuclear material, and includes **neutrophils**, **eosinophils**, and **basophils**.
- **Neutrophils.** Neutrophil are the most numerous of the WBCs; they have a multilobed granules and very fine granules that respond to acidic and basic stains; neutrophils are avid phagocytes at sites of acute infection, and are particularly partial to bacteria and fungi.
- **Eosinophils.** Eosinophils have blue red nucleus that resembles an old–fashioned telephone receiver and sport coarse, lysosome–like, brick–red cytoplasmic granules; their number increases rapidly during allergies and infections by parasitic worms or entering via the skin.
- **Basophils.** Basophils, the rarest of the WBCs, contain large, histamine–containing granules that stain dark blue; histamine is an inflammatory chemical that makes blood vessels leaky and attracts other WBCs to the inflammatory site.[4]
- **Agranulocytes.** The second group of WBCs, the agranulocytes, lack visible cytoplasmic granules; their nuclei are closer to the norm– that is, they are spherical; they are spherical, oval, or kidney–shaped; and they include **lymphocytes** and **monocytes**.
- **Lymphocytes.** Lymphocytes have a large, dark purple nucleus that occupies most of the cell

volume; they tend to take up residence in lymphatic tissues, where they play an important role in the immune response.
- **Monocytes.** Monocytes are the largest of the WBCs; when they migrate into the tissues, they transform into macrophages with huge appetites; macrophages are very important in fighting chronic infections.

Thrombocytes (Platelets): Platelets are not cells in the strict sense; they are fragments of bizarre multinucleate cells called **megakaryocytes**, which pinch off thousands of anucleate platelet "pieces" that quickly seal themselves off from surrounding fluids; platelets are needed for the clotting process that occurs in plasma when blood vessels are ruptured or broken.
- **Hematopoiesis:** Blood cell formation, or hematopoiesis, occurs in red bone marrow, or myeloid tissue. **Hemocystoblast.** All the formed elements arise from a common type of stem cell, the hematocystoblast.
- **Descendants of hemocystoblasts.** The hemocystoblast forms two types of descendants– the **lymphoid stem cell**, which produces lymphocytes, and the **myeloid stem cell**, which can produce all other classes of formed elements.

Formation of Red Blood Cells (RBC)
Because they are anucleate, RBCs are unable to synthesize proteins, grow, or divide.
- **Life span.** As they age, RBCs become more rigid and begin to fragment, or fall apart, in **100 to 120 days**.
- **Lost RBCs.** Lost cells are replaced more or less continuously by the division of hemocystoblasts in the red bone marrow.
- **Immature RBCs.** Developing RBCs divide many times and then begin synthesizing huge amounts of hemoglobin.
- **Reticulocyte.** Suddenly, when enough hemoglobin has been accumulated, the nucleus and most organelles are ejected and the cell collapses inward; the result is the young RBC, called a reticulocyte because it still contains some rough endoplasmic reticulum (ER).
- **Mature erythrocytes.** Within 2 days of release, they have rejected the remaining ER and have become fully functioning erythrocytes; the entire developmental process from hemocystoblast to mature RBC takes **3 to 5 days**.
- **Erythropoietin.** The rate of erythrocyte production is controlled by a hormone called erythropoetin; normally a small amount of erythropoeitin circulates in the blood at all times, and red blood cells are formed at a fairly constant rate.
- **Control of RBC production.** An important point to remember is that it is not the relative number of RBCS in the blood that controls RBC production; control is based on their ability to transport enough oxygen to meet the body's demands.[5]



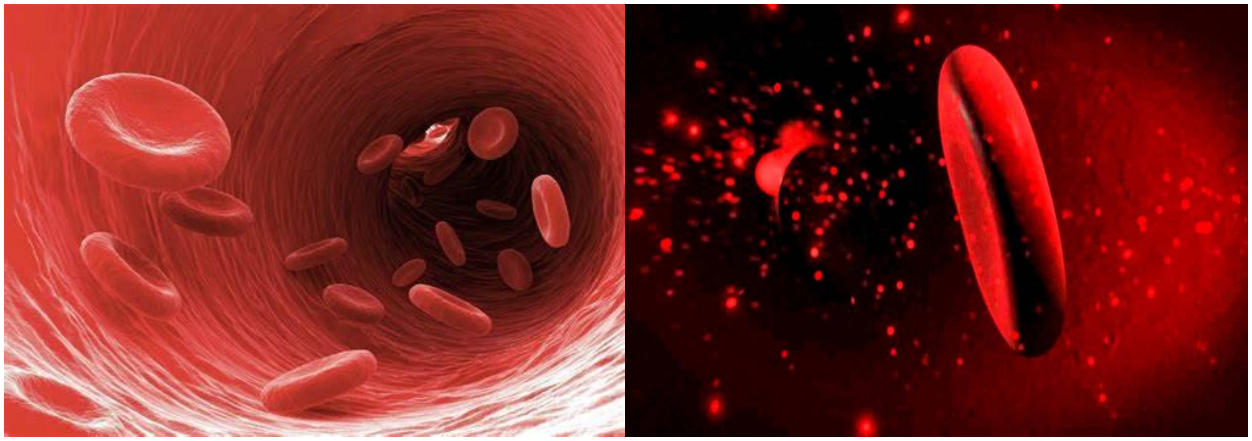
Figure–5: Origin of blood.

