Cardiovascular System

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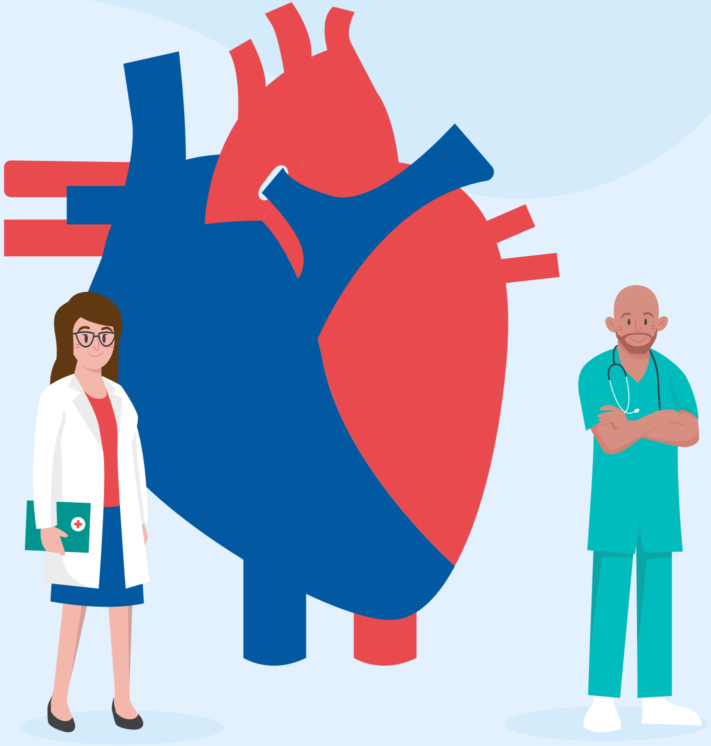

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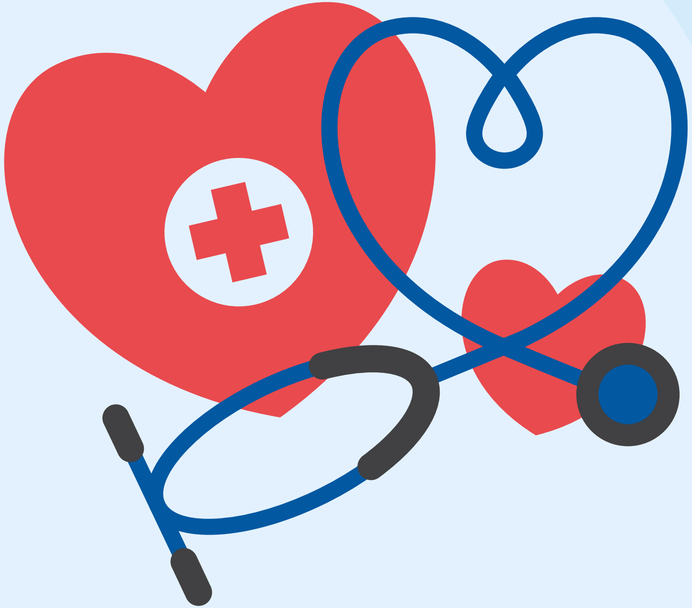
Overview



Final Exam

05

Cardiovascular System

06

Electrical Properties of Body

07

Sound, Hearing, Speech

07

Light & Vision

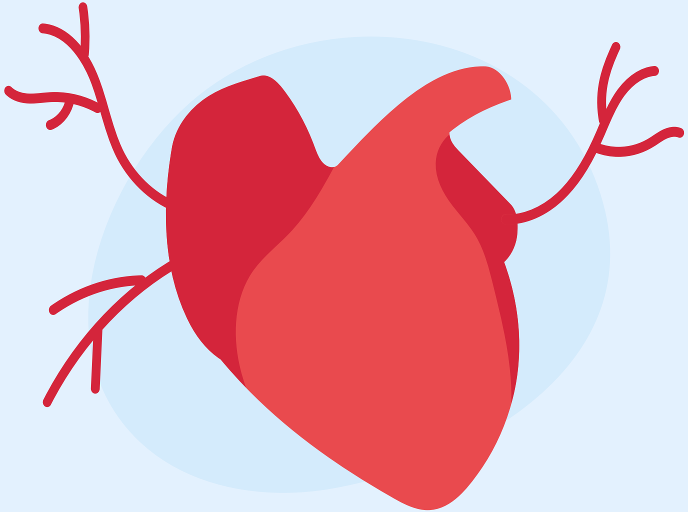
About the system itself

Structure

Disease

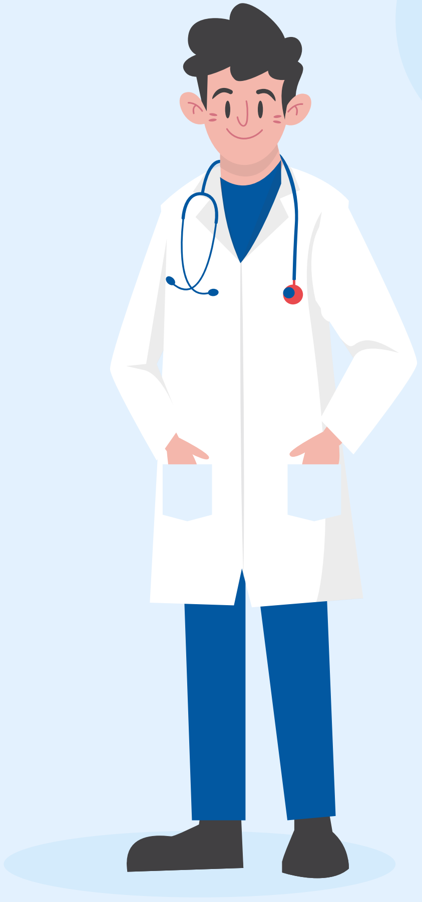
Introduction

There are three components of the cardiovascular system. (a) Blood is the vehicle for transport. It transports fuel from the digested food to the cells, transports oxygen from the air in the lungs so it can combine with fuel to release energy, and it disposes of waste products – such as carbon dioxide from the fuel engine and other metabolic wastes. (b) The circulatory system is the distribution system, and consists of a series of branched blood vessels. (c) The heart is the four-chambered pump composed mostly of cardiac muscle that enables this circulatory flow. General descriptions of the cardiovascular system can be found in.



