Foundations of Psychophysiology

Part 6.1: The cardiovascular system

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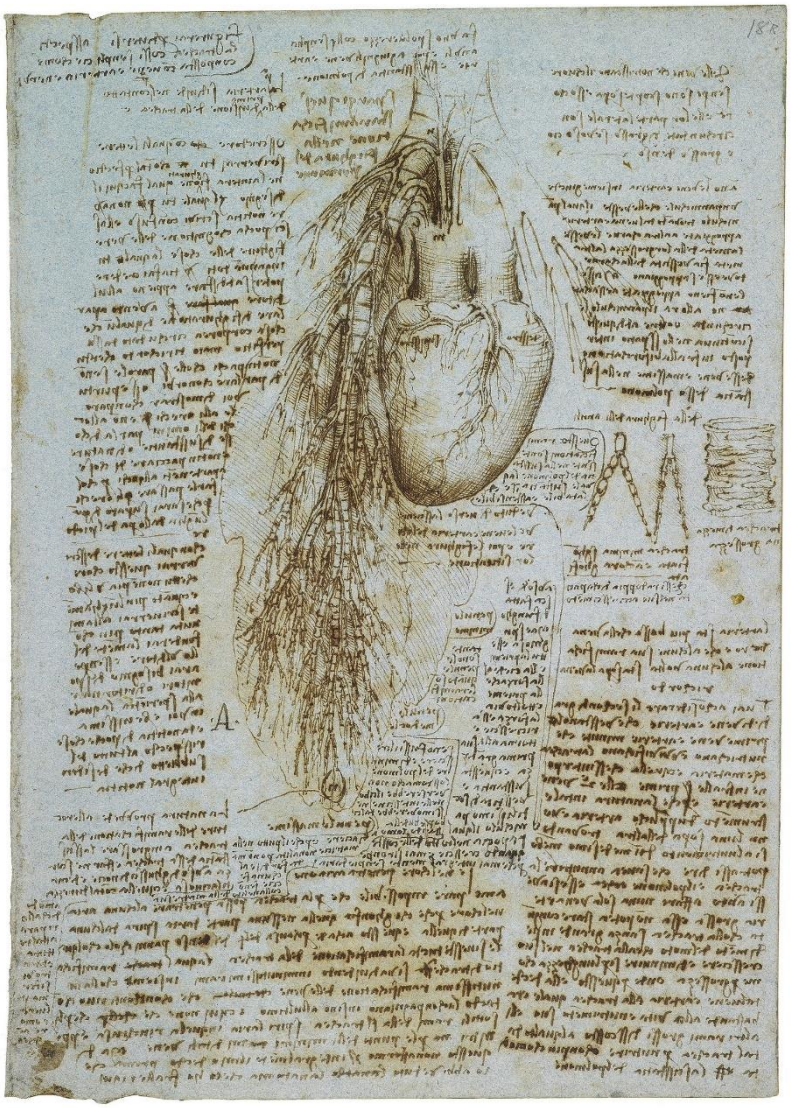
NEUROADAPTIVE
HUMAN-COMPUTER
INTERACTION

Brandenburg
University of Technology
Cottbus - Senftenberg

Psychophysiology: Cardiovascular system

Introduction



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Function

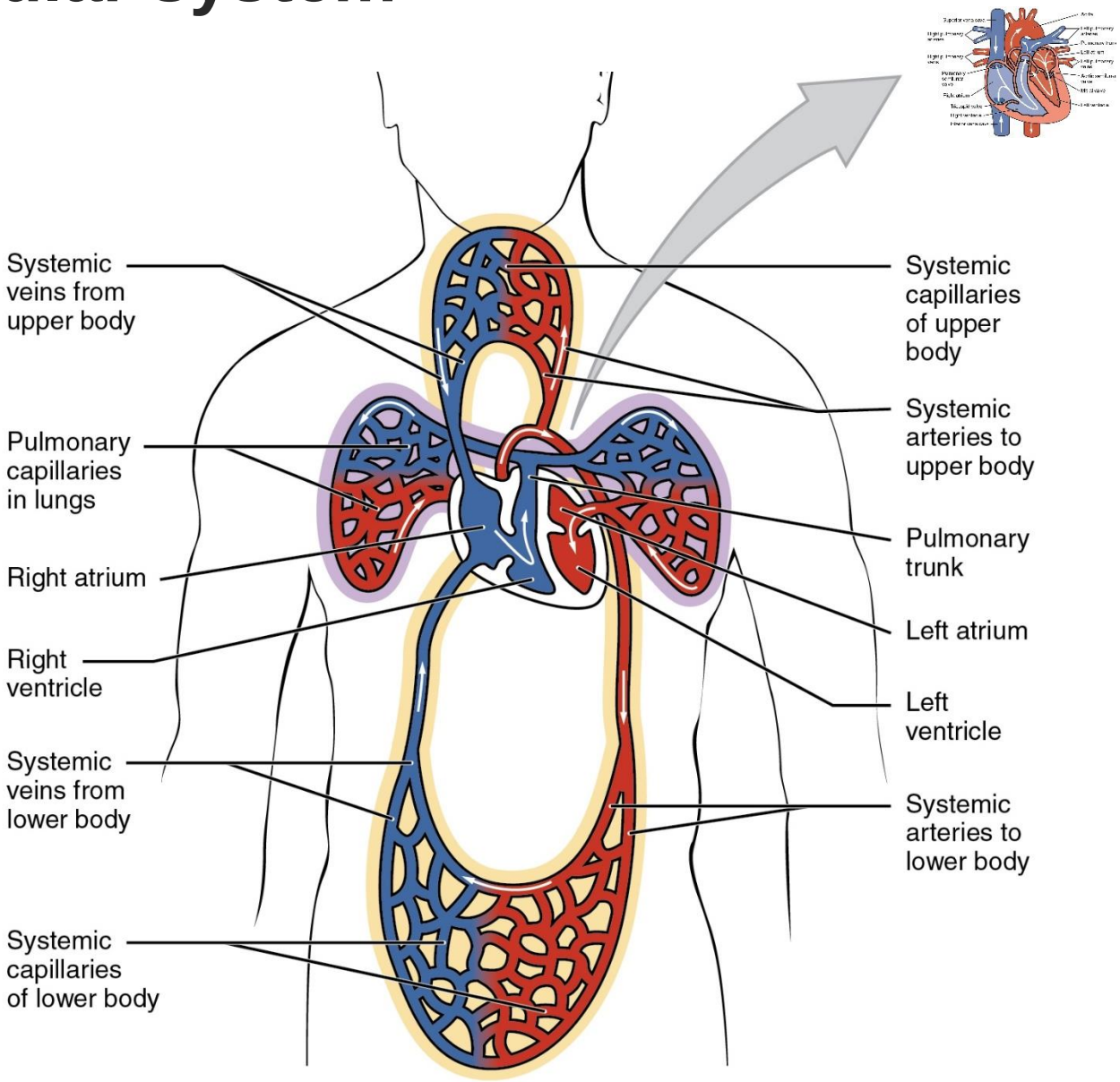
The cardiovascular system, with the heart as its main “pump”, serves to transport blood to and from the organs.

