Cardiovascular System

INTRODUCTION

The cardiovascular/circulatory system transports food, hormones, metabolic wastes, and gases (oxygen, carbon dioxide) to and from cells. Components of the circulatory system include:

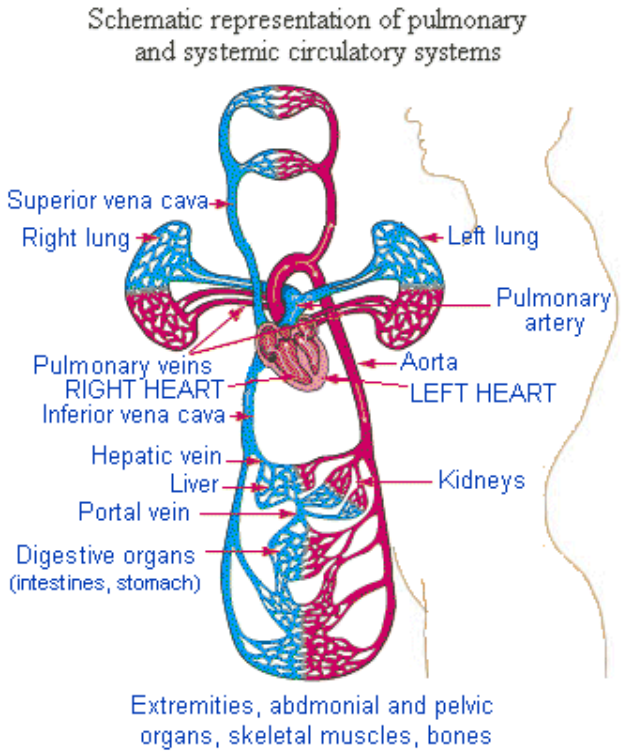
- blood: consisting of liquid plasma and cells
- blood vessels (vascular system): the "channels" (arteries, veins, capillaries) which carry blood to/from all tissues. (**Arteries** carry blood away from the heart. **Veins** return blood to the heart. **Capillaries** are thin-walled blood vessels in which gas/ nutrient/ waste exchange occurs.)
- heart: a muscular pump to move the blood

There are two circulatory "circuits": Pulmonary circulation, involving the "right heart," delivers blood **to and from the lungs**. The pulmonary artery carries oxygen-*poor* blood from the "right heart" to the lungs, where oxygenation and carbon-dioxide removal occur. Pulmonary veins carry oxygen-*rich* blood from tbe lungs back to the "left heart." *Systemic circulation*, driven by the "left heart," carries blood to the rest of the body. Food products enter the sytem from the digestive organs into the **portal vein**. Waste products are removed by the liver and kidneys. All systems ultimately return to the "right heart" via the inferior and superior vena cavae.

A specialized component of the circulatory system is the lymphatic system, consisting of a moving fluid (lymph/interstitial fluid); vessels (lymphatics); lymph nodes, and organs (bone marrow, liver, spleen, thymus). Through the flow of blood in and out of arteries, and into the veins, and through the lymph nodes and into the lymph, the body is able to eliminate the products of cellular breakdown and bacterial invasion.

Blood Components

- Forty-five percent (45%) consists of cells - platelets, red blood cells, and white blood cells (neutrophils, basophils, eosinophils, lymphocytes, monocytes). Of the white blood cells, *neutrophils* and *lymphocytes* are the most important.
- Fifty-five percent (55%) consists of plasma, the liquid component of blood.

