Circulatory System

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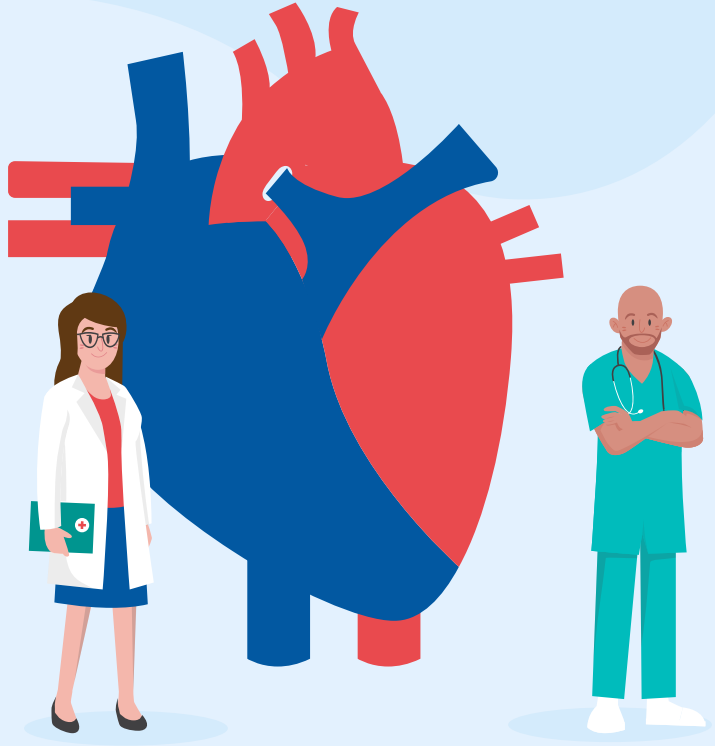


Learning Objectives:

- Circulatory systems link exchange surfaces with cells throughout the body
- Coordinated cycles of heart contraction drive double circulation in mammals
- Patterns of blood pressure and flow reflect the structure and arrangement of blood vessels
- Blood components function in exchange, transport, and defense

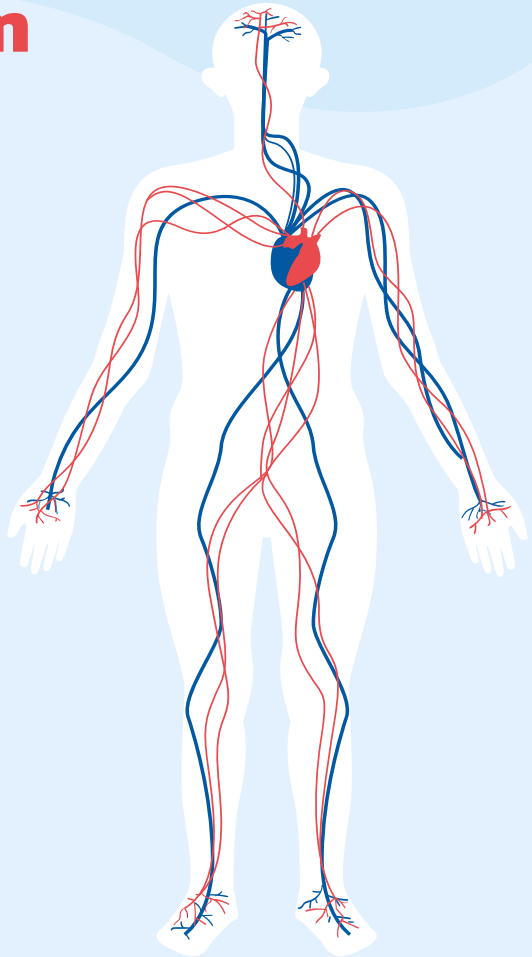
Overview of the Circulatory System

The circulatory system facilitates the exchange of materials and energy between the cells of an organism and its environment. The circulatory system works closely with the respiratory system to deliver oxygen and remove carbon dioxide waste from the body.