This

- brings necessary oxygen and nutrients to the organs;
- transports waste products;
- regulates the bodily temperature; and
- aids endocrine communication.

Cardiovascular activity varies as the energy requirements of the body vary.

Cardiovascular system

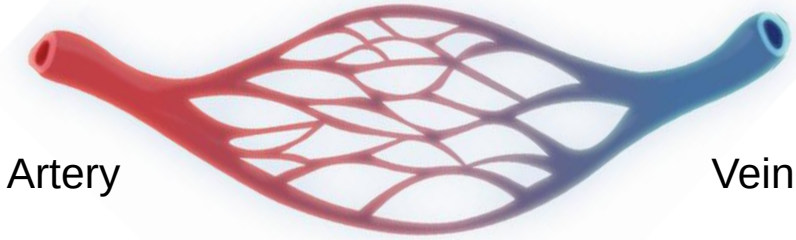


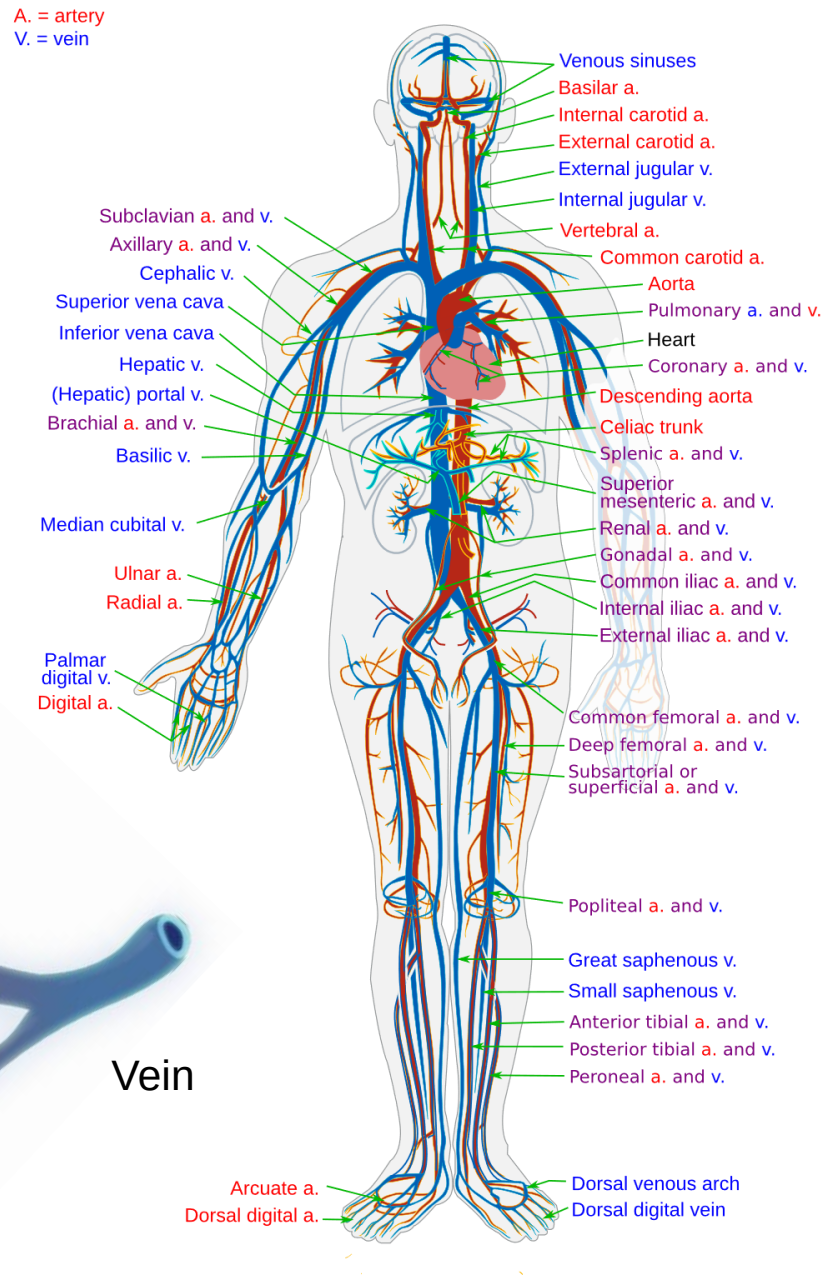
Blood vessels

Arteries carry blood *away from* the heart.

