CIRCULATORY SYSTEM

Lecture- 17

Human Circulatory System

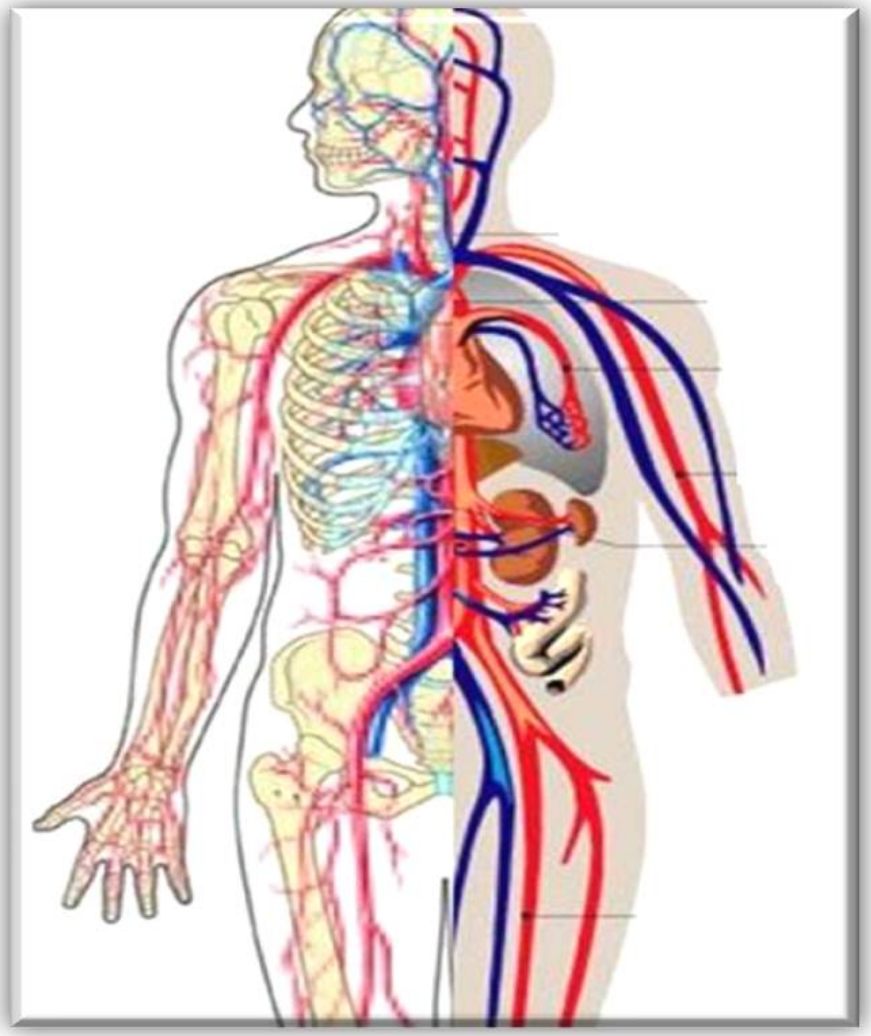
Lecture Outline:

- **Circulatory System**
- **Parts of the Circulatory System**
- **The Pathway of Blood Circulation**
  - **Systemic Circuit**
  - **Pulmonary Circuit**
- **Disorders**

Circulatory System

- ***Circulatory system*** *in humans, is the combined function of the*
  - ***heart,***
  - ***blood and***
  - ***blood vessels*** *(arteries, veins and capillaries)*

  to transport oxygen and nutrients to organs and tissues throughout the body and carry away waste products.



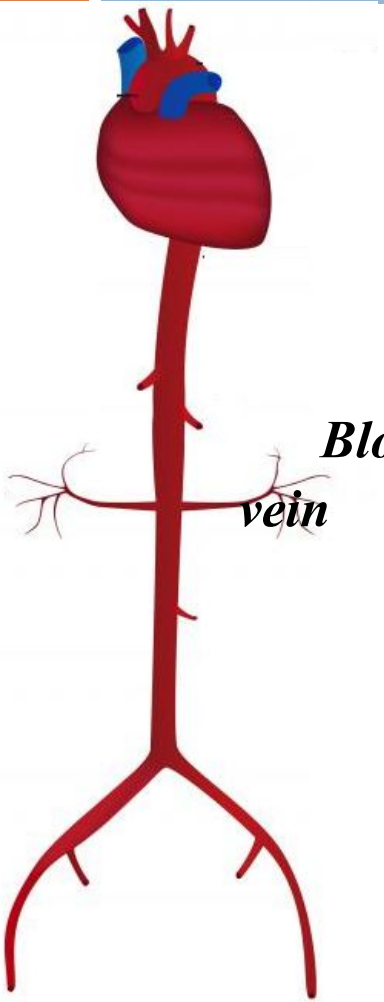
Circulatory System- Vital Functions

1. Increases the flow of blood to meet increased energy demands during exercise and regulates body temperature.
2. When foreign substances or organisms invade the body, the circulatory system swiftly conveys disease-fighting elements of the immune system, such as white blood cells and antibodies, to regions under attack.
3. In the case of injury or bleeding, the circulatory system sends clotting cells and proteins to the affected site, which quickly stop bleeding and promote healing.

Circulatory System- Basic Structures

1. A fluid tissue (the blood and lymph).
2. A network of tubing (the veins and arteries) to carry the blood.
3. Specialized tubing (the capillaries) to allow diffusion of molecules to and from blood.
4. A pump (the heart) to keep the blood moving through the arteries, veins, and capillaries.

Part of the Circulatory System



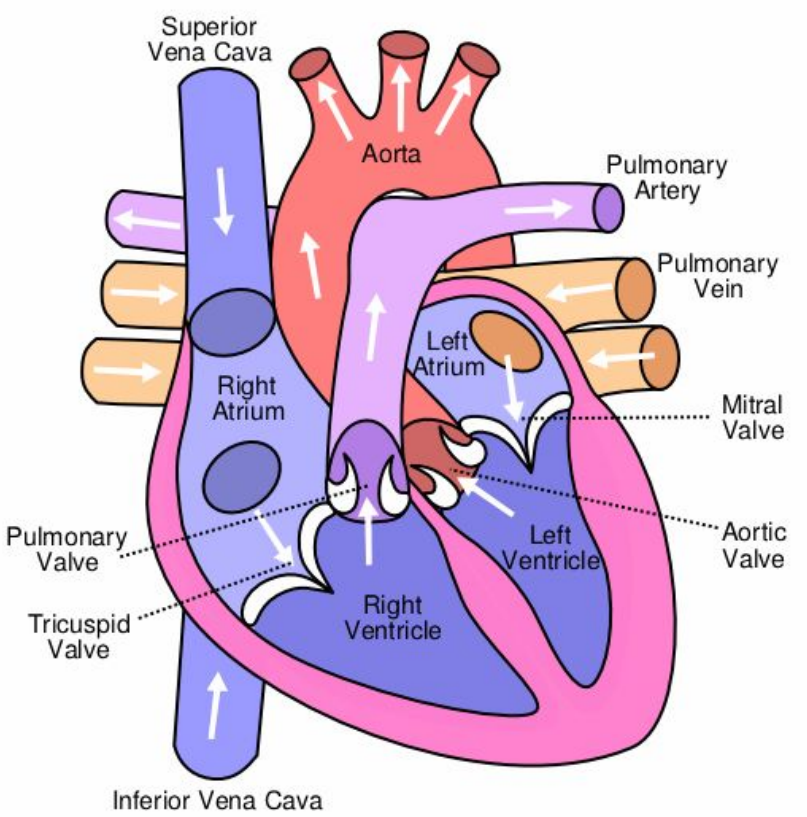
Blood cell → *Heart* → *P. Artery* *Capillary network* *p.*

vein

Anatomy- Heart

- The heart provides the pressure needed to keep the blood flowing through the network of tubing.
- The heart is the engine of the circulatory system.
- It is divided into four chambers:

