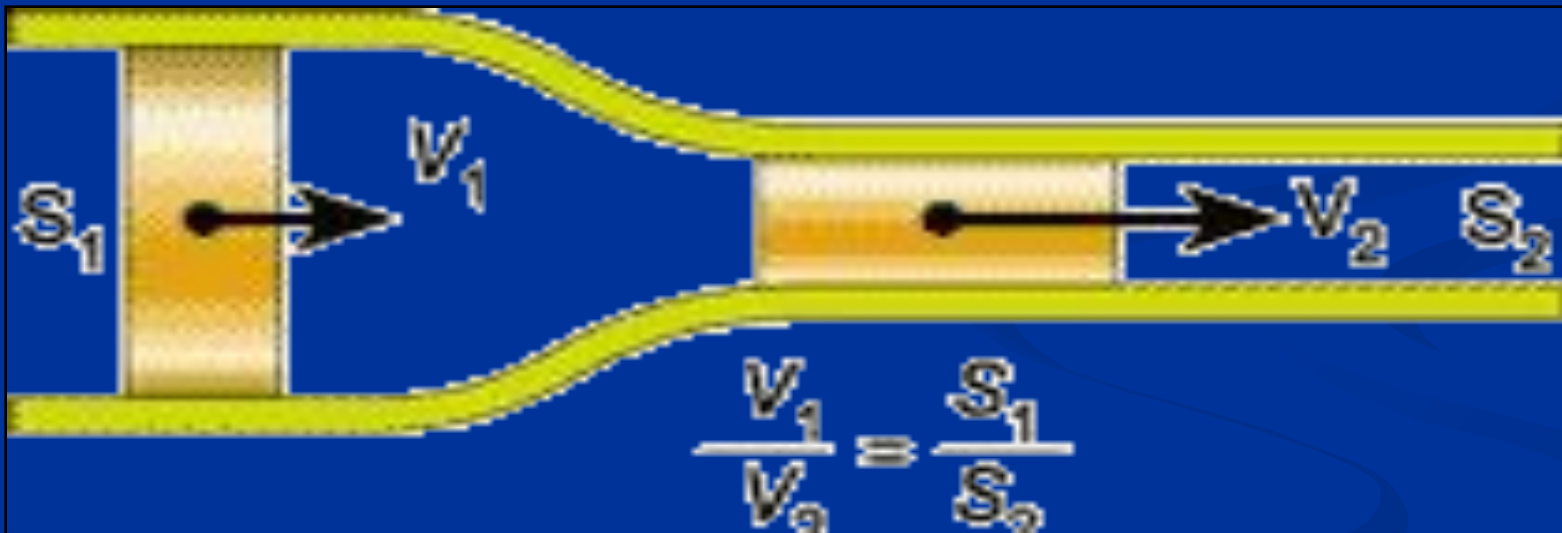# Basis of hydro- and hemodynamics
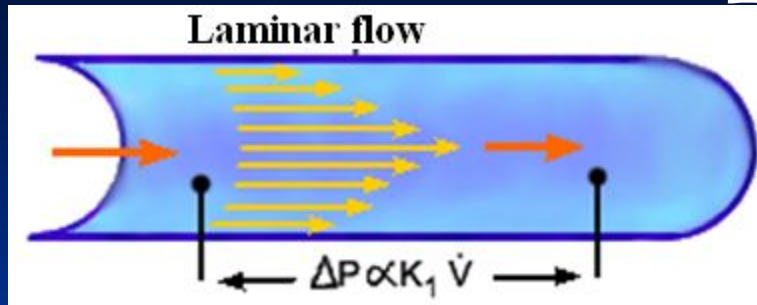
Hydrodynamics
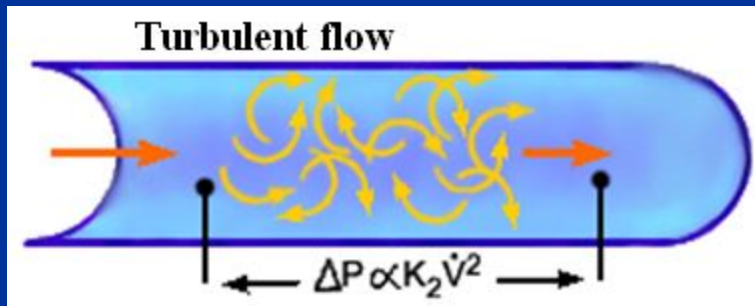
- The branch of physics, studying flow of ideal and real liquids.