Formation of White Blood Cells (WBC): Like erythrocyte production, the formation of leukocytes and platelets is stimulated by hormones.
- **Colony stimulating factors and interleukins.** These colony stimulating factors and interleukins not only prompt red bone marrow to turn out leukocytes, but also marshal up an army of WBCs to ward off attacks by enhancing the ability of mature leukocytes to protect the body.
- **Thrombopoeitin.** The hormone thrombopoeitin accelerates the production of platelets, but little is known about how that process is regulated.

Homeostasis: The multistep process of hemostasis begins when a blood vessel is damaged and connective tissue in the vessel wall is exposed to blood.
- Vascular spasms occur. The immediate response to blood vessel injury is vasoconstriction, which causes

that blood vessel to go into spasms; the spasms narrow the blood vessel, decreasing blood loss until clotting can occur.

- Platelet plug forms. Injury to the lining of vessels exposes collage fibers; platelets adhere to the damaged site and platelet plug forms.
- **Coagulation events occur.** At the same time, the injured tissues are releasing **tissue factor (TF)**, a substance that plays an important role in clotting; **PF3**, a phospholipid that coats the surfaces of the platelets, interacts with TF, vitamin K, and other blood clotting factors; this **prothrombin activator** converts **prothrombin**, present in the plasma, to **thrombin**, an enzyme; thrombin then joins soluble **fibrinogen** proteins into long, hairlike molecules of insoluble **fibrin**, which forms the meshwork that traps RBCs and forms the basis of the clot; within the hour, the clot begins to retract, squeezing **serum** from the mass and pulling the ruptured edges of the blood vessel closer together.



Figure–6: Fluid dynamics of vasculature.

Circulation of the Blood in Body: When a heart contracts and forces blood into the blood vessels, there is a certain path that the blood follows through **the human body**. The blood moves through **pulmonary circulation** and then continues on through systemic circulation. Pulmonary and systemic are the two circuits in the two–circuit system of higher animals with closed circulatory systems.[6]

The circulatory system consists of three independent systems that work together: the heart (cardiovascular), lungs (pulmonary), and arteries, veins, coronary and portal vessels (systemic). The system is responsible for the flow of blood, nutrients, oxygen and other gases, and as well as hormones to and from cells.

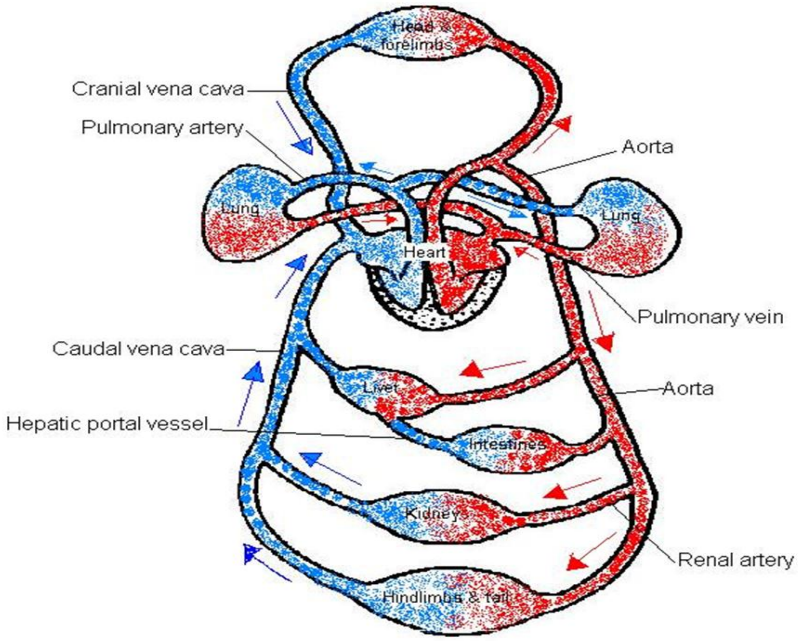
An average adult has 5 to 6 quarts (4.7 to 5.6 liters) of blood, which is made up of plasma, red blood cells, white blood cells and platelets. The heart is a muscular organ with four chambers. Located just behind and slightly left of the breastbone, it pumps blood through the network of arteries and veins called the cardiovascular system.