There are two types of circulatory systems found in organisms:

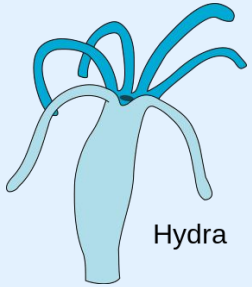
- Open circulatory system: The circulating fluid is pumped through open-ended vessels and circulates directly among cells. Organisms with this type of system include insects, octopuses, and crabs.

- Closed circulatory system: The circulating fluid is confined within the vessels. Organisms with this type of system include humans, mammals, and fish.



Why Do We Need a Circulatory System?

Every organism must exchange nutrients and wastes with its environment. In simple animals, nearly all cells are in direct contact with the outside world. Thus, the cells can easily exchange materials with the environment by diffusion.

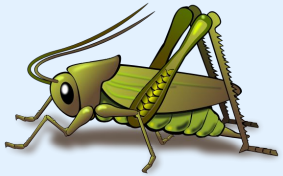


Hydra

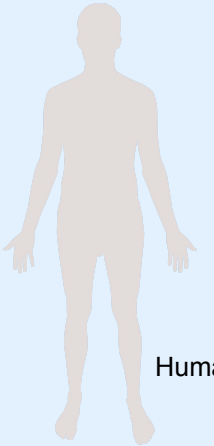
Jellyfish

However, most animals are too large and complex for exchange to take place by diffusion alone. In such animals, a circulatory system facilitates the exchange of materials, working as a rapid, long-distance internal transport system.