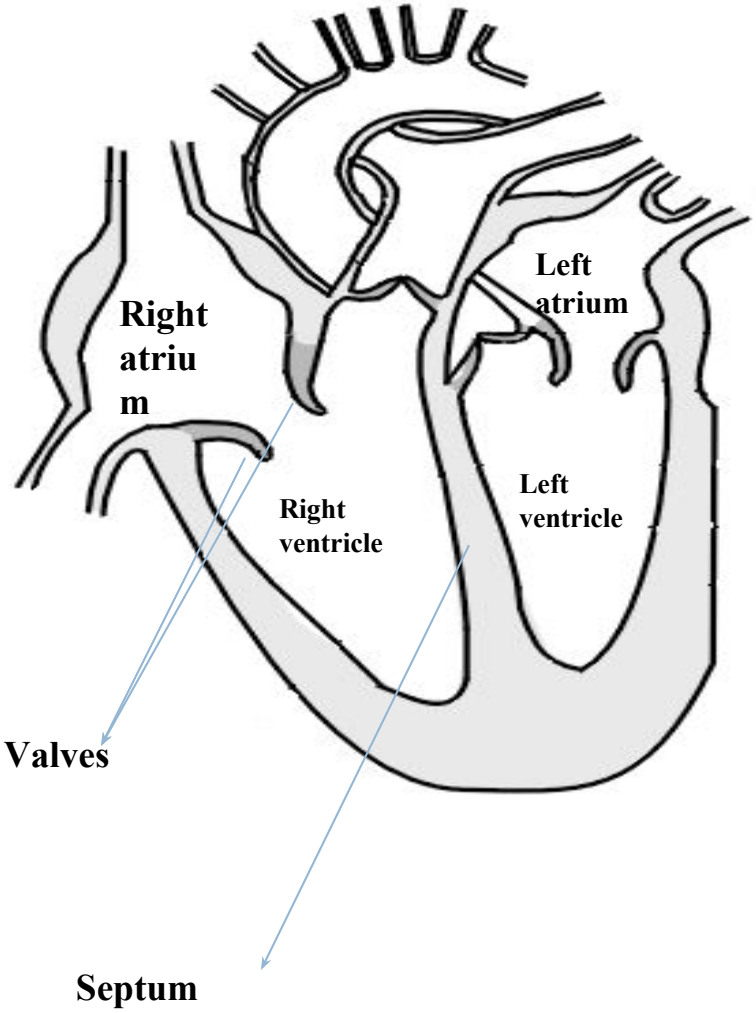
(1) the **right atrium**,
(2) the **right ventricle**,
(3) the **left atrium**, and
(4) the **left ventricle**.



Anatomy- Heart

Structure:

- The two atria collect the blood.
- The two ventricles pump the blood out of the heart.
- Valves prevent the blood from flowing backwards.
- The septum separates the two sides of the heart.
- The right side of the heart pumps de-oxygenated blood to the lungs to pick up oxygen.
- The left side of the heart pumps the oxygenated blood from the lungs around the rest of the body.

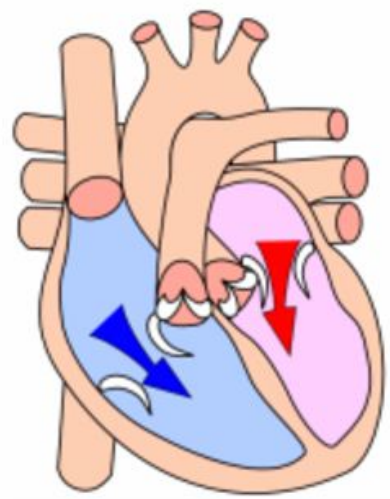
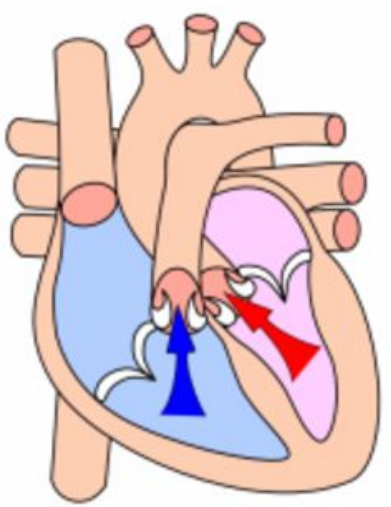


Anatomy- Heart

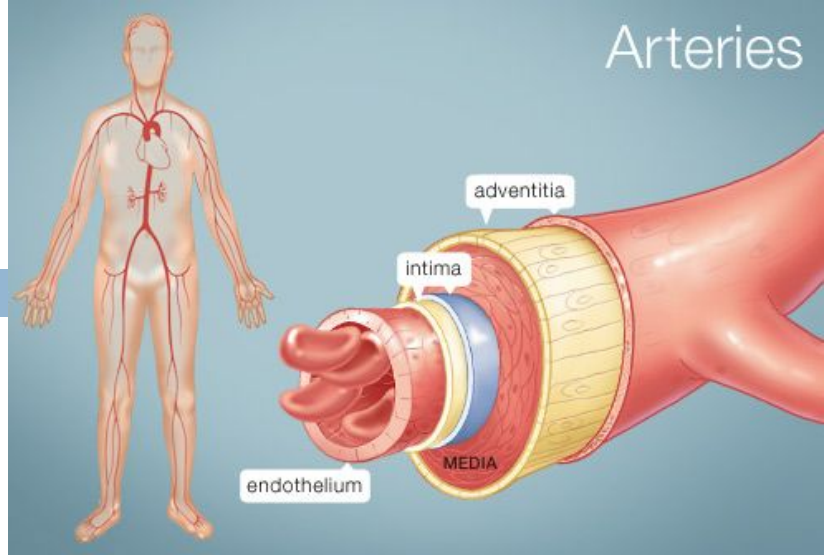
- The walls of these chambers are made of a special muscle called ***MYOCARDIUM***, which contracts continuously and rhythmically to pump blood.
- The pumping action of the heart occurs in two stages for each heartbeat:

  (1) **DIASTOLE**, when the heart is at rest; and

  (2) **SYSTOLE**, when the heart contracts to pump deoxygenated blood toward the lungs and oxygenated blood to the body.
- During each heartbeat, typically about 60 to 90 ml of blood are pumped out of the heart. If the heart stops pumping, death usually occurs within four to five minutes.

		
Normal range:	**Diastole** **60 – 80 mmHg (adults);**	**Systole** **90 – 120 mmHg (adults);)**

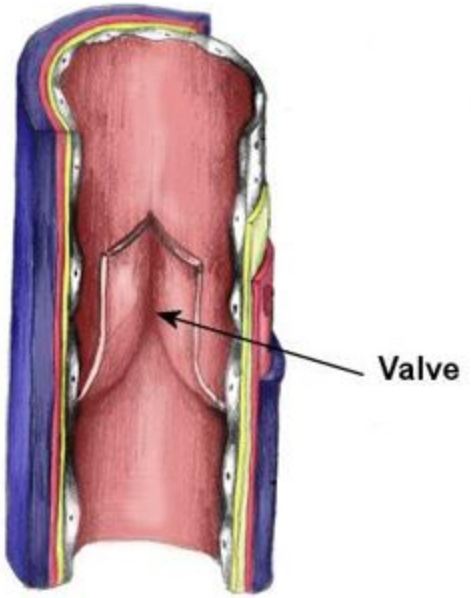
Blood Vessels



Arteries

- ***Arteries*** are tubes that carry oxygenated blood away from the heart.
- Arteries carry blood under the highest pressure (around 16 kPa).
- The structure of an artery must be able to handle both high pressure and the changes in pressure that result from the rhythmic pumping of the heart.
- Therefore, arteries are thick-walled, wrapped with elastic muscle tissue. Small arteries are called ***arterioles***.