The systemic circulation is a major portion of the circulatory system. The network of veins, arteries and blood vessels transports oxygenated blood from the heart, delivers oxygen and nutrients to the body's cells and then returns deoxygenated blood back to the heart. The system of blood vessels in the human body measure about 60,000 miles (96,560 kilometers). Arteries carry oxygen–rich blood from the heart through the body. Veins carry oxygen–poor blood back to the heart. The superior vena cava carries oxygen–poor blood into the heart. The aorta carries oxygenated blood from the heart to organs and tissues.

Pulmonary circulation: Blood that is lacking oxygen is said to be *deoxygenated*. This blood has just exchanged oxygen for carbon dioxide across cell membranes, and now contains mostly carbon dioxide. Deoxygenated blood enters the *right atrium* through the superior vena cava and the inferior vena cava. As the right ventricle contracts, it forces the deoxygenated blood through the *pulmonary semilunar valve* and into the *pulmonary artery*. S*emilunar* means half–moon and refers to the shape of the valve. Note that this is the only artery in the body that contains deoxygenated blood; all other arteries contain oxygenated blood. The semilunar valve keeps blood from flowing back into the right ventricle once it is in the pulmonary artery. The pulmonary artery carries the blood that is very low in oxygen to the *lungs*, where it becomes oxygenated.[7]

Pulmonary Hemodynamic: The pulmonary circulation system is the only system through which the entire cardiac output passes. The major role of pulmonary circulation is respiratory gas exchange. Therefore, to facilitate this role, pulmonary circulation is a low–pressure, high–flow system. Pulmonary circulation can accommodate any changes in blood flow due to relative passivity and the ability to recruit unperfused vessels. Several factors such as gravity, lung inflation, alveolar surface tension, and blood viscosity

can influence pulmonary circulation under both physiological and pathological conditions. For instance, in an upright position, gravity increases both blood flow and ventilation in caudal regions, with a greater change in blood flow than ventilation. As a result, there is a gradual decrease in ventilation–to–perfusion ratios from the apex to the base of the lung in an upright position. The inflation of the lung can compress and distort vessels and alter blood flow through pulmonary circulation. The alveolar surface tension attenuates lung capillary resistance and promotes capillary blood flow. In contrast, an increase in blood viscosity or hematocrit decreases pulmonary flow.



Figure–7: Circulatory system.

Pulmonary Circulation and Regulation of Fluid Balance: The pulmonary circulation begins at the pulmonary valve, marking the vascular exit from the right side of the heart, and extends to the orifices of the pulmonary veins in the wall of the left atrium, which marks the entrance into the left side of the heart. The pulmonary circulation includes the pulmonary trunk (also called the "right ventricular outflow tract"), the right and left main pulmonary arteries and their lobar branches, intrapulmonary arteries, large elastic arteries, small muscular arteries, arterioles, capillaries, venules, and large pulmonary veins. Because of this heterogeneity and differences in physiologic behavior, the vessels of the pulmonary circulation are subdivided on a functional basis into *extra–alveolar vessels* and *alveolar vessels*. In addition, the small vessels that participate in liquid and solute exchange are often collectively termed the "pulmonary microcirculation." The anatomic boundaries of the extra–alveolar and alveolar vessels and the microcirculation are undefined and likely depend on conditions such as lung volume and levels of intrapleural and interstitial pressures.[8]

Systemic circulation: Freshly *oxygenated blood* returns to the heart via the *pulmonary veins*. Note that these are the only veins in the body that contain oxygenated blood; all other veins contain deoxygenated blood. The pulmonary veins enter the *left atrium*. When the left atrium relaxes, the oxygenated blood drains into the *left ventricle* through the left AV valve. This valve is also called the *bicuspid valve* because it has only two flaps in its structure. Now the heart really squeezes. As the left ventricle contracts, the oxygenated blood is pumped into the main artery of the body — the *aorta*. To get to the aorta, blood passes through the *aortic semilunar valve*, which serves to keep blood flowing from the aorta back into the left ventricle. The aorta branches into other arteries, which then branch into smaller arterioles. The arterioles meet up with capillaries, which are the blood vessels where oxygen is exchanged for carbon dioxide.

