The Human Circulatory System

The circulatory system is the system that transports materials around the body to and from the cells.

Question? Why do humans need a circulatory system whereas bacteria and simple organisms do not?

Answer: Because the cells of a complex organism such as a human have many cells that are far from the outside environment where nutrients would come from. The system brings the materials to the cells that would not normally receive them.

Humans have a closed circulatory system: This means that the blood is always contained in tubes and vessels.

Parts of the Circulatory System

The human circulatory system is composed of the following:

1. Blood Vessels
2. Heart
3. Blood

**BLOOD VESSELS**

Humans have three types of blood vessels. They are:

a. **Arteries**
   Structure:
   - Thick, elastic
   - Contain layers of connective, and smooth muscle tissues
   - **DO NOT CONTAIN VALVES**

   Function: Carry Blood AWAY from the heart.

   *Arteries divide to form very small arteries called arterioles.*
b. **Veins**  
**Structure:**  
- Thin and slightly elastic.  
- Contain VALVES for one way flow of blood.  

**Function:** return blood TO the heart  
Veins divide to become **venules**.

**Medical Alert:**  
**Varicose Veins**  

This is a condition where the valves in the veins of a person are not working properly and blood seeps back into the vein causing the vein to become stretched and lose their elasticity.  

**Result:** Sagging veins and lack of blood flow to the heart.

c. **Capillaries**  
**Structure:**  
- Microscopic blood vessels that connect arterioles and venules.  
- Thin walled and narrow  
- Blood cells pass through them in single file  

**Function:** Allows material and gas exchange between the body cells and the blood.
THE HEART

Structure:
- A four chambered muscular organ located in the chest cavity of a human.
- Made of Cardiac muscle.
- It is Covered by a Pericardium that protects it.
  - Pericardium: A tough membrane that surrounds the heart.

Function: Pump blood around the body supplying the cells with nutrients and removing wastes (CO₂) from the cells.
Functions of Heart Structures

1. Inferior/Superior Vena Cava: Returns *deoxygenated* blood to the right atrium from the body.

2. Right Atrium: Thin walled chamber of the heart that receives deoxygenated blood from the body.

3. Tricuspid valve: Controls the flow of blood entering the right ventricle from the right atrium.

4. Right Ventricle: Muscular chamber that pumps blood to the lungs.

5. Semilunar Valves: Valves that control the flow of blood out of the heart.

6. Pulmonary Arteries: Arteries that carry blood to the lungs.

7. Pulmonary Veins: Veins that bring blood to the heart from the lungs.

8. Left Atrium: Thin walled chamber that receives oxygenated blood from the lungs.

9. Left Ventricle: Thick walled chamber that pumps blood out of the heart and to the body.

10. Aorta: Large artery that carries blood away from the heart and to all parts of the body.

11. Septum: A wall of muscle that separates the left side of the heart from the right side. This prevents the mixing of oxygenated and deoxygenated blood.

12. Chordae Tendonae: Control the opening and closing of the Tricuspid and Bicuspid (Mitral) valves.

13. Bicuspid Valve: A valve that controls the flow of blood from the left atrium to the left ventricle.
Blood Flow through the Heart

Deoxygenated blood from the body enters the right Atrium via the Inferior and Superior Vena Cava (e). Here the blood is passed through the tricuspid valve to the right ventricle. The right ventricle contracts and forces blood up through the Semilunar valves and out through the left and right pulmonary arteries. This brings blood to the lungs to be oxygenated.

Oxygenated blood from the lungs returns to the heart via the left and right pulmonary veins to the left atrium. The blood is passed to the left ventricle through the bicuspid valve. The left ventricle contracts and pushes blood through the Semilunar valves and out through the aorta to the body.

THE HEARTBEAT CYCLE

The human heartbeat occurs in two main stages.

These two stages are: a. Diastole

b. Systole

Diastole The stage where the heart is Relaxing

During this stage the A-V valves (bicuspid, tricuspid) are open and the semilunar valves close. The ventricles fill with blood.

Systole The stage where the heart is Contracting

During this stage the ventricles contract. This causes the A-V valves to close and the semilunar valves to open. Blood is forced out through the semilunar valves to the lungs and body.

The “LubDub” sound of the Heartbeat

The “LubDub” sound of the heartbeat is caused by the closing of the heart’s valves.

Lub Sound -- caused by the closing of the A-V valves (tricuspid, bicuspid).