LAMINAR AND TURBULENT FLOW

Laminar flow

$$\Delta P \propto K_1 \dot{V}$$
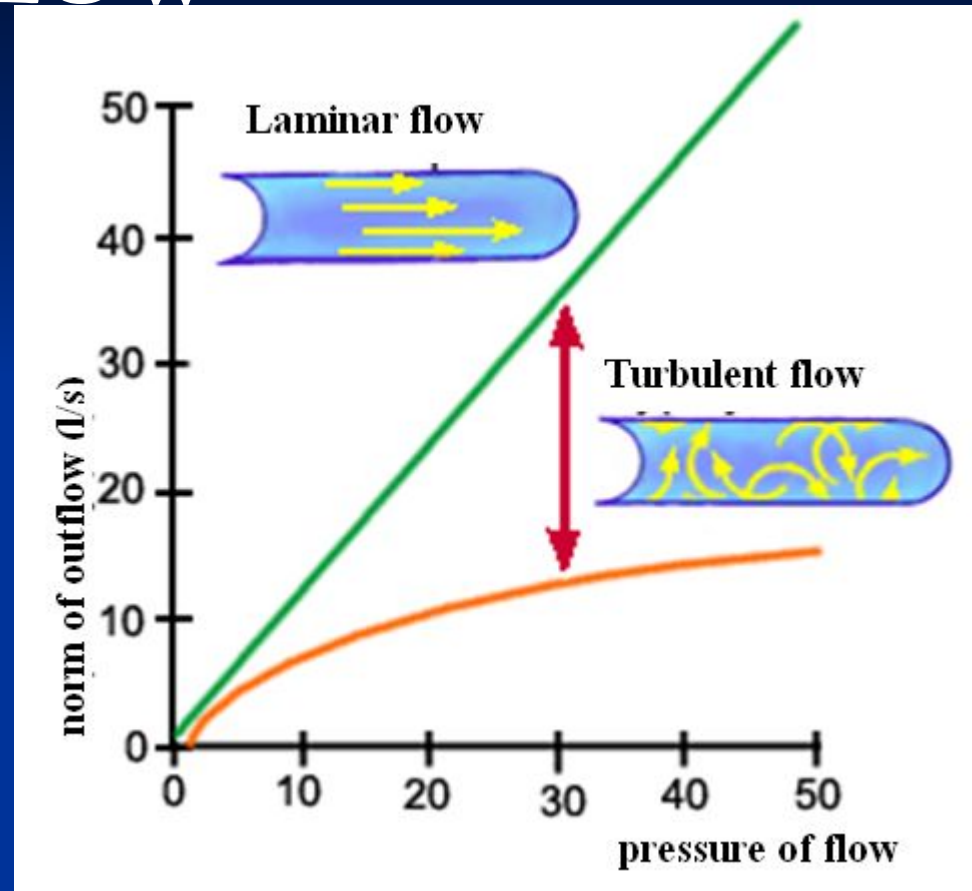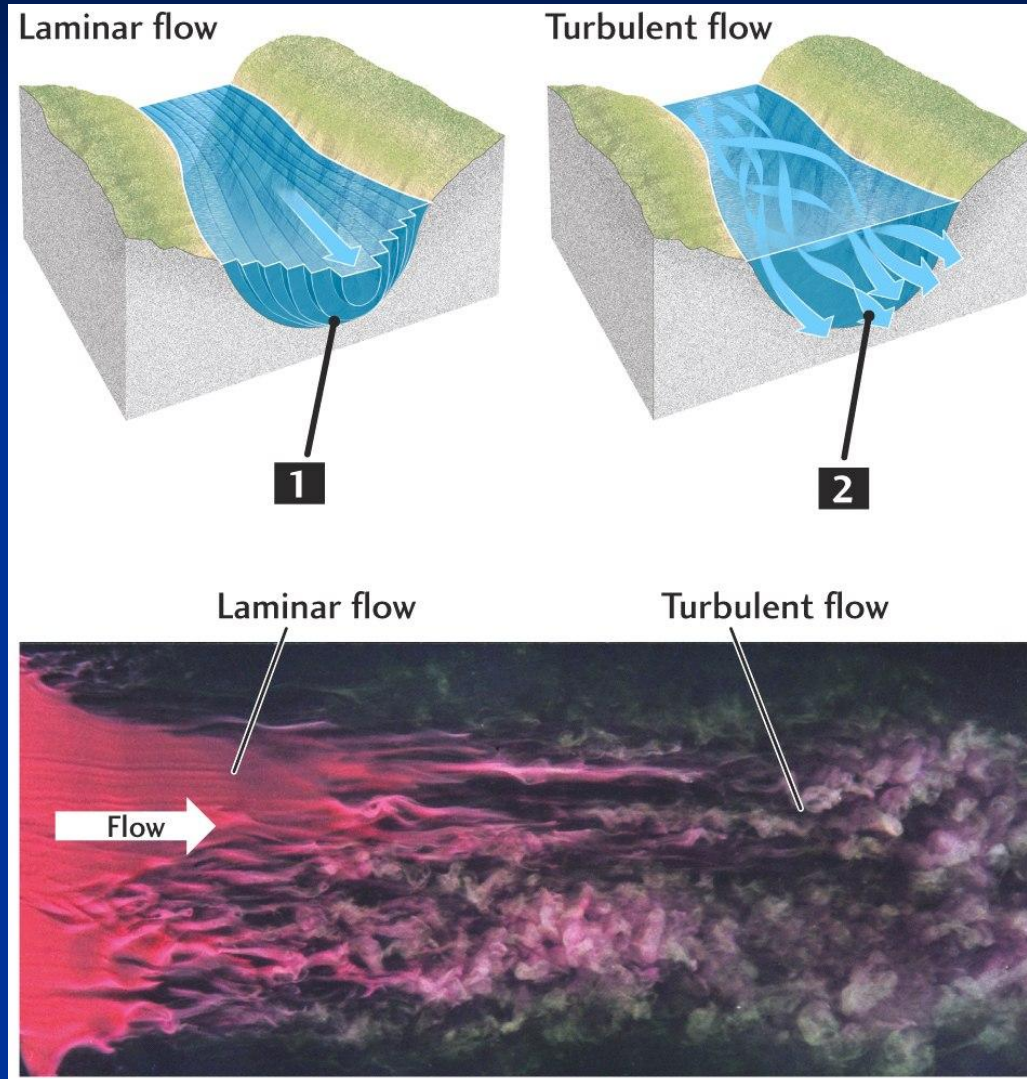
Laminar flow (lat. lamina - plate, lamella) – a flow where gas or liquid moves by layers, not mixing .

Turbulent flow

$$\Delta P \propto K_2 \dot{V}^2$$

Laminar flow

Turbulent flow

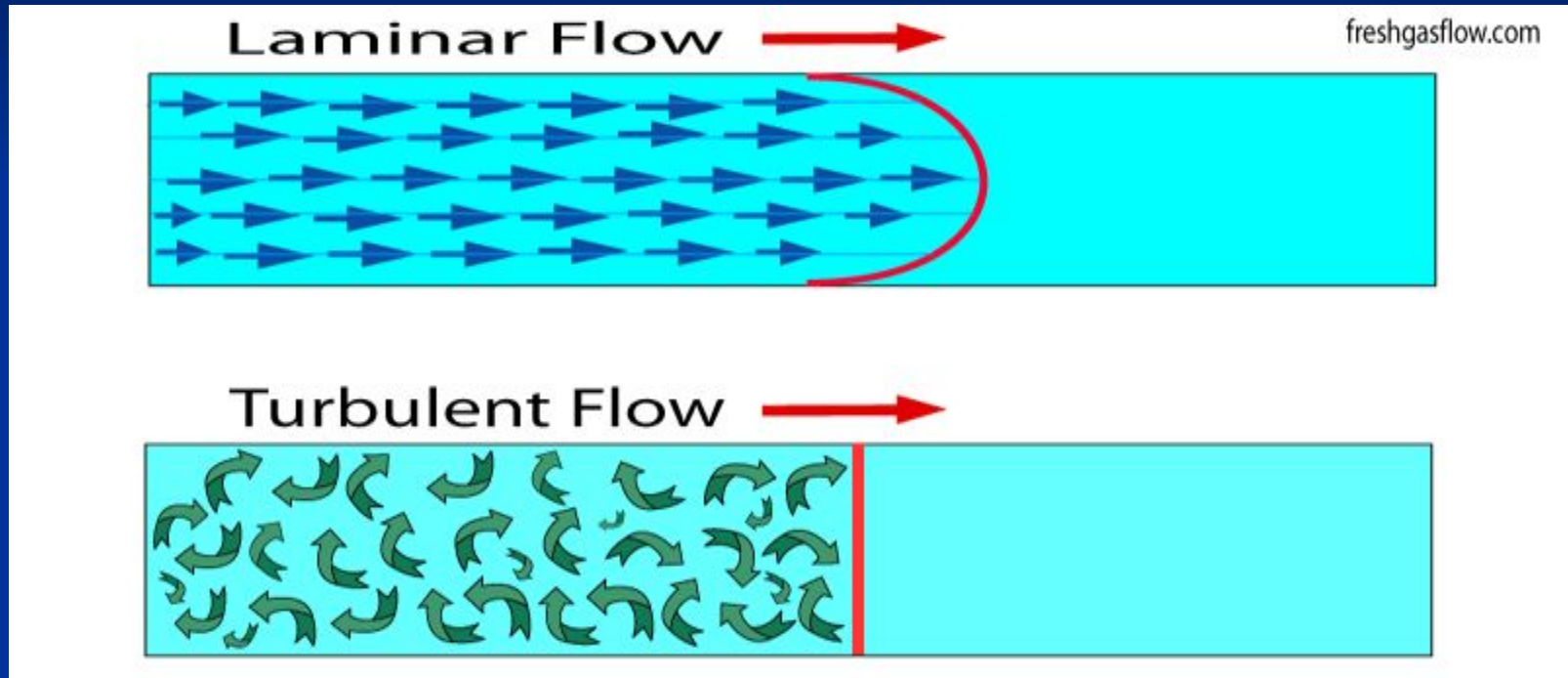norm of outflow (l/s)

pressure of flow

Turbulent flow – is a flow where gas or liquids move on a high speed, the layers mix.