Dog



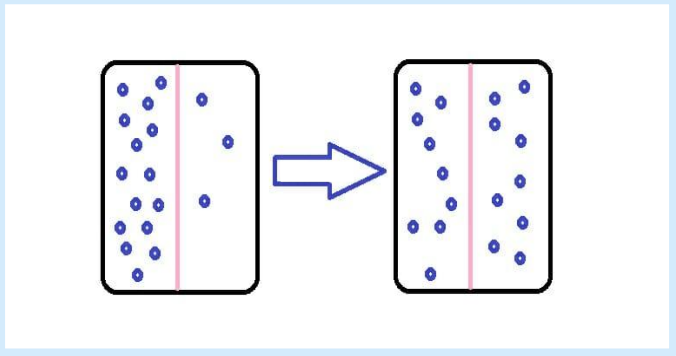
Cricket

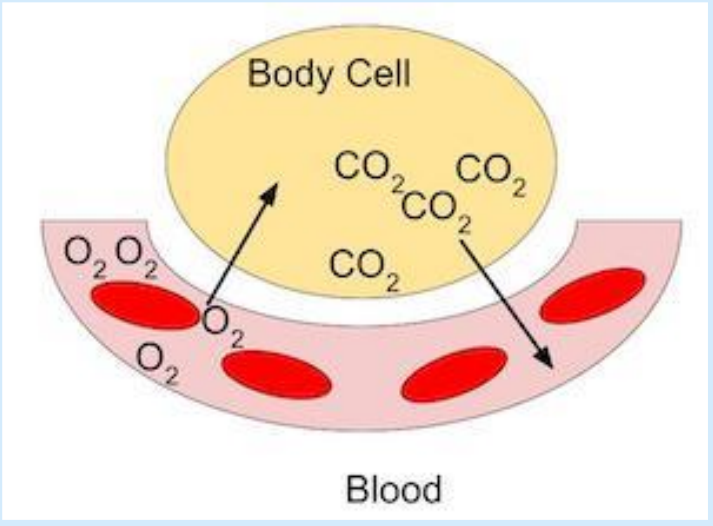


Human

Diffusion

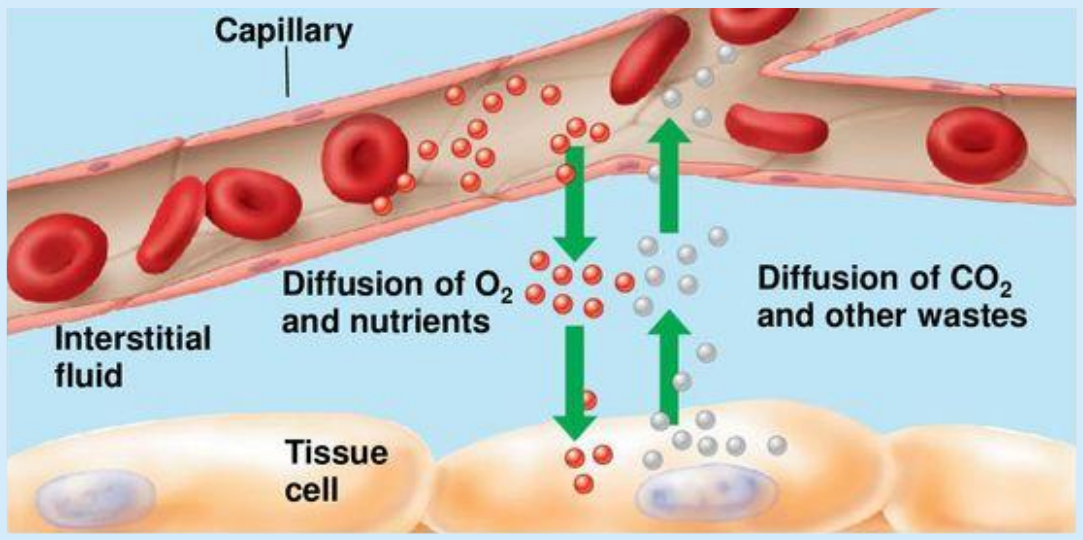
The main purpose of the human circulatory system is to bring resources close enough for exchange to occur between the blood and cells. The exchange of materials occurs through **diffusion**, the spontaneous movement of molecules from an area of higher concentration to an area of lower concentration. Diffusion occurs in the circulatory system through **interstitial fluid**.



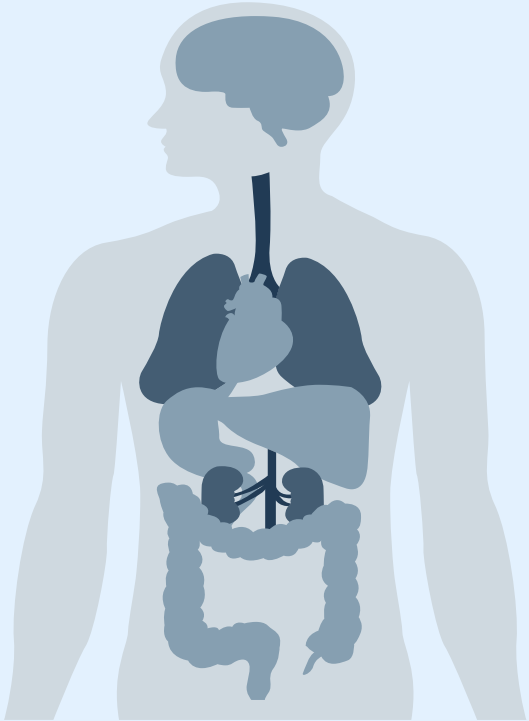


Interstitial Fluid

Interstitial fluid is an aqueous solution that surrounds body cells and through which material pass back and forth between the blood and the body tissues. Exchange between the blood and interstitial fluid occurs across the thin walls of **capillaries**. The exchanged substances then diffuse from the interstitial fluid into nearby tissue cells.



