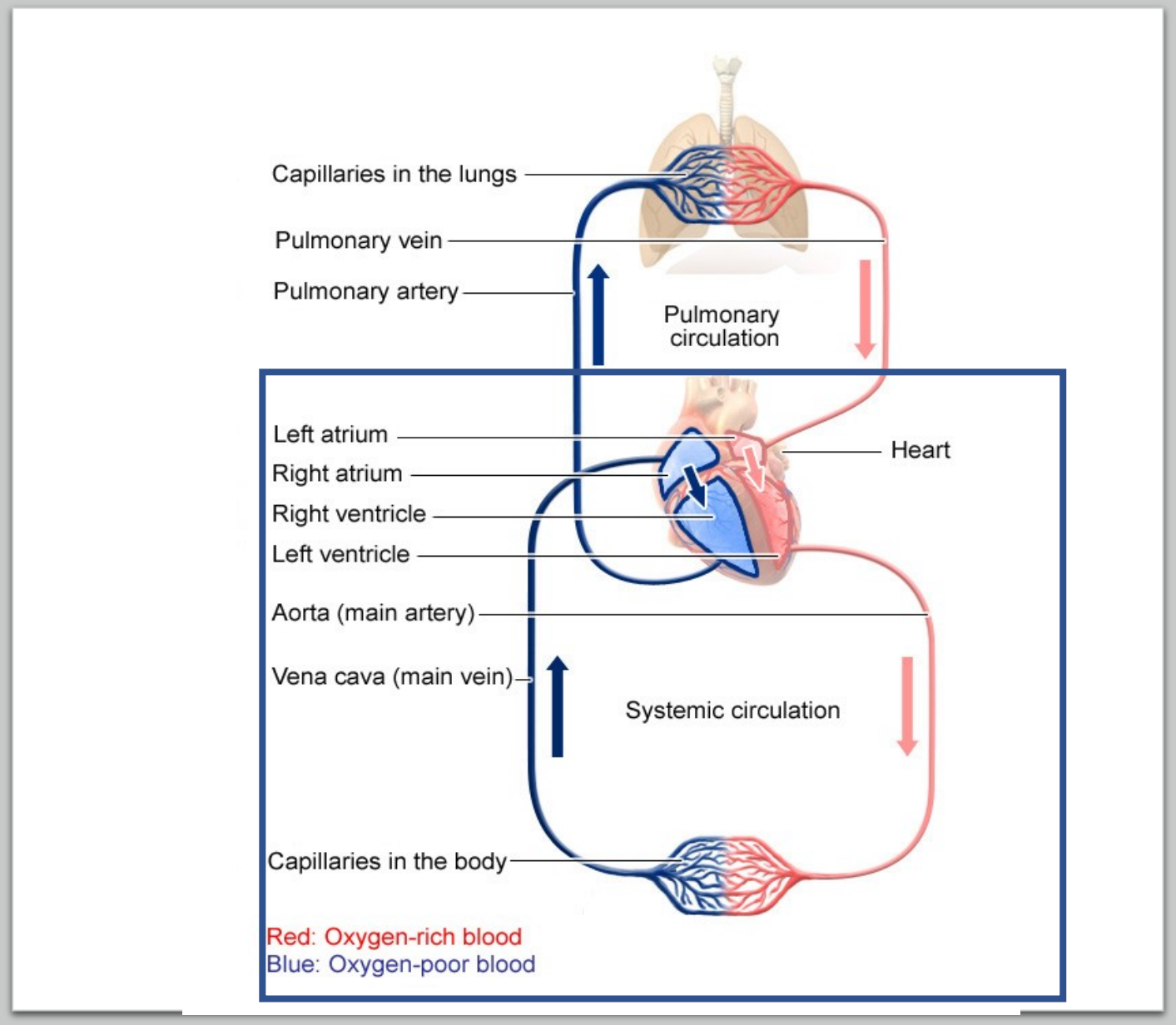
Heart and circulation

23.01.2024

Circulation

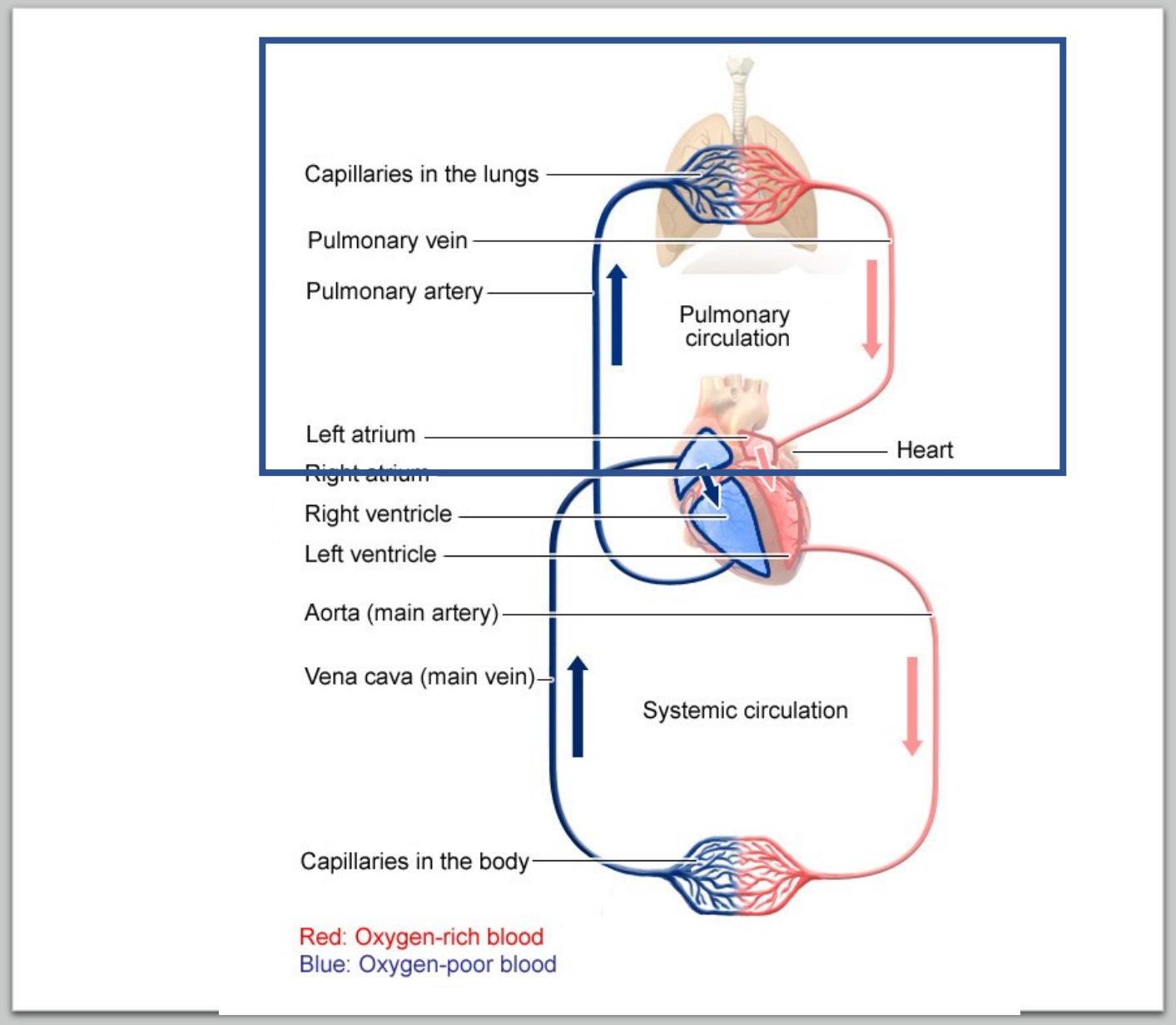
- Heart and vessels
- *Great circulation*
  - Starts from the left ventricle
  - Carries the blood in the arteries everywhere in the body
  - Large → small arteries → capillaries → veins back to the right atrium of the heart



Informedhealth.com

Circulation

- *Small circulation*
  - Pulmonary circulation
  - Starts from the right ventricle
  - Large → small pulmonary arteries→ capillaries → pulmonary veins to the left atrium



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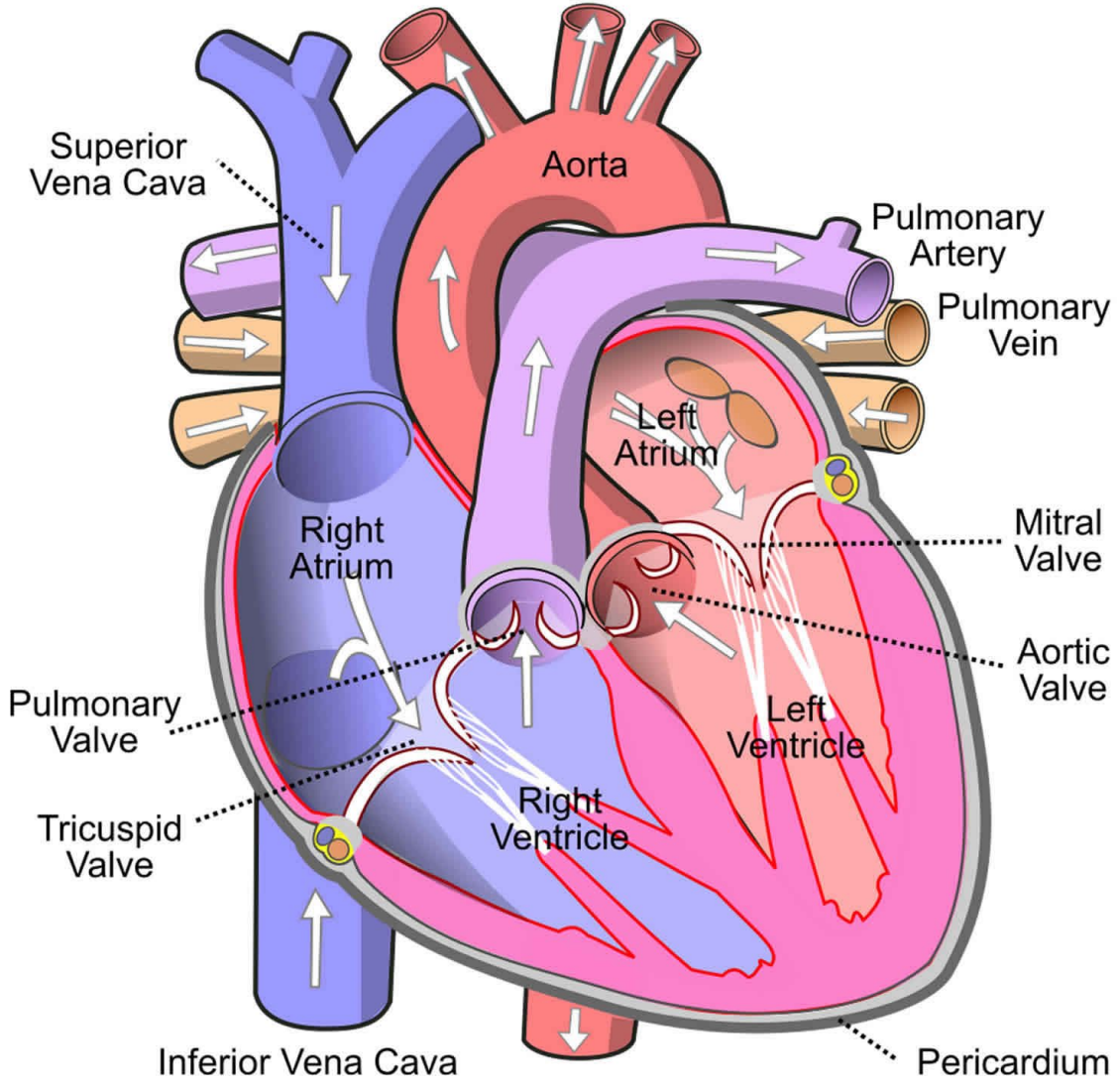
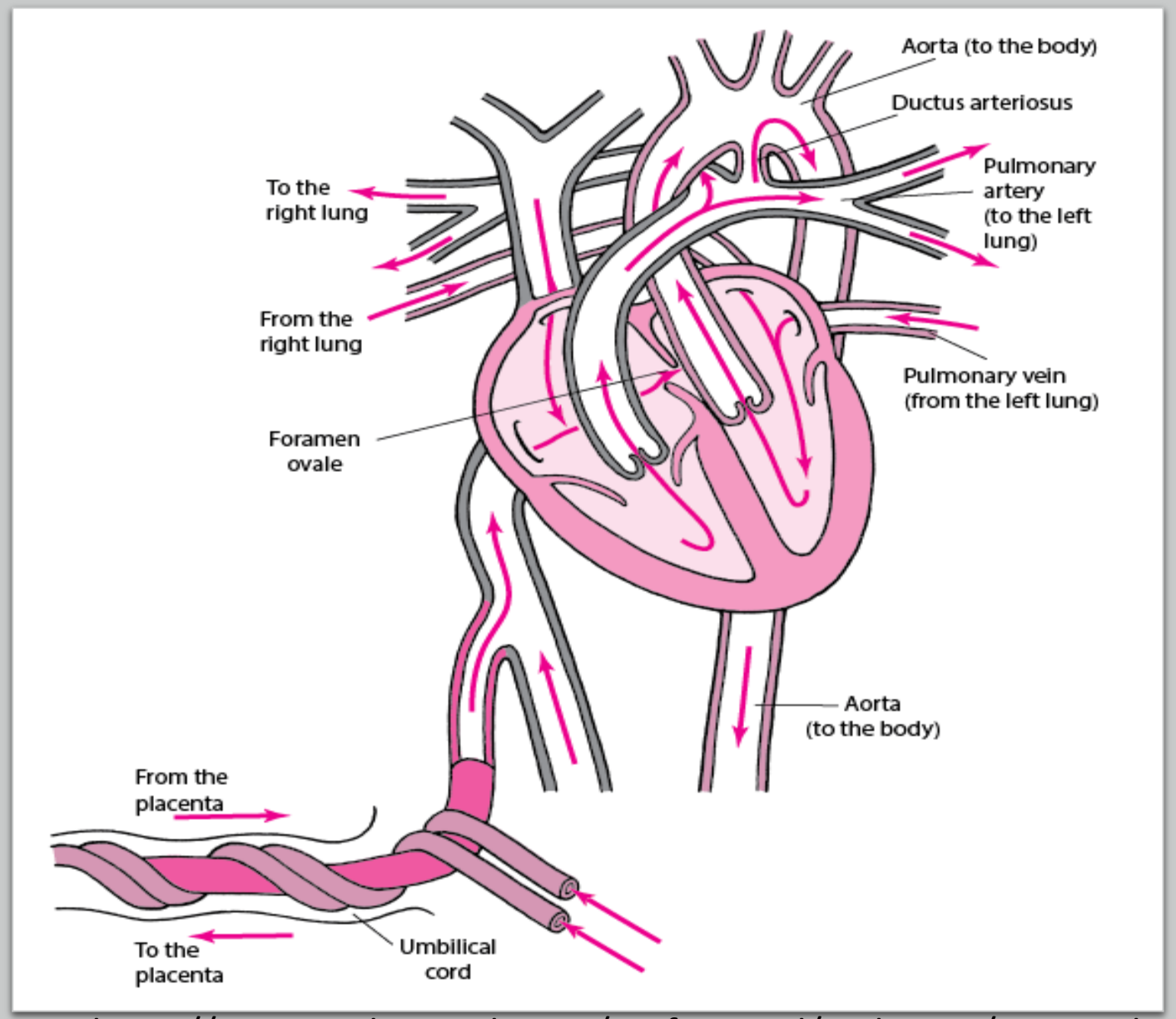
- Blood circulates always in the same direction
- Important structures:
  right and left atrium,
  right and left ventricle,
  superior and inferior vena cava,
  pulmonary artery, pulmonary veins, aorta



