Medical Physics

Physics of Cardiovascular System

Lecture Six

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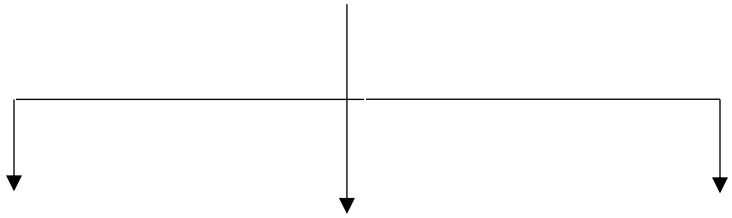
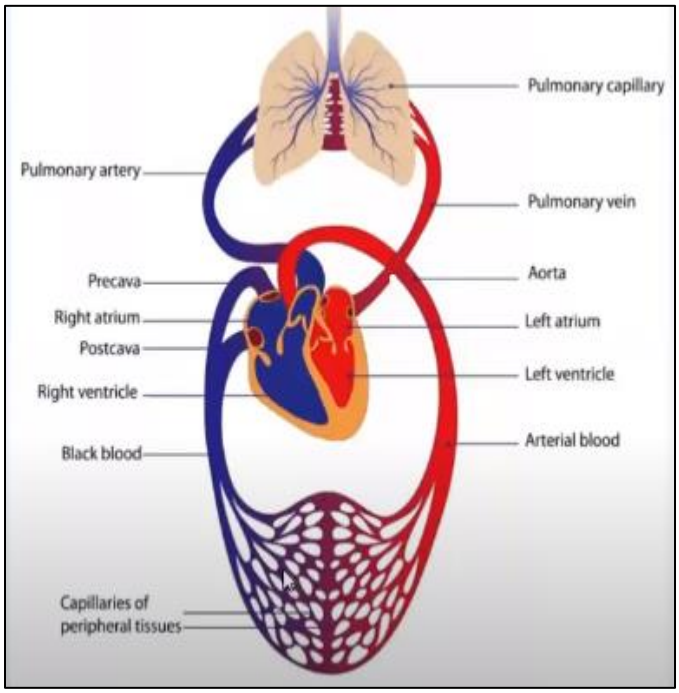
Cardiovascular system CVS



Heart Blood Vessel



The cardiovascular system (CVS) has important functions:

- Supply energy (fuel from food).
- Supply O_2 from the air we breathe.
- Dispose of by-products of combustion (mostly CO_2, H_2O, heat)

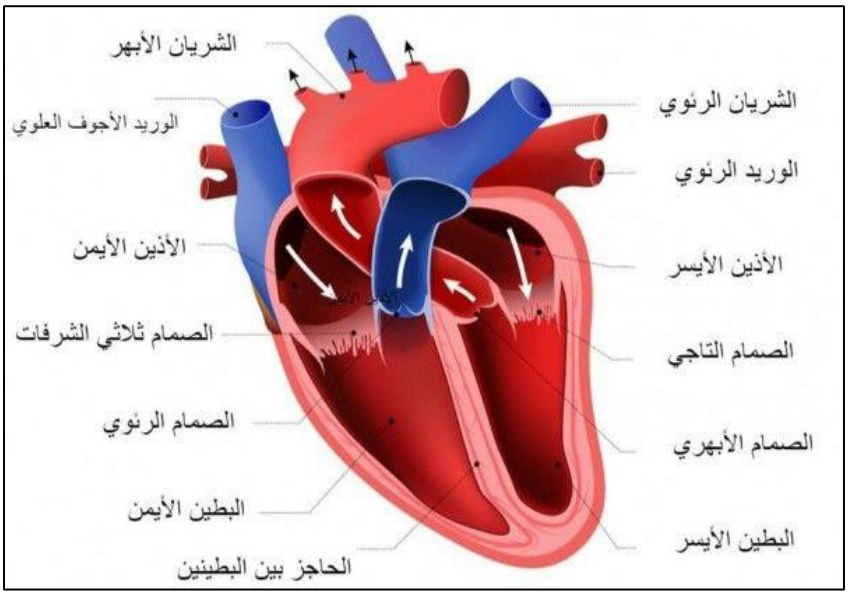
Heart:-

The heart is a double pump, it provides the force needed to circulate the blood through the two major circulatory systems:-

1. The pulmonary circulation in the lungs.

2. The systemic circulation in the rest of the body.

The heart has a system of valves that, if functioning properly, permit the blood to flow only in the correct direction. If these valves become diseased and do not open, or else properly the pumping of the blood becomes insufficient.