“Heat, vital spirit, nerves all come from arteries.”

—William Harvey



Functions of the cardiovascular system

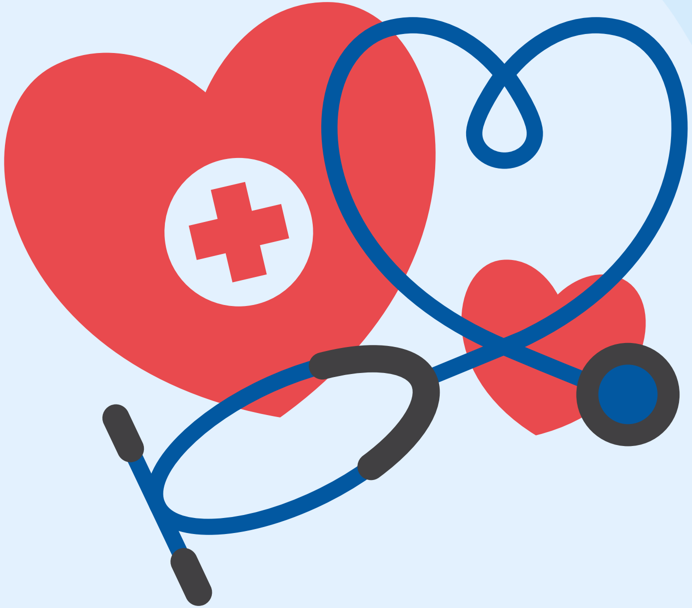
Transfer of oxygen from food to tissues

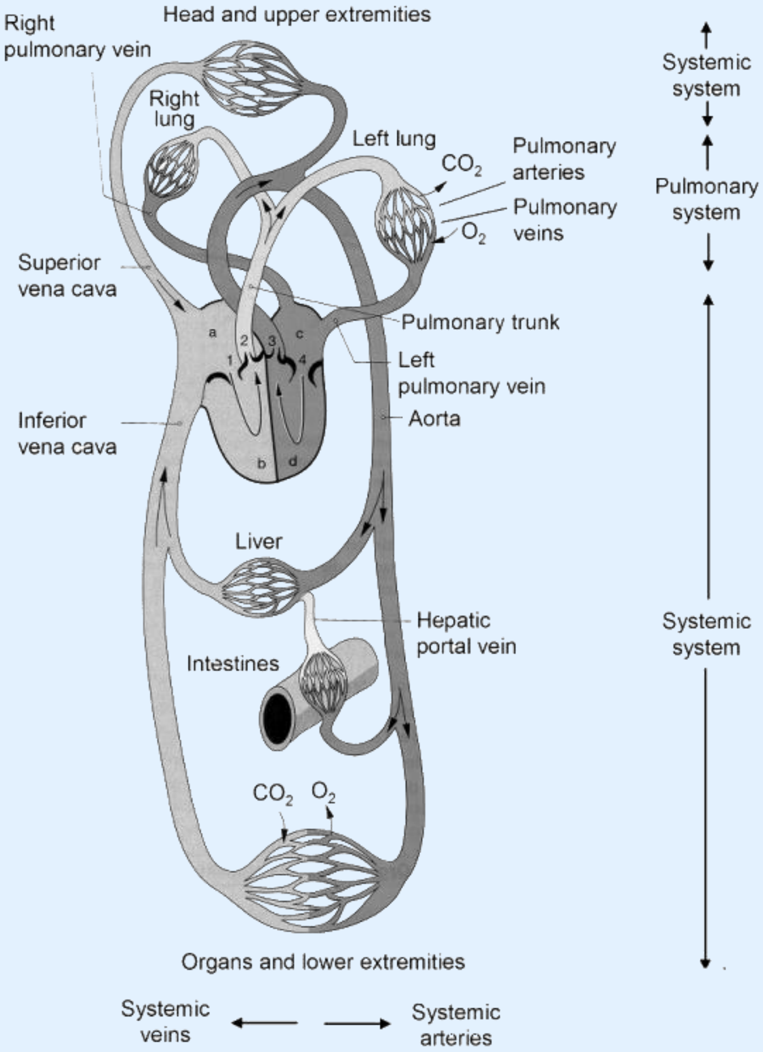
Collection of carbon dioxide and waste materials from tissues

Body temperature regulation

02

Generals





Circulation!

Blood circulation system, and labeled within the heart: the (a) right atrium, (b) right ventricle, (c) left atrium, (d) left ventricle, (1) right atrioventricular (tricuspid) valve, (2) pulmonary semilunar valve, (3) aortic semilunar valve, (4) left atrioventricular (bicuspid, mitral) valve.