https://healthjade.net/superior-vena-cava/

Fetal circulation

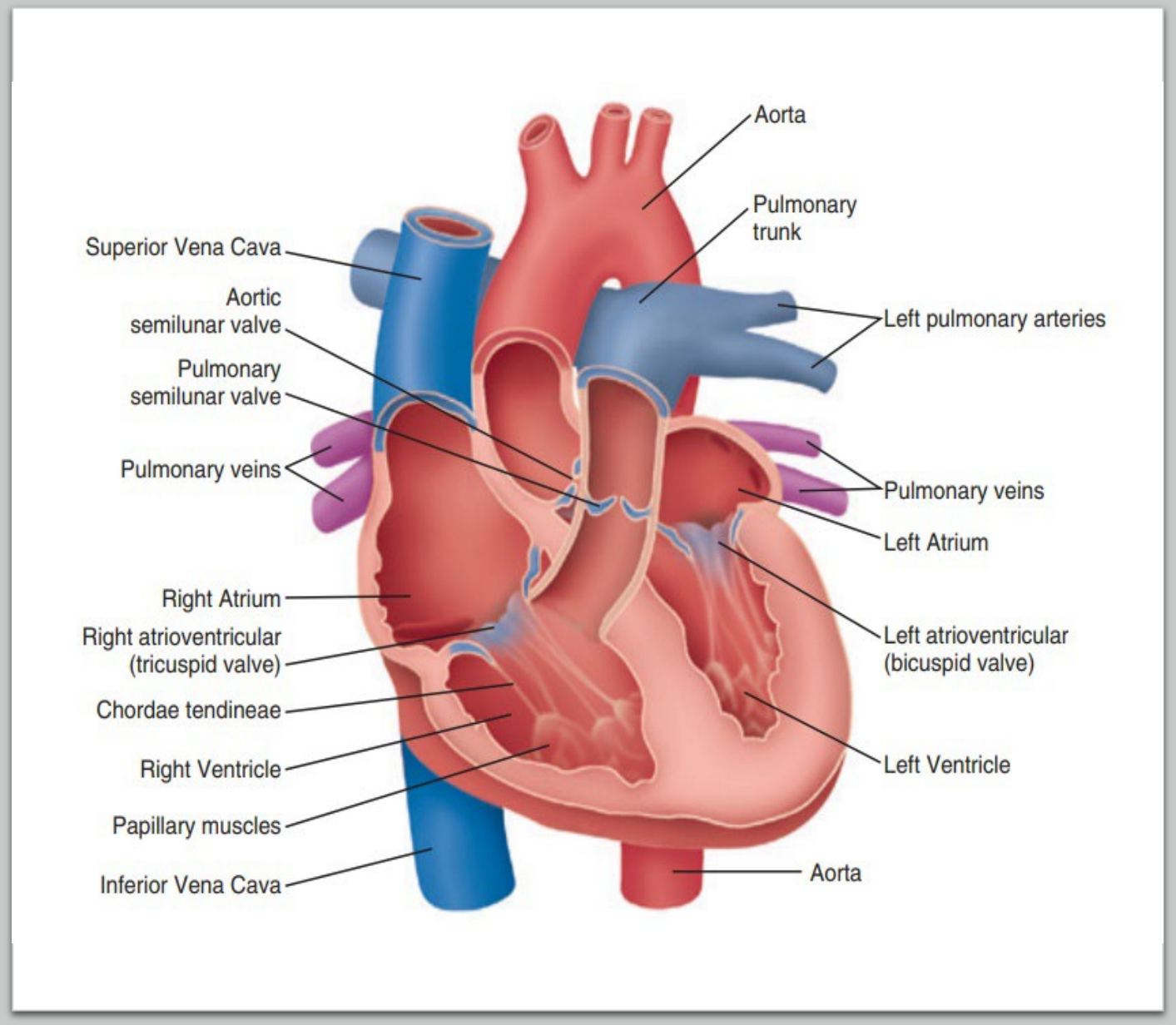
- Only 10% of blood circulates via lungs
- Left ventricle pumps the blood to brain and upper body, while the right ventricle provides the circulation for lungs, lower body and placenta
- This is possible thanks to structures called *ductus arteriosus and foramen ovale*



https://www.msdmanuals.com/professional/pediatrics/perinatal-physiology/perinatal-physiology

Structure of the heart

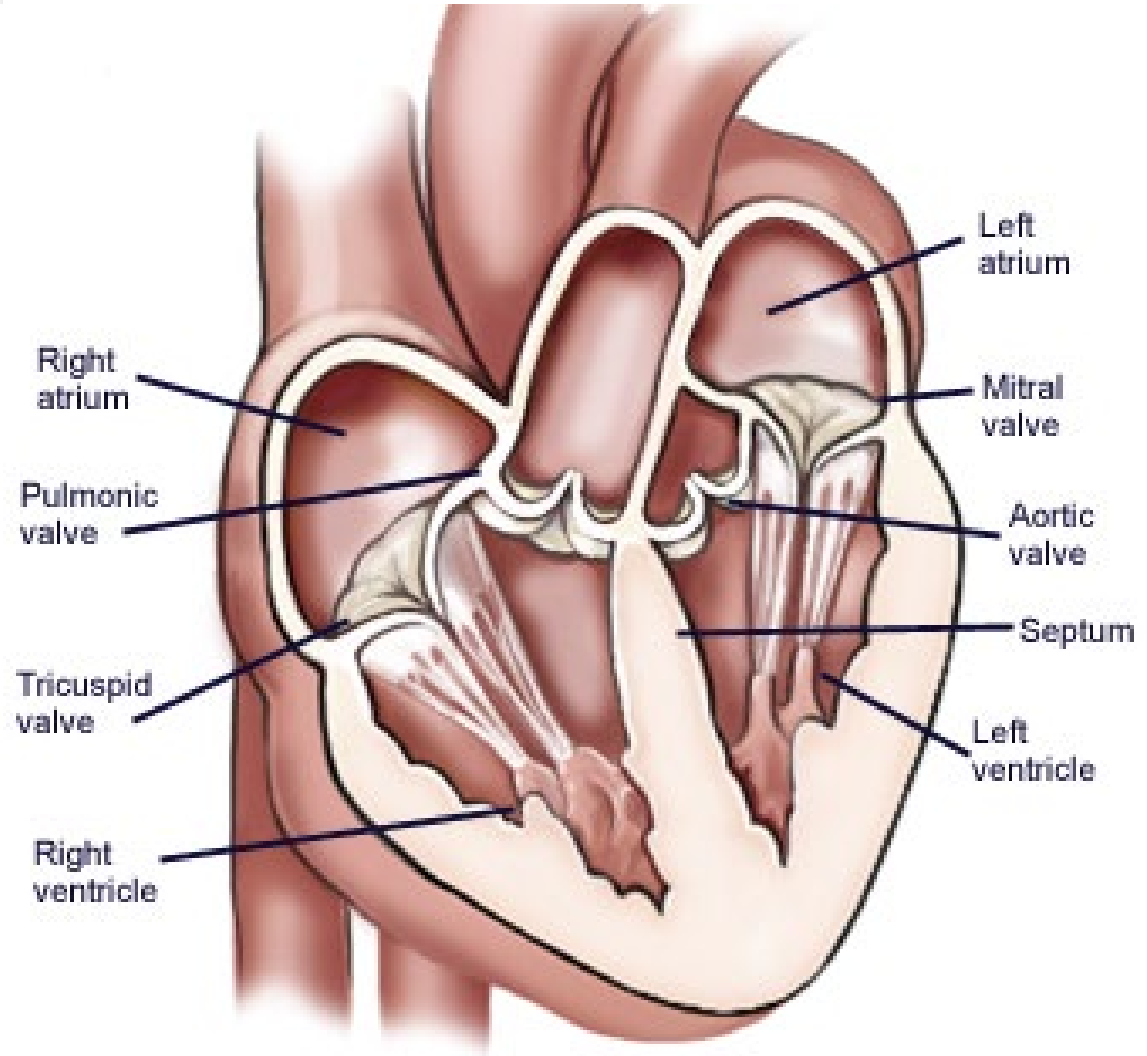
- Muscle that weights 300-350 g in adults
- Two atriums and two ventricles
- Septum separates the left and right part of the heart
  - Except for fetal circulation



http://www.pharmacy180.com/article/structures-of-the-heart-3619/

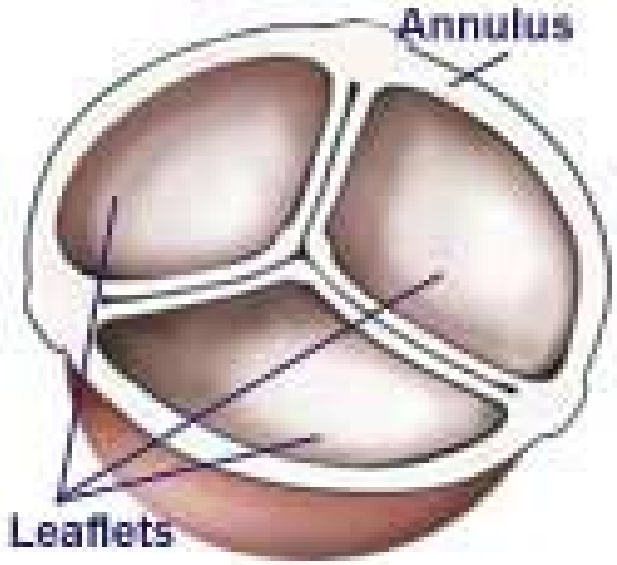
Heart valves

- 3-layer heart wall:
  - Innermost layer *endocardium*
  - Muscular layer *myocardium*
  - Outer layer *epicardium*
- Fibrous sac *pericardium*
- Valves are made of endocardium