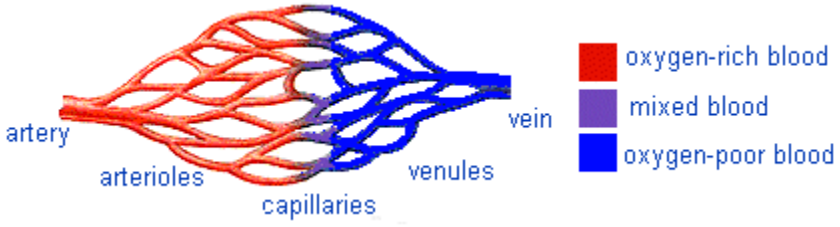


Major Blood Components

Component Type	Source	Function
Platelets, cell fragments	Bone marrow life-span: 10 days	Blood clotting
Lymphocytes (leukocytes)	Bone marrow, spleen, lymph nodes	Immunity T-cells attack cells containing viruses. B-cells produce antibodies.
Red blood cells (erythrocytes), Filled with hemoglobin, a compound of iron and protein	Bone marrow life-span: 120 days	Oxygen transport
Neutrophil (leukocyte)	Bone marrow	Phagocytosis
Plasma, consisting of 90% water and 10% dissolved materials -- *nutrients* (proteins, salts, glucose), *wastes* (urea, creatinine), *hormones*, *enzymes*		1. Maintenance of pH level near 7.4 2. Transport of large molecules (e.g. cholesterol) 3. Immunity (globulin) 4. Blood clotting (fibrinogen)

Vascular System - the Blood Vessels

Arteries, **veins**, and **capillaries** comprise the vascular system. Arteries and veins run parallel throughout the body with a web-like network of capillaries connecting them. Arteries use vessel size, controlled by the sympathetic nervous system, to move blood by pressure; veins use one-way valves controlled by muscle contractions.



Arteries

Arteries are strong, elastic vessels adapted for carrying blood **away from the heart** at relatively high pumping pressure. Arteries divide into progressively thinner tubes and eventually become fine branches called *arterioles*. Blood in arteries is oxygen-rich, with the exception of the pulmonary artery, which carries blood to the lungs to be oxygenated.

The **aorta** is the largest artery in the body, the main artery for systemic circulation. The major branches of the aorta (aortic arch, ascending aorta, descending aorta) supply blood to the head, abdomen, and extremities. Of special importance are the right and left coronary arteries, that supply blood to the heart itself.

Major Branches of Systemic Circulation

	Name	Serves
Head	Carotid	Brain & skull
Abdomen	Mesenteric	Intestines
	Celiac (Abdominal)	Stomach, liver, spleen
	Renal	Kidney
	Iliac	Pelvis
Upper Extremity	Brachial (axillary)	Upper arm
	Radial & Ulnar	Forearm & hand
	Dorsal Carpal	Fingers
Lower Extremity	Femoral	Thigh
	Popliteal	Leg
	Dorsal pedis	Foot
	Posterior tibial	Foot

Capillaries

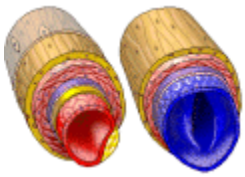
The arterioles branch into the microscopic capillaries, or *capillary beds,* which lie bathed in *interstitial fluid,* or lymph, produced by the lymphatic system. Capillaries are the points of exchange between the blood and surrounding tissues. Materials cross in and out of the capillaries by passing through or between the cells that line the capillary. The extensive network of capillaries is estimated at between 50,000 and 60,000 miles long.

Veins

Blood leaving the capillary beds flows into a series of progressively larger vessels, called *venules*, which in turn unite to form veins. Veins are responsible for returning blood **to the heart** after the blood and the body cells exchange gases, nutrients, and wastes. Pressure in veins is low, so veins depend on nearby muscular contractions to move blood along. Veins have valves that prevent back-flow of blood.

Blood in veins is oxygen-poor, with the exception of the pulmonary veins, which carry oxygenated blood from the lungs back to the heart. The major veins, like their companion arteries, often take the name of the organ served. The exceptions are the **superior vena cava** and the inferior vena cava, which collect body from all parts of the body (except from the lungs) and channel it back to the heart.