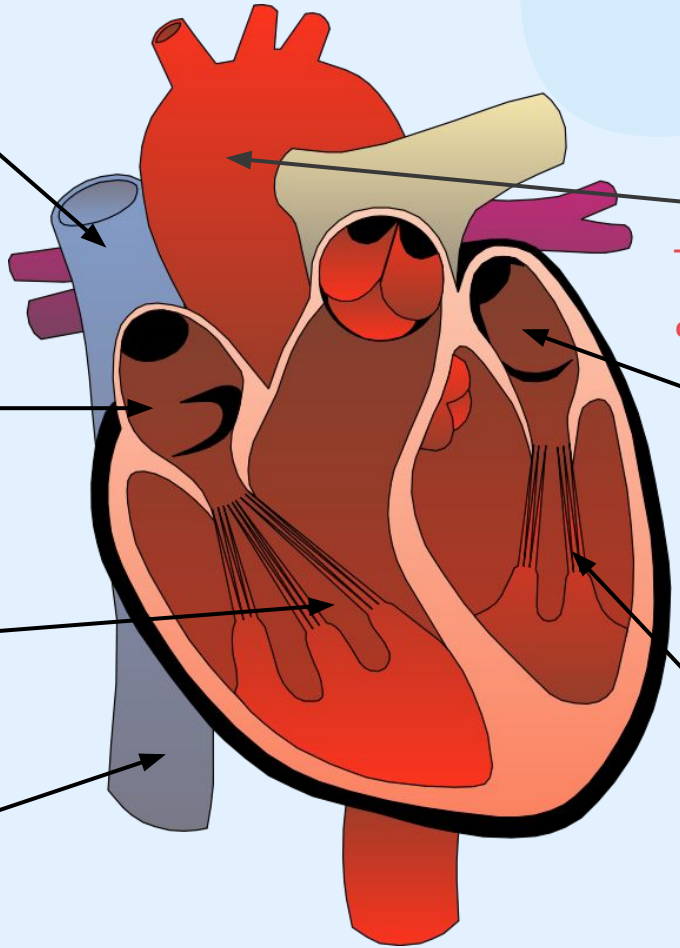
Homeostasis



The circulatory system performs several homeostatic functions.

- By exchanging nutrients and wastes with the interstitial fluid, the circulatory system helps maintain the chemical balance of the fluid that surrounds cells.
- The circulatory system helps to maintain the composition of blood by continuously moving it through organs, such as the lungs, liver, and kidneys, that regulate the blood's contents.
- The circulatory system is involved in thermoregulation, hormone distribution, and defense against foreign invaders.

The Heart



Superior Vena Cava

-Carries oxygen-poor blood from the upper body to the heart

Aorta

-The largest blood vessel in the body, carries oxygen-rich blood to the body

Right Atrium

-Receives oxygen-poor blood from the body

Left Atrium

-Receives oxygen-rich blood from the lungs

Right Ventricle

-Pumps oxygen-poor blood to the lungs

Left Ventricle

-Pumps oxygen-rich blood to the body

Inferior Vena Cava

-Carries oxygen-poor blood from the lower-body to the heart

Form & Function of the Heart

- The two atria **receive** blood.
  -The **right atrium** receives oxygen-poor blood from the body's tissue.
  -The **left atrium** receives oxygen-rich blood from the lungs.
- The two ventricles **send out** blood.
  -The **right ventricle** pumps oxygen-poor blood to the lungs.
  -The **left ventricle** pumps oxygen-rich blood to the body's tissue.

The valves separating the atria and their respective ventricles prevent backflow and keep the blood moving in the proper direction.
The four chambers also prevent oxygen-poor and oxygen-rich blood from mixing.
The ventricles are larger and more powerful than the atria, allowing them to pump blood with more force, which is needed to keep blood moving through vessels.

Blood vessels

Arteries

- Blood vessels that carry blood **away** from the heart.
- Branches into smaller **arterioles** as they approach the organs.
- The **pulse** is the rhythmic stretching of the arteries from the pressure of blood forced into them.

Capillaries

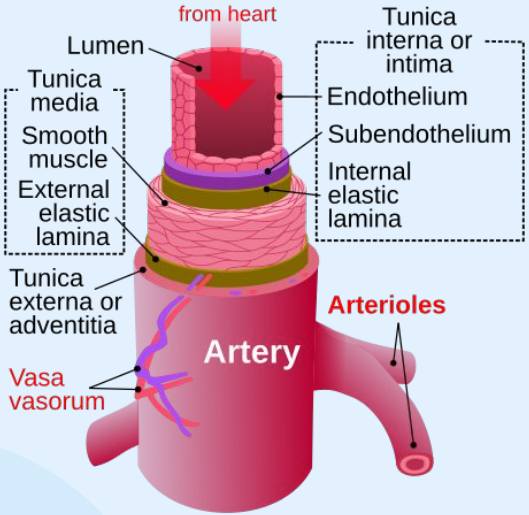
- Tiny blood vessels that infiltrate every organ and tissue in the body.
- **Semi-permeable** walls which allow substances to diffuse in and out between the blood and the interstitial fluid.