https://my.clevelandclinic.org/health/articles/17067-heart-valves

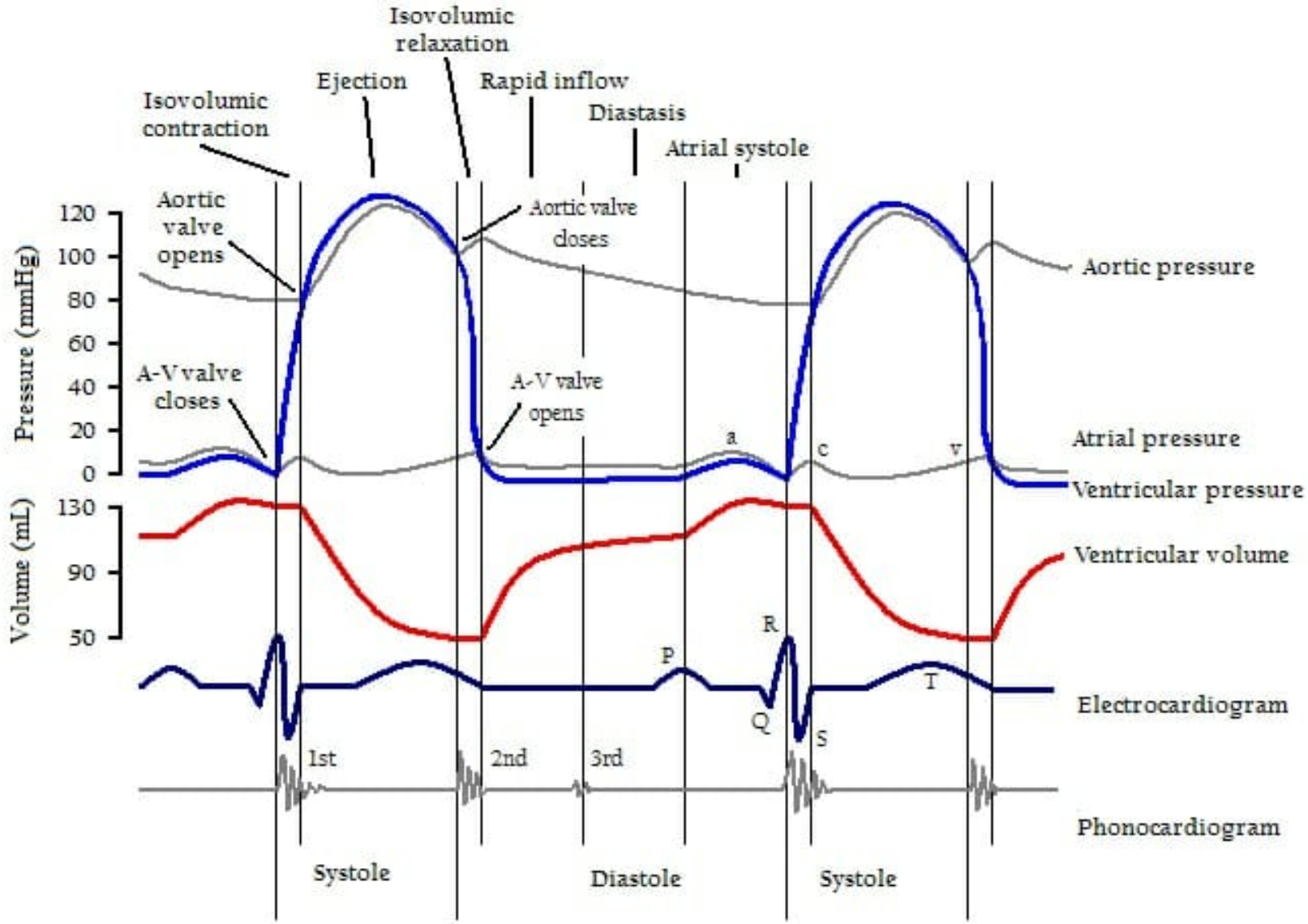
- **Tricuspid and mitral valve** are supported by chorda tendineae
- **Aortic and pulmonary valves** consist of flap pockets
- Valve movement is based on pressure differences



https://my.clevelandclinic.org/health/articles/17067-heart-valves

Cardiac cycle

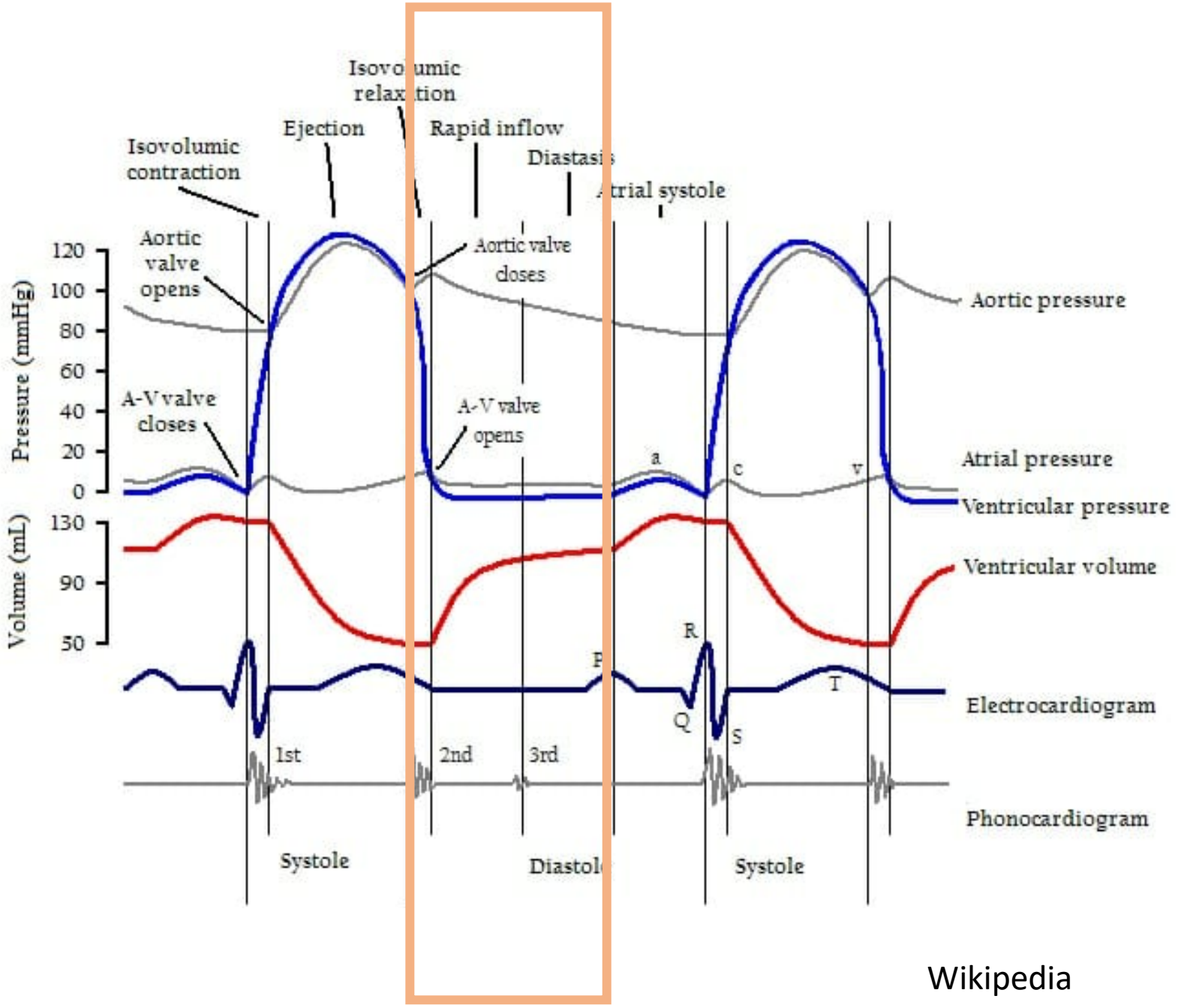
- Contraction phase, systole
- Relaxation phase, diastole
- Heart muscle does not fatigue
- Long repolarization time hinders tetanic contraction
- One functional cycle appr. 0.8 sec



Wikipedia

Diastole

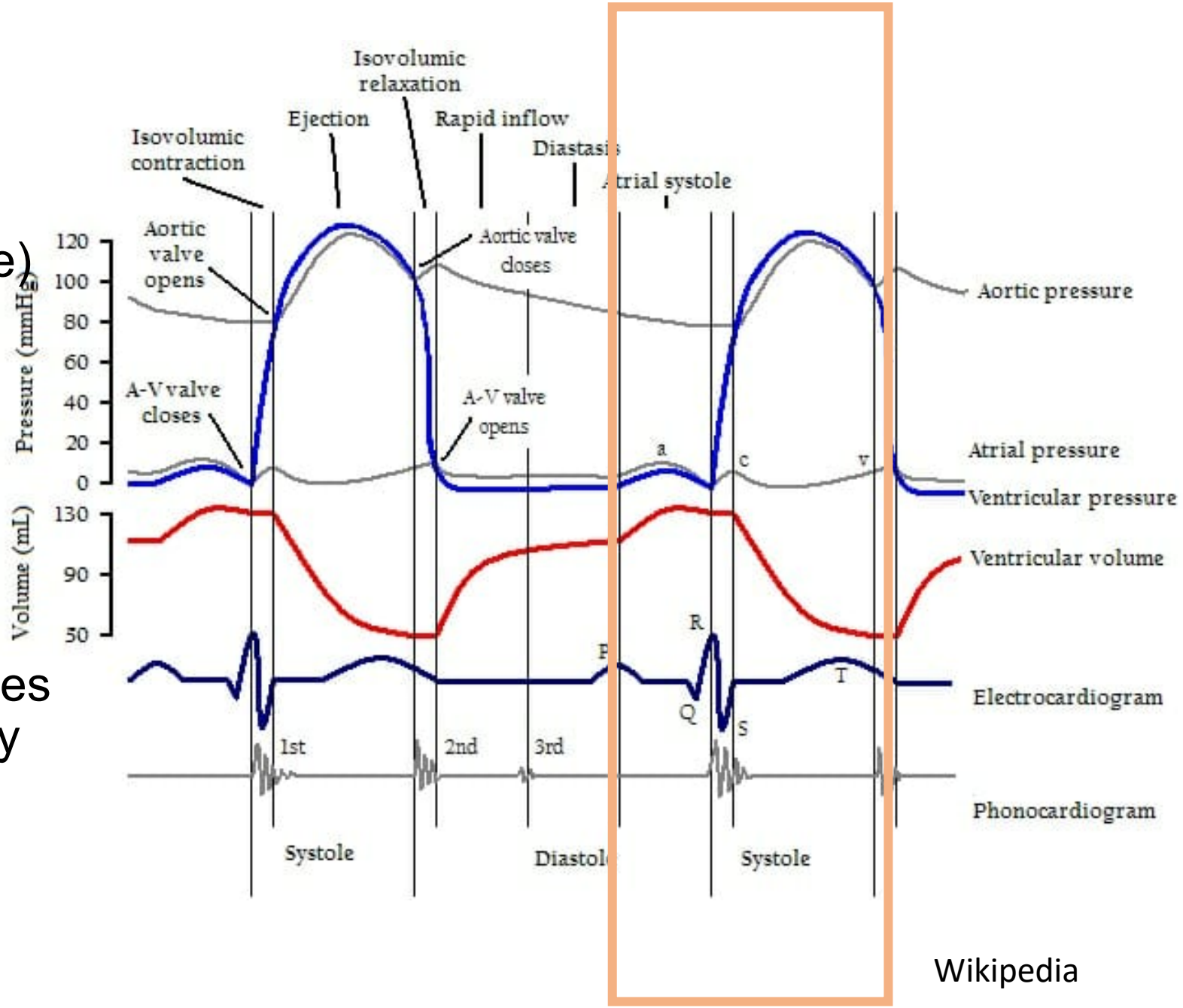
- Both atria and ventricles are relaxed
- Blood enters the atria
- The increase of pressure in atria opens the A-V valves and blood enters the ventricles