Blood Vessels



Veins

- ***Veins*** are tubes that return deoxygenated blood to the heart.
- Veins provide a return system for blood under lower pressure that the blood in the arteries.
- Therefore, the walls of veins do not need to be as thick or elastic as those of arteries.
- The pressure of the blood coming out of the venous end of some capillaries often is not high enough to push the blood all the way back to the heart
- For this reason, some veins in the legs and arms have one-way **valves** to ensure that the blood travels only toward the heart. Small veins are called ***venules***.

Difference between Artery and Vein

Artery	Vein
▪ Carry oxygenated blood (except pulmonary artery).	▪ Carry deoxygenated blood (except pulmonary vein)
▪ Carry blood away from the heart	▪ Carry blood to the heart
▪ Thick and elastic muscular wall.	▪ Thin and slightly muscular wall.
▪ Blood under high pressure.	▪ Blood under low pressure.
▪ Contain no valve	▪ Contain valve
▪ Blood moves in pulses.	▪ No pulses.
▪ Blood flows rapidly.	▪ Blood flows smoothly

Blood Circulation in Heart:

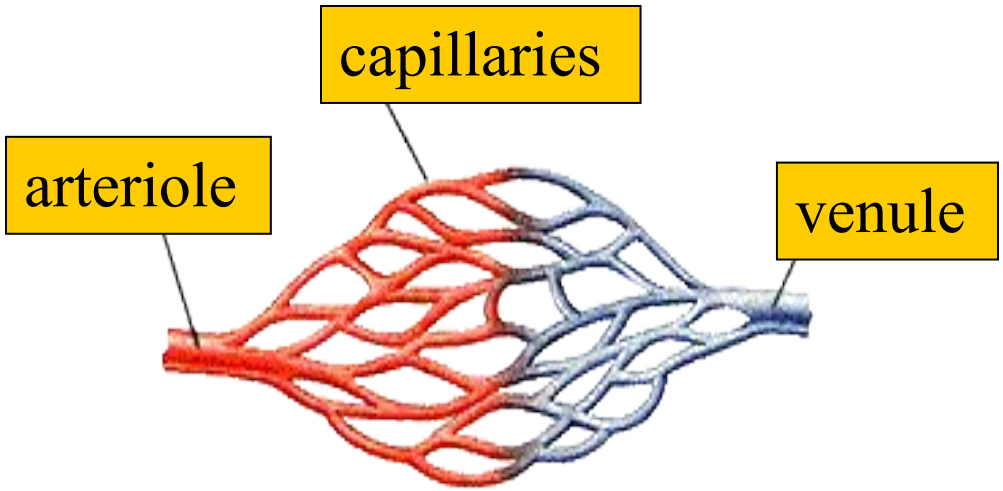
- Oxygenated blood from lungs to heart– Pulmonary vein left Atrium [diastole] Left Ventricle [systole] Aorta (to body)

- Deoxygenated blood from body to heart – Superior and Inferior Vena cava Right Atrium [diastole] Right Ventricle [systole] Pulmonary Artery (to lungs)

Blood Vessels

Capillaries

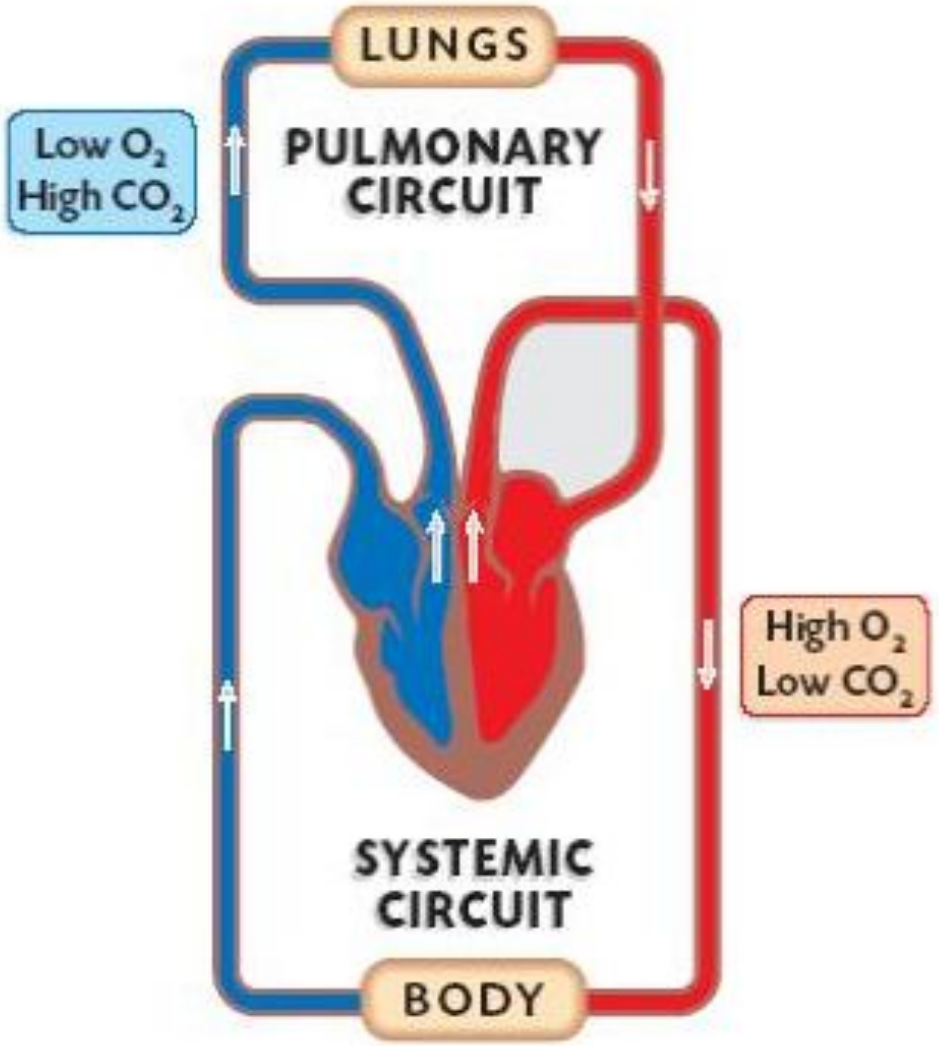
- ***Capillaries*** connect arteries and veins.
- They are a finely divided network of tiny tubes that exchange food, oxygen and wastes between blood and body cells.
- Capillaries leak nutrients from the bloodstream to all cells in the body.
- Cell wastes diffuse through the capillary back into the blood.