LAMINAR AND TURBULENT FLOW

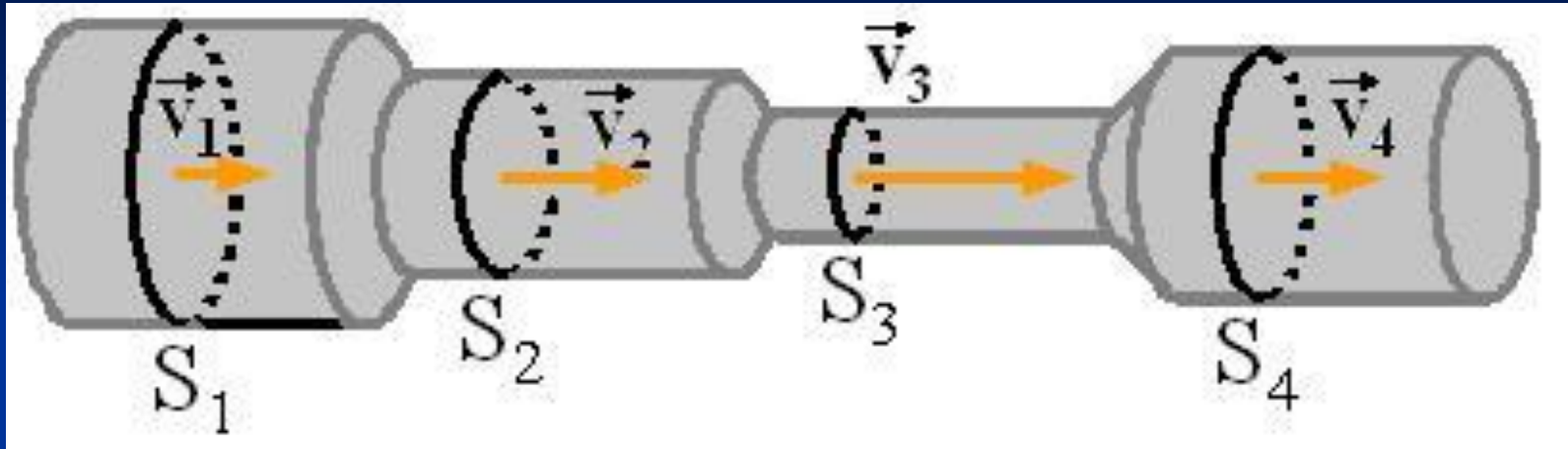# LAMINAR AND TURBULENT FLOW

Equation of continuity

S*V=const

Volume velocity (flow) (Q) – characterizes the volume amount of substance, going through the crossection of flow per unit of time
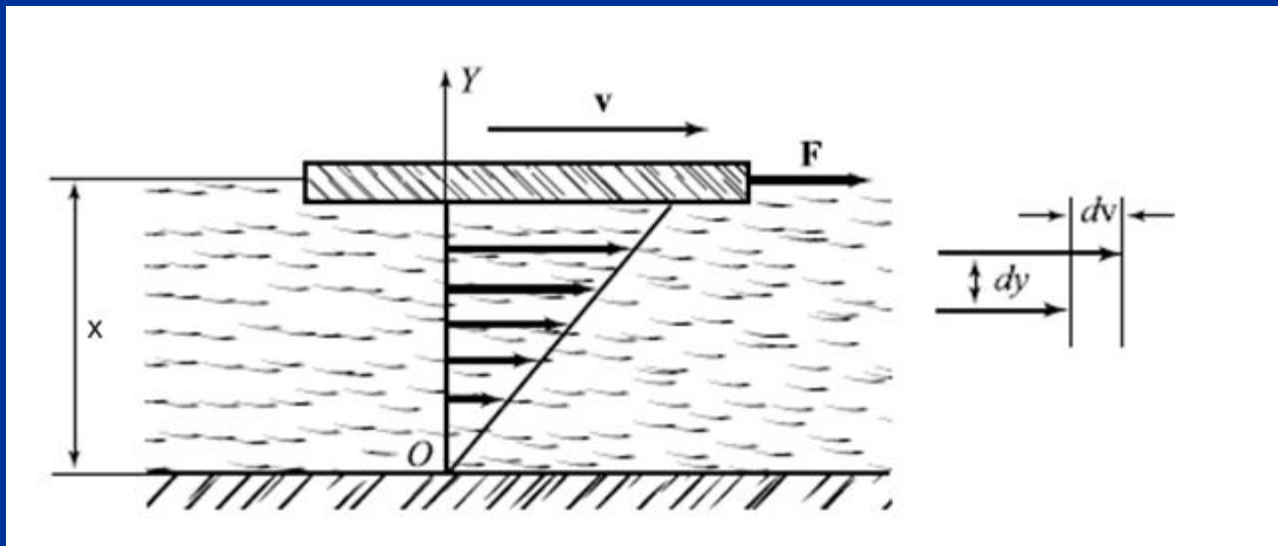
$Q_1 = Q_2$ Q=S*V

Q1=S1*v1
Q2=S2*v2

S1*v1=S2*v2

VISCOSITY OF LIQUIDS

■   The main law of flow viscosity was presented by I. Newton.

$$F = -\eta \cdot \frac{d\upsilon}{dx} \cdot S$$

Newton's experiment

Reynold's number

Where d – linear size, v – flow velocity, η - viscosity, ρ – density

$$Re = \frac{v\,d\,\rho}{\eta}$$

Reynold's number doesn't have a unit. It shows the laminar or turbulent flow it is.

Poiseuille law

$$Q = \frac{(P_1 - P_2) \cdot \pi \cdot r^4}{8 \cdot \eta \cdot l}$$

the law which expresses the relationship between the rate of flow of a liquid in a tube and the pressure gradient in the tube, the radius of the tube, the length of the tube and the viscosity of the liquid. This law is used only for laminar flow.
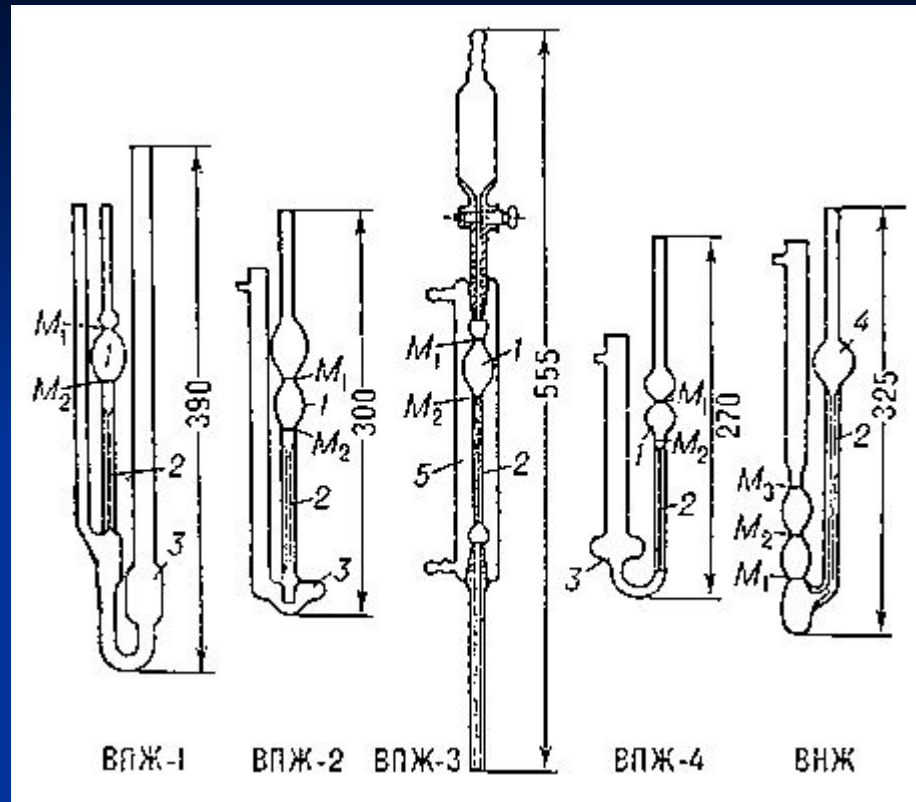
BLOOD VISCOSITY MEASUREMENT