Wikipedia

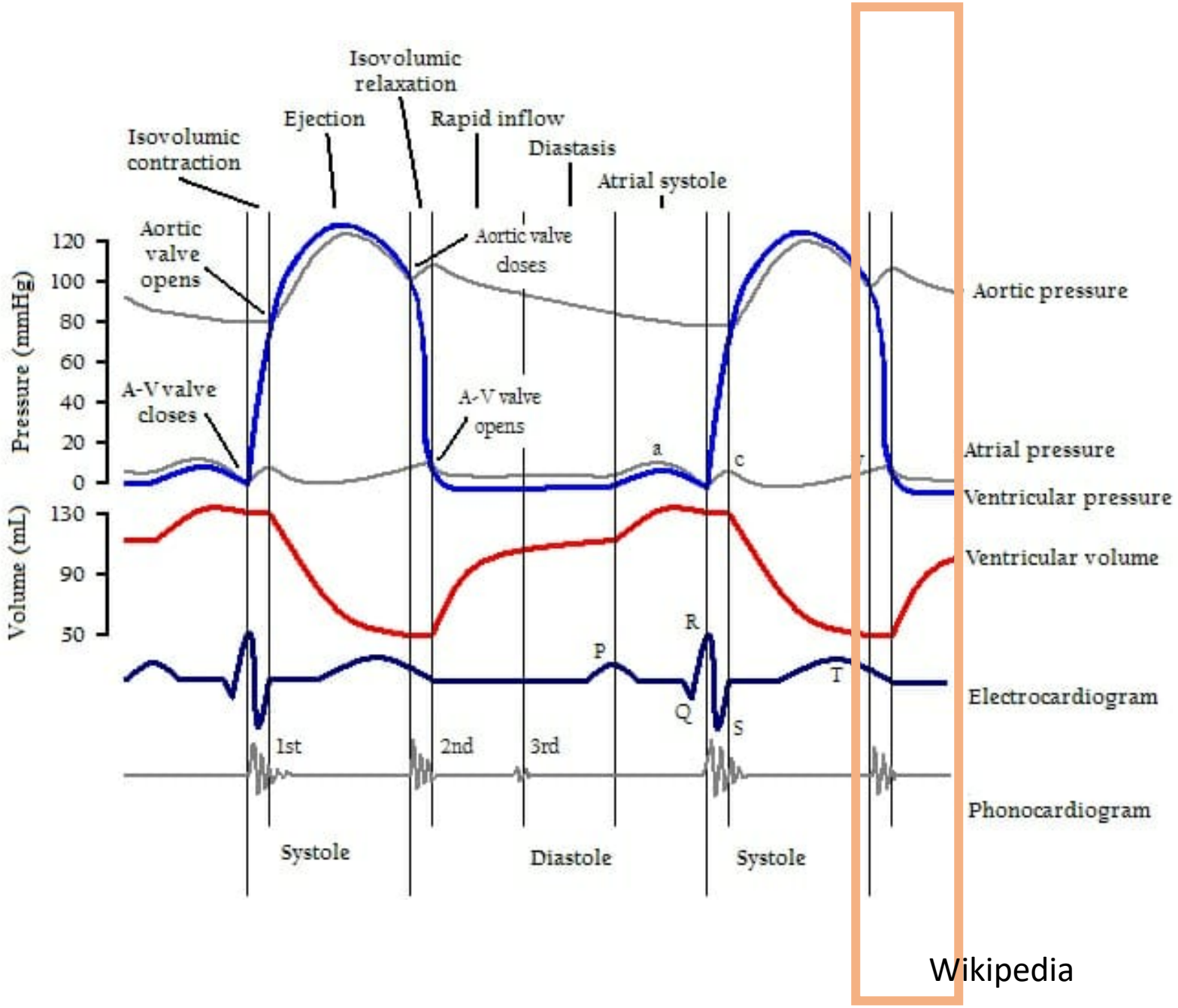
Systole

- Atria contract first (atrial systole)
- Valves hinder the blood from flowing to wrong direction
- Atria relax (atrial diastole)
- Ventricles contract and their pressure increases
- A-V valves close
- Increase of pressure in ventricles opens the aortic and pulmonary valves



Wikipedia

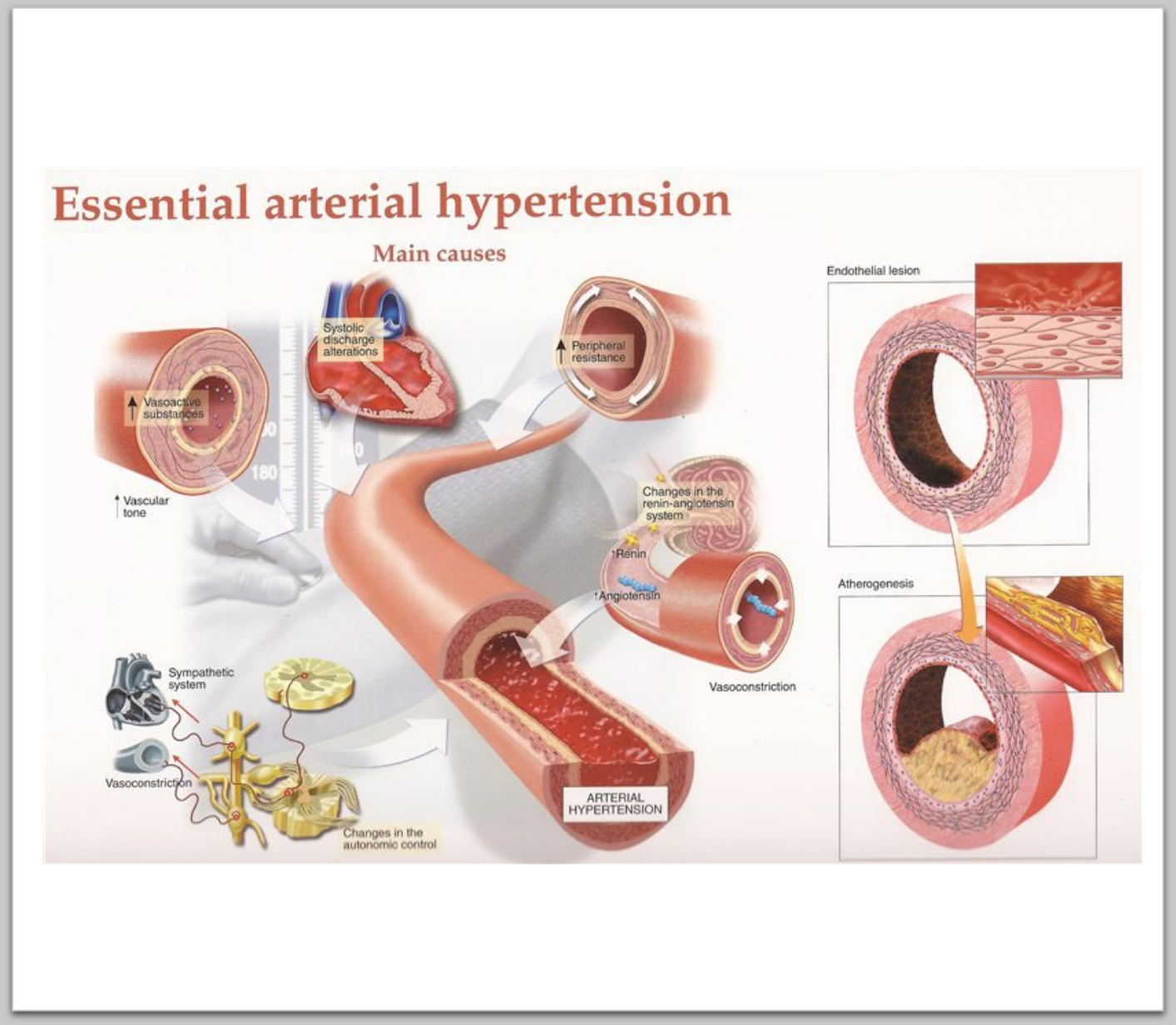
- Ventricles relax
- Pressure decreases in the ventricles, and aortic/ pulmonary valves close
- When ventricle pressure gets lower than the atrial pressure, A-V valves open



Wikipedia

Blood pressure

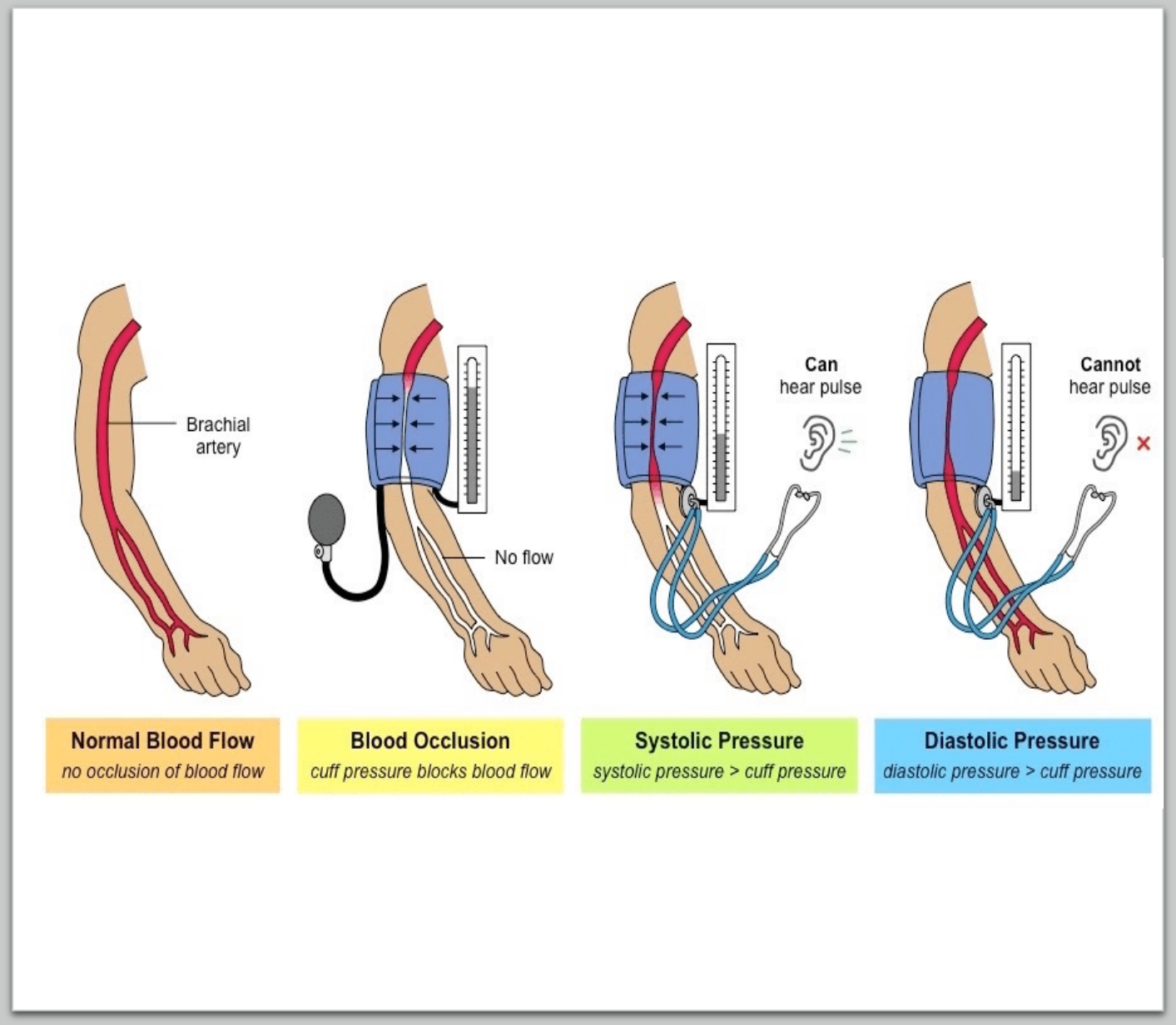
- Contraction of heart muscle creates blood pressure and it is maintained by arteries
- Blood pressure depends on *cardiac output* and *peripheral resistance*
- *cardiac output* = pulse x heart volume
- *Ejection fraction* = The difference between systolic and diastolic left-ventricle volume
- Peripheral resistance is affected by vessel diameter and blood viscosity