Artery/Vein Tissues



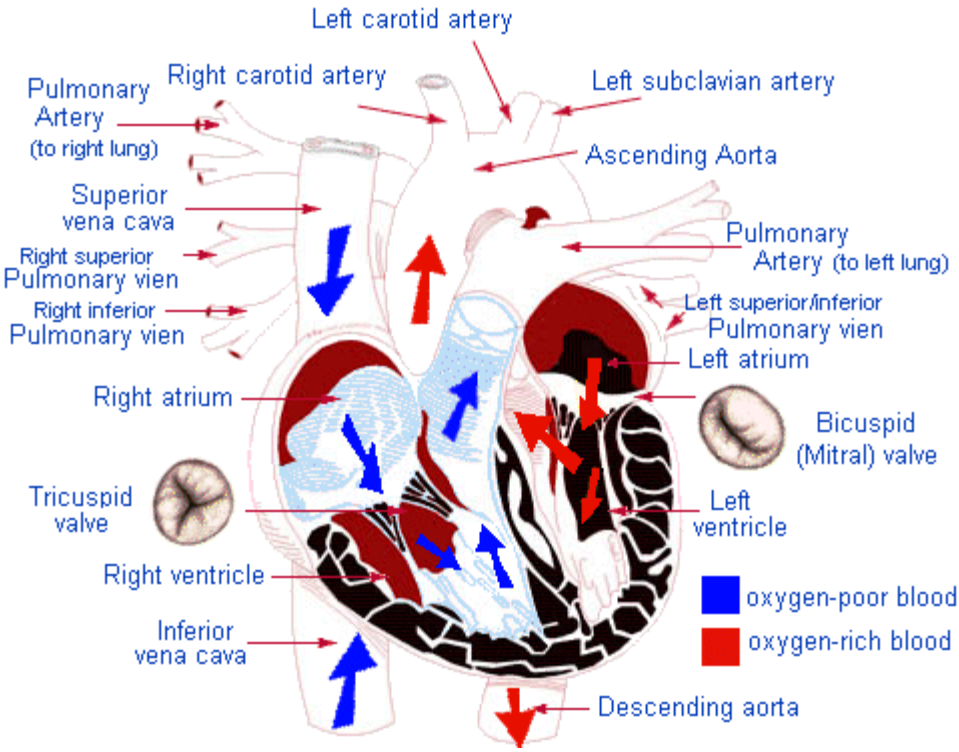
Blood vessel anatomy

Arteries and veins have the same three tissue layers, but the proportions of these layers differ. The innermost is the *intima*; next comes the *media;* and the outermost is the *adventitia*. Arteries have thick media to absorb the pressure waves created by the heart's pumping. The smooth-muscle media walls expand when pressure surges, then snap back to push the blood forward when the heart rests. Valves in the arteries prevent back-flow. As blood enters the capillaries, the pressure falls off. By the time blood reaches the veins, there is little pressure. Thus, a thick media is no longer needed. Surrounding muscles act to squeeze the blood along veins. As with arteries, valves are again used to ensure flow in the right direction.

Anatomy of the Heart

The heart is about the size of a man's fist. Located between the lungs, two-thirds of it lies left of the chest midline The heart, along with the pulmonary (to and from the lungs) and systemic (to and from the body) circuits, completely separates oxygenated from deoxygenated blood.

Internally, the heart is divided into four hollow chambers, two on the left and two on the right. The upper chambers of the heart, the atria (singular: atrium), receive blood via **veins**. Passing through valves (atrioventricular (AV) valves), blood then enters the lower chambers, the ventricles. Ventricular contraction forces blood into the arteries**.**



Oxygen-poor blood empties into the right atrium via the superior and inferior vena cavae. Blood then passes through the tricuspid valve into the right ventricle which contracts, propelling the blood into the pulmonary artery. The pulmonary artery is the only artery that carries oxygen-poor blood. It branches to the right and left lungs. There, gas exchange occurs -- carbon dioxide diffuses out, oxygen diffuses in.