Veins

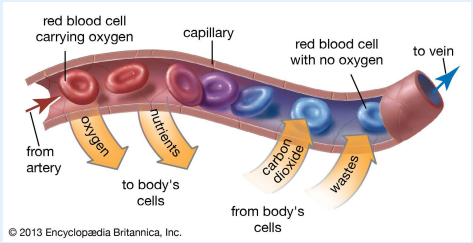
- Blood vessels that carry blood **back** to the heart.
- Capillaries converge into **venules**, which in turn converge into veins.
- Veins have one-way **valves** to direct blood and prevent backflow.

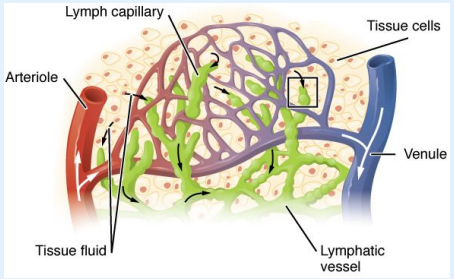
Blood vessels

Arteries

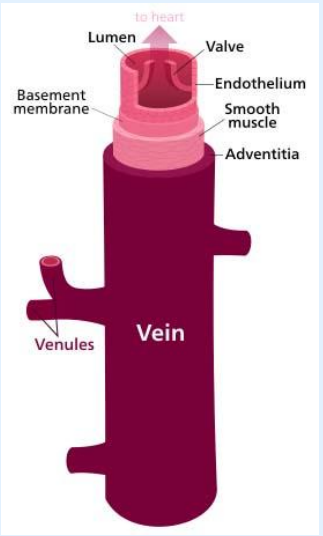


Capillaries





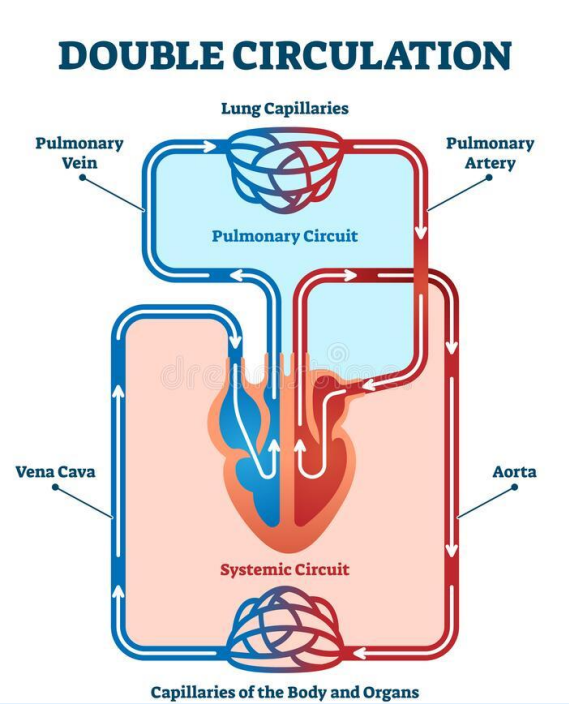
Veins



The Pulmonary & Systemic Circuits

Pulmonary Circuit

1.) The **venae cavae** carry O_2-poor blood from the body to the **right atrium**.
2.) The blood is pumped to the **right ventricle**, which pumps it to the lungs through two pulmonary arteries.
3.) In the **capillaries** of the lungs, O_2 diffuses into the blood and CO_2 diffuses out.
4.) The O_2-rich blood is carried by pulmonary veins back to the **left atrium**.