www.hopeplack.com

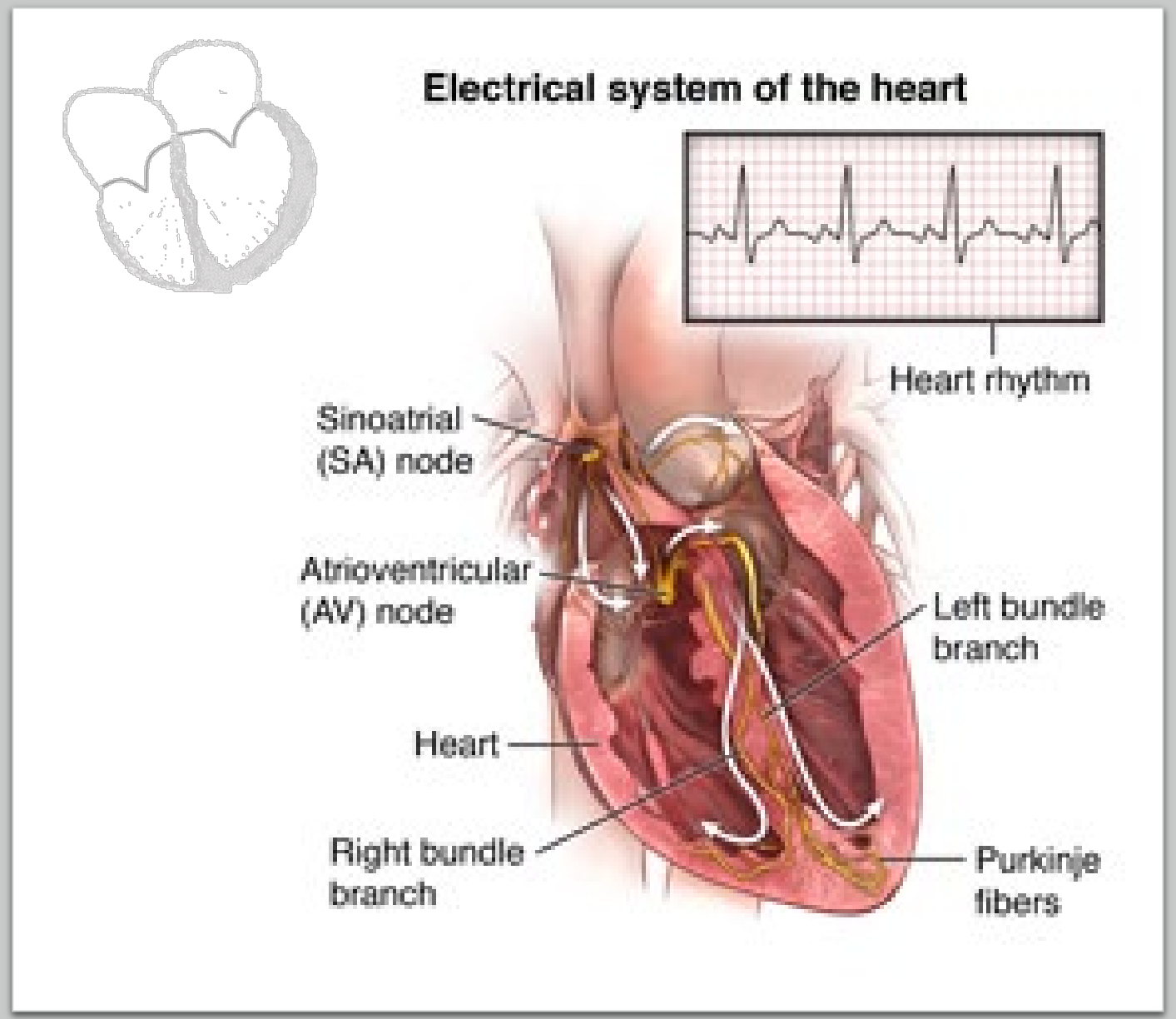
Blood pressure

- Usually refers to the pressure in larger arteries
- *Systolic pressure* = Pressure in ventricles during contraction
- *Diastolic pressure* = Lowest pressure in large vessels before systole
- Elastic fibers in vessels equalize the pressure
- Pulse = The travelling pressure wave in arteries
- Measuring of blood pressure (see Figure)



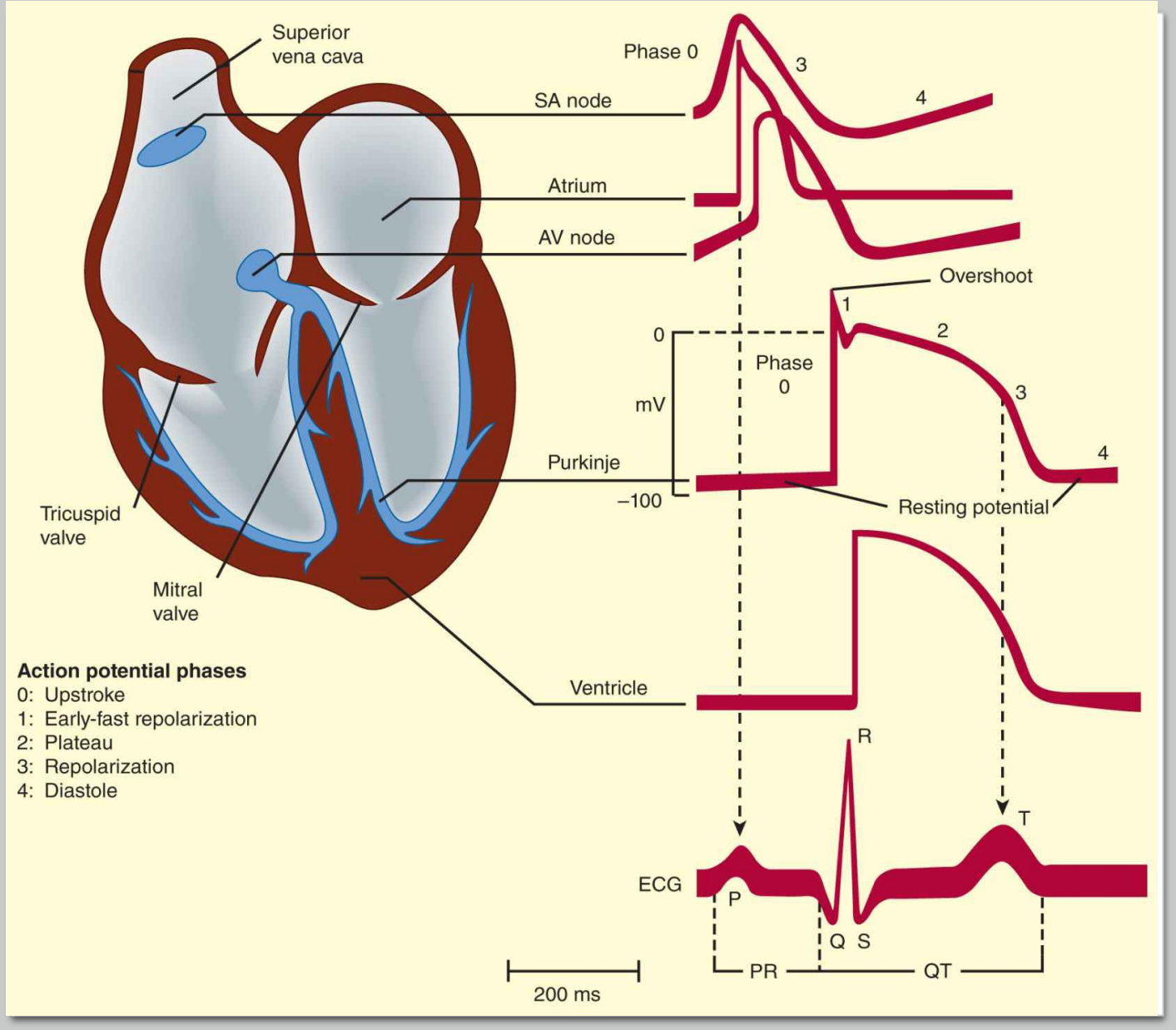
Electrocardiac activity

- *Sinoatrial node* in the right atrium works as a pacemaker
- Bundle of His
- Heart muscle cells connect to each other with tight junctions → action potential travels directly from one cell to another



Wikipedia, https://www.hopkinsmedicine.org/health/treatment-tests-and-therapies/pacemaker-insertion

- From SA node the action potential travels to the walls of atria and to the *atrioventricular (AV) node*
- *Bundle of His* travels from AV node as two tracts to the ventricular walls
- *Purkinje fibers* carry the electrical impulses to the ventricles



https://basicmedicalkey.com/

Electrocardiography

- Registration of the electric field produced by the atria and ventricles
- Different electrodes detect different parts of the heart
- Usually min. 12 leads

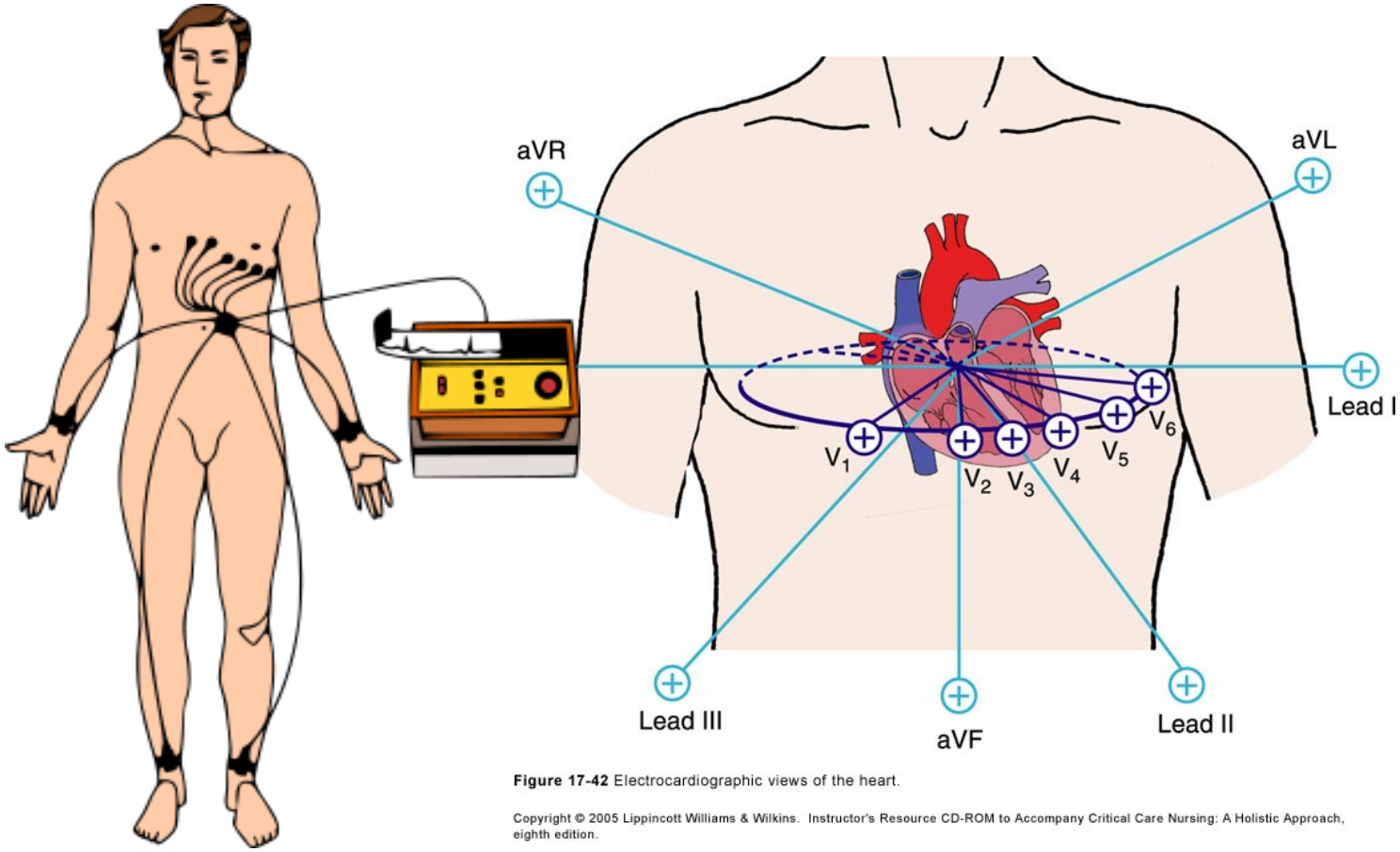
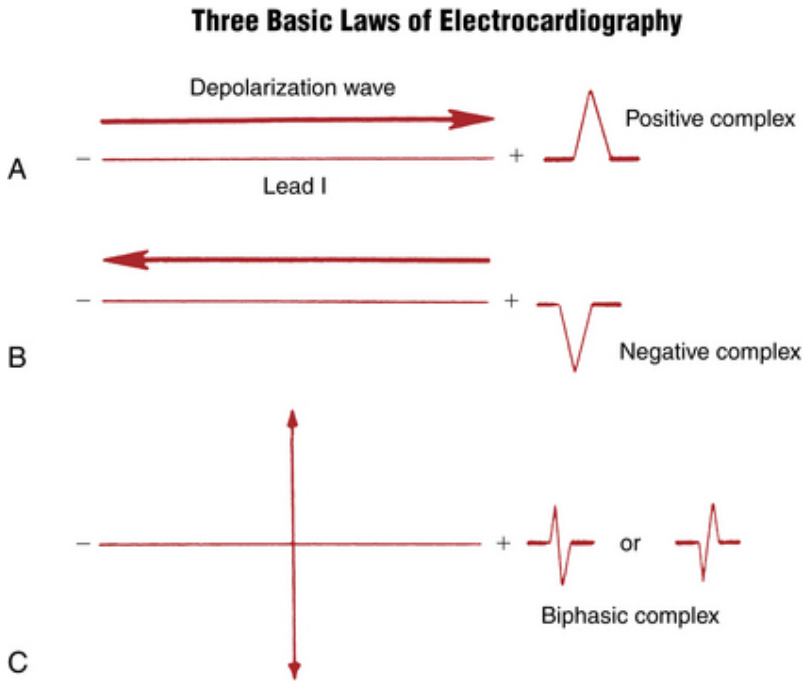
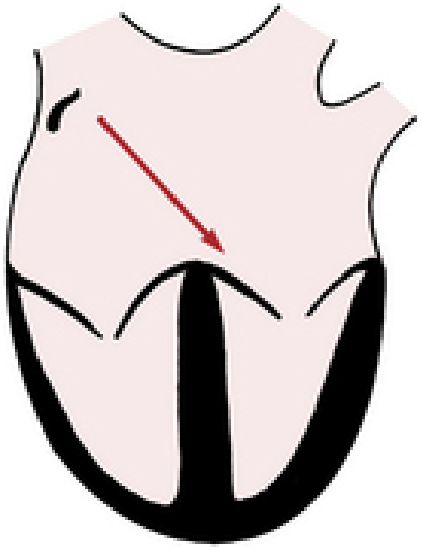
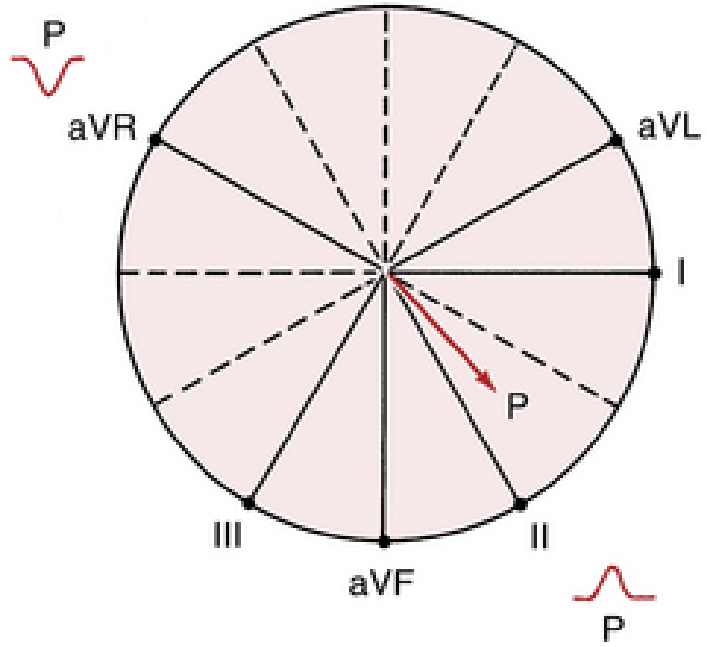
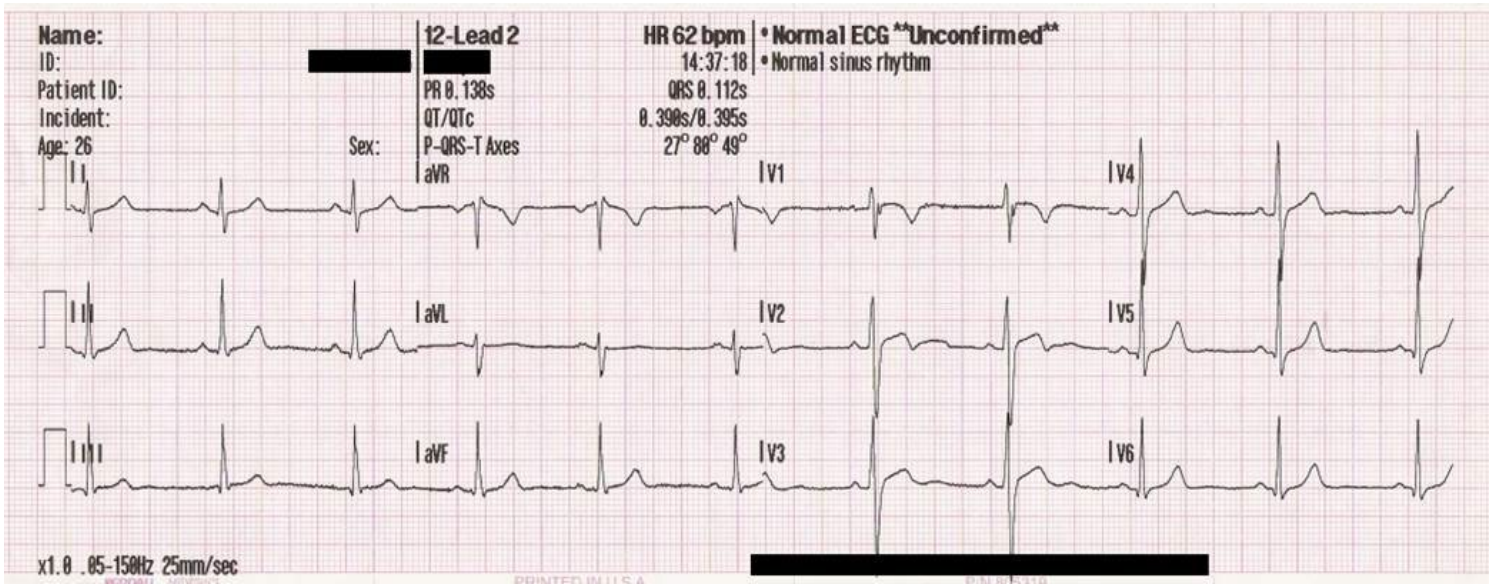