Dub Sound -- caused by the closing of the semilunar valves.
CONTROL OF THE HEARTBEAT

The heart is caused to beat regularly by a structure called the *Sinoatrial Node* (S - A node) or the **PACEMAKER**.

**How it happens**

An electrical impulse from the brain is received by the S-A node (pacemaker) in the right atrium. The SA node sends a signal to the **A-V node (atrioventricular node)** in the right ventricle. This electrical impulse causes the heart (ventricles) to contract.

The pacemaker controls the heartbeat for a human from the time they are born until they die or the pacemaker gives out.

Q. What happens if the pacemaker gives out?

A. The person’s heart will stop beating because the ventricles are not receiving electrical impulses causing them to contract.

A person whose pacemaker gives out can get an artificial one inserted into their chest.

CONTROL OF THE HEART RATE

The heart rate (speed) at which the heart beats is controlled by two nerves.

**Medulla Oblongata** (Sometimes called the *Cardioaccelerator nerve*):
Nerve in the brain that causes the heart to speed up when needed.

**Vagus nerve**: Nerve in the brain that causes the heart to slow down when needed.

The medulla sends a message to the SA node to cause an impulse to be sent to the AV node causing the heart to contract more or less in an attempt to set the heart rate.
**BLOOD PRESSURE**

**Blood Pressure:** A measure of the pressure blood exerts on the walls of blood vessels.

Q. How is blood pressure measured?

A. Blood pressure is measured using a blood pressure cuff or **Sphygmomanometer**.

It measures the pressure in an artery while the heart is contracting (systolic pressure) and the pressure while the heart is resting (diastolic pressure). A simple fraction is calculated using the following formula:

\[
\text{Blood Pressure} = \frac{\text{Systolic Pressure}}{\text{Diastolic Pressure}}
\]

For example: A person with a pressure 120/80 means that the person has a pressure of 120 while the heart is contracting and 80 when the heart is relaxing.

P.S. Normal blood pressure is different for each person but is usually around 120/80.
DIVISIONS OF CIRCULATION

There are two types of circulation that happen in the human organism.

1. Pulmonary Circulation  
2. Systemic circulation

1. **PULMONARY CIRCULATION**

   This is circulation of blood from the heart and to the lungs and vice versa.

   This type of circulation **adds** oxygen and **removes** carbon dioxide from the blood.

2. **SYSTEMIC CIRCULATION**

   This is circulation of blood between the heart and the body.

   This type of circulation brings blood to the cells and from the cells.

   Systemic circulation has **three** subdivisions. They are:

   A. Coronary Circulation  
   B. Hepatic-portal circulation  
   C. Renal circulation

   A. **Coronary circulation** is circulation that supplies blood and nutrients directly to the **heart** muscle.

   B. **Hepatic - portal circulation** is circulation that carries nutrients and blood from the **digestive system** to the **liver** to maintain glucose levels in the body.

   C. **Renal Circulation** is circulation that carries blood to and from the **kidneys** so that **nitrogenous wastes** may be **removed** from the blood and excreted by the kidneys.
THE LYMPHATIC SYSTEM

This is the part of the circulatory system that returns excess fluids to the blood from the body.

Parts of the Lymphatic System

1. **Lymph**
   
   This is the fluid that is found within the lymphatic system. It contains water, proteins and intercellular fluid.

2. **Lymph Nodes**
   
   These are small glands at various locations in the body that filter foreign matter from the lymph. Foreign matter usually means bacteria, cancer cells and other disease causing organisms.

   The Lymph nodes also contain *White Blood Cells* that fight off infection.

   If you have swollen lymph nodes then this is an indication that you may have an infection.

3. **Intercellular Fluid**
   
   This is the fluid that is usually squeezed out of a capillary during normal cell activities. It helps move materials between the cells and the capillaries.

   It usually contains *salt, water, proteins and nutrients.*

4. **Spleen**
   
   An organ near the stomach that contains lymph tissue.

   **Function:** Filter out *bacteria* and worn out *RBC's* from the blood.
**BLOOD**

**BLOOD:** Fluid found in the circulatory system of humans that carries nutrients and Oxygen to the cells and carries wastes (carbon dioxide) away from the cells.

Helps to control and regulate body temperature as well.

**COMPONENTS OF BLOOD**

There are **three** components to blood:

A. Plasma  
B. Blood Cells  
C. Platelets

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**A. Plasma**

- The liquid part of blood.  
- Makes up 55% of the volume of blood.  
  92% water and 7% proteins, 1% dissolved solutes.