Capillary Exchange: Capillaries bridge the smallest of the arteries and the smallest of the veins. Near the arterial end, the capillaries allow materials essential for maintaining the health of cells to diffuse out (water, glucose, oxygen, and amino acids). To maintain the health of cells, it is also necessary for the capillaries to transport wastes and carbon dioxide to places in the body that can dispose of them. The waste products enter near the venous end of the capillary. Water diffuses in and out of capillaries to maintain blood volume, which adjusts to achieve homeostasis. Capillaries are only as thick as one cell, so the contents within the cells of the capillaries can easily pass out of the capillary by diffusing through the capillary membrane. And, because the capillary membrane abuts the membrane of other cells all over the

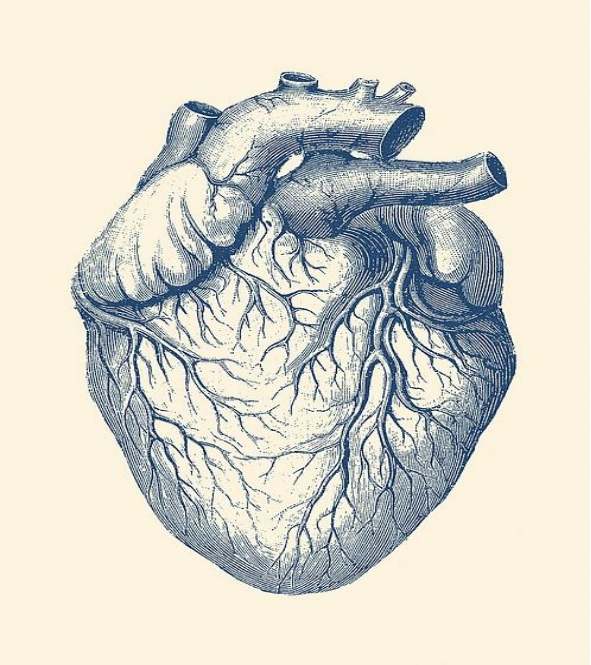
body, the capillary's contents can easily continue through the abutting cell's membrane and get inside the adjoining cell. The process of capillary exchange is how oxygen leaves red blood cells in the bloodstream and gets into all the other cells of the body. Capillary exchange also allows nutrients to diffuse out of the bloodstream and into other cells. At the same time, the other cells expel waste products that then enter the capillaries, and carbon dioxide diffuses out of the body's cells and into the capillaries. After the capillaries "pick up" the garbage from other cells, the capillaries carry the wastes and carbon dioxide through the deoxygenated blood to the smallest of the veins, which are called *venules*. The venules branch into bigger vessels called *veins*. The veins then carry the deoxygenated blood toward the main vein, which is the *vena cava*. The two branches of the vena cava enter the right atrium, which is where pulmonary circulation begins.

Circulatory Systems Parts: The circulatory system consists of the heart, blood, blood vessels, lymph, and lymphatic vessels. While the **heart is the only "organ"** of the circulatory system, it is really only a vessel surrounded by muscles. The circulatory system does not have standard organs. In humans, the heart is a four–chambered organ, containing two atria and two ventricles. **The atria are the receiving chambers and receive blood from veins. On the other hand, ventricles are designed to be efficient pumps, sending blood into arteries.** Oxygenated blood from the lungs arrives through the pulmonary vein to the left atrium. It passes into the left ventricle through the mitral valve during atrial systole or contraction. During ventricular systole, this blood is pumped into the aorta to be circulated in the body through arteries, arterioles, and capillaries. Exchange of materials occurs through the single–celled endothelial walls of capillaries. Deoxygenated blood from various tissues then returns to the right atrium of the heart through two major veins – the superior and inferior vena cava. Once deoxygenated blood reaches the right ventricle through the tricuspid valve, it is pumped to the lungs during ventricular systole through the pulmonary artery. In the lungs, gas exchange at alveoli. The image above shows the four chambers of the heart along with major blood vessels and valves. **The circulatory system in humans can, therefore, be divided into two loops that center around the heart.** The first is called pulmonary circulation and it carries blood between the heart and the lungs. The other extensive loop is called systemic circulation and begins from the aorta and supplies oxygen and nutrients to all the tissues of the body, including the muscles of the heart itself.

Is Heart is Mechanical Pump? The heart is a sophisticated mechanical pump made of strong muscle. Thus, to understand how the heart works, it is helpful to know a little about pumps.

A pump is a mechanical device that moves fluid or gas by pressure or suction. Consider, for example, a simple bicycle pump. When you pull the handle up, you create a vacuum inside the metal tube, which fills with air through a hole in the side. When you push the handle down, a one–way valve in the hole closes and air moves through the rubber tube, into the bike tire. What keeps the air from coming out of the tire and back into the pump? Another one–way valve at the end of the rubber tube prevents the air from moving backward.

A lotion dispenser illustrates the same principle. A plastic tube goes down from the top of the dispenser into the lotion. When you push down on the dispenser, the lotion already in the top of the tube (above the pump) squirts out into your hand. It does not flow back down into the pump mechanism because a one–way valve closes behind it when you push down. When you let go of the dispenser, a spring–driven pump pushes the top back up, sucking more lotion up into the top of the tube and pulling more lotion from the bottle to fill the tube below the pump.



Note that both a pumping mechanism and a one–way valve are required to make a pump work. The lotion bottle has two chambers (in the tube below the pump and in the dispenser above the pump). The lower chamber of the dispenser holds a portion of lotion, ready to move up into the pump.