Figure 17-42 Electrocardiographic views of the heart.



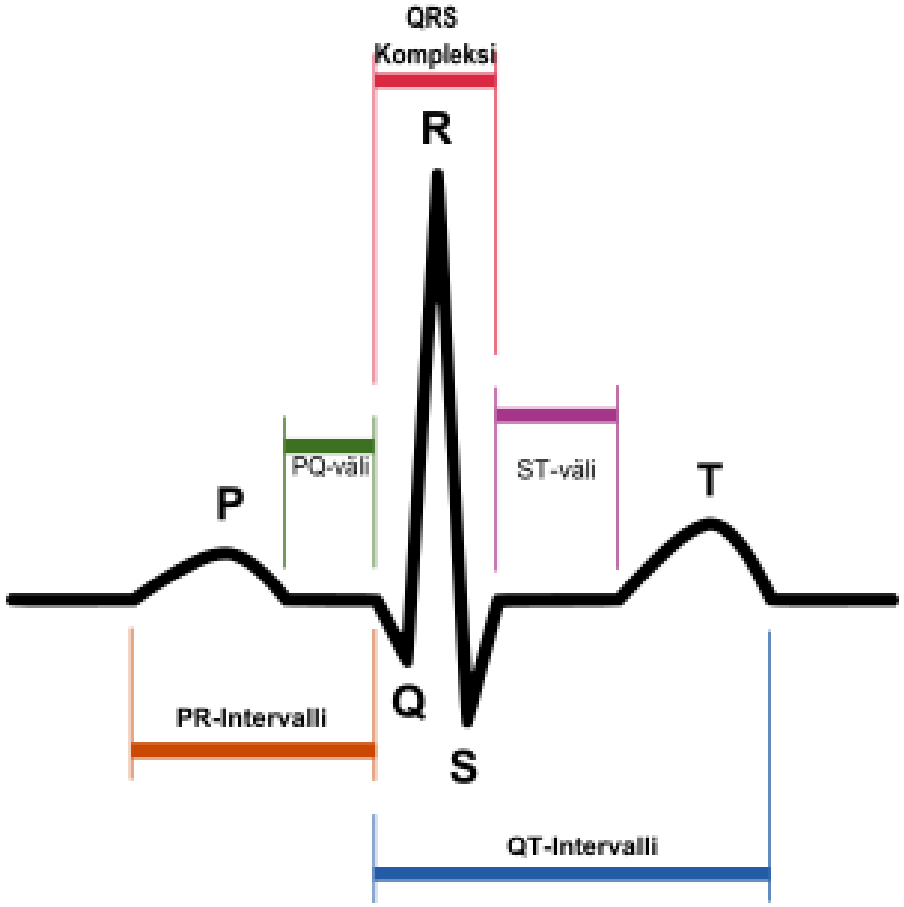


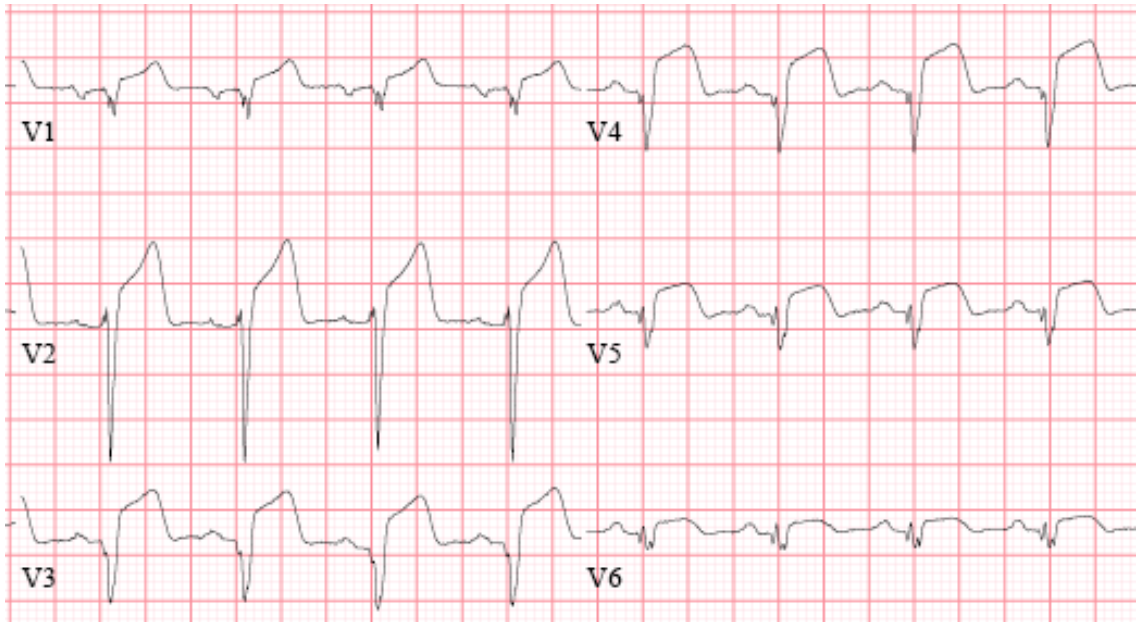




thoracickey.com/understanding-the-normal-ecg, Wikipedia

ECG is necessary for diagnostics of arythmias, conduction disorders, and ischemia



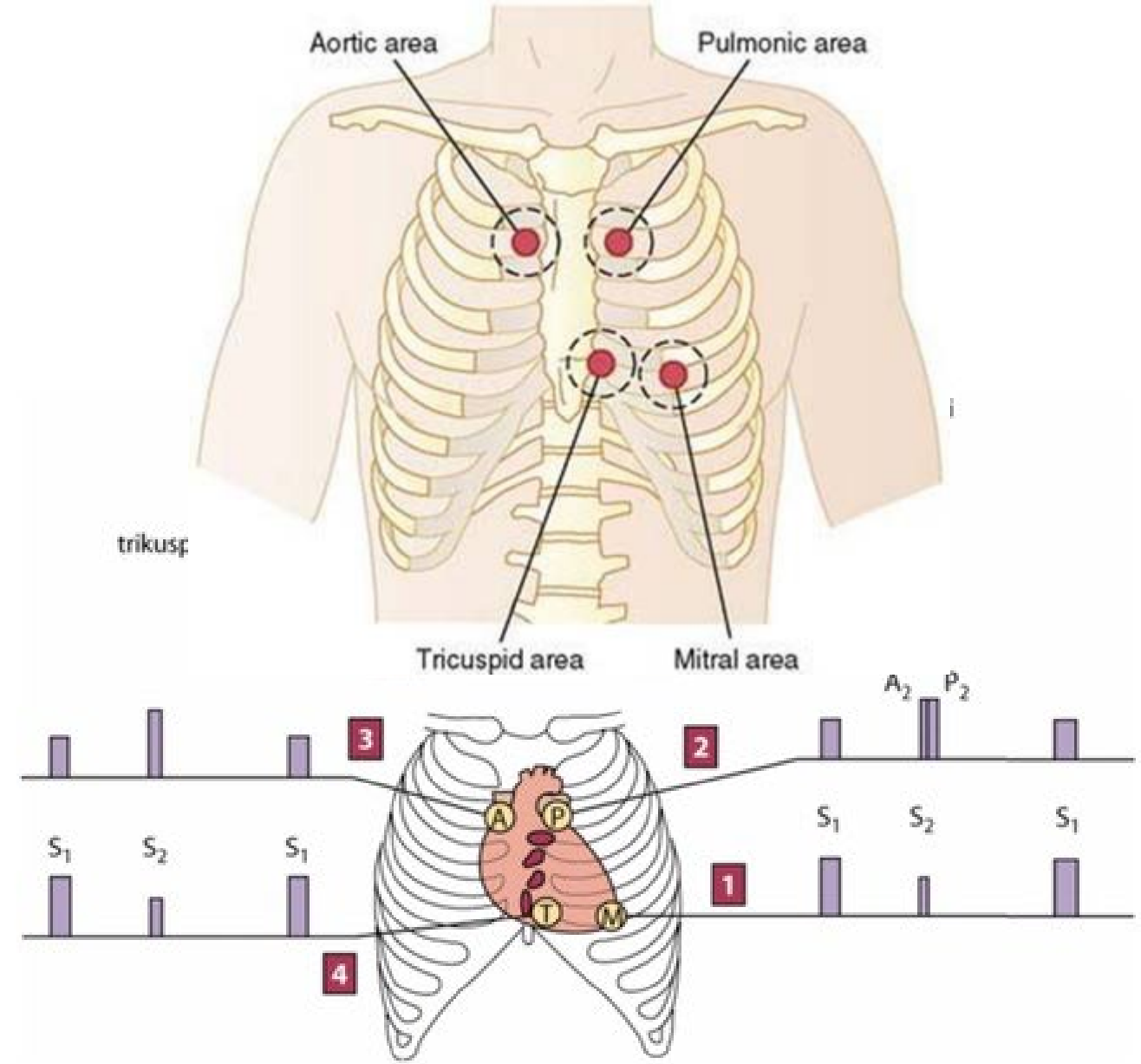


ACLS Medical Training

Heart sounds

- The closing of valves can be heard with a stethoscope
- 1. heart sound: Mitral and tricuspidal valves close
- 2. heart sound: Aortic and pulmonary valves close