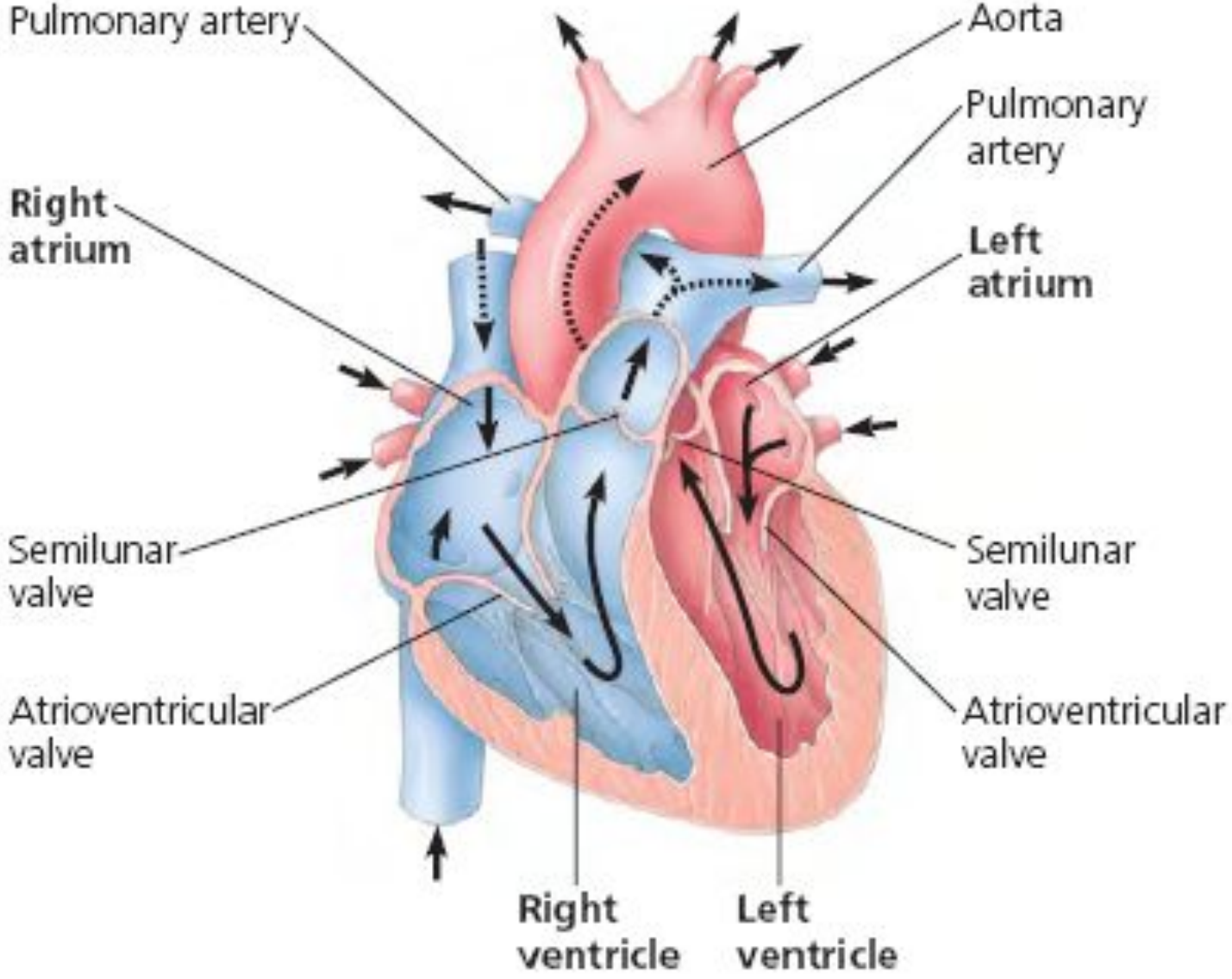


The Pathway of Blood Circulation

- Blood returning to the heart from the arms, head, abdomen, and legs has little oxygen left in it.
- As a result, the pathway that the blood follows should put more oxygen into the blood and then direct the re-oxygenated blood back out to the body tissues.
- **Systemic circulation** is the movement of blood between the heart and the rest of the body.
- **Pulmonary circulation** is the movement of blood between the heart and lungs.
- Each of these circuits requires its own **pump**.
  - The pulmonary circuit uses the right half of the heart;
  - the systemic circuit uses the left half.

Systemic Circuit & Pulmonary Circuit




Pulmonary artery
Aorta
Pulmonary artery
Right atrium
Left atrium
Semilunar valve
Semilunar valve
Atrioventricular valve
Atrioventricular valve
Right ventricle
Left ventricle

Composition of Blood

1. Plasma
   - Fluid part of blood
   - Carries carbon dioxide, hormones and waste
2. Red blood cells
   - Contain haemoglobin which carries oxygen
3. White blood cells
   - An important part of the immune system, they produce antibodies and destroy harmful microorganisms
4. Platelets
   - Clump together to form clots
   - Protect the body by stopping bleeding

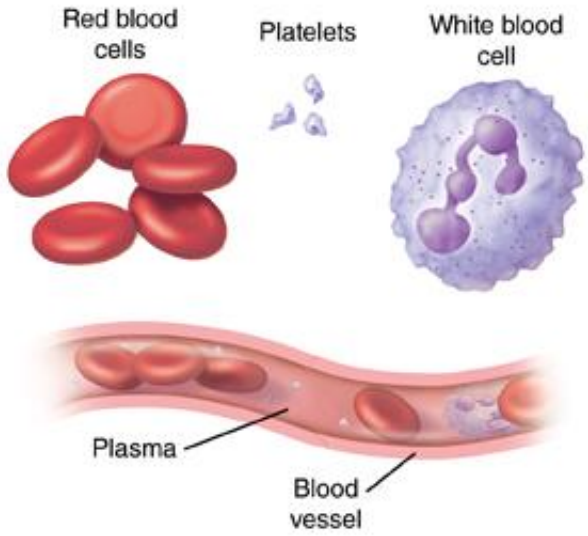
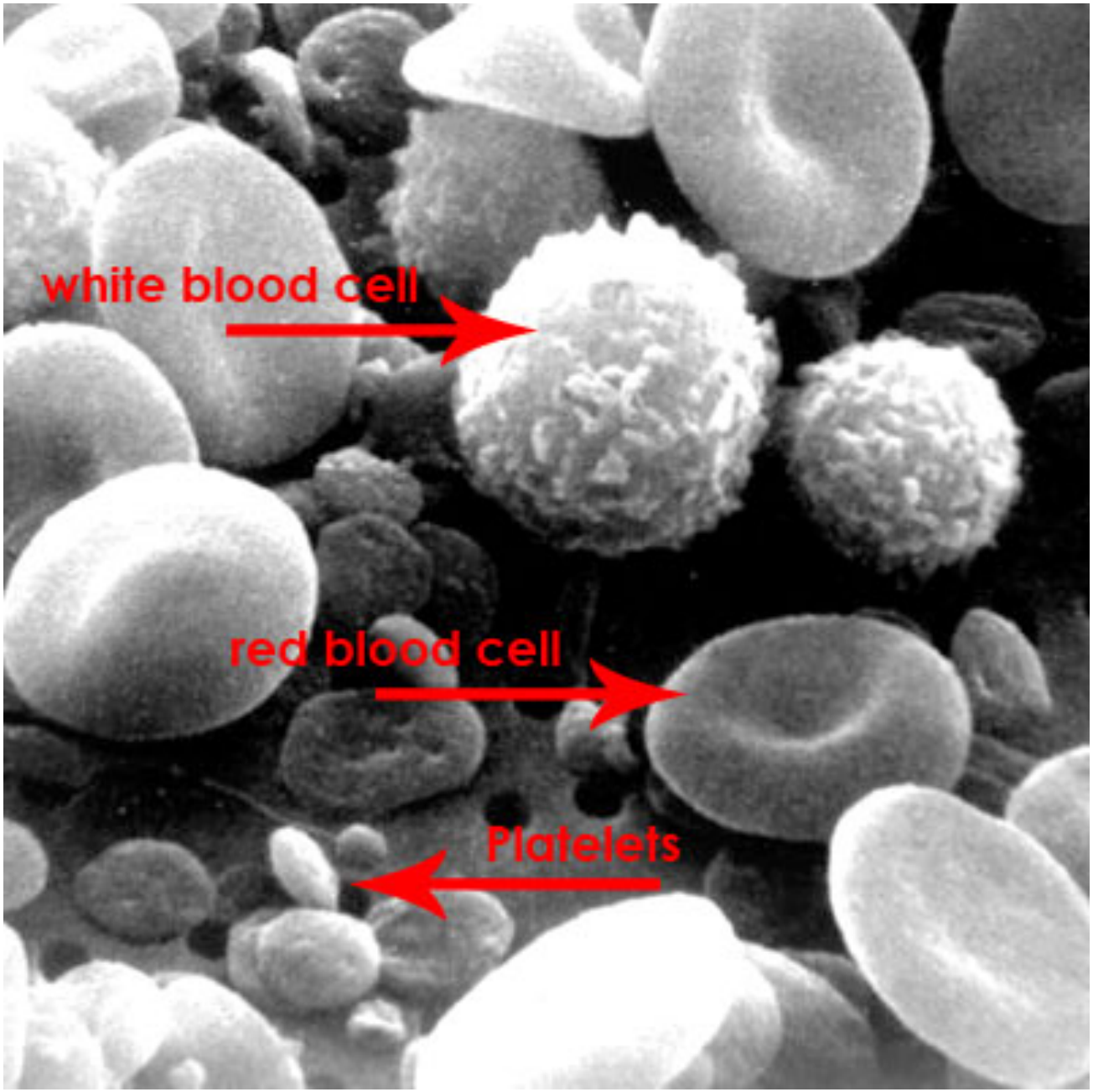