Viscometer - (from lat. viscosus - viscous) instrument for determining the viscosity of the substance. Viscosity is measured
in puazah (Pa * s). Viscosimeters are: capillary, rotational, with
the falling ball. Capillary viscometer:
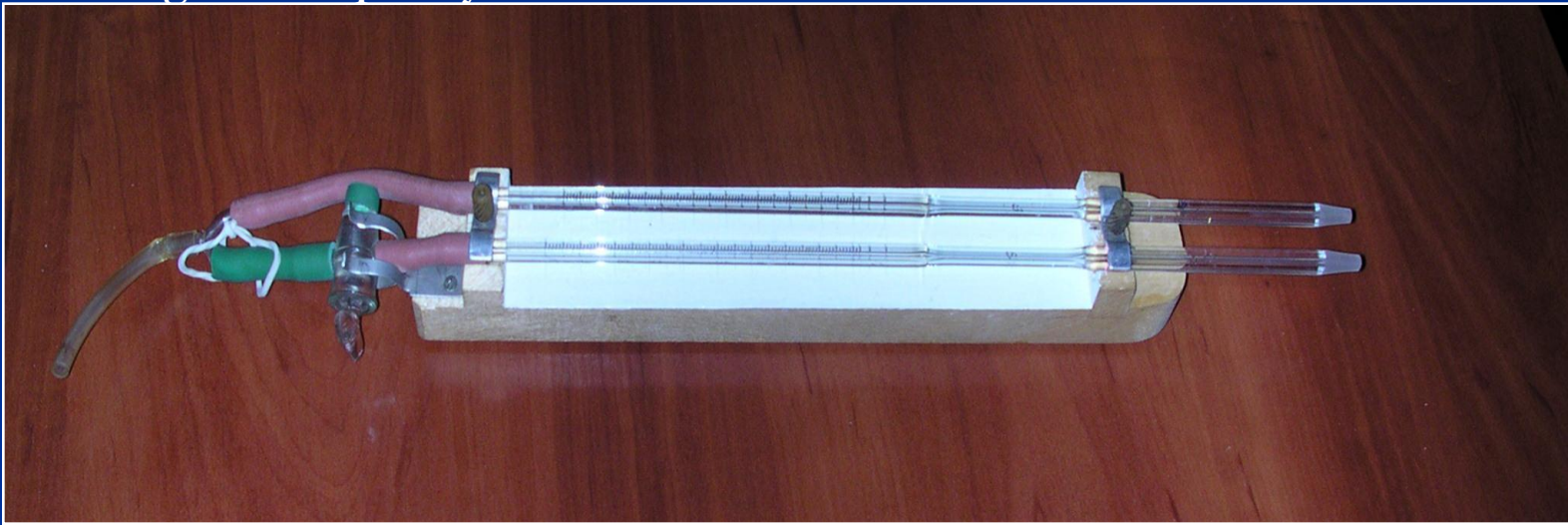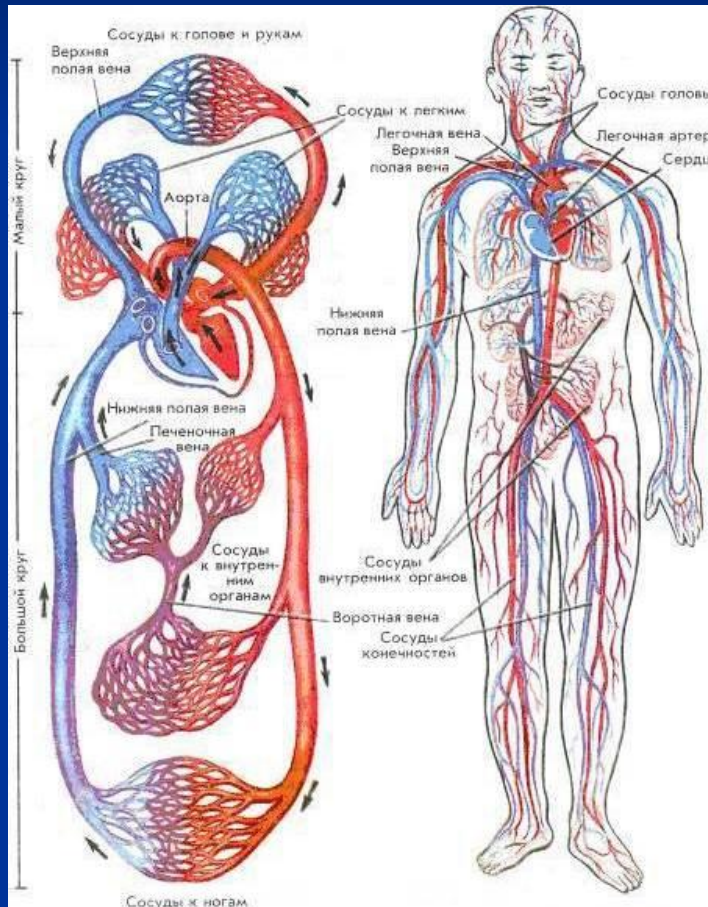

Viscometer **BK-4**

$$Q = \Delta P \frac{\pi r^4}{8 \eta L}$$

Viscometer kinds

Glass capillary viscometers : 1 — measuring tank; 2 — capillaries; 3 — receiving vessels; 4 — supply tank (for opaque fluids viscometer ВНЖ); 5 — thermostatic cover; M1, M2 (for ВНЖ also M3) — marks for measurement of time, needed for fluid to outgo the tanks or to fill them (for ВНЖ).

Hemodynamics
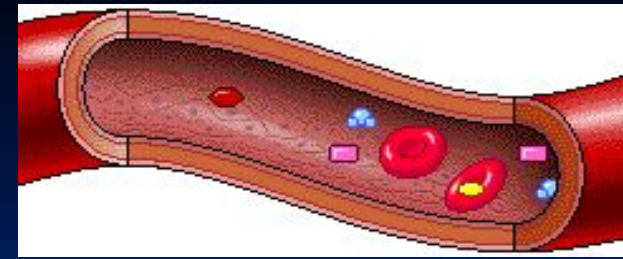
- Blood flow through the vessels which arises from difference of hydrostatic pressure in different parts of blood circulatory system. Blood always moves from area with high pressure to area with low pressure.