Subsystems of the cardiovascular system

80%

Systemic Circulation

Starting from the aorta to feed the systemic capillaries

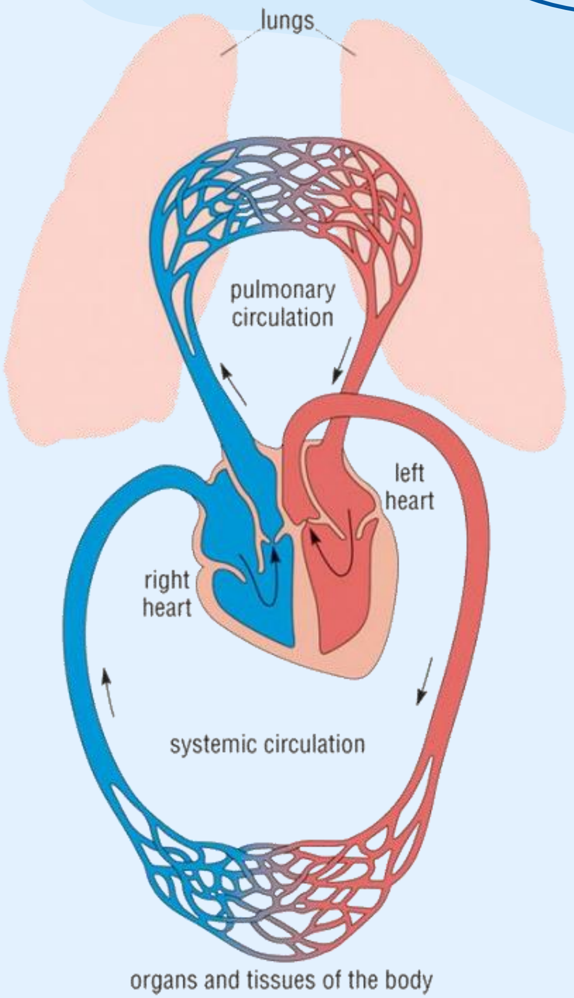
80% of the blood volume

20%

Pulmonary Circulation

Starting from the pulmonary artery to feed the pulmonary capillaries

20% of the blood volume



Prevention

Atrio-Ventricular (AV) Valves

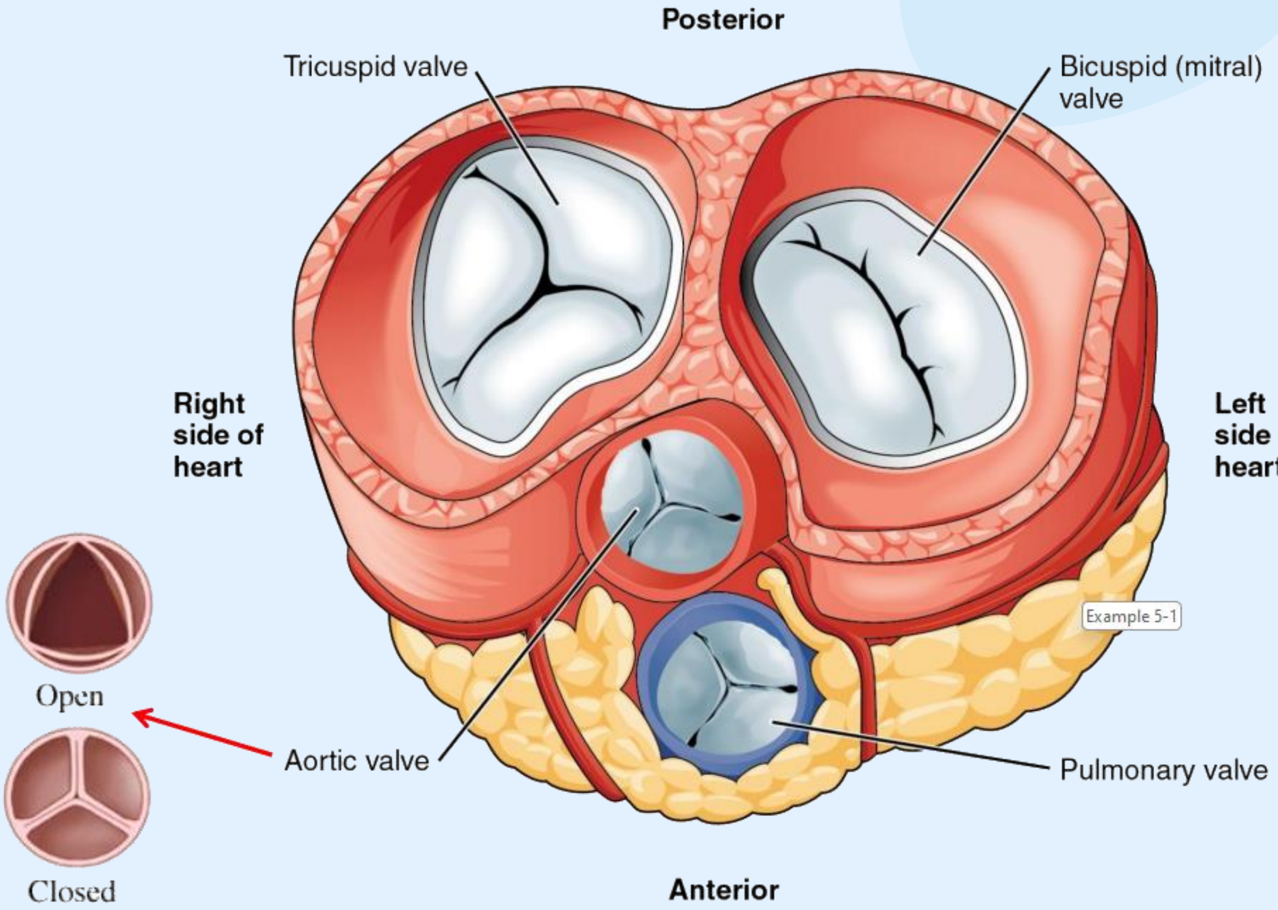
01

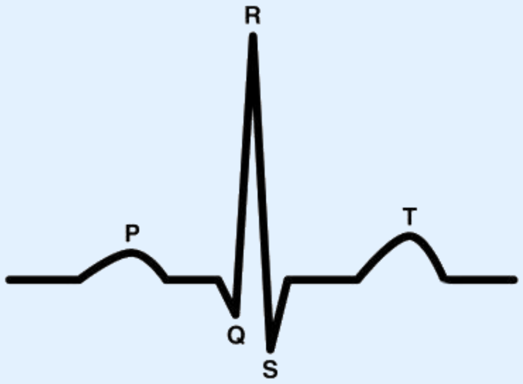
Between atrium and right ventricle: **Tricuspid**
Between atrium and left ventricle: **Bicuspid or Mitral**