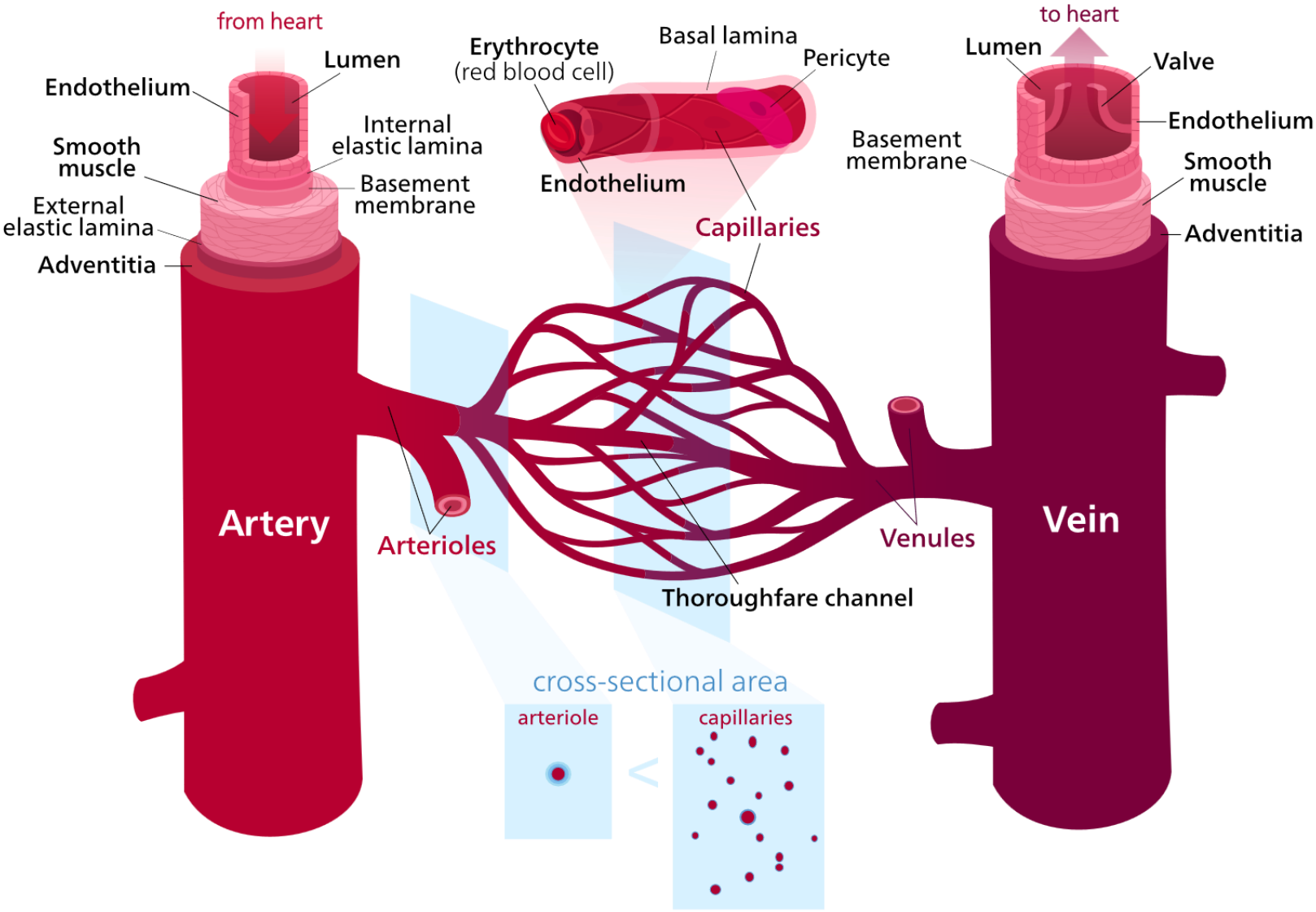
Capillaries are microvessels; oxygen, nutrients, and waste products can pass through their walls.

Veins carry blood *towards* the heart.