Like the lotion pump, some animals, such as fish, have a two–chambered heart. The first chamber (atrium) fills with blood returning from the body and then passes it to the second, more muscular chamber (ventricle). The ventricle contracts, pushing the blood out into the vessels that carry it through the gills for oxygenation and on to the body. A one–way valve prevents the blood from

flowing backward into the atrium. Other animals, such as reptiles and amphibians, have three–chambered hearts.

Birds and mammals, including humans, have four–chambered hearts. Two chambers receive blood and the other two pump it out. The receiving chambers are known as atria (the singular form is atrium). The right atrium receives oxygen–depleted blood from the body's major veins (vessels that bring blood to the heart), and the left atrium receives oxygen–rich blood from the lungs. The atria transfer their blood, through one–way valves, into the two different pumping chambers, called ventricles. The right ventricle pumps oxygen–depleted blood via smaller blood vessels through the lungs, where it is replenished with oxygen, and cleansed of carbon dioxide. The left ventricle squeezes (contracts) to pump oxygenated blood out into the rest of the body through large arteries (vessels that carry blood away from the heart).

So ultimately, animals with four– chambered hearts have two circulation loops. The first loop travels to and from the lungs (pulmonary circulation). Blood filled with carbon dioxide enters the lungs, where carbon dioxide is replaced with oxygen, and then carried from the lungs back to the heart for pumping to the rest of the body. The second loop carries blood to all parts of the body, delivering oxygen and nutrients and gathering wastes for proper disposal (systemic circulation). This very efficient system keeps blood moving in the right direction, and to the right parts of the body, 24 hours a day.[9]

Why doesn't the blood get pushed back into the atria when the ventricles contract? Valves! Remember the one–way valves in the mechanical pumps? Similar one–way valves between each chamber in our hearts ensure that blood moves in only one direction. The heart also has valves at the exits to the ventricles, so blood can't get sucked back in. Thanks to valves, the blood in our bodies always moves forward, never backward.

Blood Vessels: There are two major types of blood vessels – those that bring blood towards the heart are called veins and those that carry blood from the heart towards other tissues and organs are called arteries. Arteries and veins undergo repeated branching to produce arterioles and venules. The thinnest blood vessels are capillaries, made of a single layer of squamous epithelial cells. These thin tubular structures are the primary site for the exchange of materials between the circulatory system and tissues. The image above shows the network of blood vessels through the body, with the arteries represented in red and the veins in blue. This is the case with real blood, as arterial blood is usually bright red in color because of the large amount of oxygen it carries, while venous blood is darker and more blue/purple. The blood drawn for routine tests is often from the veins. Arteries of the systemic circulation contain oxygenated blood, while the veins bring deoxygenated blood containing high amounts of carbon dioxide towards the heart. The reverse is true for pulmonary circulation since the blood receives oxygen in the lungs, then makes its way back to the heart to be pumped out to the body.

Is Blood is flow like mechanical flow

FLUID CONVEYANCE: Fluids comprise liquids, gases, steam, fuels, blood, since they can flow in tubular devices such as arteries and pipes. They are characterized by their physical properties, such as density, velocity, viscosity, temperature, pressure as functions of space and time. Fluids flow when a force is applied and, then, they take the shape of their container. Fluid motion, such as blood flow, is governed by the basic laws of fluid dynamics, thermodynamics and conservation of mass and energy. The flow regimen may change from laminar, smooth flow to turbulent, irregular flow, affecting its behavior and its interaction with the internal walls of the tubes and pipes. Fluid mechanics deals with fluids at rest and at motion and the forces acting on them, from a macroscopic point of view. The following paragraph covers the basic concepts of transport phenomena 7, 8 in water pipelines and blood vessels, both being cylindrical tubes. The Reynolds transport theorem represents an useful tool to study flow behavior in water. pipelines and in blood arteries and veins. It states that for a conserved quantity of B in a control volume of the fluid, its rate of change in the system (B_{sys}) must be equal to the total of the rate change of B in the control volume (BCV) plus the flux of B through the control surface (Q_B).

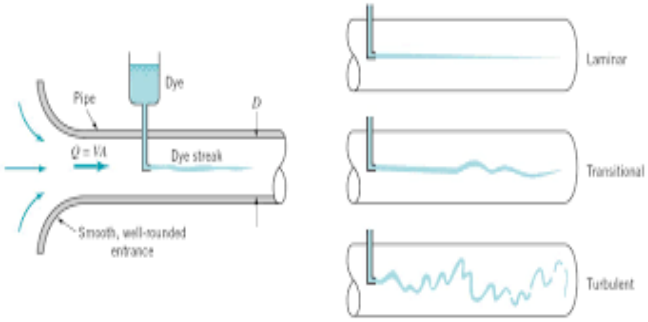
$B_{sys} = B_{CV} + Q_B$ ……………………………… (1)