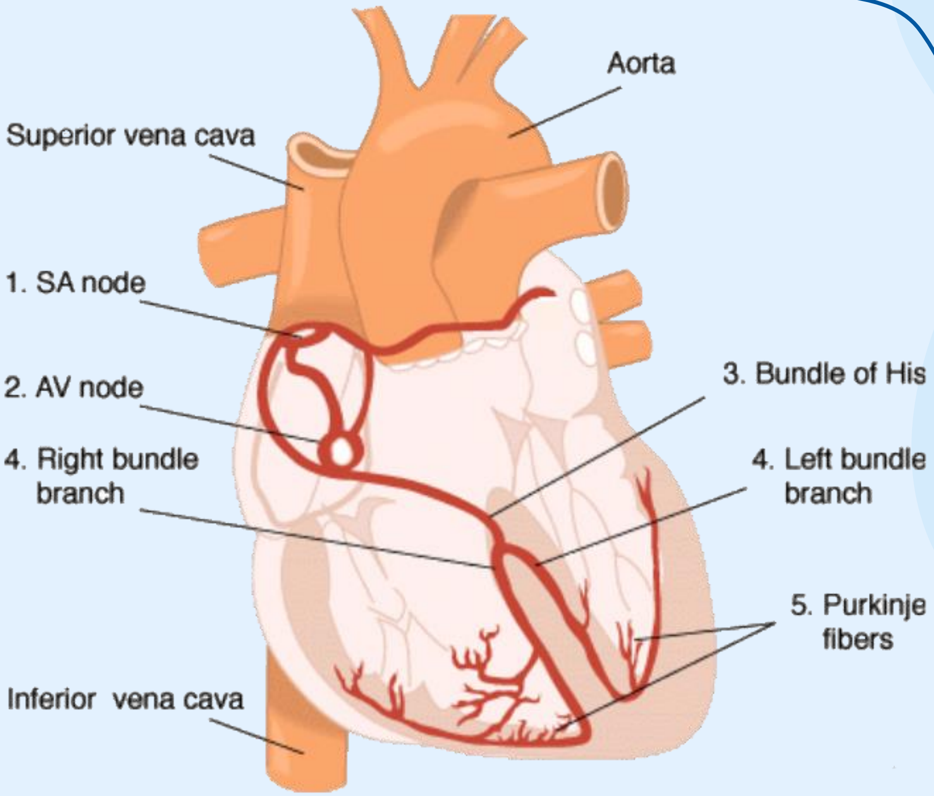
SemiLunar (SL) Valves

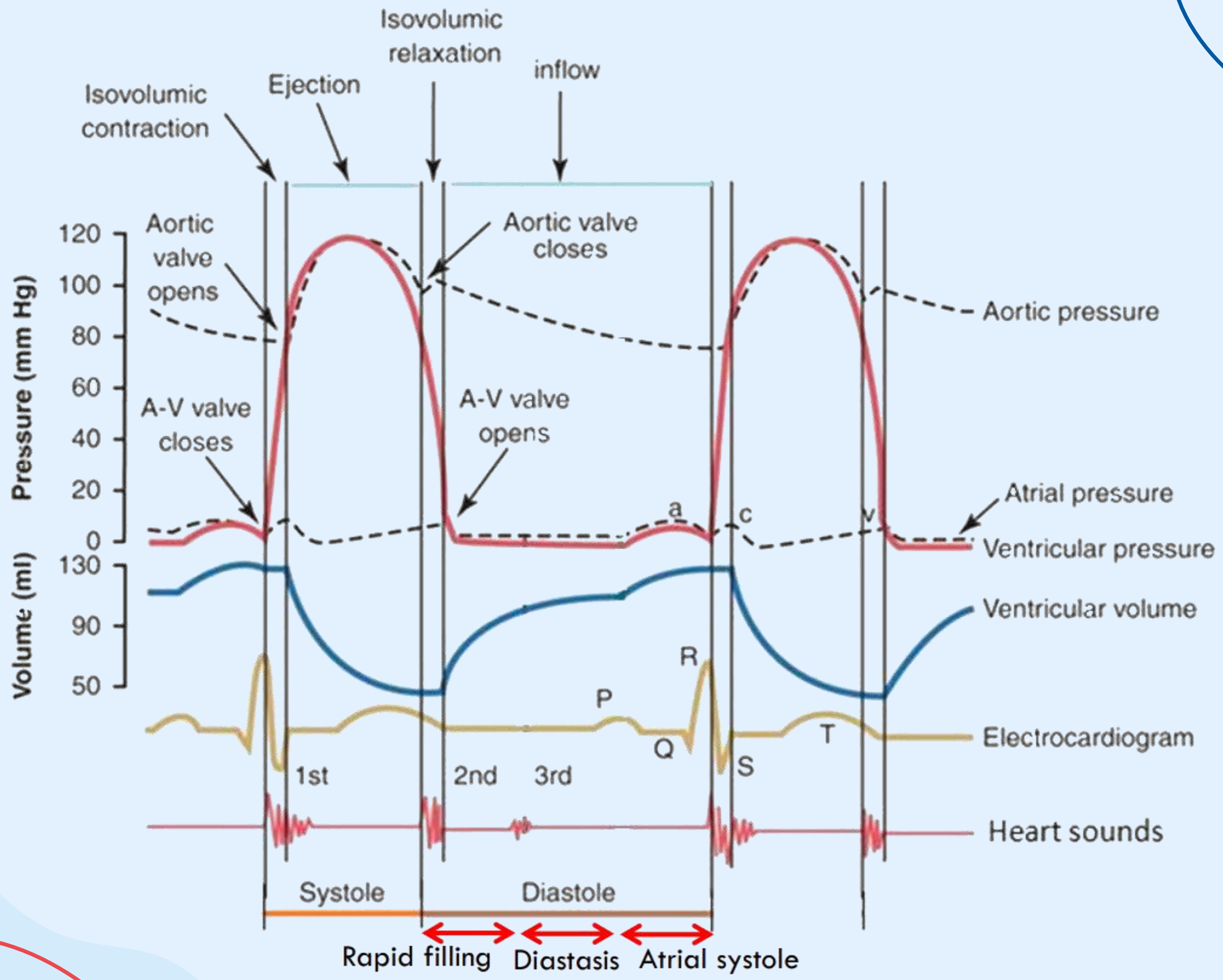
02

Between the right ventricle and the pulmonary artery: **pulmonary semilunar**
Between the left ventricle and the aorta: **aortic semilunar**