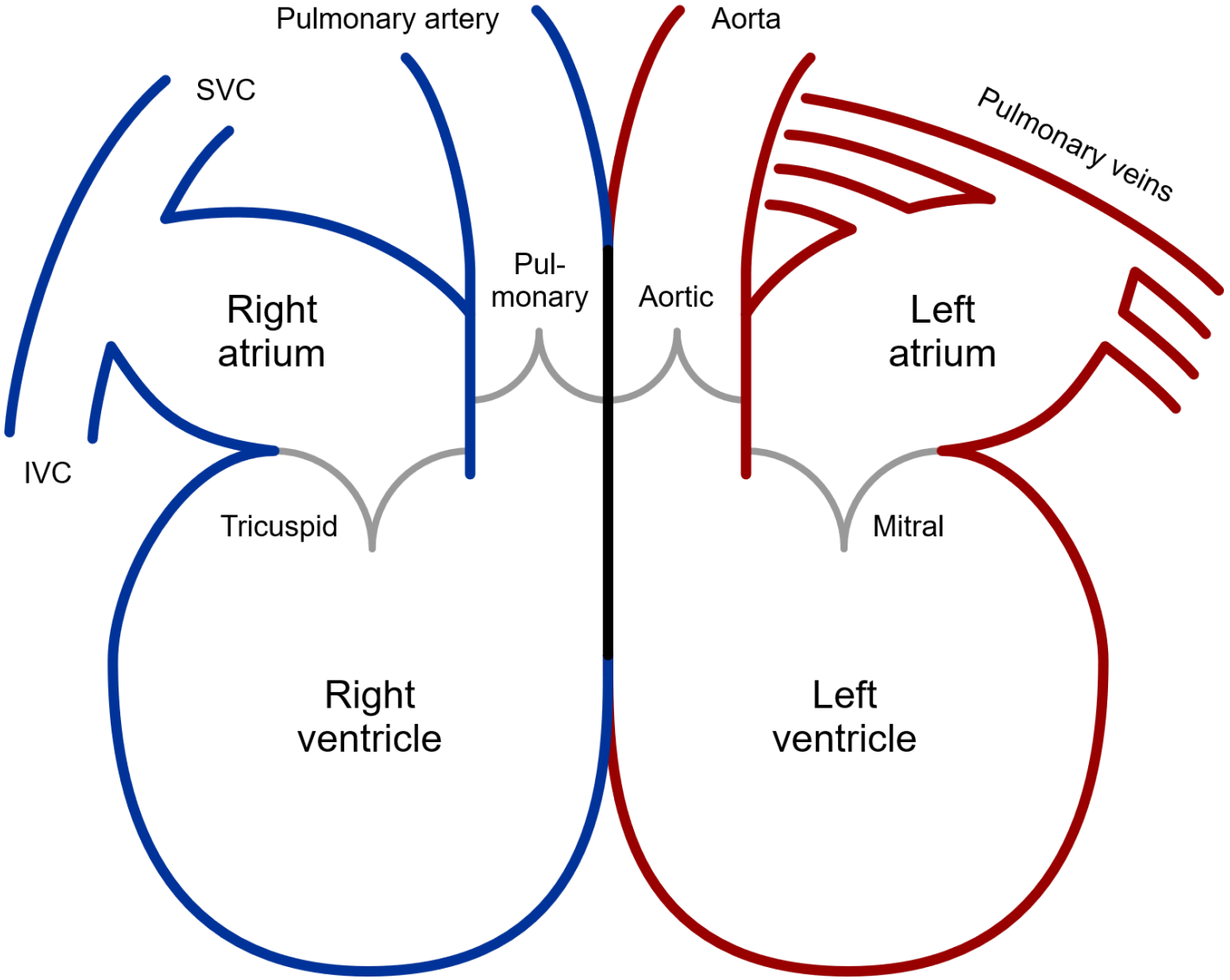




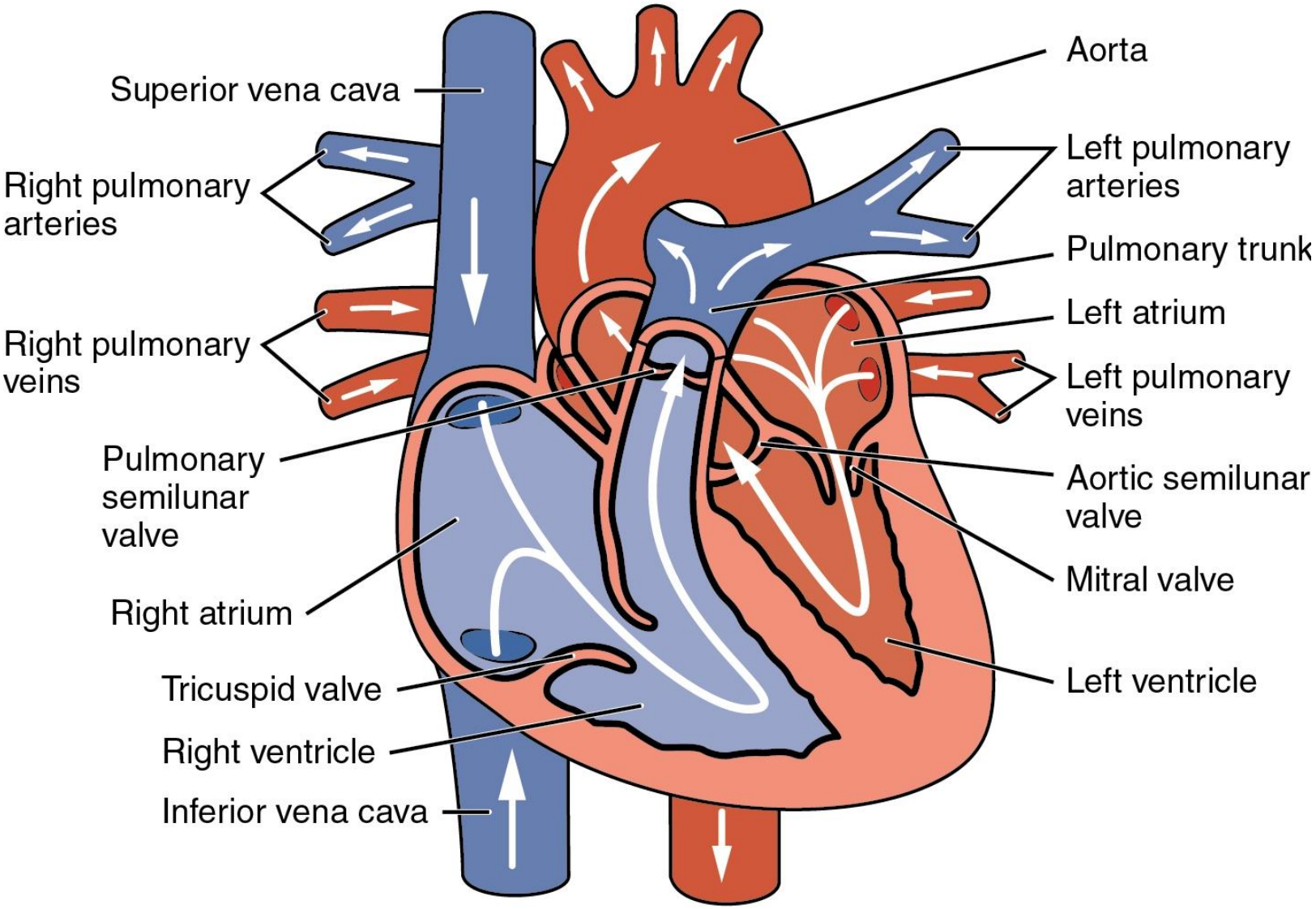
Blood vessels



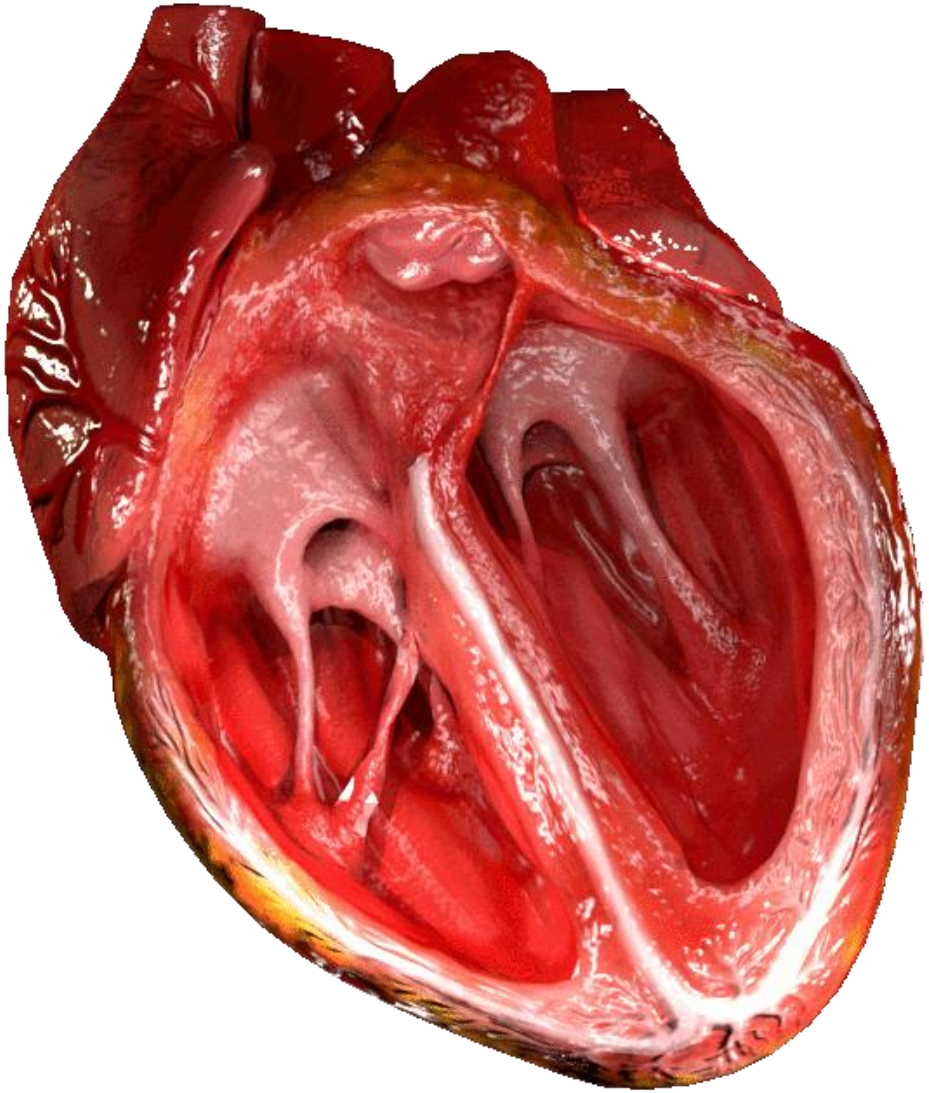
The heart


Pulmonary artery
Aorta
SVC
Pulmonary veins
Pul-
monary
Aortic
Right
atrium
Left
atrium
IVC
Tricuspid
Mitral
Right
ventricle
Left
ventricle