Blood composition

Blood – is a fluid tissue, which fills a heard-vascular system of some invertebrate animals, vertebral animals and human beings as well. It consists of plasma, (intrasticial substance), and cells: erythrocytes, leucocytes, and thrombocytes.

Blood composition

A -- blood in microscope
1-- erythrocytes
2-- leucocytes
3-- thrombocytes
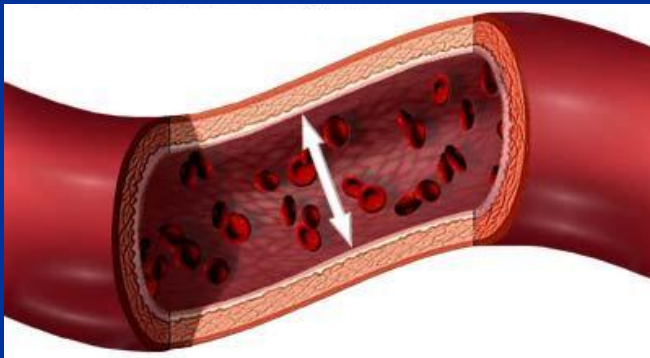B -- laminated blood:
1 -- plasm
2-- leucocytes
3-- erythrocytes
C -- blood cells:
1-- erythrocytes
2-- leucocytes
3-- thrombocytes

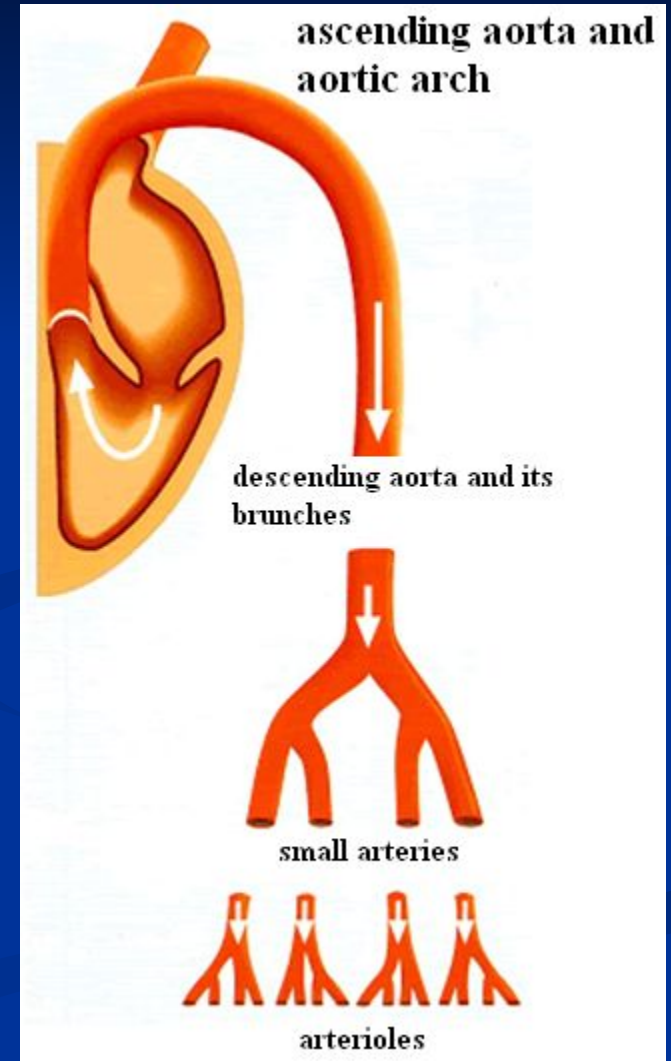# Erythrocytes

- *Erythrocytes (from greek Erythro - red and cytos – cell), are also called "red blood cells". Erythrocytes are the cells of human blood, vertebrates' blood and some invertebrates' (sipunkulida) blood cells.*