Pulmonary veins, the only veins that carry oxygen-rich blood, now carry the oxygenated blood from lungs to the left atrium of the heart. Blood passes through the bicuspid (mitral) valve into the left ventricle. The ventricle contracts, sending blood under high pressure through the aorta, the main artery for systemic circulation. The ascending aorta carries blood to the upper body; the descending aorta, to the lower body.

Blood Pressure and Heart Rate

The heart beats or contracts around 70 times per minute.[1] The human heart will undergo over 3 billion contraction/cardiac cycles during a normal lifetime.

One heartbeat, or cardiac cycle, includes atrial contraction and relaxation, ventricular contraction and relaxation, and a short pause. Atria contract while ventricles relax, and *vice versa*. Heart valves open and close to limit flow to a single direction. The sound of the heart contracting and the valves opening and closing produces a characteristic "lub-dub" sound.

The cardiac cycle consists of two parts: systole (contraction of the heart muscle in the ventricles) and diastole (relaxation of the ventricular heart muscles). When the ventricles contract, they force the blood from their chambers into the arteries leaving the heart. The

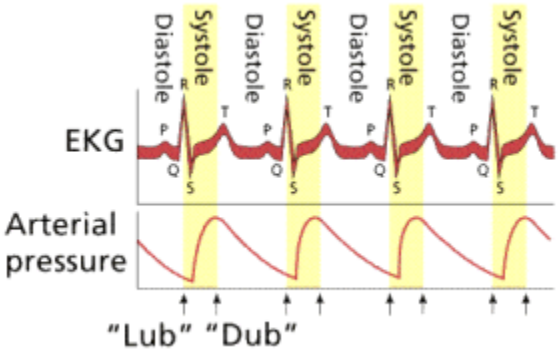
left ventricle empties into the aorta (systemic circuit) and the right ventricle into the pulmonary artery (pulmonary circuit). The increased pressure on the arteries due to the **contraction** of the ventricles (heart pumping) is called *systolic pressure*.

When the ventricles relax, blood flows in from the atria. The decreased pressure due to the **relaxation** of the ventricles (heart resting) is called *diastolic pressure*.

Blood pressure is measured in mm of mercury, with the systole in ratio to the diastole. Healthy young adults should have a ventricular systole of 120mm, and 80mm at ventricular diastole, or 120/80.

Receptors in the arteries and atria sense systemic pressure. Nerve messages from these sensors communicate conditions to the medulla in the brain. Signals from the medulla regulate blood pressure.

Electrocardiography (ECG, EKG)
An electrocardiogram measures changes in electrical potential across the heart and detects contraction pulses that pass over the surface of the heart. There are three slow, negative changes, known as P, R, and T. Positive deflections are the Q and S waves. The P wave represents atrial contraction ("the lub"), the T wave the ventricular contraction ("the dub").



The Lymphatic System
The lymphatic system functions 1) to absorb excess fluid, thus preventing tissues from swelling; 2) to defend the body against microorganisms and harmful foreign particles; and 3) to facilitate the absorption of fat (in the villi of the small intestine).

Capillaries release excess water and plasma into intracellular spaces, where they mix with *lymph,* or *interstitial fluid.* "Lymph" is a milky body fluid that also contains proteins, fats, and a type of white blood cells, called "lymphocytes," which are the body's first-line defense in the immune system.

Lymph flows from small lymph capillaries into lymph vessels that are similar to veins in having valves that prevent backflow. Contraction of skeletal muscle causes movement of

the lymph fluid through valves. Lymph vessels connect to lymph nodes, lymph organs (bone marrow, liver, spleen, thymus), or to the cardiovascular system.

- Lymph nodes are small irregularly shaped masses through which lymph vessels flow. Clusters of nodes occur in the armpits, groin, and neck. All lymph nodes have the primary function (along with bone marrow) of producing lymphocytes.
- The spleen filters, or purifies, the blood and lymph flowing through it.
- The thymus secretes a hormone, thymosin, that produces T-cells, a form of lymphocyte.