The flux through the control surface (the boundary of the control volume) is found in general by considering an infinitesimal area of the surface and finding the amount of B that flows through it. To find the mass flux into a parent artery it is necessary to consider that every unit of time, a length μ_0 of blood flows into the artery. Therefore, every unit of time, a volume $A_0\ \mu_0$ of blood flows into the artery (this is the volume flux Q_0 with dimensions volume per unit time). Also, every unit of

time, a mass ρ $A_0\mu_0$ of blood (with density ρ) flows into the artery. This is the mass flux m0 through the parent artery (dimensions mass divided by time). Similarly the mass flux out of each of the daughter arteries is m1 = $\rho A_1\mu_1$. We can define β as the amount of B per unit mass, and the amount of B per unit volume is ρβ. To find the infinitesimal volume, consider a small rectangle of area dA on the surface. During a short time dt, a parallelepiped of fluid flows through the surface. Its volume is the area of the base (dA), multiplied by its perpendicular height. The dynamic viscosity component for the edge of the parallelepiped (vector u) thus leads to the expression for the volume of the parallelepiped as (u●n)dAdt, where n is the unit normal vector to the surface. Hence the amount of B crossing the infinitesimal surface in the infinitesimal time is ρβ (u●n) dA dt and the rate of crossing is ρβ(u●n)dA.

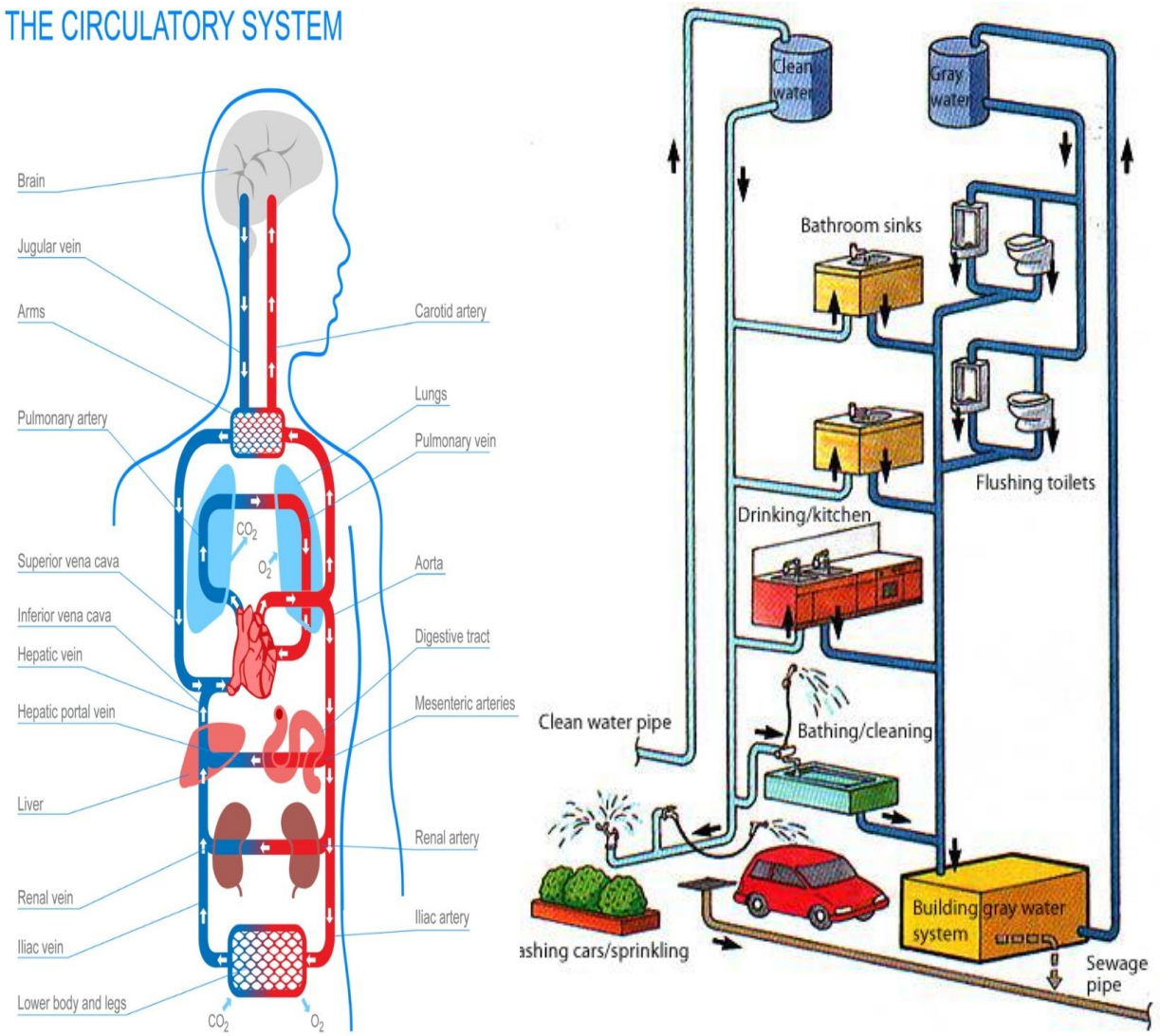
Thus QB = ∫ ρβ (u●n) dA…….. (2)

