**BLOOD**

Blood is a connective tissue made of living cells called formed elements suspended in a nonliving fluid matrix called plasma.

**FUNCTIONS** -
- Transportation – gases, nutrients, waste products, hormones
- Regulation – maintaining temperature, pH and fluid volume
- Protection – prevent blood loss and infection

**PLASMA**
1. Water – 90% of plasma; solvent for carrying substances and absorbing heat
2. Proteins – maintain osmotic pressure, lipid transport, antibodies, clotting of blood
3. Inorganic constituents (electrolytes - salts) – assist in osmotic balance, pH buffering, regulation of membrane permeability
4. Dissolved substances - nutrients, waste, gases, hormones

**FORMED ELEMENTS**

**ERYTHROCYTES (RBC):**
- Biconcave shaped cells that contain hemoglobin, an iron-bearing protein, to transport oxygen. A single RBC contain 250 million hemoglobin molecules, each capable of binding 4 molecules of O₂. RBCs are anucleated and amitotic with a lifespan of ~120 days. Aged and damaged RBC are broken down in the spleen and the liver.
- Erythropoiesis occurs in red bone marrow where stem cells produce RBCs. Cells synthesize hemoglobin then eject the nucleus and mature. The rate of erythropoiesis is controlled by a hormone called erythropoietin. When blood levels of O₂ are low (hypoxia), kidney cells produce and release erythropoietin which stimulate stem cells in marrow to form RBCs.

**LEUKOCYTES (WBC):**
- Cells are crucial to body defense against disease. These cells contain nuclei and organelles.
- Cells are capable of moving in and out of blood vessels, a process called diapedesis. Cells can locate areas of tissue damage and infection by responding to chemicals that diffuse from damaged cells. This capability is called positive chemotaxis.
- When a bacterial or viral infection is detected, the body speeds up production of WBCs and this process is called leukocytosis.

**PLATELETS (Thrombocytes):**
- Platelets help initiate formation of blood clots to close breaks in damaged blood vessels.
- Myeloid stem cells in bone marrow form megakaryocytes. Megakaryocytes rupture and break off into thousands of anucleated platelet fragments. The hormone, thrombopoietin, accelerates the production of platelets which is triggered by damaged blood vessels.
CARDIOVASCULAR SYSTEM

The major function of the cardiovascular system is transportation, using the blood to carry oxygen, nutrients, cellular wastes, hormones and other substances vital for body homeostasis to and from the cells. The heart begins as a tube that is beating and pumping blood by the 4th week of embryonic development.

Membranes & Layers of the Heart

- **Pericardium** – double-walled sac encloses the heart.
- **Epicardium** – outer layer of heart
- **Myocardium** – thick bundles of cardiac muscle
- **Endocardium** – lines the chambers and the blood vessels entering and leaving the heart

- **Coronary arteries** – arteries oxygenate and nourish the myocardium
- **Coronary veins** – veins drain the blood from the myocardium and empty into the right atrium

### Anemia
Anemia – decrease in the oxygen-carrying ability of the blood -- results from a low RBC or abnormal hemoglobin.

### Sickle cell anemia
Sickle cell anemia – genetic disorder resulting in abnormal hemoglobin

### Polycythemia
Polycythemia – abnormal increase in RBCs that may result from bone marrow cancer or response to living at high altitudes

### Leukopenia
Leukopenia – low WBC count; commonly caused by corticosteroids & anticancer drugs

### Leukemia
Leukemia – bone marrow becomes cancerous; rapid production of WBC that are immature and incapable of carrying out normal functions.

### Thrombus
Thrombus – floating clot

### Embolus
Emboli – stationary clot

### Thrombocytopenia
Thrombocytopenia – insufficient number of circulating platelets; can result from bone marrow cancer, radiation or certain drugs

### Hemophilia
Hemophilia – genetic disorder resulting from a lack of any of the factors needed for clotting
Heart Anatomy
- 4 hollow chambers lined with endocardium – **two atria (superior) & two ventricles (inferior)**
- **Interventricular & Interatrial septum** – separates the left and right side
- **Atrioventricular (AV) valves** – between the atria & the ventricles
  - right AV valve is a tricuspid and left AV valve is a bicuspid (mitral valve)
  - prevents back flow into the atria
- **Semilunar (SL) valves (tricuspsids)** – between an artery & a ventricle
  - Aortic SL valve – between the aorta and left ventricle…..Pulmonary SL valve – between the pulmonary artery and right ventricle
  - Prevents back flow into the ventricles
- **Superior & Inferior Vena Cava** – vessels that returns blood to the heart from the body
- **Pulmonary Arteries** (trunk) – pulmonary trunk splits into right and left pulmonary arteries
- **Pulmonary Veins** – returns oxygenated blood from lungs
- **Aorta** – vessel that delivers blood to the body
- **Chordae tendineae** – anchors the AV valves to the papillary muscles protruding from the walls of ventricles