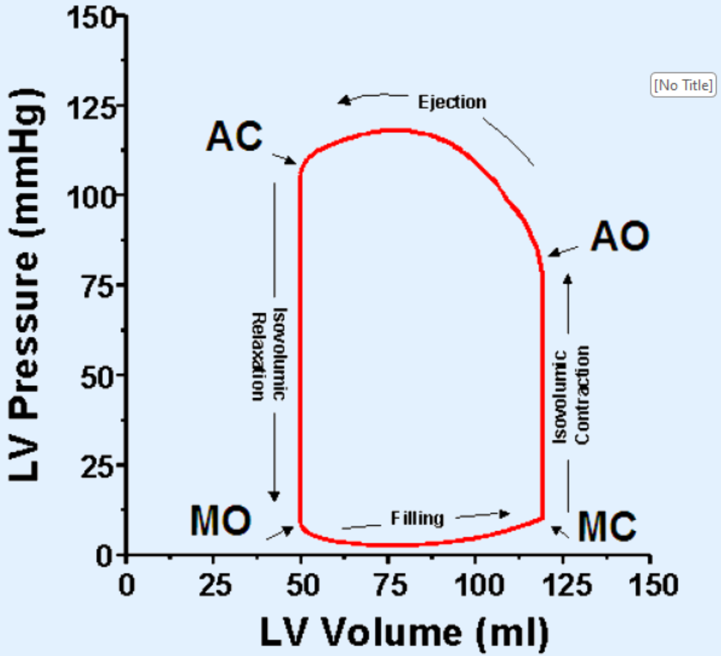

Posterior
Tricuspid valve
Bicuspid (mitral) valve
Right side of heart
Left side of heart
Example 5-1
Open
Closed
Aortic valve
Pulmonary valve
Anterior

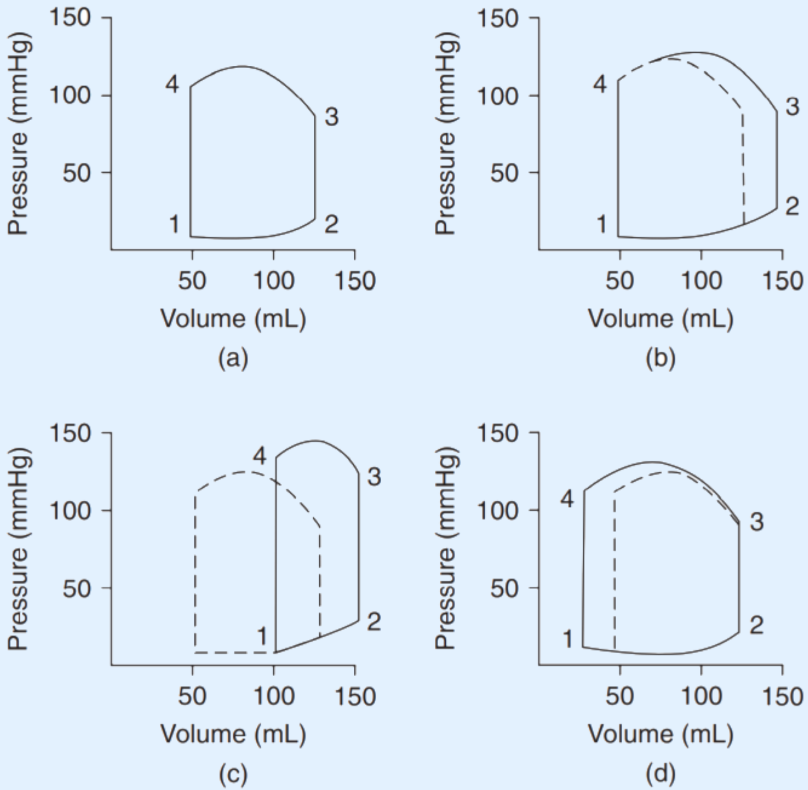

R
P
T
Q
S


Aorta
Superior vena cava
1. SA node
2. AV node
4. Right bundle branch
3. Bundle of His
4. Left bundle branch
5. Purkinje fibers
Inferior vena cava



Isovolumic relaxation
inflow
Ejection
Isovolumic contraction
Aortic valve opens
Aortic valve closes
Aortic pressure
A-V valve closes
A-V valve opens
Atrial pressure
Ventricular pressure
Ventricular volume
Electrocardiogram
Heart sounds
Pressure (mm Hg)
120
100
80
60
40
20
0
Volume (ml)
130
90
50
a
c
v
P
Q
R
S
T
1st
2nd
3rd
Systole
Diastole
Rapid filling
Diastasis
Atrial systole

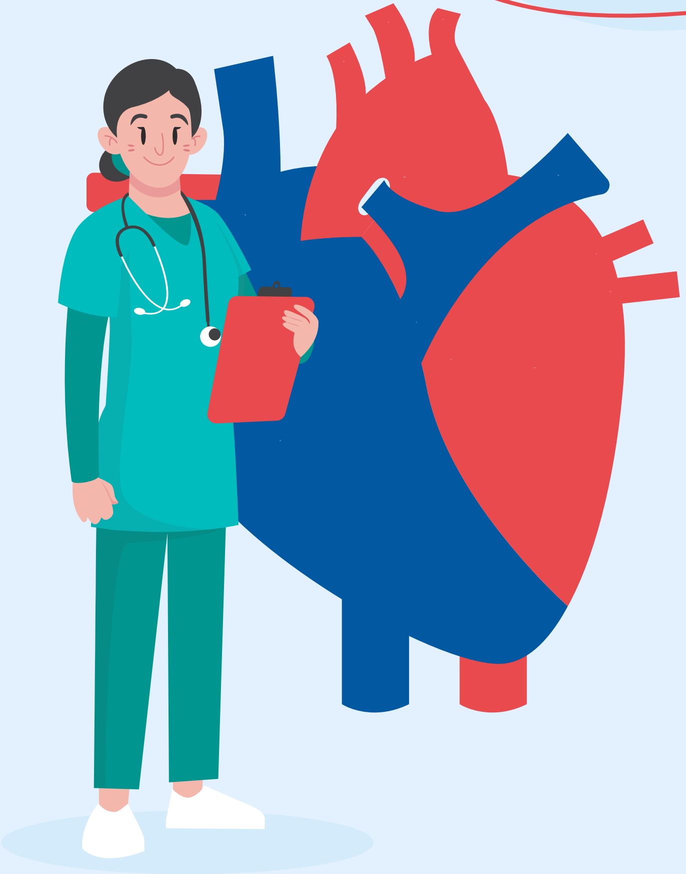

LV Pressure (mmHg)
150
125
100
75
50
25
0
0
25
50
75
100
125
150
LV Volume (ml)
AC
AO
MO
MC
Ejection
Isovolumic Relaxation
Isovolumic Contraction
Filling
[No Title]