Plasma has **three** proteins in it.

i) Albumins — Keeps water from leaving the blood.  

ii) Fibrinogen — Used for blood clotting.  

iii) Globulins — Transport proteins around the body. Some are **antibodies**.

*Antibody:* **Proteins that binds to and helps destroy a foreign substance in the body.**
B. **Blood Cells**

Two types:

- Red Blood Cells (RBC’s)
- White Blood Cells (WBC’s)

i) **Red Blood Cells** --- called **Erythrocytes**

- Human blood contains about 30 trillion RBC’s.
- DO NOT contain Nuclei (NONNUCLEATED)
- Created by the bone marrow - stem cells.
- live about 120 days
- double concave shaped
- Contain a protein called **hemoglobin**.
- Worn out RBC’s are removed by the liver and spleen.

**Hemoglobin:**
A protein found in the blood that is made up of IRON. It carries oxygen to the cells and removes CO₂

Composed of an Alpha and Beta Chain with 2 Heme (Iron) groups on each chain. The Heme groups bind to and attach Oxygen and CO₂

**Function of RBC’s:**
Transport oxygen to cells from the lungs.
Transport carbon dioxide from the cells to the lungs.

ii) **White Blood Cells** – called **Leukocytes**

- Larger than RBC’s
- have a nucleus
- less numerous than RBC’s
- Can move on their own

**FUNCTION OF WBC’S:**
Fight foreign invaders and Infections.
Types of White Blood Cells

a) **Macrophages**
   Phagocytic cells that protect the body by engulfing and digesting foreign invaders (pathogens).

b) **Lymphocytes**
   Non-phagocytic blood cells that produce **antibodies**.
   
   Two types: T Cells and B Cells

C. **Platelets**

- Small pieces of cells found in the blood.
- NO Nuclei
- Live about 7 days.

**FUNCTION OF PLATELETS:** Blood Clotting Process.
THE BLOOD CLOTTING PROCESS

Blood Clotting is actually a complicated chemical process. This is how it works.

When a blood vessel is ruptured the following happens:

Step 1:

Platelets rush to the area. They release an enzyme called Thromboplastin.

Step 2:

Thromboplastin causes prothrombin (a protein) to be converted into thrombin (enzyme).

\[
\text{Thromboplastin} \\
\text{Prothrombin} \rightarrow \text{Thrombin}
\]

Step 3:

Thrombin causes fibrinogen (found in blood plasma) to be changed into fibrin.

\[
\text{Thrombin} \\
\text{Fibrinogen} \rightarrow \text{Fibrin}
\]

Step 4:

Fibrin forms a net of fibres over the cut and traps red blood cells and platelets and forms a blood clot.
Circulatory System Disorders

1. **Hypertension**  High Blood Pressure

   *Causes:* diet, stress, inactivity

   *Effects on body:* Leads to heart disease and possible failure

2. **Arteriosclerosis**  Hardening of the Arteries

   *Causes:* Diet – High in Cholesterol (LDL) and Fats.

   *Effect on body:* Causes arteries to become inelastic which can reduce the amount of blood flow in them. This can lead to a heart attack and/or stroke.

3. **Atherosclerosis**  Narrowing of Arteries

   *Causes:* Fatty deposits within the artery walls from poor diet/fat intake etc.

   *Effect on body:* Narrowing of arteries reduces blood flow to heart and brain which may lead to heart attack and/or stroke.

4. **Stroke:**  Loss of blood flow to brain tissue causing cell death.

   *Causes:* Any one of the above and others

   *Effect on Body:* loss of brain function and/or motor control (paralysis), death.

5. **Coronary Blockage**  A blockage in the coronary arteries of the heart.

   *Causes:* Diet, lack of exercise

   *Effect on Body:* Heart attack, death.
Treatments for Circulatory System Disorders

1. **Thrombolytics**

   Thrombolytics are a class of drugs known as “Clot busting” drugs.

   These drugs help to bust up blood clots that have formed. They help to clear blocked passageways etc.

   Ex: Streptokinase or t - PA: A Clot busting drug that converts plasminogen to plasmin. Plasmin dissolves the clot.

2. **Angioplasty**

   Procedure in which a small catheter (tube) with a balloon attached is inserted into an artery and then inflated. The inflation helps to stretch the artery in an attempt to increase blood flow to the heart.

   Sometimes a **Stent** (small mesh netting) is put in place to keep the artery open after the balloon is removed.

3. **Coronary Bypass Surgery**

   Surgery in which a healthy blood vessel from another area in the body is used to create a new pathway around a blockage in a blood vessel near the heart, usually a coronary artery.