Figure – RBC, WBC and Platelets

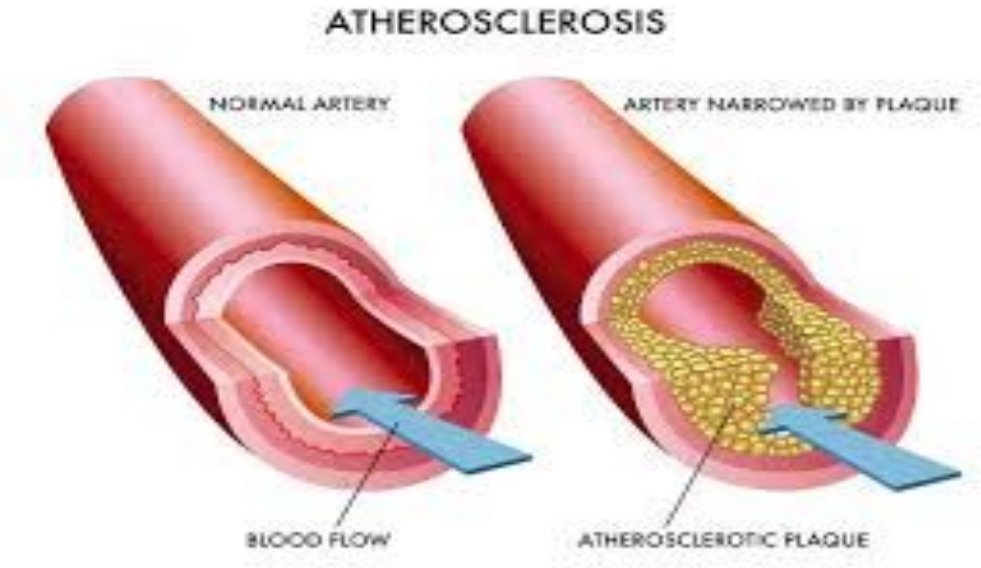


Function of Blood

- Blood performs many important functions within the body including:
- Supply of oxygen to tissues (bound to hemoglobin which is carried in red cells)
- Supply of nutrients such as glucose, amino acids and fatty acids (dissolved in the blood or bound to plasma proteins)
- Removal of waste such as carbon dioxide, urea and lactic acid
- Immunological functions, including circulation of white cells, and detection of foreign material by antibodies
- It maintains acid base balance, body temperature.
- Messenger functions, including the transport of hormones and the signaling of tissue damage.

Disorders

- **Atherosclerosis/ Arteriosclerosis**
  - deposits inside arteries (plaques)
  - develop in inner wall of the arteries, narrowing their channel
  - increase blood pressure
  - increase risk of heart attack, stroke, kidney damage



Disorders

Heart Attack

- Acute myocardial infarction
- Interruption of oxygen supply to the heart
- Causes death of the heart muscle
- Leading cause of death in both men and women

Stroke

- Strokes usually result from rupture or blockage of arteries in the head
- Brain cells are starved of oxygen and nutrients
- Loss of function may occur
- Can cause paralysis, loss of ability to speak or death.

How arteries get blocked

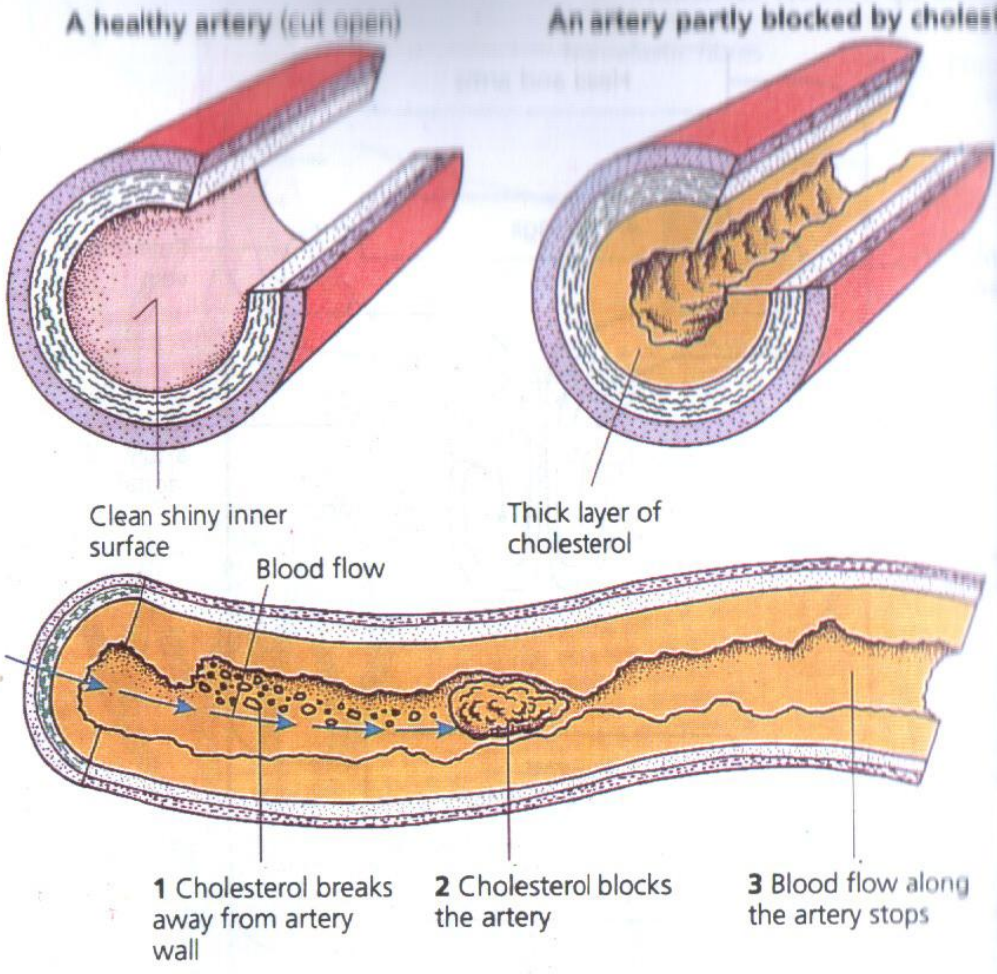
How arteries get blocked

A fatty substance called **cholesterol** can stick to the walls of an artery. The arteries become narrower. So blood gets slowed down.

Cholesterol can make artery walls rough. This causes blood to clot, as it flows past. A blood clot can block an artery completely. The blockage is called a **thrombosis**. The blood flow is stopped.

Bits of cholesterol can break off into the blood stream, and block narrow blood vessels.

A thrombosis in blood vessels in the brain is called a **stroke**. Brain cells die. A person suffering from a stroke may get paralysed or even die.



How to avoid heart diseases

- Cutting down on fried food. We can grill, boil or steam, rather than fry. If we do fry, we should use corn, soya or sunflower oils.
- Eating less red meat.
- Cutting off any fat while eating anything
- Eating less dairy foods (eggs, butter, milk and cream)
- Eating more poultry and fish, because they are less fatty.
- Eating more fresh fruit and vegetables.
- No smoking.
- Taking exercise regularly.
- Taking time to relax before we go to bed.

What is blood?

- Blood is a specialized bodily fluid that consists of a liquid matrix called **plasma** containing a number of **cellular components** and cell fragment.