Pressure (mmHg)
150
100
50
50
100
150
Volume (mL)
4
3
1
2
(a)
(b)
(c)
(d)

Arterial Compliance

$$C = \frac{\Delta A}{\Delta p} = \frac{2\pi r^3}{Eh}$$



Some useful formulas

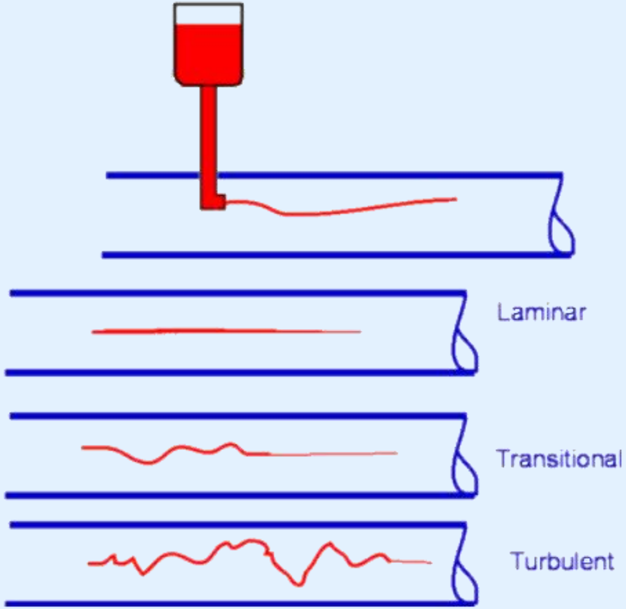
$$Q = A_1.V_1 = A_2.V_2 = const.$$

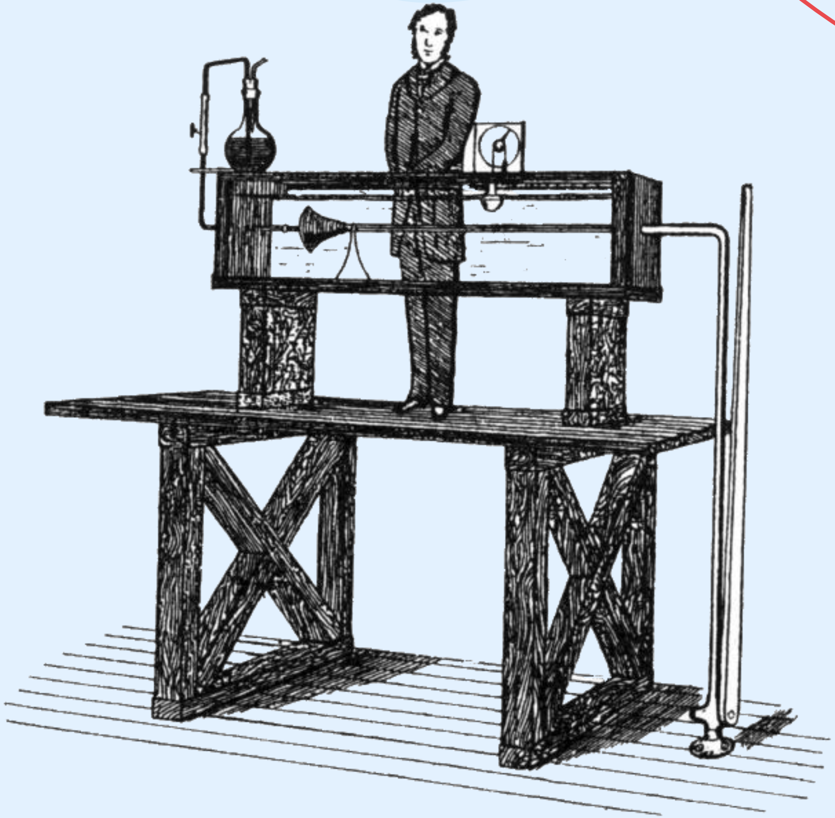
Bernoulli's eqn.

$$P_1 + \frac{1}{2}\rho V_1^2 + \rho g h_1 = P_2 + \frac{1}{2}\rho V_2^2 + \rho g h_2$$

Poiseuille's eqn.

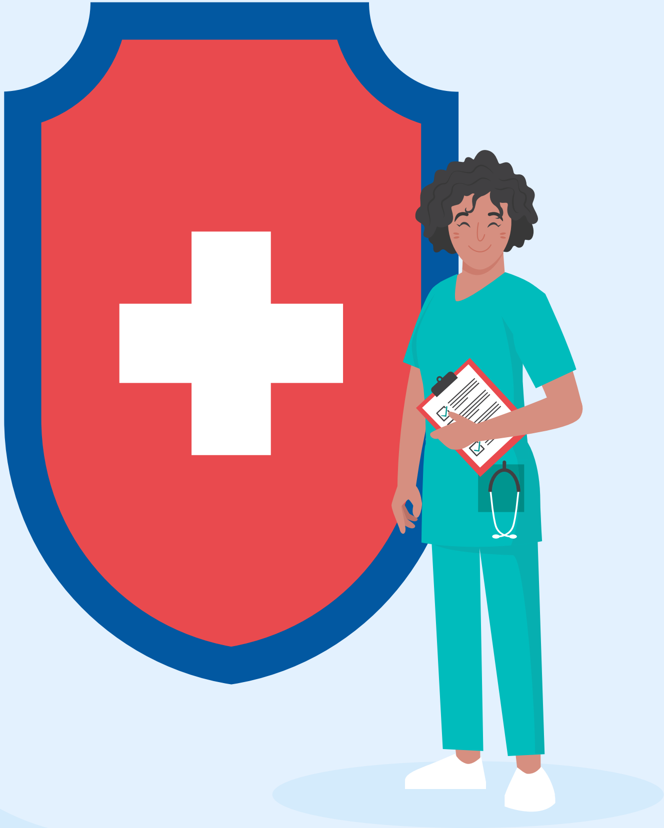
$$Q = \frac{\Delta P \times \pi \times R^4}{8\mu L} \rightarrow \Delta P = Q \times \frac{8\mu L}{\pi \times R^4}$$