control surface Until now, we assumed uniform flow neglecting the effects of the viscosity of the fluid, which is a kind of internal friction in the fluid. It also enforces a no–slip boundary condition on rigid surface, meaning that the velocity of the fluid at the wall equals the velocity of the wall. For the pipe, this constrains the flow to be zero at the walls. Hence the velocity is slow around the edges and rises to a maximum in the centre of the pipe and the flow has a profile as shown in Figure 7.

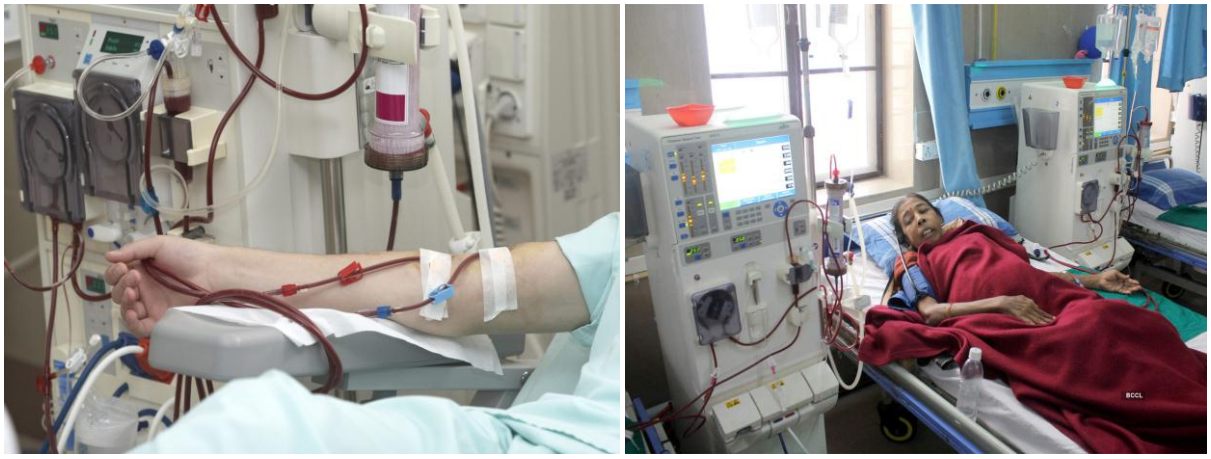


Figure–8: Fluid flow.

Comparison Talk: On the other hand, the mechanical procedures necessary to clean and repair WP and BV are – in principle – similar, since both WP and BV are hollow cylinders that should be maintained open and without leaking holes or cracks to ensure their operation and function. Furthermore, both of them age with the passing of time and both should be rehabilitated or replaced with new material. The cardiovascular circulatory system of the human body can be compared with a network of tubes. It consists of a pump and a system of branched vessels. The arteries transport the blood to the periphery in a manner similar to that of a water supply network. It is important to know what kind of forces act upon "fittings", bends and bifurcations. It is also essential to assess whether the flow is laminar or turbulent, attached or separated. The flow should be optimized in such a manner as to minimize the drop in pressure. This means that no additional pressure loss due to separation or turbulence should occur, since such losses increase the pump power requirements. The loss appears in heating and acoustic energy. The necessary understanding of blood flow in human vessels is also of great interest to physicians since it is believed that the local flow behavior of blood determines the formation of atherosclerotic plaques. As in tubing systems, deposits in blood vessels are found close to bends and bifurcations. These deposits lead to impaired cerebral circulation and to myocardial infarction. A partial review of recent research into the details of flow behavior (like separation, stagnation and reattachment points) in bends and bifurcations of arterial models is presented. Studies involving steady and pulsatile flow conditions in rigid and elastic models with Newtonian and non–Newtonian fluids are shown here. The most important differences between blood vessels and tubes are discussed. This modern biofluidmechanical approach of detailed flow examination is compared with the more classical hemodynamic approach considering only gross features such as pressure loss coefficients.[10]



Figure–9: Engineering biofluid mechanics.



Figure–10: Dialysis.