- Blood cells produced in bone marrow from stem cells

Blood Components

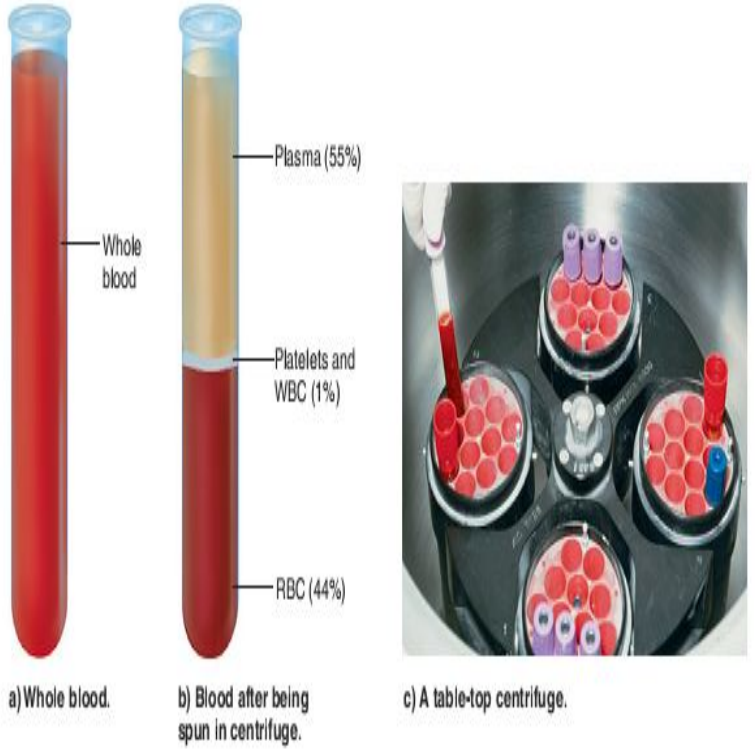
- They fall into two major categories:

1) The liquid component (plasma) and

2) The cellular component or formed elements (red cells, white cells, and platelets)

Blood Component: Plasma

- **If you centrifuge a blood sample, the** yellowish clear liquid will be found on the on the top, called plasma (55%)
- Plasma composed of <u>water</u> (90%), <u>proteins</u> (~10%) and other <u>solutes</u>.



Plasma

- The largest group of solutes in plasma consists of plasma proteins, which serve a variety of functions.
- Important plasma proteins include albumins, globulins, and clotting proteins.

Albumins:

- 2/3 of total protein
- Maintain the proper water balance between blood and the interstitial fluid.
- Manufactured in the liver.
- Albumins also bind to certain molecules (such as bilirubin and fatty acids) and drugs (such as penicillin) and assist in their transport in blood.

Plasma

Globulins:

- Globulins (designated alpha, beta, and gamma) transport various substances in the blood.
- Many beta globulins bind to lipid (fat) molecules, such as cholesterol. When a protein attaches to one of these molecules, it creates a complex called a lipoprotein.
- Two medically important lipoproteins are the low-density lipoproteins (LDLs) and high-density lipoproteins (HDLs).

Plasma

Globulins:

- **The LDLs are sometimes called "bad cholesterol," because high blood levels of these lipoproteins are associated with increased risk of cardiovascular health problems.**

- High levels of HDLs often indicate a lower risk of cardiovascular disease.

Plasma

Clotting proteins:

- **Clotting proteins, a third group of plasma proteins, play an important role in the process of blood clotting. blood clotting minimizes blood loss and helps maintain homeostasis after injury.**

- Plasma also contains other substrate;

  Electrolytes - Na^{+}, K^{+}, Ca^{++}, Mg^{++}

  Nutrients - glucose, amino acids, fatty acids, monoglycerides

  Gases - O_2, N_2, CO_2

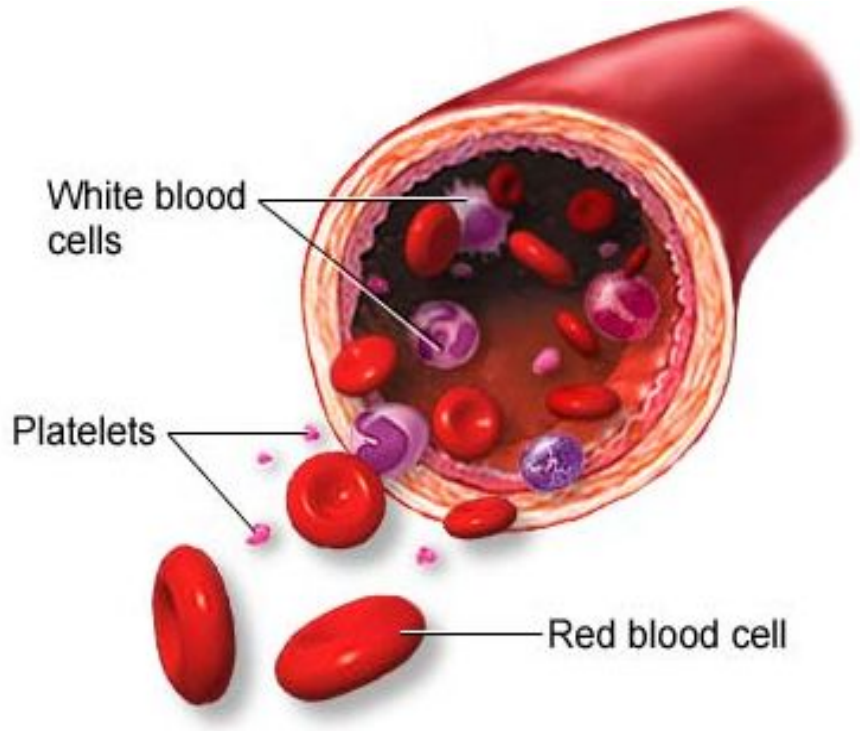
  Regulatory substance - hormones, enzymes, Vitamins

  Wastes

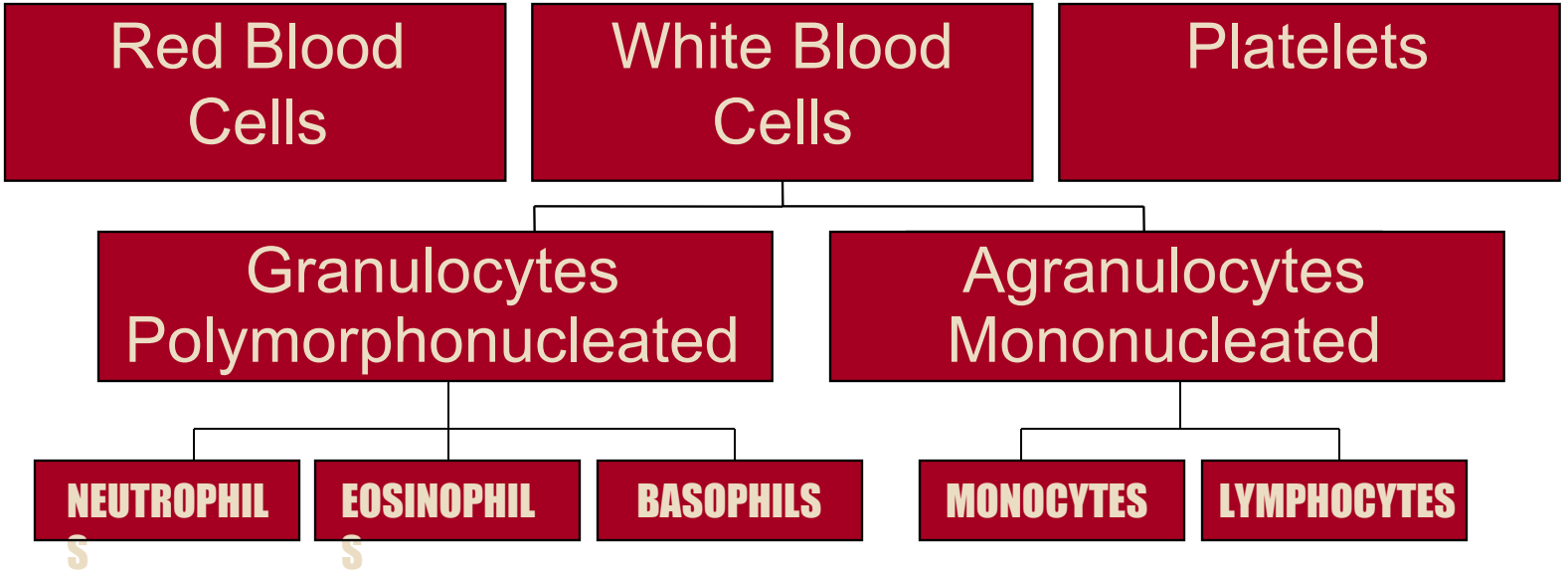
Blood Components: Formed elements

There are mainly 3 types of blood cells;