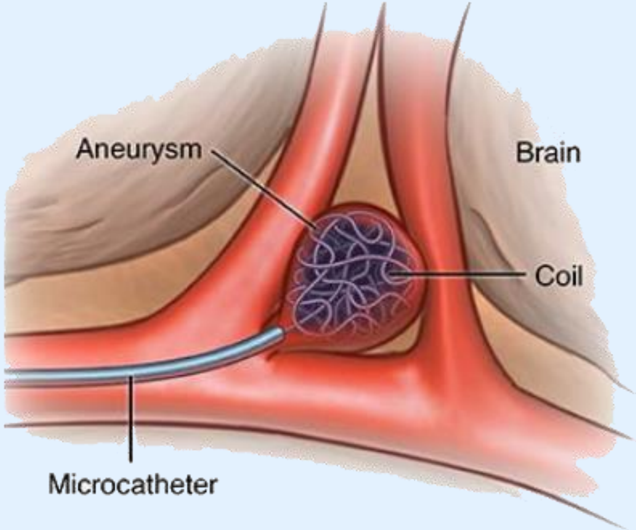


Reynolds number

$$Re = \frac{\rho V D}{\mu}$$

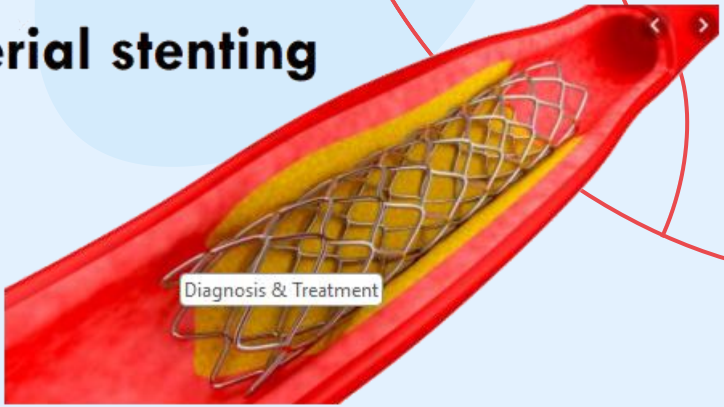


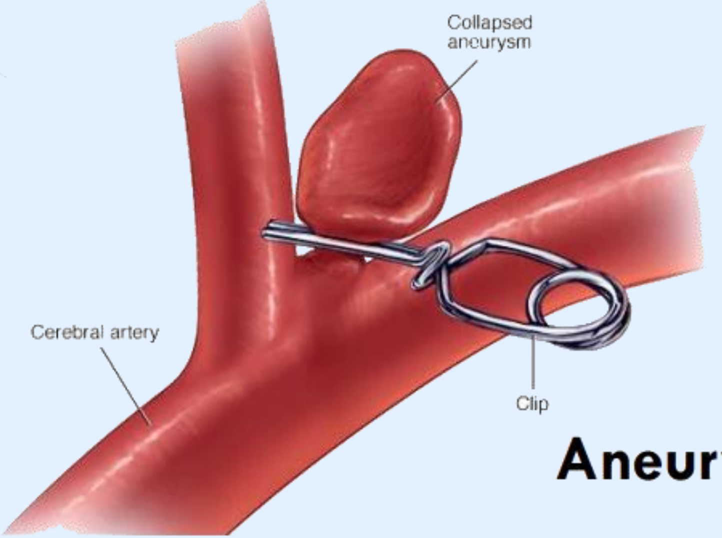
Diagnosis & Treatment



Aneurysm Coiling

Arterial stenting

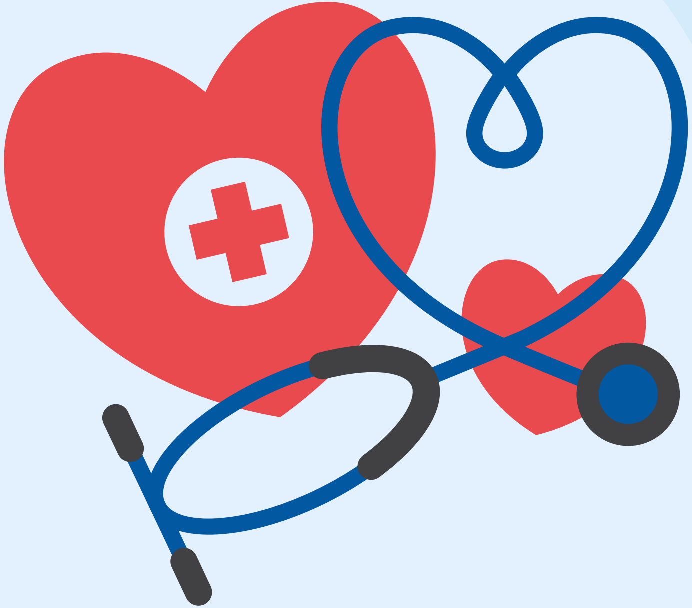




Aneurysm Clipping

03

Examples



Example 5-1

If the diameter of an arteriole is changed from 100 μm to 80 μm, find the percentage change in blood flow due to this change.

Example 5-1

Answer:

$$\frac{\Delta Q}{Q_1} = \frac{Q_2 - Q_1}{Q_1} = \frac{Q_2}{Q_1} - 1 = \left(\frac{R_2}{R_1}\right)^4 - 1 = \left(\frac{80}{100}\right)^4 - 1 = 0.4 - 1 = -0.6$$

It is reduced by 60%

$$Q = \frac{\Delta P \times \pi \times R^4}{8\mu L}$$

Example 5-2

The radius of the aorta in an adult human is about 1 cm. What is the maximum speed so that the blood flow Reynolds number is not more than 1000?