Pathway of Blood –
1. Deoxygenated blood enters the right atrium from the superior & inferior vena cava
2. Blood moves through the AV valves into the right ventricle (SL valve is closed)…when filled, the AV valve closes and the pulmonary SL valve opens…..the right ventricle contracts pushing the blood into the pulmonary arteries
3. Pulmonary arteries carry blood to lungs to pick up O\textsubscript{2} & release CO\textsubscript{2} in the capillaries ---- O\textsubscript{2} rich blood returns to heart and enters the left atrium
4. Blood moves through AV mitral valve into left ventricle (SL valve is closed)….when filled, the AV valve closes and the aortic SL valve opens…..the left ventricle contracts pushing the blood into the aorta to carry blood to the rest of the body
Pulmonary Circuit – circulation of blood from the right side of the heart to the lungs and back to the left side of heart

Systemic Circuit – circulation of blood from the left side of the heart through the body tissues and back to the right side of the heart

**Cardiac Cycle (complete heartbeat = .8 secs)**

1. During relaxation phase (diastole), blood flows into atria. AV valves are open and SL valves are closed.
2. A brief period of atrial systole (contraction) forces blood out of the atria into the ventricles.
3. As pressure rises in ventricles, the AV valves close (lub) and the SL valves are forced open. The ventricles contract (systole) pushing blood into the pulmonary arteries and aorta.
4. Atria relax (diastole), then ventricles begin to relax and SL valves close (dub). AV valves open and the cycle continues.

**REGULATION of heart:**

1. **Autonomic Nervous System (ANS)** – decrease or increase the heart rate
2. **Intrinsic conduction system** (nodal system) – built into the heart tissue and sets cardiac rhythm. It enforces a contraction rate of approximately 75 beats per minute on the heart.
   - Sinoatrial (SA) node (pacemaker) – it starts each heartbeat and sets the pace for the whole heart. SA node triggers the impulse to spread across the atria to the AV node and the atria contract pushing blood into ventricles. (labeled A)
   - Atrioventricular (AV) node – AV node receives impulse and sends impulse over the ventricles causing the ventricles to contract. (labeled B)
**Blood Vessels**

Arteries carry blood away from heart. Arteries branch into smaller arteries and eventually into arterioles, which feed into capillaries. Capillaries drain into venules, which eventually turn into veins that return blood to the heart. Veins have valves to prevent back flow.
**Arterial Pulse** – the alternating expansion and recoil of an artery that occurs with each beat of the left ventricle creates a pressure wave – a pulse – that travels through the entire arterial system. Normally, pulse rate (pressure surges/min) equals heart rate (beats/min) ---- average 70 beats/min. Body sites where the pulse is easily palpated can also be compressed to stop the blood flow into distal tissues during hemorrhage --- they are called pressure points.

**Cardiac Output** – the amount of blood pumped out by each ventricle in 1 minute. It is a product of heart rate and stroke volume. **Stroke volume** is the volume of blood pumped out by each ventricle with each heartbeat. **Heart rate** is the number of beats per minute. For example if: HR (75 beats/min) x SV (70 mL/beat) = CO (5250 mL/min). Since the normal adult blood volume is about 5000 ml, the entire blood supply passes through the body once each minute.

The critical factor controlling stroke volume is how much the cardiac muscle cells are stretched prior to contraction. The venous return, amount of blood entering heart and distending its ventricles, determines the extent of stretching. When stroke volume declines, cardiac output is maintained by faster heartbeat. Heart rate is modified by the ANS, various chemicals, hormones and ions. Age, gender, exercise and body temperature influence heart rate.

- Tachycardia – rapid heart rate over 100 beats/min
- Bradycardia – slower heart rate lower than 60 beats/min

**Blood Pressure** – the pressure that blood exerts against the inner walls of the blood vessels. When ventricles contract, they force blood into arteries that expand as the blood is pushed into them. The high pressure forces the blood to continually move into areas where pressure is lower and eventually back to the heart.

- Use a sphygmomanometer to measure blood pressure: systolic (ventricle contraction) & diastolic (ventricle relaxation). Normal blood pressure is 120/80 (S/D).
- Blood pressure is directly related to cardiac output and peripheral resistance, the amount of friction the blood encounters as it flows through the vessels. Several factors influence pressure: ANS, kidney functions, temperature, chemicals (drugs), diet…..these factors can alter the viscosity of blood, the elasticity of vessels and the amount of blood.

- Hypotension – low blood pressure; systolic below 100 mm Hg
- Hypertension – high blood pressure; sustained 140/90 mm Hg

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**Valvular Stenosis** – valve flaps become stiff; often because of repeated bacterial infections of endocardium (endocarditis)

**Angina Pectoris** – chest pain due to lack of oxygen to myocardium

**Myocardial Infarction** – heart attack due to prolonged lack of oxygen

**Heart block** – damage to AV nodes can partially or totally release control of the SA node resulting in the ventricles beating at their own rate which is slower

**Ischemia** – lack of adequate blood supply to the heart muscle may lead to fibrillation – a rapid uncoordinated shuddering of the heart muscle; can result in heart attack

**Murmur** – abnormal or unusual heart sounds

**Congestive heart failure** – heart is ‘worn-out’ due to age, hypertensive heart disease or another pathological process that weakens the heart

**Atherosclerosis** – clogging of the coronary vessels with fatty buildup