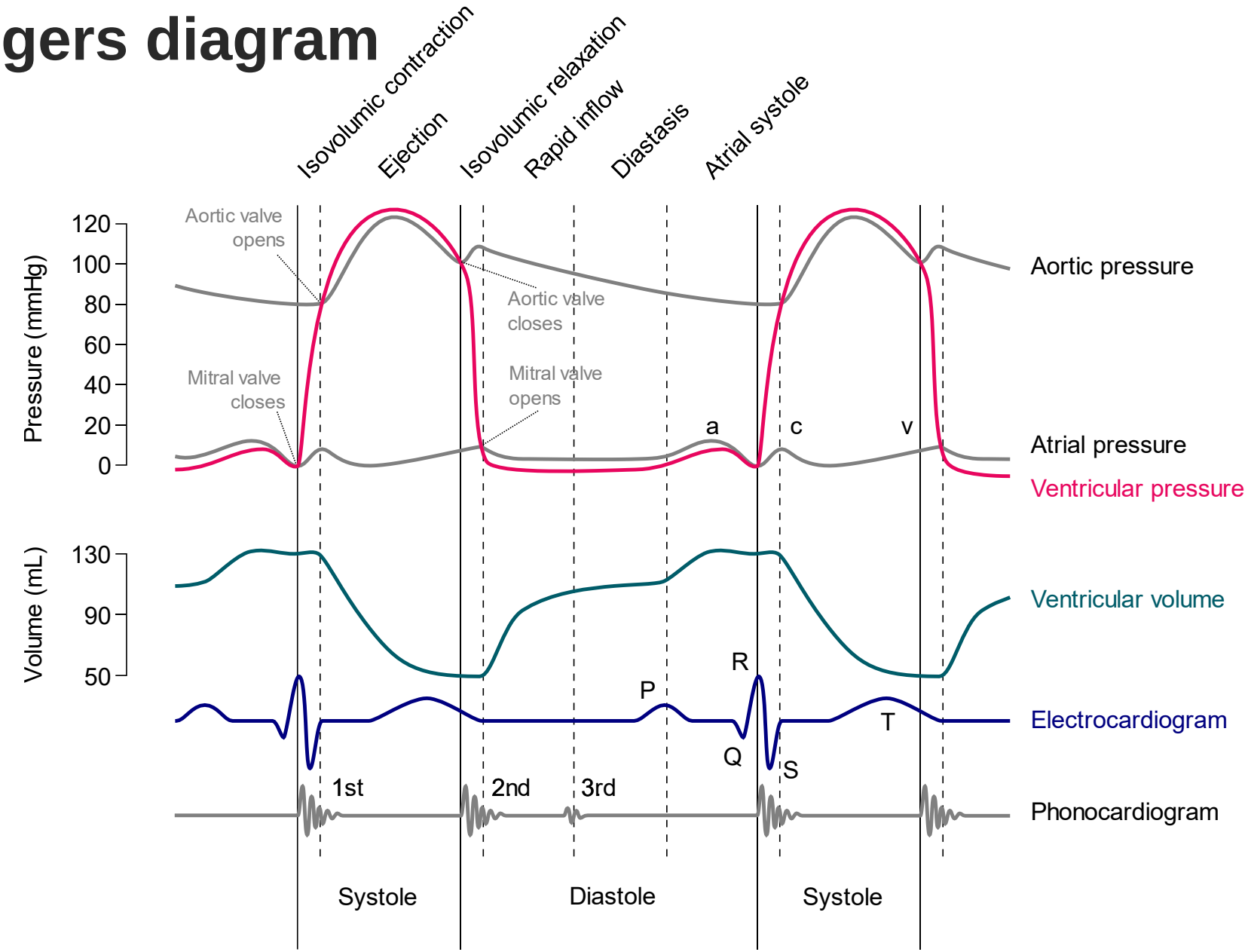
Cardiac anatomy



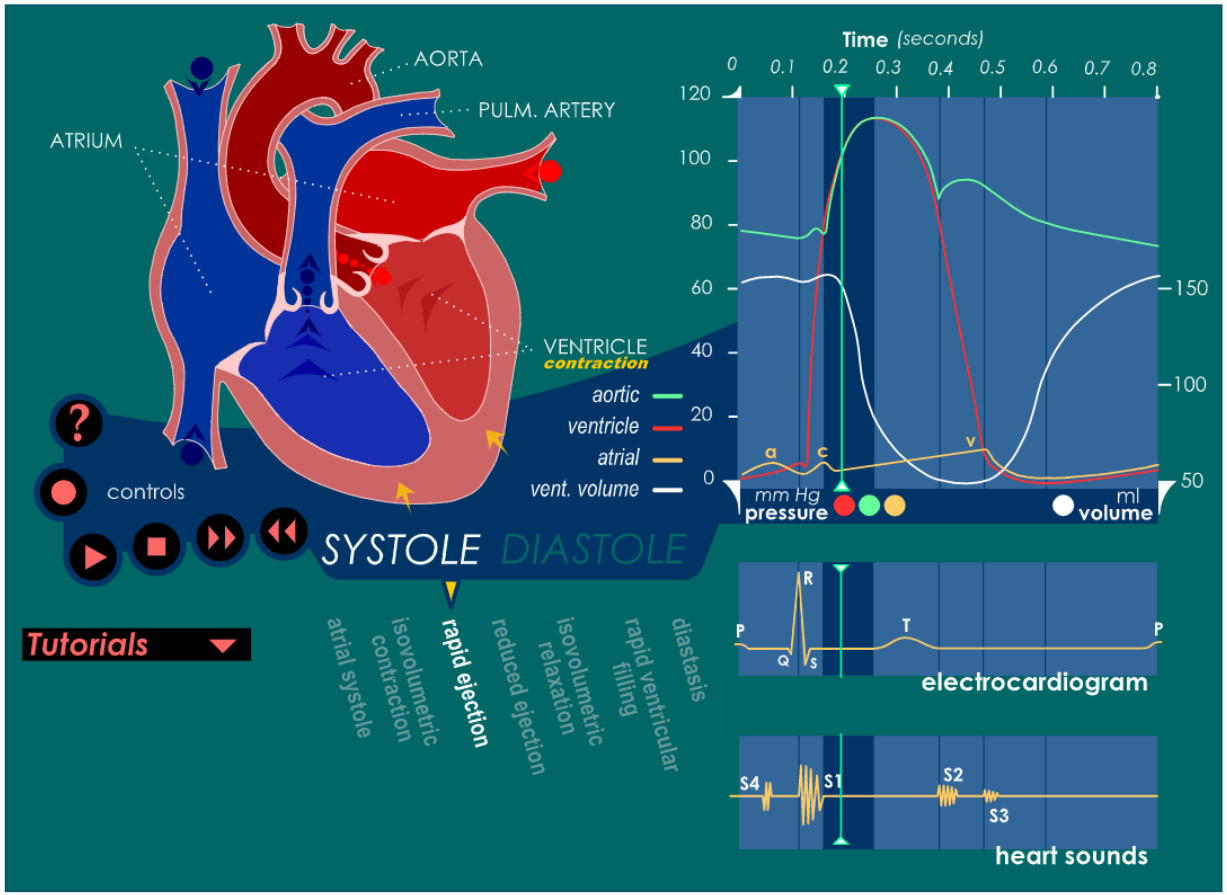
Cardiac activity



Wiggers diagram

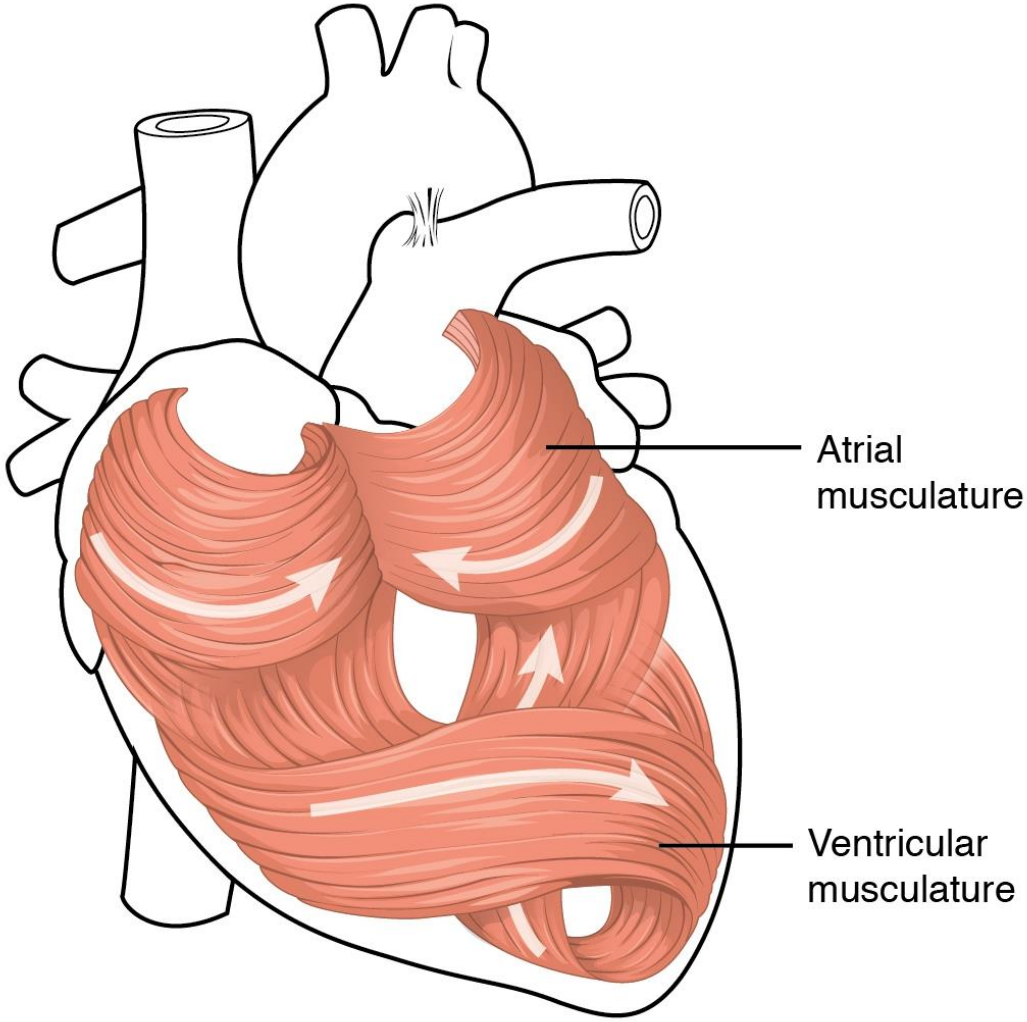


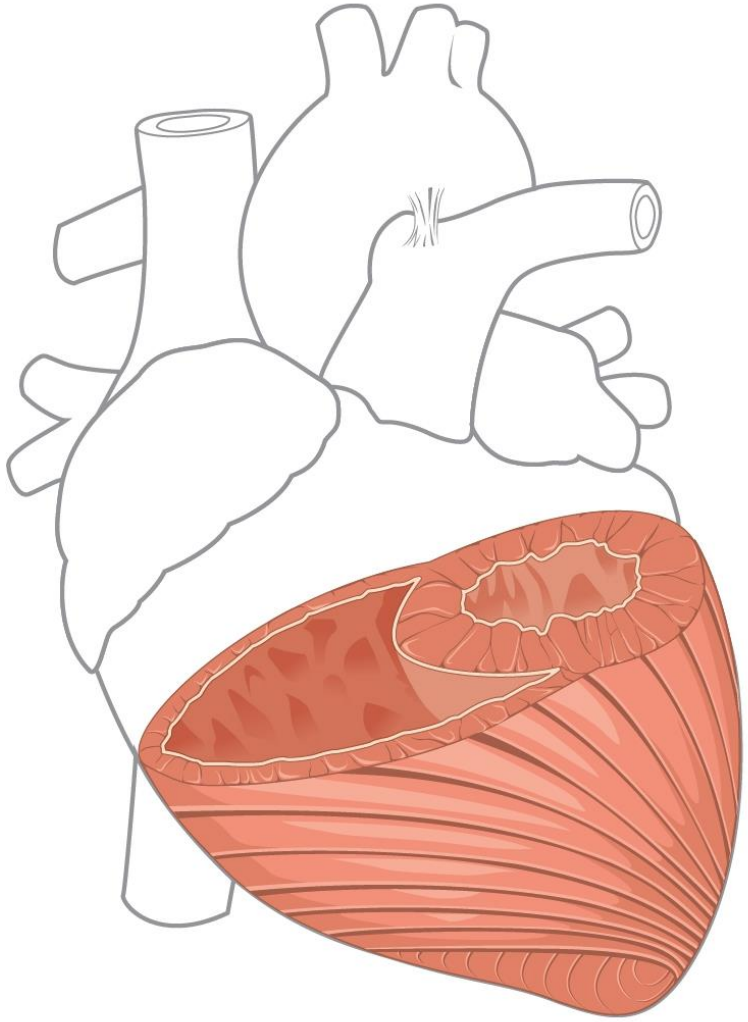
Interactive Wiggers diagram