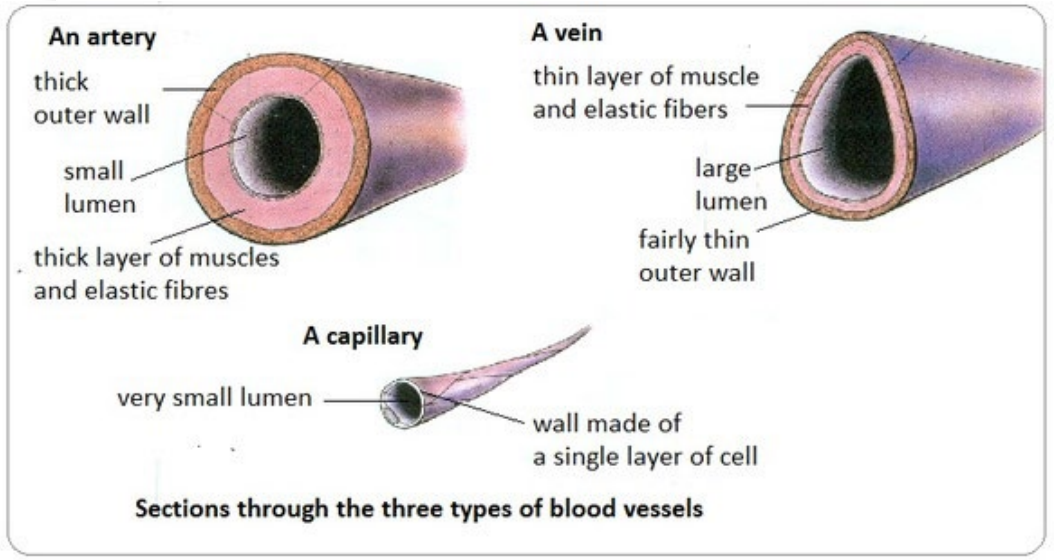
https://www.youtube.com/watch?v=FtXNnmifbhE

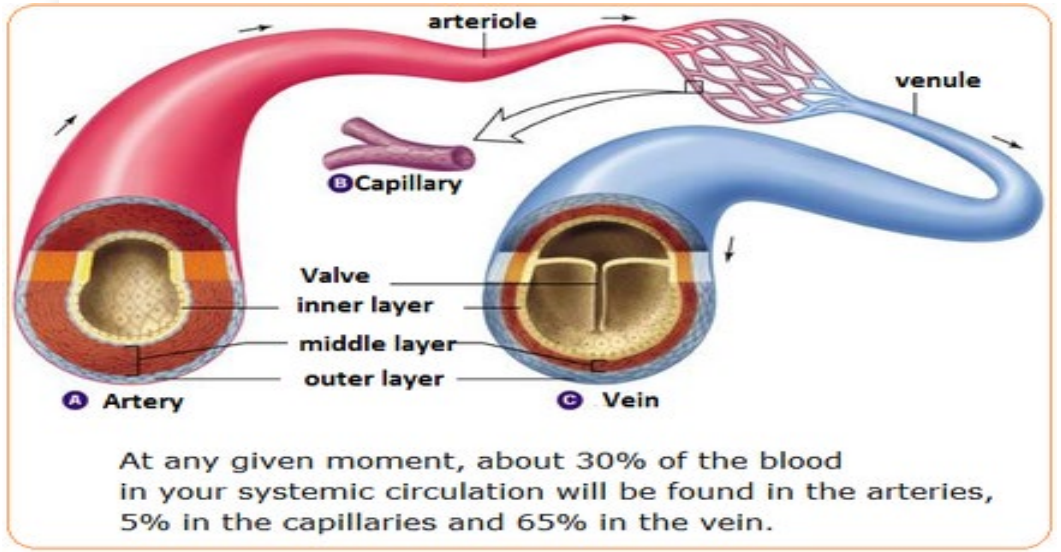


https://diagnosisbook.com/medical-physiology/normal-heart-sound-listen-to-the-heart-with-a-stethoscope

Vessels

- Arteria, veins, capillaries
- Smallest capillaries covered with only one epithelium cell layer (endotelium)
- Large arteria covered by thick muscle cell layer with elastic fibers
- Venous return is supported by the cardiac cycle, valves in the venous tree, and the muscles (pumps)

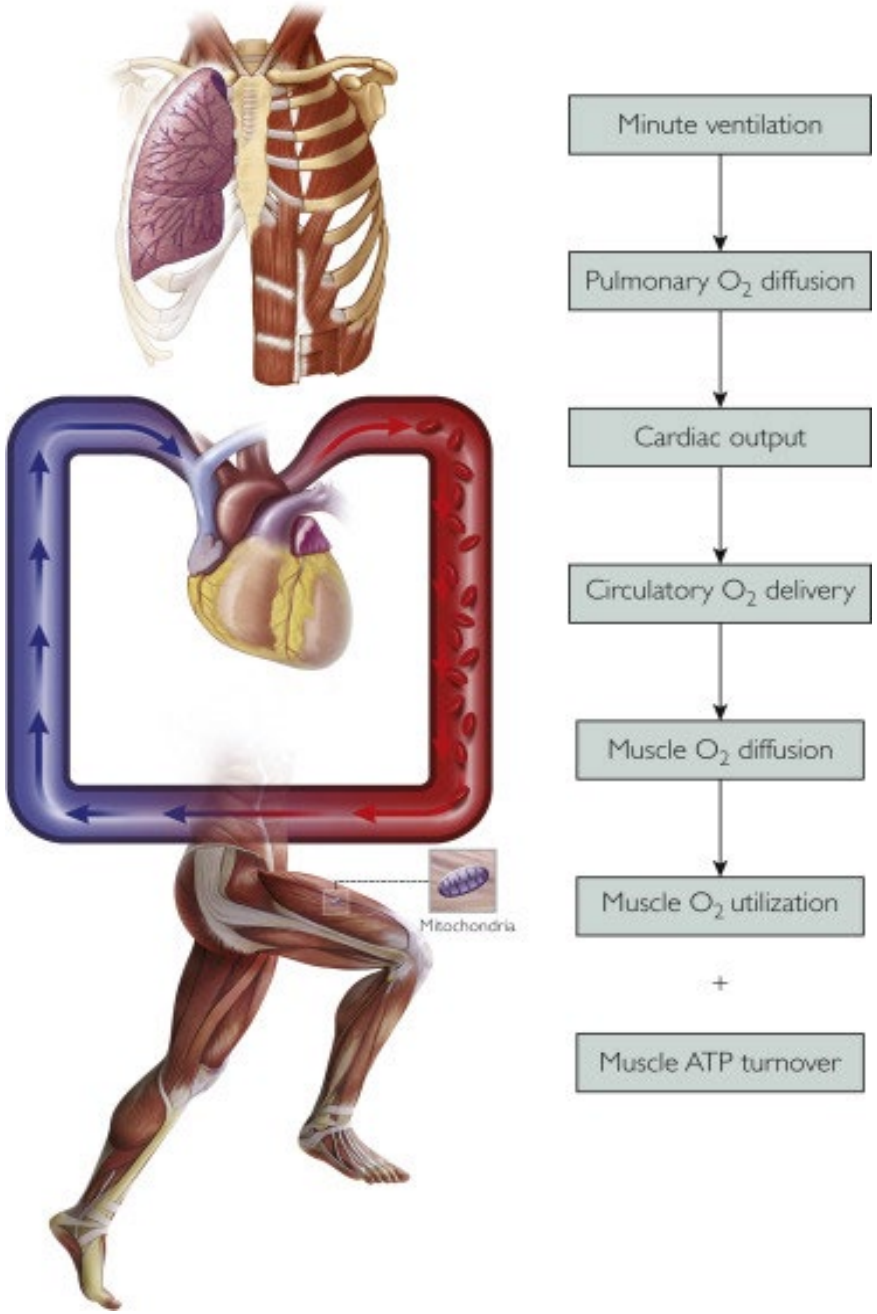




biology-igcse.weebly.com/arteries-veins-and-capillaries---structure-and-functions.html

Organs have different oxygen demands

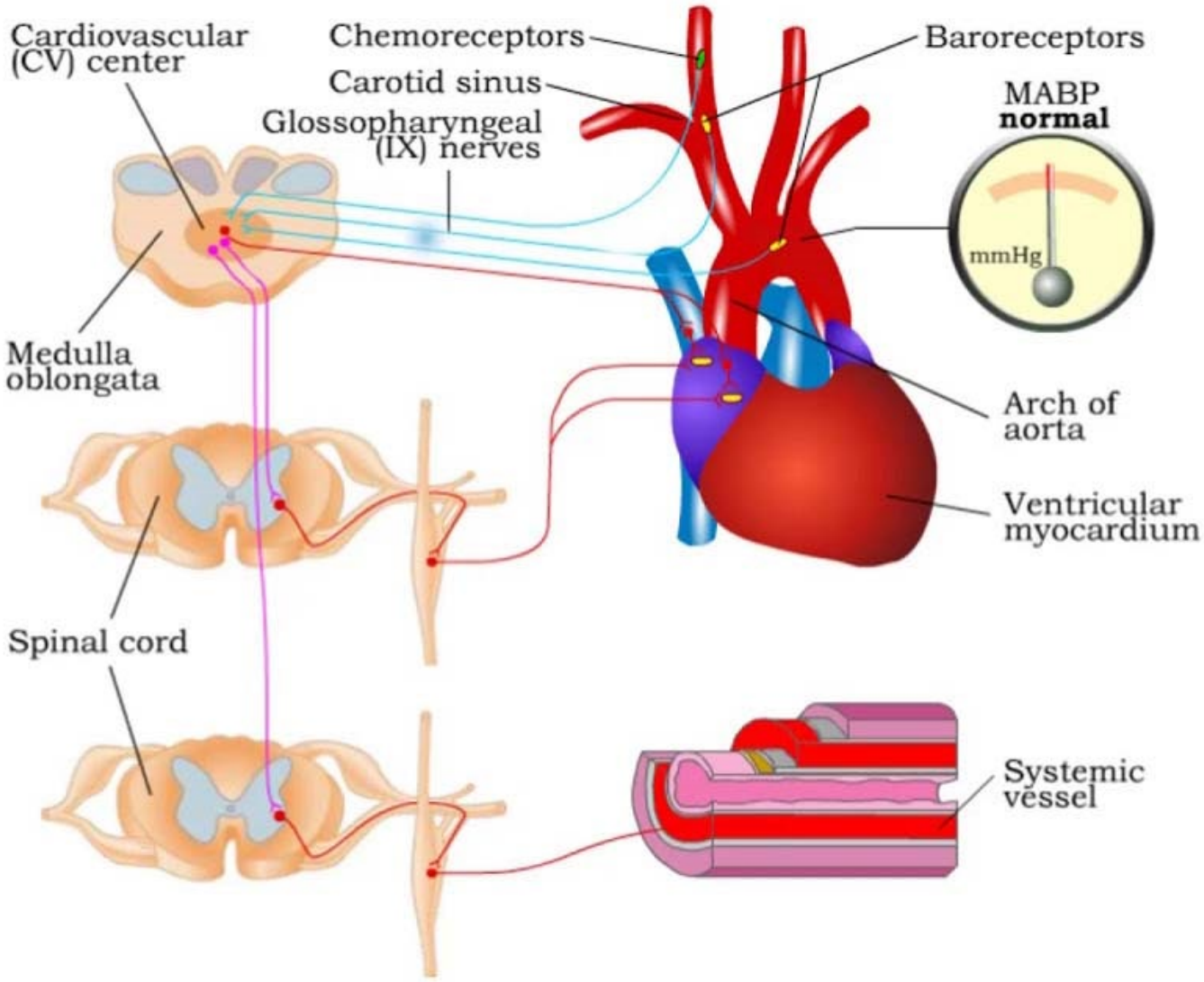
- In rest, brains 15-20%, coronary arteries 4%, kidneys 20%, liver 25%, muscles 20%
- During exercise, muscle demand rises to 80-90% and circulation in inner organs goes down
- Aorta is the largest artery in the body