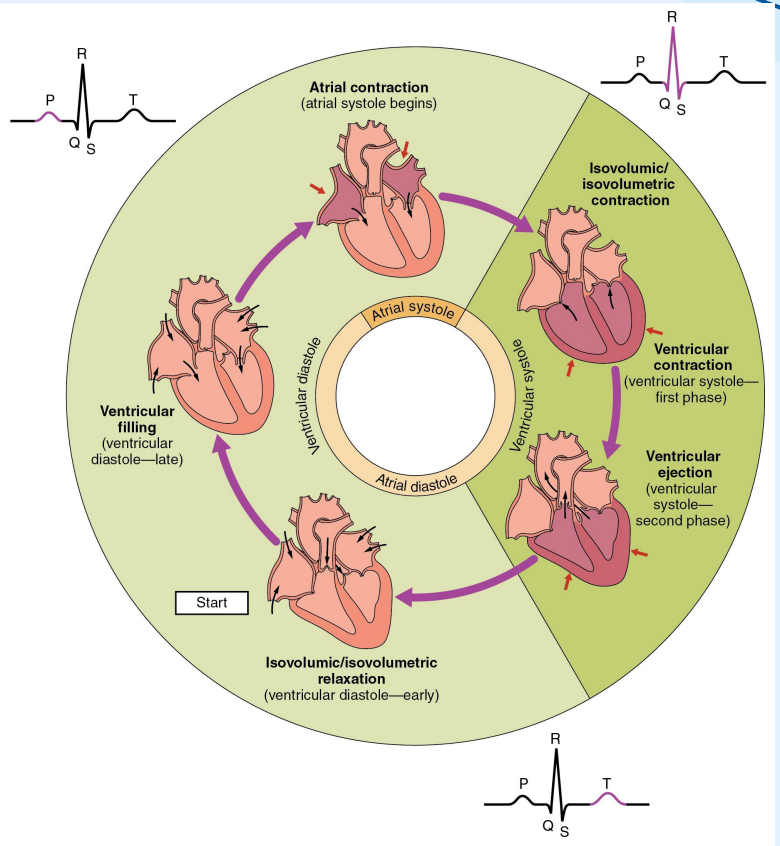
Systemic Circuit

1.) Blood is pumped from the **left atrium** to the **left ventricle**, which then pumps the blood out through the **aorta**.
2.) The **aorta** branches off into large arteries that carry blood to the head, arms, abdomen, and legs. These arteries branch into smaller **arterioles**, which then branch off into **capillaries** that permeate **tissue cells**.
3.) **CO_2 diffuses out** into the blood and **O_2 diffuses in** from the blood.
4.) Newly O_2-poor blood is carried back to the **right atrium** of the heart via the **superior vena cava** (upper-body) and the **inferior vena cava** (lower-body).

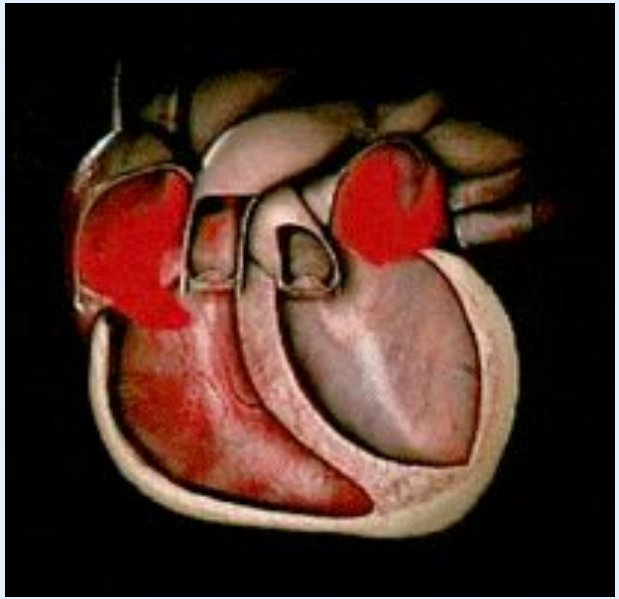
The Cardiac Cycle

The rhythmic relaxation and contraction of the heart is called the **cardiac cycle**. It is made up of two parts, **diastole** (relaxation) and **systole** (contraction). A heartbeat is one full completion of the cycle.