- Red blood cells or erythrocytes
- White blood cells or leukocytes
- Platelet or thrombocytes



Formed elements

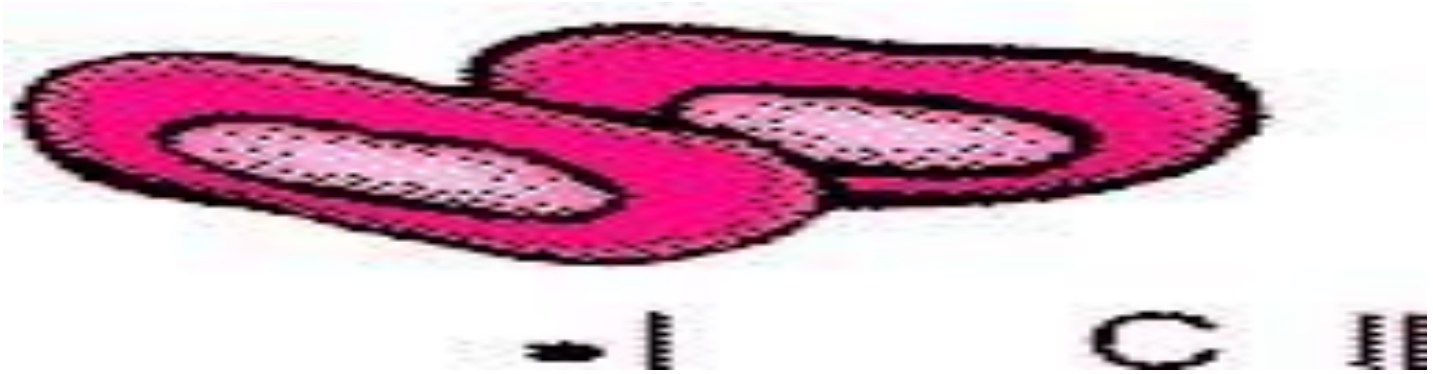


Blood cells – Formed Elements

Element	Diameter (in um)	Number (per mm^3)	Scientific notation (per mm^3)	Main function
 red blood cells	7 - 8	4,500,000 - 52500,000	4.5×10^6 5.5×10^6	oxygen transport
 white blood cells	9 - 12	7,000 - 10,000	7×10^3 1×10^4	defense against microorganisms
 platelets	2 - 4	300,000	3×10^5	blood-clotting

Red blood cell

- Red blood cells are small, flattened, doughnut-shaped disks whose centers are thinner than their edges.
- It makes them flexible, so they can bend and flex to squeeze through tiny blood vessels.
- They are red because they contain a protein called hemoglobin that is red in color because of iron



Red blood cell

- Red blood cells carry oxygen to body tissues and remove carbon dioxide (which bound with hemoglobin).
- The process by which red blood cells are produced is called erythropoiesis.
- Erythrocytes are continuously being produced in the bone marrow of large bones, at a rate of about 2 million per second. (In the embryo, the liver is the main site of red blood cell production).
- In an adult, the total count of RBC is 4.5 to 5.5 million per mm^3 of blood.

White blood cell

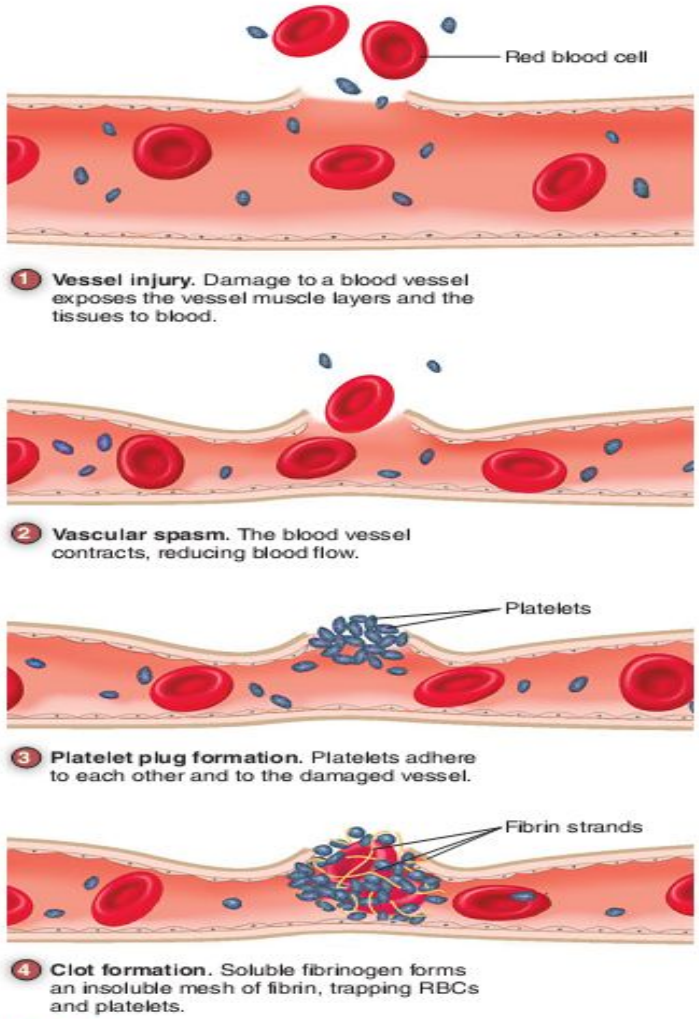
- White blood cells are cells of the immune system defending the body against both infectious disease and foreign materials.
- WBCs are found throughout the body, including the blood and lymphatic system.
- **White cells called** phagocytes can eat up the germs that cause diseases.

Platelets

- Platelets result from cell fragmentation and are involved with clotting by carrying chemicals essential to blood clotting.
- There are 150,000 to 300,000 platelets in each milliliter of blood.
- Without blood platelets, you would bleed to death.
- Platelets survive for 10 days before being removed by the liver and spleen.

Platelets (contd.)

- If a blood vessel is cut, platelets stick to the edges of the cut and to one another, forming a plug that stops bleeding.
- They then release chemicals that react with *fibrinogen* and other clotting proteins, leading to the formation of a blood clot.
- The blood vessel can then heal over the cut area.