Blood:-

The blood is pumped by contraction of the heart muscle, from left ventricle at pressure of 125 mm Hg into a system of arteries that subdivided into smaller and smaller arteries and finally into a very fine

meshwork of vessels called the capillary bed. During the few seconds it is in capillary bed the blood supplies O_2 to the cells and picks up CO_2 from the cells.

To the eye blood appears to be a red liquid slightly thicker than water. When examined by various physical techniques it is found to consist of several different components.

Blood cells: contain 45% of the volume of blood.

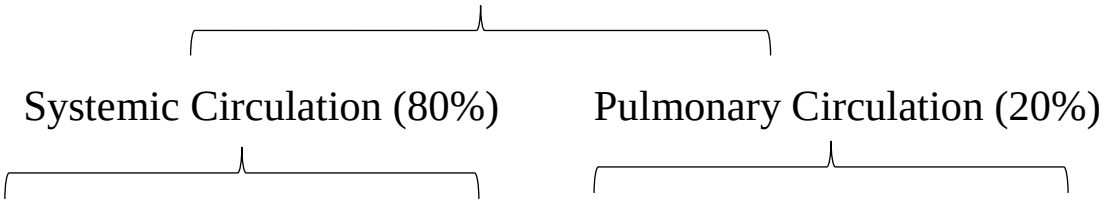
- **The red blood cells (erythrocytes)** is caused the red color of blood.
- **The white blood cells (leukocytes)** present in small amounts.
- **Platelets** are involved in the clotting function of blood.

Plasma: a nearly clear fluid called blood plasma accounts for the other 55%.

Blood represents about 7% of the body mass or about (4.5 liters) in a 64kg person.

The blood volume is not uniformly divided between the pulmonary and systemic circulation, but it is:

Blood Circulation (100%)



Arteries	Capillaries	Veins	Arteries	Capillaries	Veins
(15%)	(10%)	(75%)	(46.5%)	(7%)	(46.5%)

Vessels:-

The vascular system consists of arteries, veins and capillaries.

In a typical adult, each contraction of the heart muscles forces about 80ml (about one-third of a cup) of blood through the lungs from the right ventricle and a similar volume to the systemic circulation from the left ventricle.

Work done by the heart

The work done W by a pump working at a constant pressure P is equal to the product of the pressure and the volume pumped ΔV:

W= P ΔV

While W in erg

P in dyne/cm^2

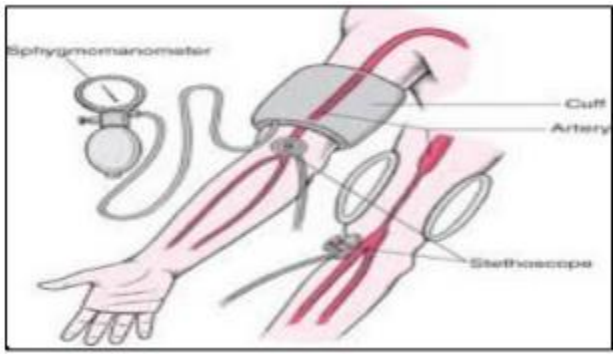
ΔV in cm^3

1joule=107 erg

We can estimate the physical work done by the heart by multiplying its average pressure by the volume of blood that is pumped.

Blood pressure and its measurement

The instrument that is commonly used is called a sphygmomanometer. It consists of a pressure cuff and gauge on the upper arm and a stethoscope placed over the brachial artery at the elbow.



The static blood pressure can be calculated from the law:

P= ρ h g

ρ :density of blood.

h: height of blood column.

g: gravity acceleration.

The density of blood = 1.04 g/cm^3

The density of mercury = 13.6 g/cm^3

The physics of some heart diseases

- Blood pressure disease: for example, high blood pressure (hypertension) causes muscle tension to increase in proportion to the pressure.
- A fast heart rate (tachycardia) the workload the amount of time the heart muscles spend contracting increases.

To reduce the workload of the heart, bed rest and O_2 therapy are prescribed. Giving O_2 increases the O_2 in the blood so that less blood must be pumped to the tissues.

- **Heart valve defects** are of two types, the valve either does not open enough (stenosis) or it does not close well enough (insufficiency)
- **Heart attack:**

Is caused by a blockage of one or more arteries to the heart muscle.