Example 5-2

Answer:

$$Re = \frac{\rho v d}{\mu} \rightarrow v_{max} = \frac{1000 \times 4 \times 10^{-3}}{1000 \times 2 \times 10^{-2}} = 0.2 \left(\frac{m}{s}\right)$$

Example 5-3

If the radius of the artery is 3 mm and it is closed by a plaque and reaches a radius of 2 mm. The average speed is 0.5 m/s. Find the average speed in the closed area. What is the type of flow in two states?

Example 5-3

Answer:

$$Q = const \rightarrow A_1 \times V_1 = A_2 \times V_2$$

$$\pi(3^2) \times \frac{1}{2} = \pi(2)^2 \times V_2 \rightarrow V_2 = \frac{9}{8} = 1.125 \left(\frac{m}{s}\right)$$

$$\left.\begin{aligned} Re &= \frac{\rho v d}{\mu} \\ \rho &= 1060 \frac{kg}{m^3} \\ \mu &= 4 \times 10^{-3} \end{aligned}\right\} \begin{aligned} &1 \quad Re = \frac{1060 \times \left(\frac{1}{2}\right) \times (6 \times 10^{-3})}{4 \times 10^{-3}} = 795 \\ &2 \quad Re = \frac{1060 \times \left(\frac{9}{8}\right) \times (4 \times 10^{-3})}{4 \times 10^{-3}} = 1192.5 \end{aligned}$$

Both flows are slow!!

Example 5-4

If the average power consumed by the heart is equal to 10 watts and the daily caloric intake of a person is equal to 2500 kcal, what percentage of the daily energy intake is spent on heart function?

Example 5-4

Answer:

$$10\ W = 10\frac{J}{s} \rightarrow daily\ 10\left(\frac{J}{s}\right) \times (24 \times 3600s) = 864\ \times 10^3 J$$

$$2500\ kcal = 2500\ \times 4.19 = 10475\ kJ = 10.475\ MJ$$

$$\Longrightarrow \frac{864\ \times 10^3}{10.475\ \times 10^6} = 0.082\ \rightarrow 8.2\%$$

Example 5-5

If the volume of blood pumped by the heart is equal to 8×10^{-8} cubic meters per second and the average blood pressure is equal to 13 kilopascals, calculate the power of the heart in this movement.

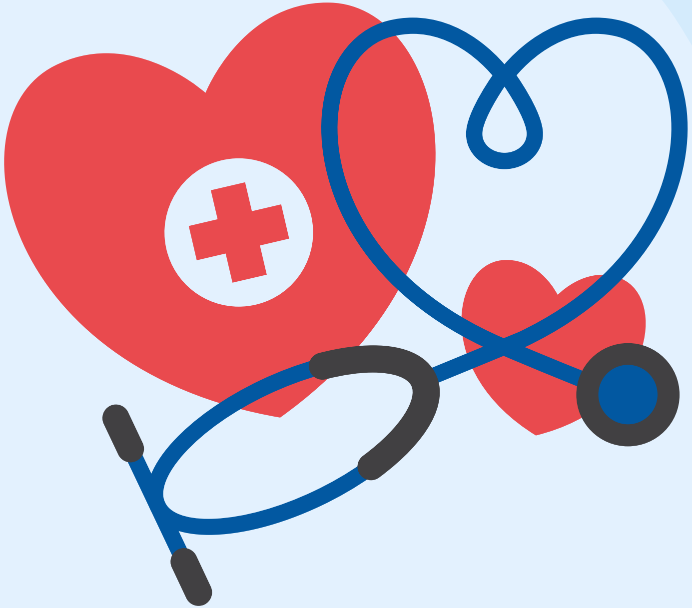
Example 5-5

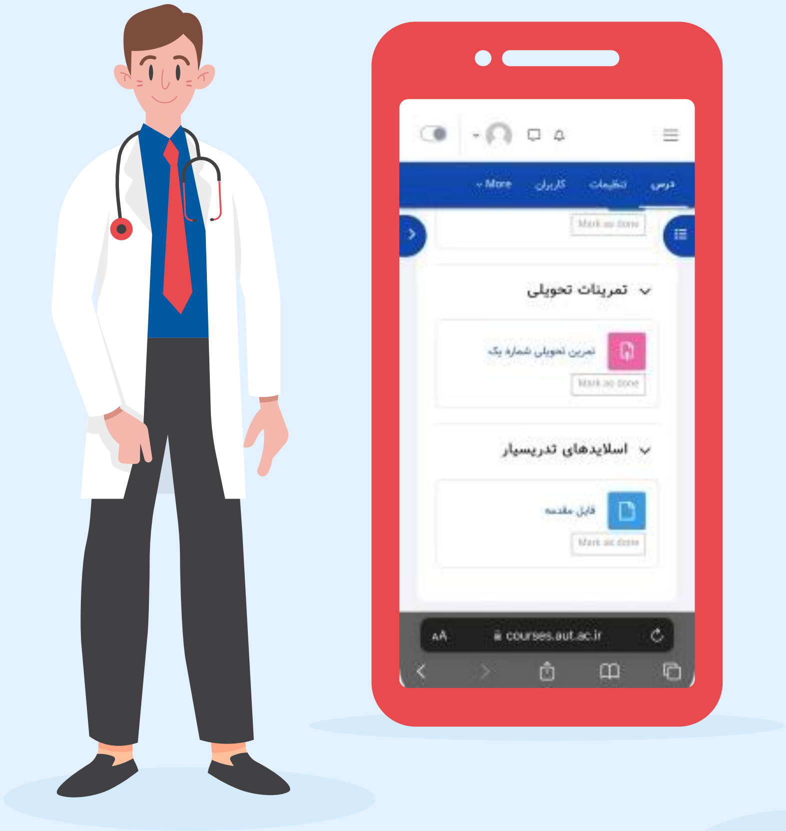
Answer:

$$Power = \frac{W}{t} = \frac{P \times \ \Delta V}{t} = 13 \times 10^{3} \times 8 \times 10^{-5} = 1.04\ \left(\frac{J}{s}\right)$$

04

Assignment

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HWh04

HWc04

Have a Healthy Heart

Resources

Dr. Malikeh Nabaei:

- Slides
- Classes

Faezeh Jahani:

- Slides

biological and medical physics, biomedical engineering

- The reference book

Thanks!

Does anyone have any questions?

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Have a good afternoon