During diastole, the heart muscles relax and blood flows into all four chambers. During the first part of systole, the atria contract, pushing blood into the ventricles. During the second part of systole, the ventricles contract, pushing blood out through the aorta and the pulmonary arteries.



The Pacemaker

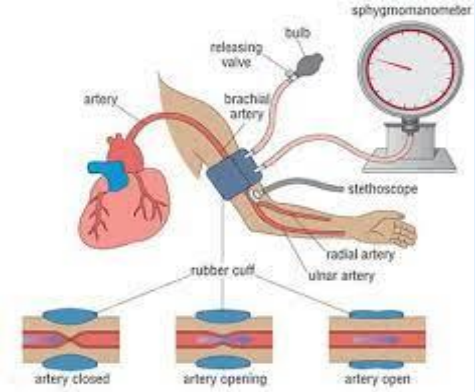


The **pacemaker**, the **SA** (sinoatrial) **node**, is a region of specialized muscle tissue located in the wall of the right atrium that can generate electrical impulses. These impulses travel through the atria, causing them to contract. When the signal reaches the **AV** (atrioventricular) **node**, it is delayed by 0.1 second, allowing the atria to empty fully, before causing the ventricles to contract and push blood out of the heart. Epinephrine and stimulants like caffeine can increase heart rate. Heart rate also increases during exercise, which allows the circulatory system to provide the body with the needed oxygen.

Blood Pressure

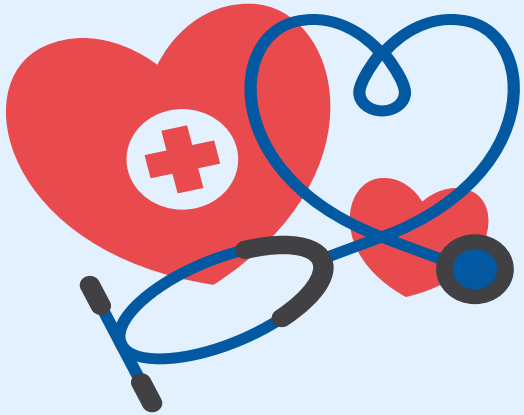
Blood pressure is the force exerted on the walls of the blood vessels by the beating of the heart. This is the main force pushing blood through the arteries and arterioles to the capillaries. Blood pressure is expressed as systolic pressure over diastolic pressure. The normal blood pressure for adults is around 120/80, and anything above 140/90 is cause for concern.

When the blood reaches the **venules**, most of the initial force has dissipated. Contraction of your skeletal muscles keeps blood flowing through your veins, even against the force of gravity.



Cardiovascular Disease

Cardiovascular diseases affect the heart and blood vessels, accounting for 40% of all deaths nationwide.
Atherosclerosis is the gradual buildup of **cholesterol** and other substances on artery walls, narrowing the passages of blood flow and increasing blood pressure, which makes arteries more vulnerable to clots.
Coronary arteries are arteries that immediately branch off from the aorta and supply the heart's muscle tissue with the oxygen. If one or more of these arteries is blocked, a **heart attack** occurs, as the heart's cells will quickly die from lack of oxygen.



What Makes Up Blood

Plasma

A yellowish liquid in blood. 55% of our blood. 90% water, 10% dissolved salts, proteins, and various other molecules being transported by the blood.

Platelets

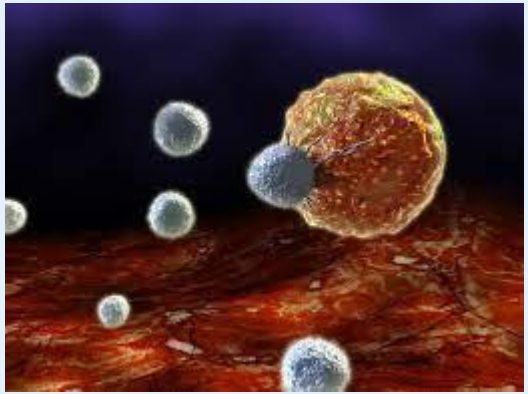
Blood clotting that occurs to prevent bleeding. Bits of membrane-wrapped cytoplasm pinched off from larger cells in the bone marrow.