BLOOD FLOW THROUGH THE VESSELS

vena cava

main veins

small veins

venules

ascending aorta and aortic arch

descending aorta and its brunches

small arteries
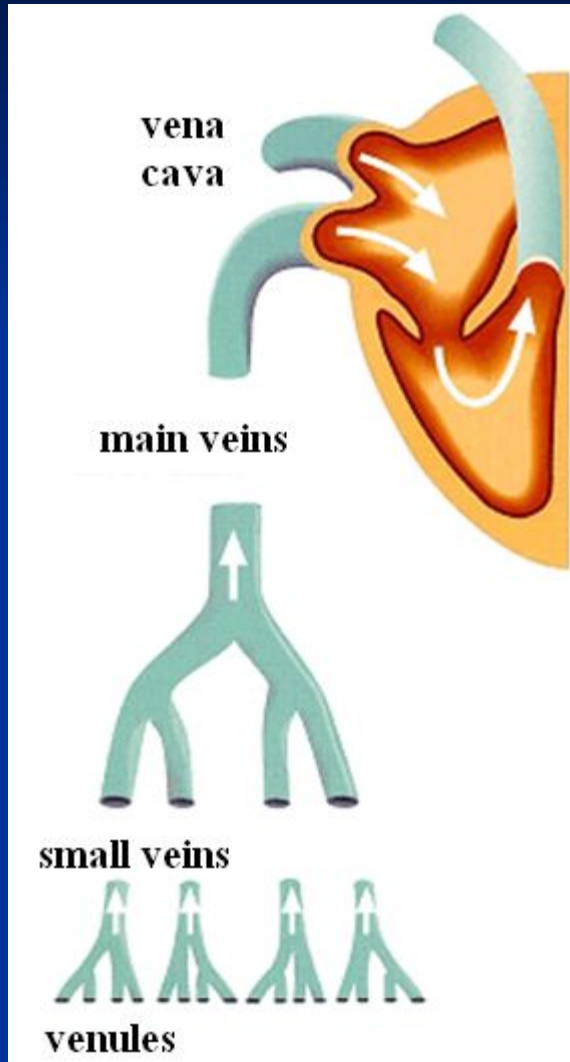
arterioles

Change of blood pressure in different parts of vascular system
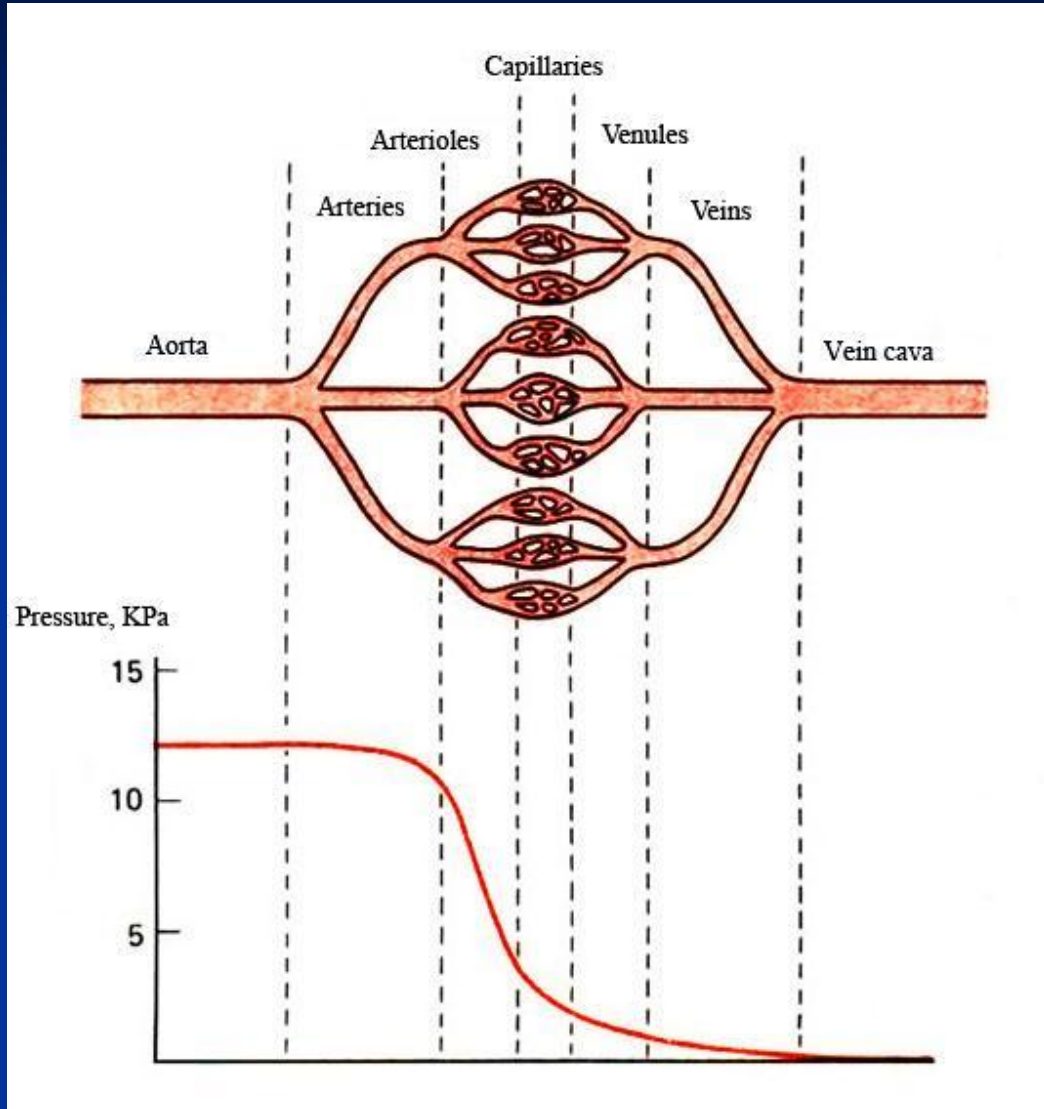
The main pressure decrease is in arterioles. That's why these vessels are often called resistive.

BLOOD FLOW VELOSITY IN DIFFERENT PARTS OF VASCULAR SYSTEM

A linear velocity of blood flow in different parts of vascular system is inversely proportional to area of cross-section of this part. The highest velocity of blood flow is observed in main vessels of circulatory system – arteries and veins. The smallest blood flow velocity is in capillaries. The cross-section of all arteries or all veins is smaller then cross-section of capillaries. As the capillaries are the most numerous vessels in circulatory system.
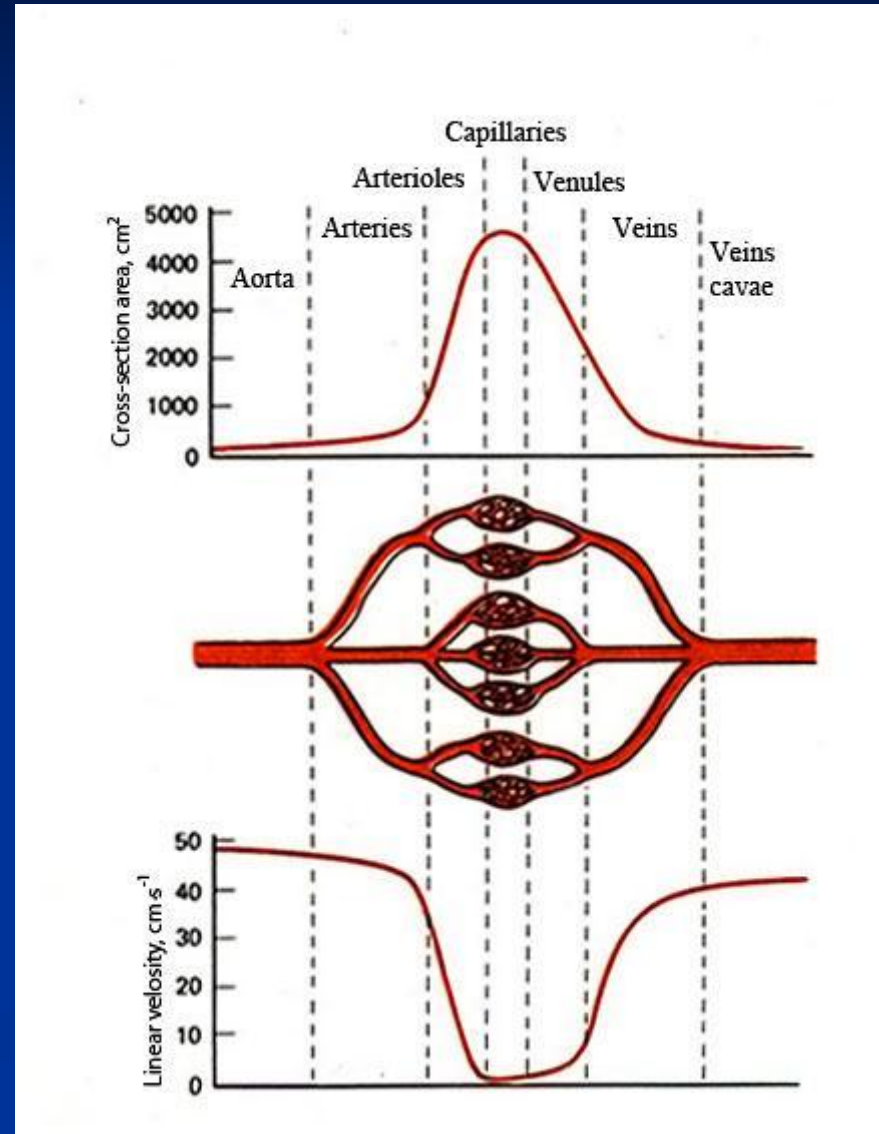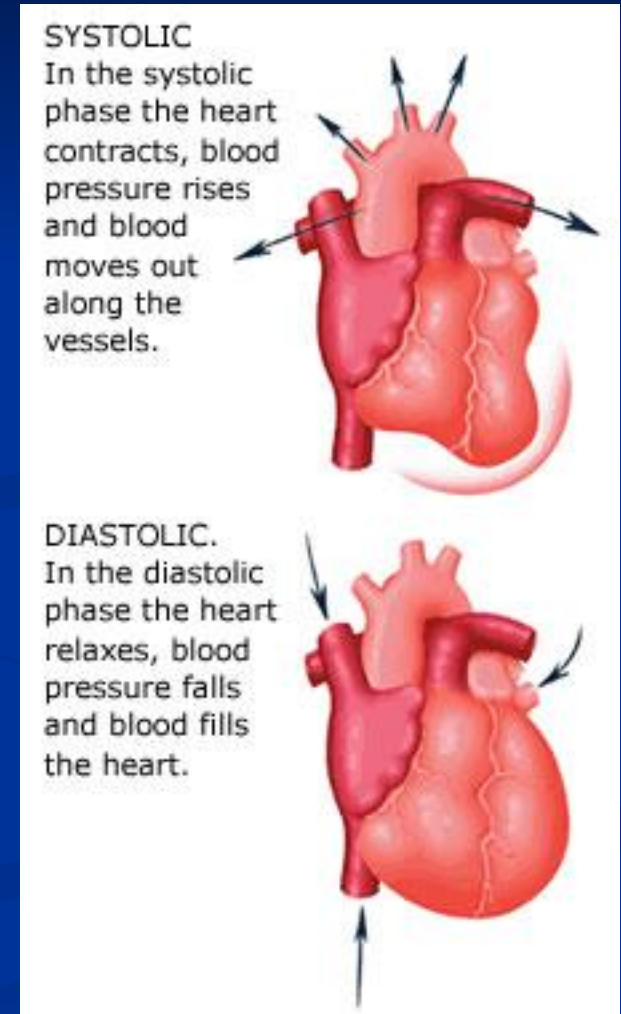
The main parameters of cardio vascular system