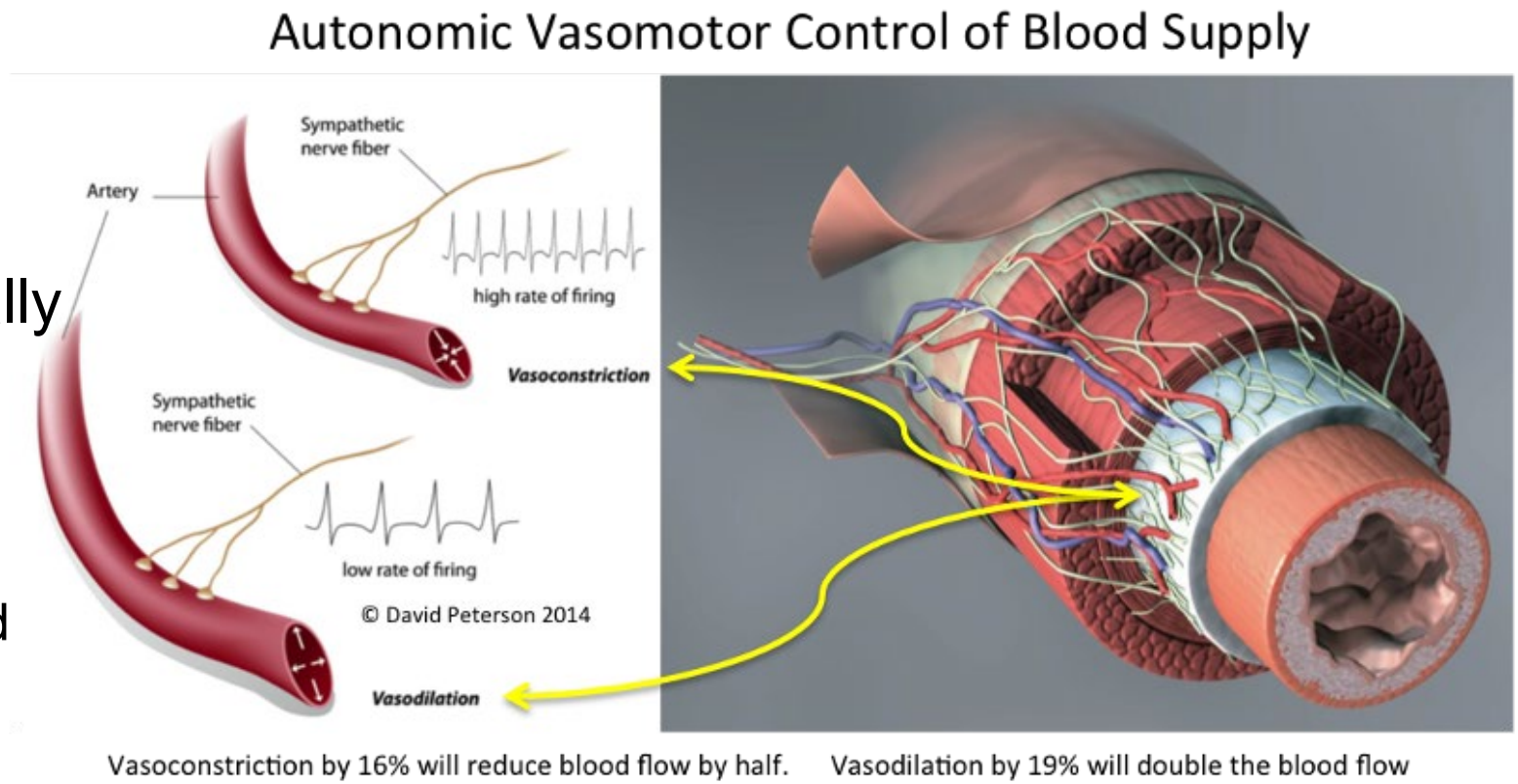
Dominelli et al. 2021

Regulation of circulation

- Autoregulation: Vessels contract and dilate on the basis of CO_2 and O_2 content, stretching, acidity and temperature
- Neural regulation in the vasomotor centre of brainstem
  - Receives both neural and humoral messages
  - Operates via autonomic nervous system

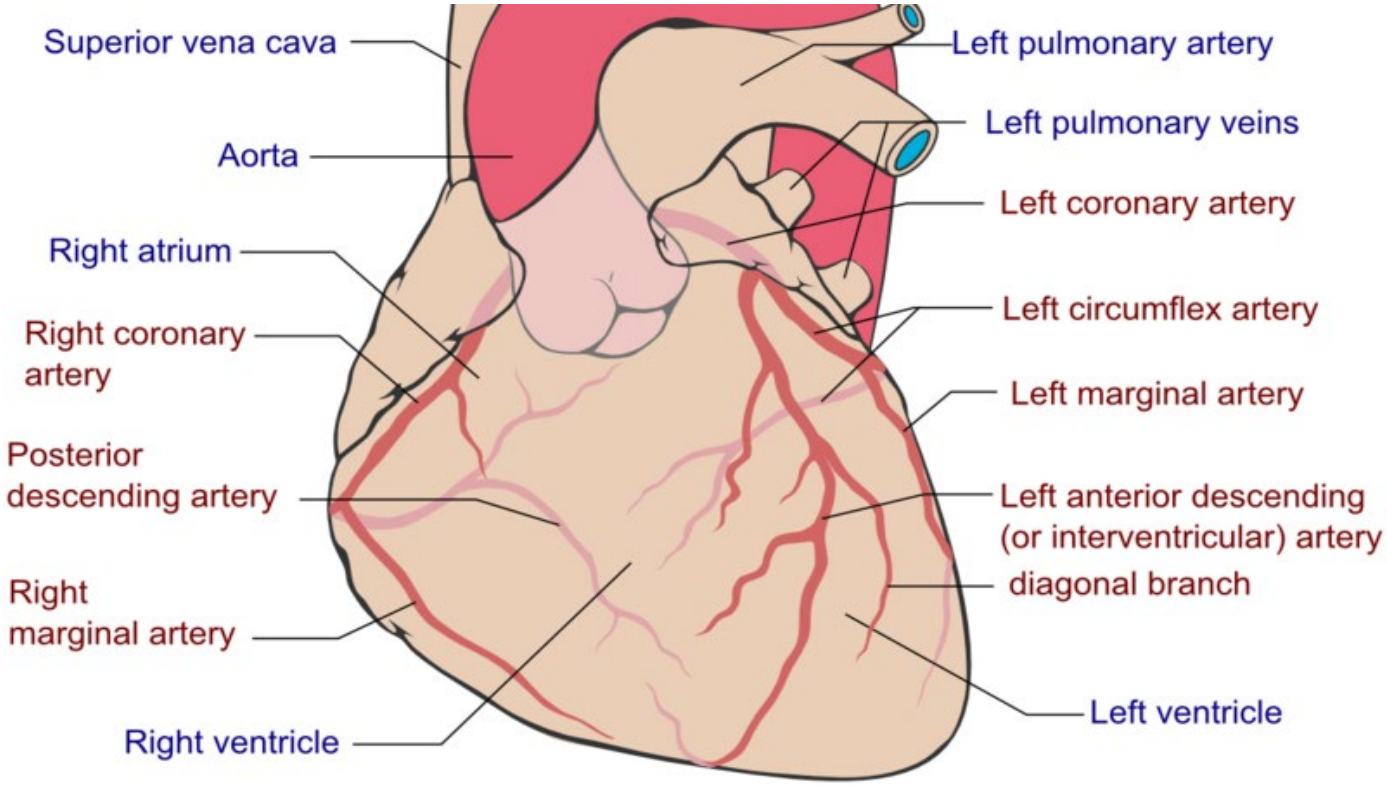


- Humoral factors affect both locally and via the vasomotor centre (chemoreceptors)
  - CO_2 and O_2 content, renin from kidneys, epinephrine and norepinephrine from adrenal gland



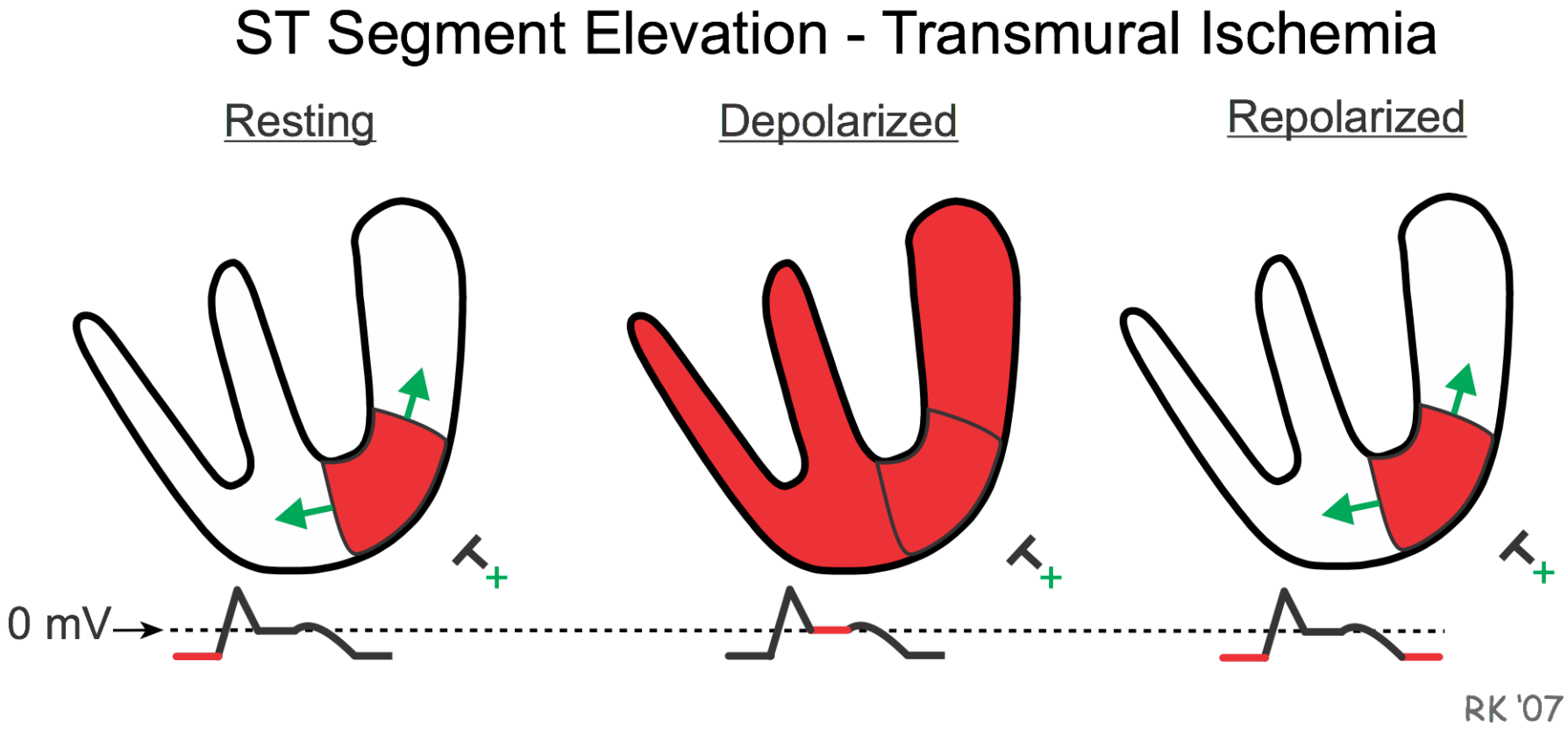
Coronary arteries

- Heart weight only 0.5% of body weight, circulation 4-5%, oxygen consumption 10%
- Coronary arteries nurture the heart
- Ventricular contraction and the related increase in pressure hinders blood flow in left ventricle → most infarctions here



Wikipedia

Why ECG changes in cardiac infarction?



https://www.cvphysiology.com/