https://library.med.utah.edu/kw/pharm/hyperheart

Cardiac muscles





Myocardium

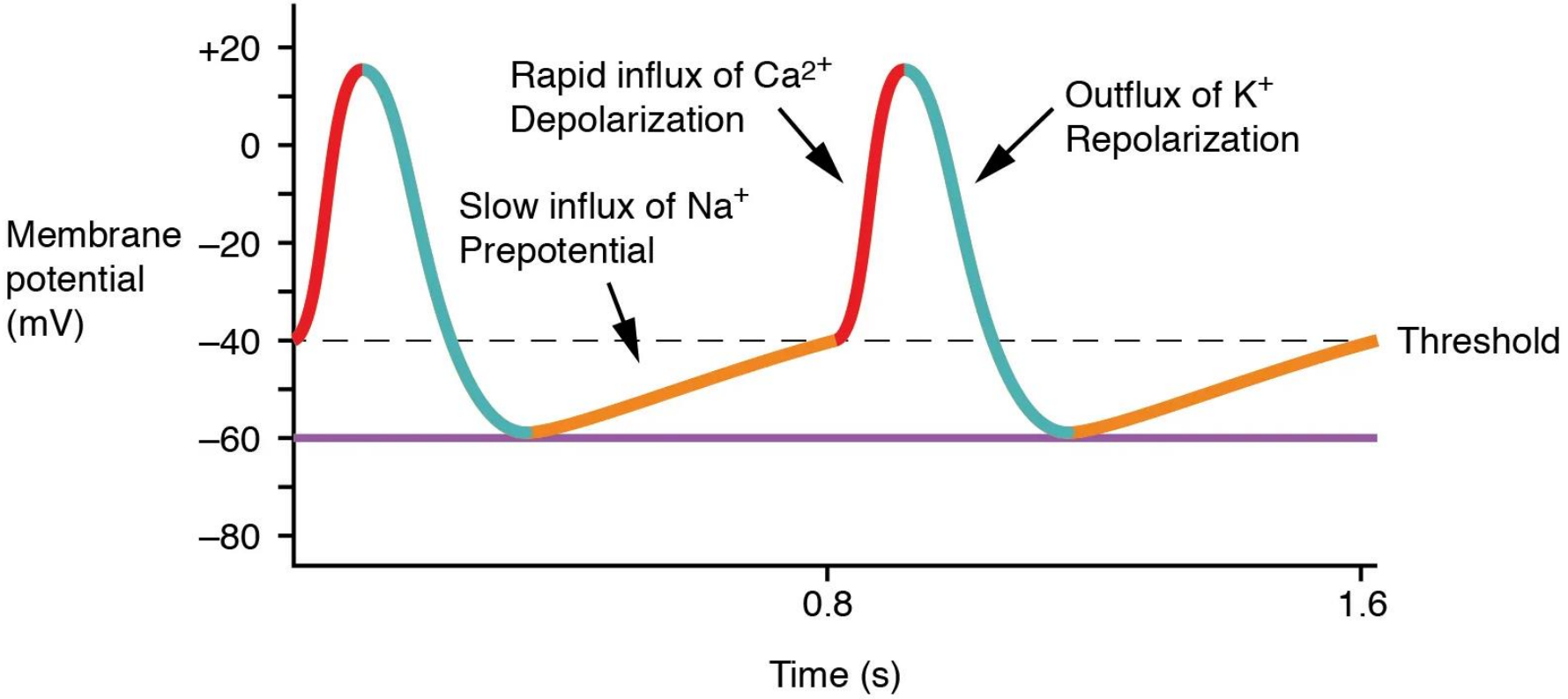
The **myocardium**, or the heart muscles, comprises the thickest of the multiple layers of the heart.