Parameter	Aorta	Capillaries	Veins cavae
Cross-section, cm^2	3 – 4	2500 – 3000	6 – 8
Linear velocity (average), cm/s	20 – 25	0,03 – 0,05	10 – 15
Pressure (average), mm of mercury	100	30 – 15	6 – 0

Total cross-section of aorta brunches is larger, then cross-section of aorta itself. Capillaries have the greatest total cross-section area as their number is greater then number of any other vessels. In rest the cross-section area of systemic circulation capillaries is equal to 3000 cm². As capillaries then merge to venules ang venules merge to veins the total cross-section area decreases and for veins cavae it is equal to 6-8 cm² which is twice more than the cross section of aorta.
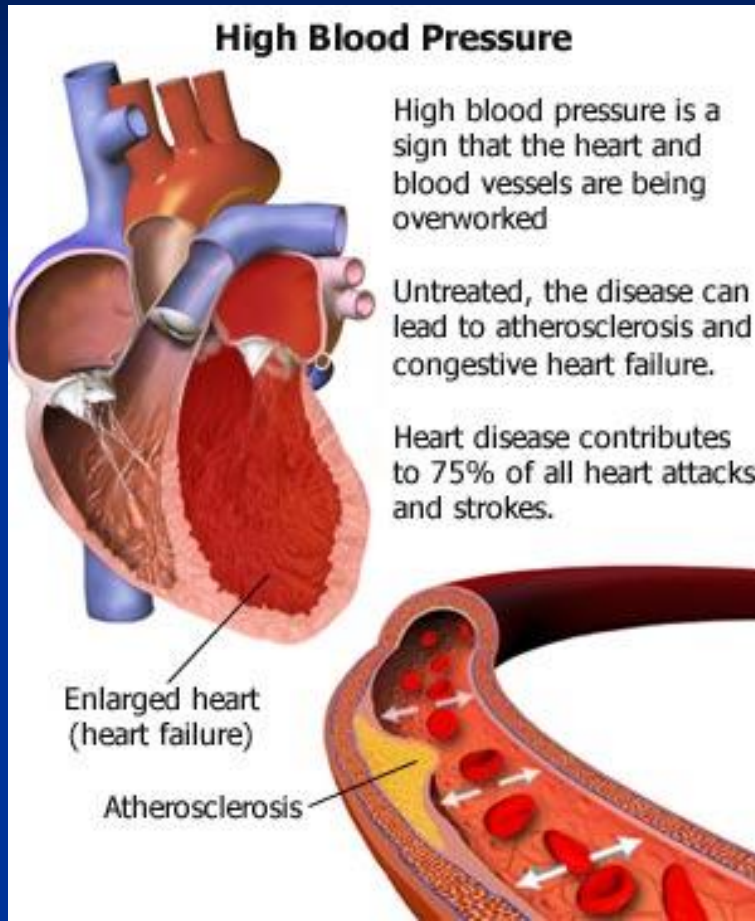
BLOOD PRESSURE (BP)

- Blood Pressure - the force BLOOD exerts against the walls of the arteries as it travels through them, as a combination of resistance and the HEART's pumping effort.

- For each heartbeat, BP varies between systolic and diastolic pressures. Systolic pressure is peak pressure in the arteries, which occurs near the end of the cardiac cycle when the ventricles are contracting. Diastolic pressure is minimum pressure in the arteries, which occurs near the beginning of the cardiac cycle when the ventricles are filled with blood. An example of normal measured values for a resting, healthy adult human is 120 mmHg systolic and 80 mmHg diastolic (written as 120/80 mmHg, and spoken [in the US and UK] as "one-twenty over eighty").

SYSTOLIC
In the systolic phase the heart contracts, blood pressure rises and blood moves out along the vessels.

DIASTOLIC.
In the diastolic phase the heart relaxes, blood pressure falls and blood fills the heart.

BLOOD PRESSURE

High Blood Pressure

High blood pressure is a sign that the heart and blood vessels are being overworked

Untreated, the disease can lead to atherosclerosis and congestive heart failure.

Heart disease contributes to 75% of all heart attacks and strokes.

Enlarged heart
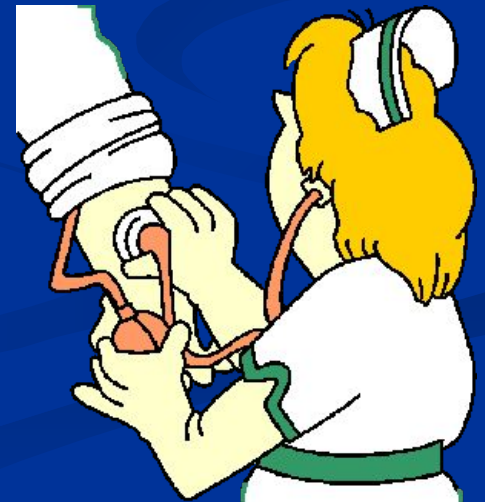(heart failure)

Atherosclerosis

Korotkoff M.S. (1874 – 1920)