What Makes Up Blood

White blood cells

01

It helps the body fight infections and diseases (leukocytes).



Red blood cells

02

Numerous types of blood cells. They transport oxygen.

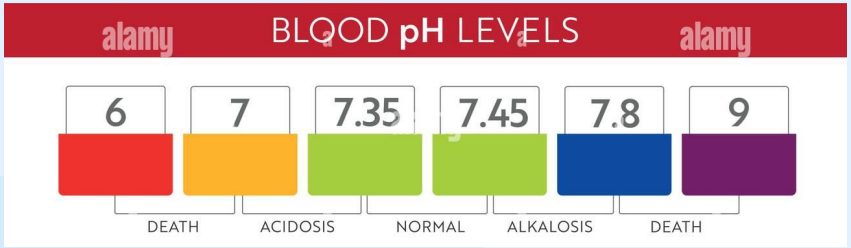
pH of Blood

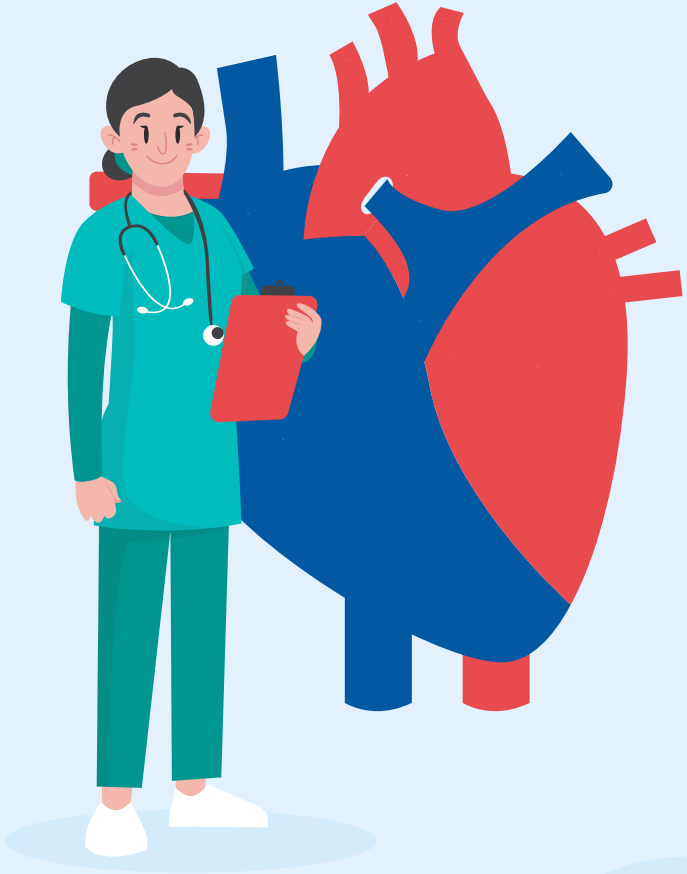
The blood must keep a pH between **7.35 and 7.45** to maintain protein stability and other chemical processes. If pH drops below this range, it's called **acidosis**. If pH exceeds this range, it's called **alkalosis**.

$$CO_2 + H_2O \longleftrightarrow H_2CO_3 \longleftrightarrow HCO_3^- + H^+$$

CO_2 is produced during cellular respiration which binds with **H_2O** in the blood to form **H_2CO_3** (carbonic acid). H_2CO_3 breaks up into **HCO_3^-** (bicarbonate) and **H^+**. This process also works in reverse, and the body tries to keep a balance of all components.

Too much CO_2 results in an increase in hydrogen ions, lowering the pH of the blood (acidosis). **Exhalation** by the lungs helps keep CO_2 levels in check.
The **kidneys** regulate the release/uptake of HCO_3 which bonds with hydrogen ions, raising the pH if it's too low. Too much HCO_3 results in a rise in pH (alkalosis).





Homework

Note taking on:

Oxygen’s surprisingly complex journey through your body - Enda Butler

How blood pressure works - Wilfred Manzano