In medicine, dialysis (from Greek διάλυσις, dialysis, "dissolution"; from διά, dia, "through", and λύσις, lysis, "loosening or splitting") is the process of removing excess water, solutes, and toxins from the blood in people whose kidneys can no longer perform these functions naturally. This is referred to as renal replacement therapy. The first successful dialysis was performed in 1943. Dialysis may need to be initiated when there is a sudden rapid loss of kidney function, known as acute kidney injury (previously called acute renal failure), or when a gradual decline in kidney function –chronic kidney disease reaches stage 5. Stage 5

chronic renal failure is reached when the glomerular filtration rate is 10–15% of normal, creatinine clearance is less than 10mL per minute and uremia is present. Dialysis is used as a temporary measure in either acute kidney injury or in those awaiting kidney transplant and as a permanent measure in those for whom a transplant is not indicated or not possible. In Australia, Canada, the United Kingdom, and the United States, dialysis is paid for by the government for those who are eligible. In research laboratories, dialysis technique can also be used to separate molecules based on their size. Additionally, it can be used to balance buffer between a sample and the solution "dialysis bath" or "dialysate" that the sample is in. For dialysis in a laboratory, a tubular semipermeable membrane made of cellulose acetate or nitrocellulose is used. Pore size is varied according to the size separation required with larger pore sizes allowing larger molecules to pass through the membrane. Solvents, ions and buffer can diffuse easily across the semipermeable membrane, but larger molecules are unable to pass through the pores. This can be used to purify proteins of interest from a complex mixture by removing smaller proteins and molecules.

CONCLUSION

In conversation with science and technology students, they expressed their interest and feeling that the subject of this paper arouses their curiosity, as well as expanding their understanding and knowledge into two different fields: metallurgy of metals and biology of the human body. During teaching and discussing the contents of this paper with students, we emphasized that the similarities and disparities between pipelines and blood vessels are related to their basic features: material, structure, dimension, function, maintenance, deterioration and preventive and curative procedures. Comparative studies have been carried out about various aspects of educational systems to promote the understanding of the differences between the two systems considered and their contribution to the student's academic achievement. Human body and engineering both are a combo pack of science [physics, chemistry, biology]. Both run by the application of basic science in the form of technology in body system which runs through supernatural powerhouse of flowchart which controls the entire body system that follows the engineered architecture of technology. Salutes to the entire creativity by Almighty in such a scrutinized way that entire human body macro parts & micro parts follow the engineering pathways so meticulously that is beyond the thinking of natural thoughts. All the engineering subtopics are minutely and silently following the embedded applications in all body system. Entire body system follows physics [entropy, enthalpy, partition coefficient, surface tension, viscosity, electrical property, colloids, thermodynamics, thermochemistry, magnetism, atomic physics, optics, acoustics, magnetism, quantum mechanics etc], chemistry [biochemistry, macromolecules, action potential, potentiometry, stereochemistry, Van der Waal bonding, hydrogen bonding, etc], biology [biostatistics, biophysics, biomedical engineering, biotechnology, bioreceptors, bioengineering, genetics, etc] which is a marvellous implementation of outlook of nature to engineering approach.

Human body is the reflection of engineering: Whole body=Structural engineering, **Blood/Lymph=Fluid engineering**, Brain=Electronics engineering, Action potential=Electrical engineering, Muscle=Mechanical engineering, Micronutrients=Chemical engineering, Skeleton=Civil engineering, Glands (bile, blood, lymph, sweat, sperm, ovum, tears, wax, sputum, milk etc)=Production engineering, Eye=Optical engineering, Ear–Nose–Throat=Bioengineering, Biochemistry = Metallurgical engineering, Energy=Power engineering, Hormones = Computer engineering, Biostatistics = Automobile engineering, Dream=Aeronautical engineering.

Acknowledgement

Foundation of body homeostasis salutes coronation of engineering is the cream of fundamental basement of correlation approach of living body homeostasis compiled with engineering approach. REFLECTION OF FLUID MECHANICS ON BIO–MEDICAL ENGINEERING is the megaproject fruitful outcome of the enormous effort by team members: Arunava Chandra Chandra, Dr. Dhananjoy Saha, Dr. Sampa Dhabal & Dr. Dhrubo Jyoti Sen who are being inspired to complete the grand project successfully.

Arunava Chandra Chandra

Dr. Dhananjoy Saha

Dr. Sampa Dhabal

Dr. Dhrubo Jyoti Sen

Team members are: Fourth Year BPharm student: Arunava Chandra Chandra, Dr. Dhananjoy Saha [Deputy Director of Technical Education, Directorate of Technical Education, Bikash Bhavan, Salt Lake City, Kolkata–700091, West Bengal, India], Dr. Sampa Dhabal [Forensic Scientist, Kolkata, West Bengal, India] & Prof. Dr. Dhrubo Jyoti Sen [Department of Pharmaceutical Chemistry, School of Pharmacy, Techno India University, Kolkata]. Team leadership have given the excellent finishing touch to this gala project. Megaproject team salutes to God for giving the mastermind idea to compile the entire theme into a fruitful outcome.

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