**Mykola Sergiyovich Korotkoff
(1874-1920)**

- The 13 of February Mykola Sergiyovich Korotkoff was born – russian surgeon who developed the vessels surgery. He is also an author of auscultatory method of blood pressure measurement.
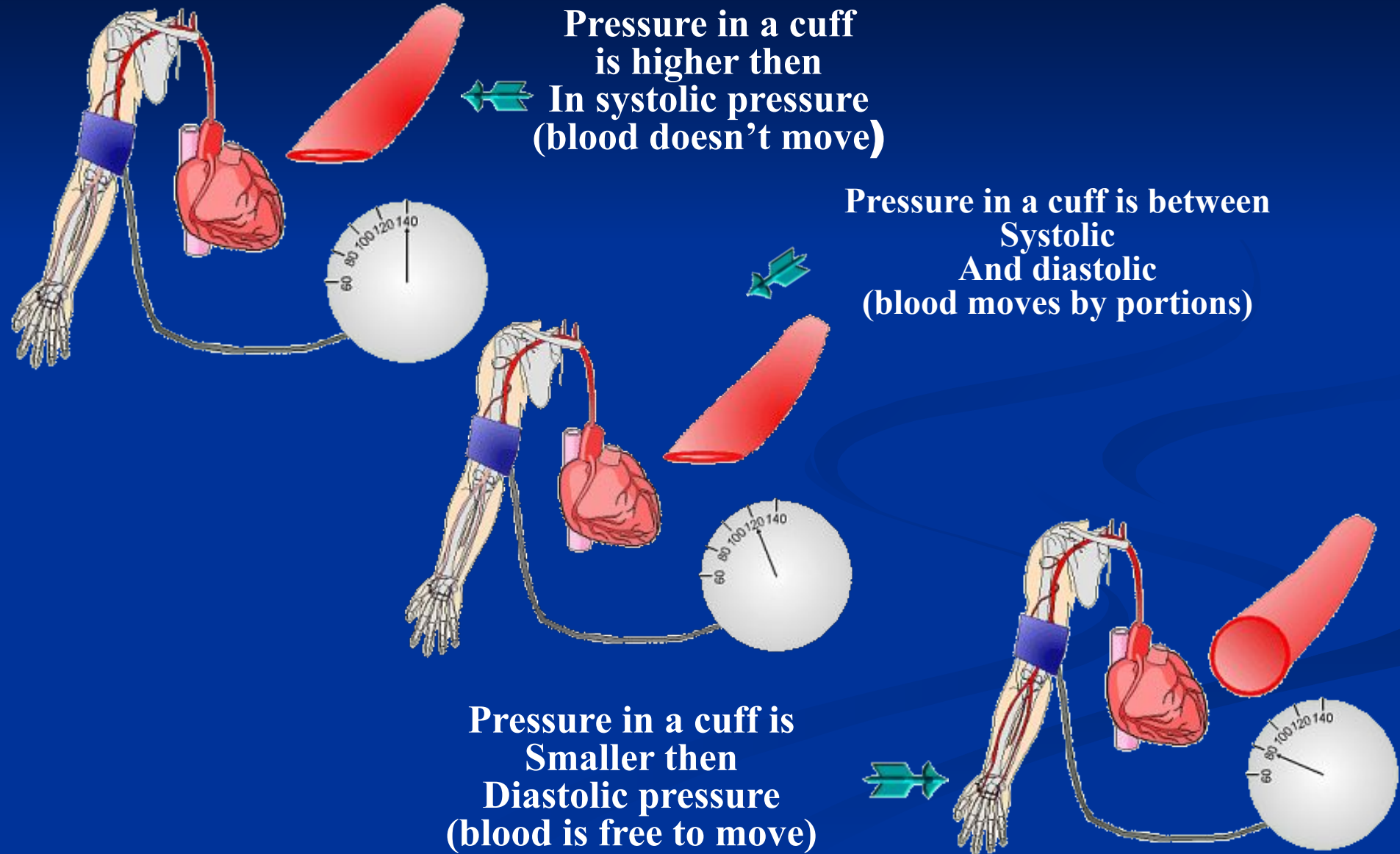
KOROTKOFF'S TONES

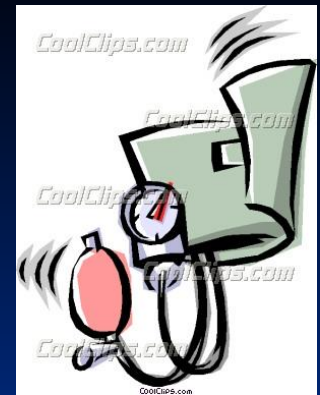
**Pressure in a cuff
is higher then
In systolic pressure
(blood doesn't move)**

**Pressure in a cuff is between
Systolic
And diastolic
(blood moves by portions)**

**Pressure in a cuff is
Smaller then
Diastolic pressure
(blood is free to move)**

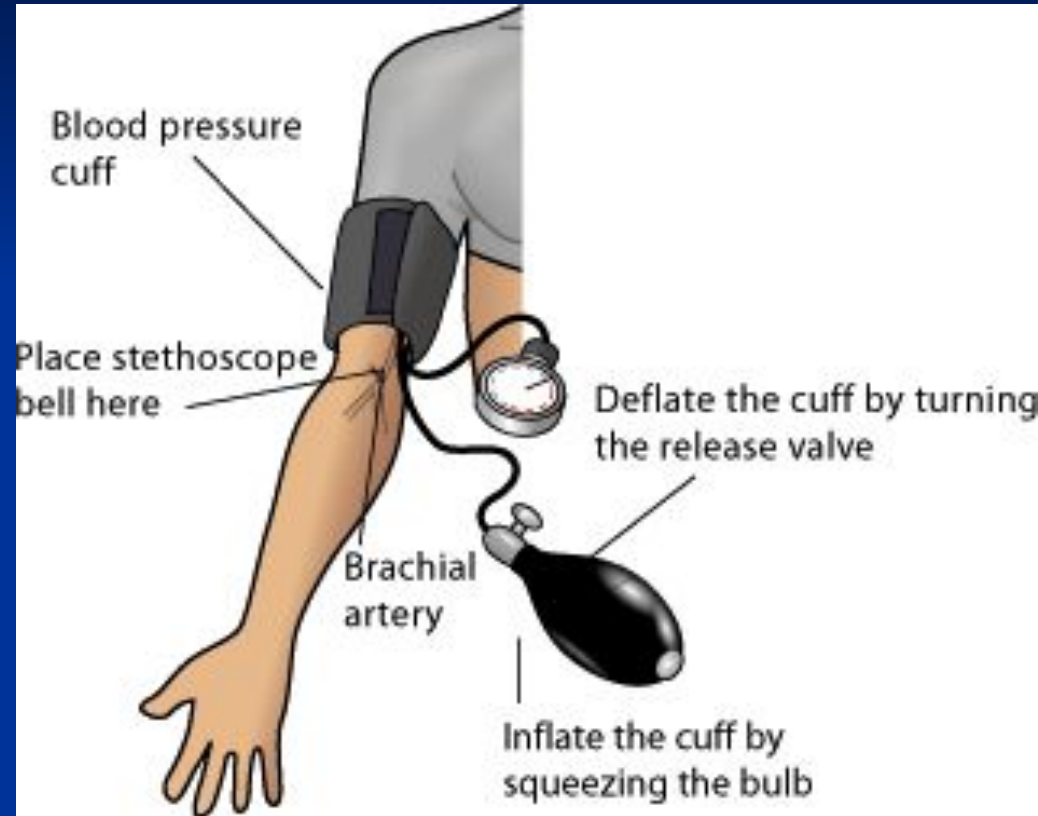# Kinds of sphygmomanometers

Mercury

Mechanical

Electronic

Blood pressure measurement

A cuff of appropriate size is fitted smoothly and snugly, then inflated manually by repeatedly squeezing a rubber bulb until the artery is completely occluded. Listening with the stethoscope to the brachial artery at the elbow, the examiner slowly releases the pressure in the cuff. When blood just starts to flow in the artery, the turbulent flow creates a "whooshing" or pounding (first Korotkoff sound). The pressure at which this sound is first heard is the systolic BP. The cuff pressure is further released until no sound can be heard (fifth Korotkoff sound), at the diastolic arterial pressure.

Blood pressure cuff

Place stethoscope bell here

Brachial artery

Deflate the cuff by turning the release valve

Inflate the cuff by squeezing the bulb

Blood pressure measurement

Mercury sphygmomanometer
blood pressure measurement

Electronic
sphygmomanometers

This Blood Pressure Monitor will provide you with the confidence of accurate measurement under easiest use.