igure 7.8 **The stages of hemostasis.**

Production of Blood Cells

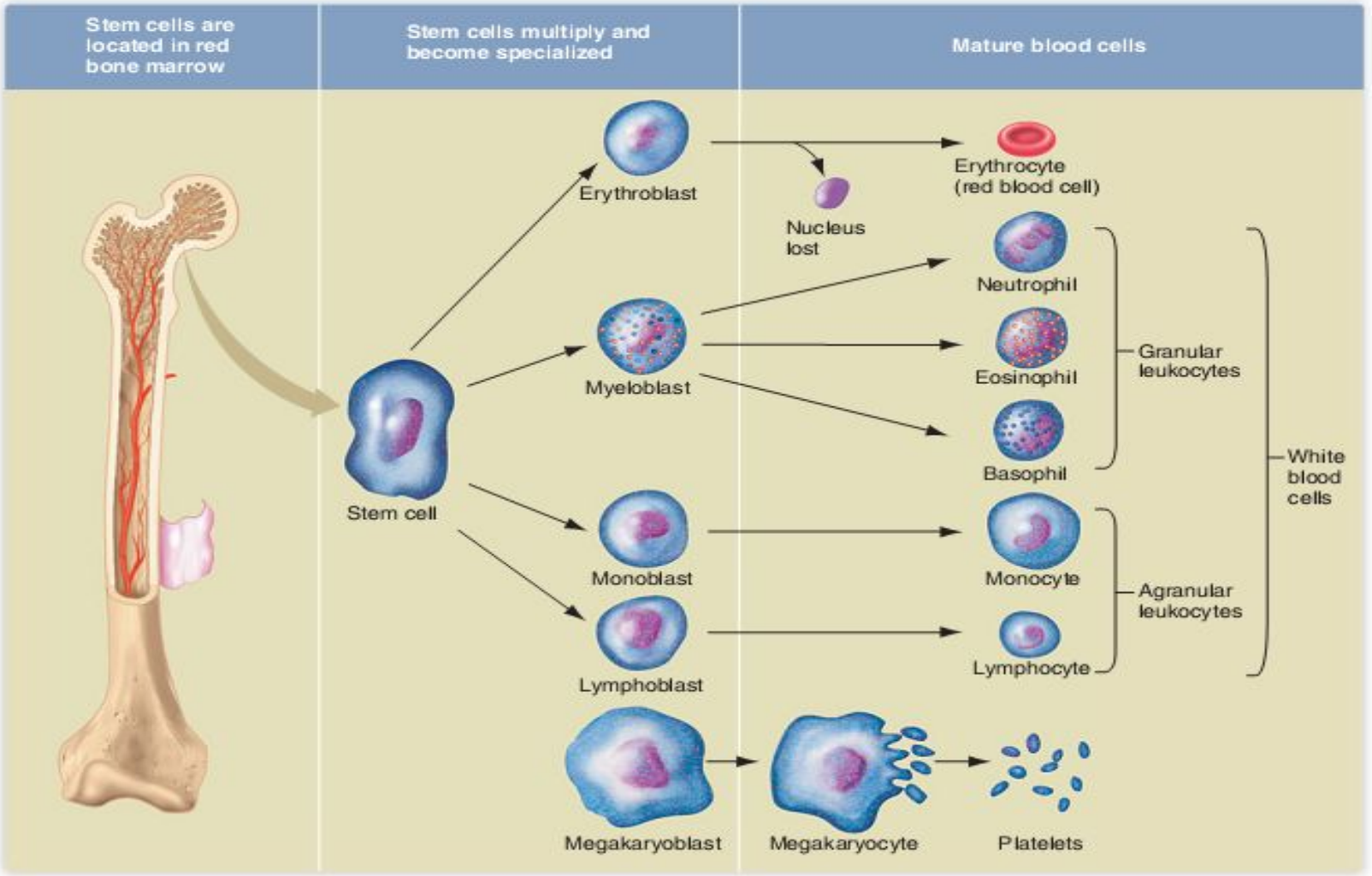


Figure 7.5 The production of blood cells and platelets. Blood cells have short life spans and must be continually replaced. Stem cells in the red marrow of bones continually divide and give rise to a variety of types of blood cells.

Types Of Blood

Human blood is grouped into four types:

- A, B, AB, and O based on two antigens A and B
- Each letter refers to a kind of antigen, or protein, on the surface of red blood cells.
- Each blood type is also grouped by its Rhesus factor, or Rh factor
- Blood is either Rh positive (Rh+) or Rh negative (Rh-).

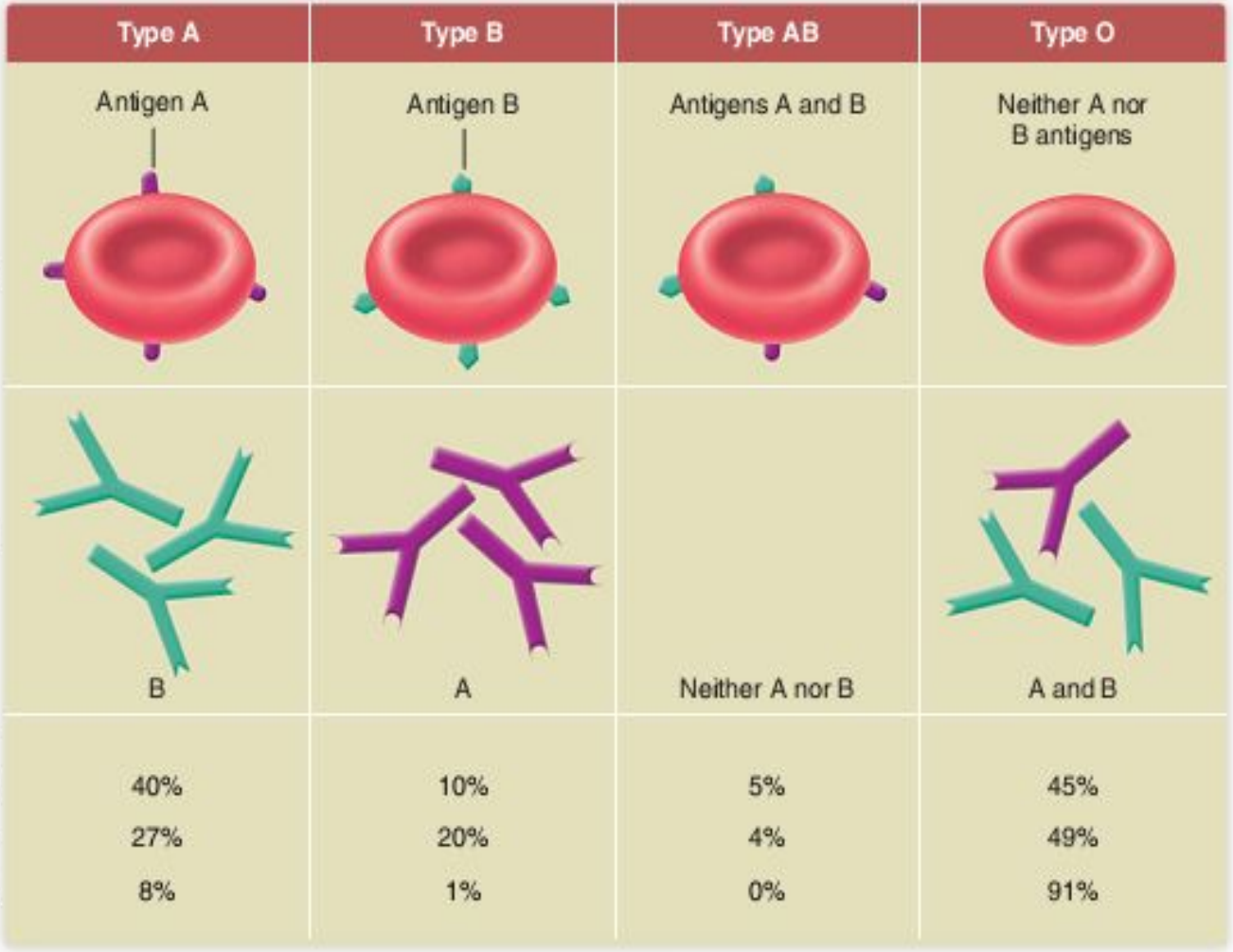


Figure 7.12 Characteristics of the four major blood types of the ABO typing system, showing their RBC surface antigens, antibodies, and relative incidences among various populations.

Types Of Blood

- Type **O-** blood is considered the **"universal donor"** because it can be donated to people of any blood type. It contains no antigen.

- Type **AB+** blood is considered the **"universal recipient"** because people with this type can receive any blood type. It contain both the antigens and will not produce any antibody against foreign antigen.

Rh blood type

Another red blood cell surface antigen, called Rh factor

Rh+ ……individual has Rh antigen

Rh-……individual do not has Rh antigen; their immune systems respond to any foreign Rh antigen by making antibodies against it

Questions?