This heart musculature is different from smooth and skeletal muscles.

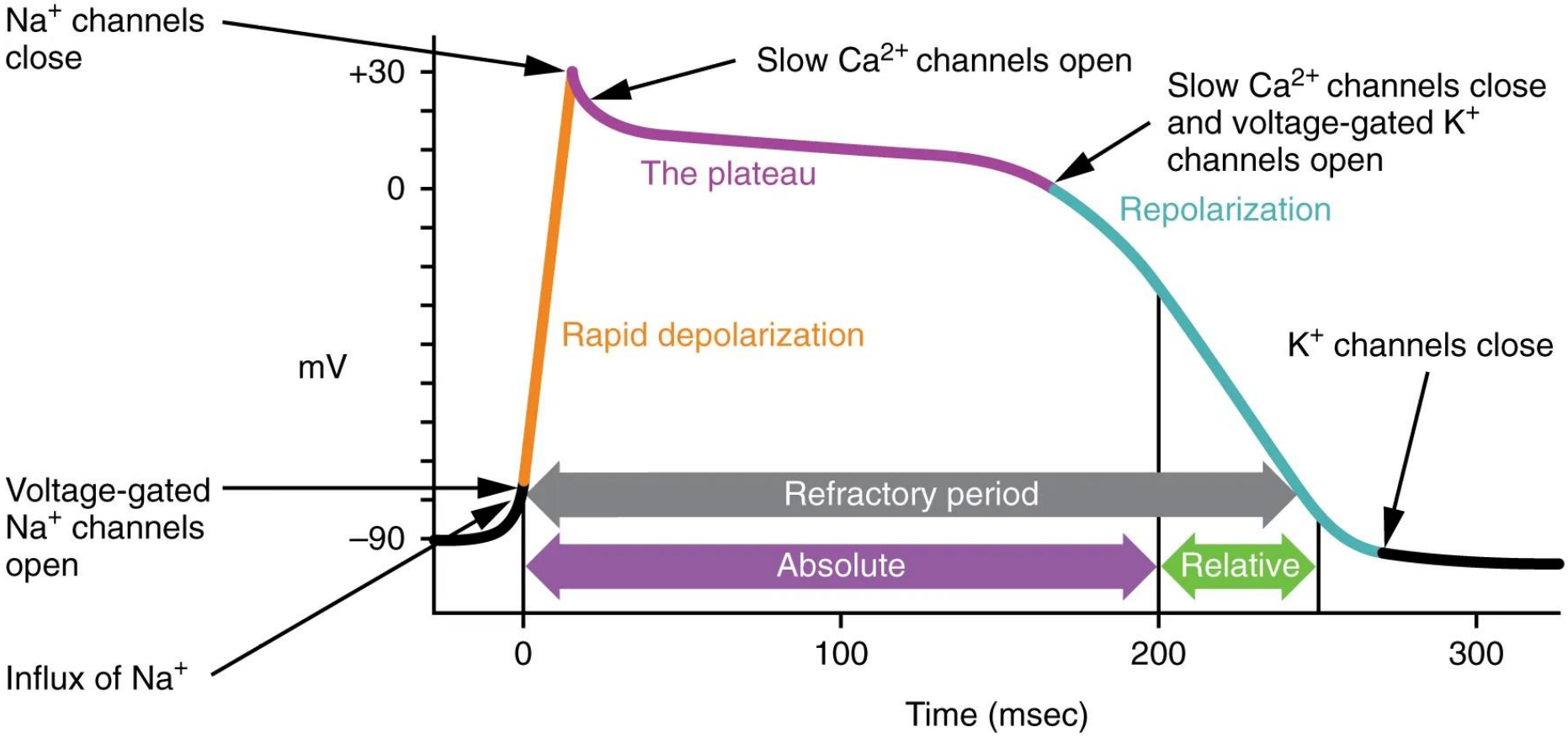
A small percentage of cardiac muscle cells, known as **pacemaker cells**, has the ability to spontaneously produce action potentials. They automatically depolarise over time without external stimulation, and cause the muscle to contract. This is known as **autorhythmicity**.

Cardiac muscle cells (**cardiomyocites**) are connected to each other through **gap junctions**, allowing cardiac action potentials to be freely conducted between cells.

Pacemaker (conductive) cells



Contractive cells



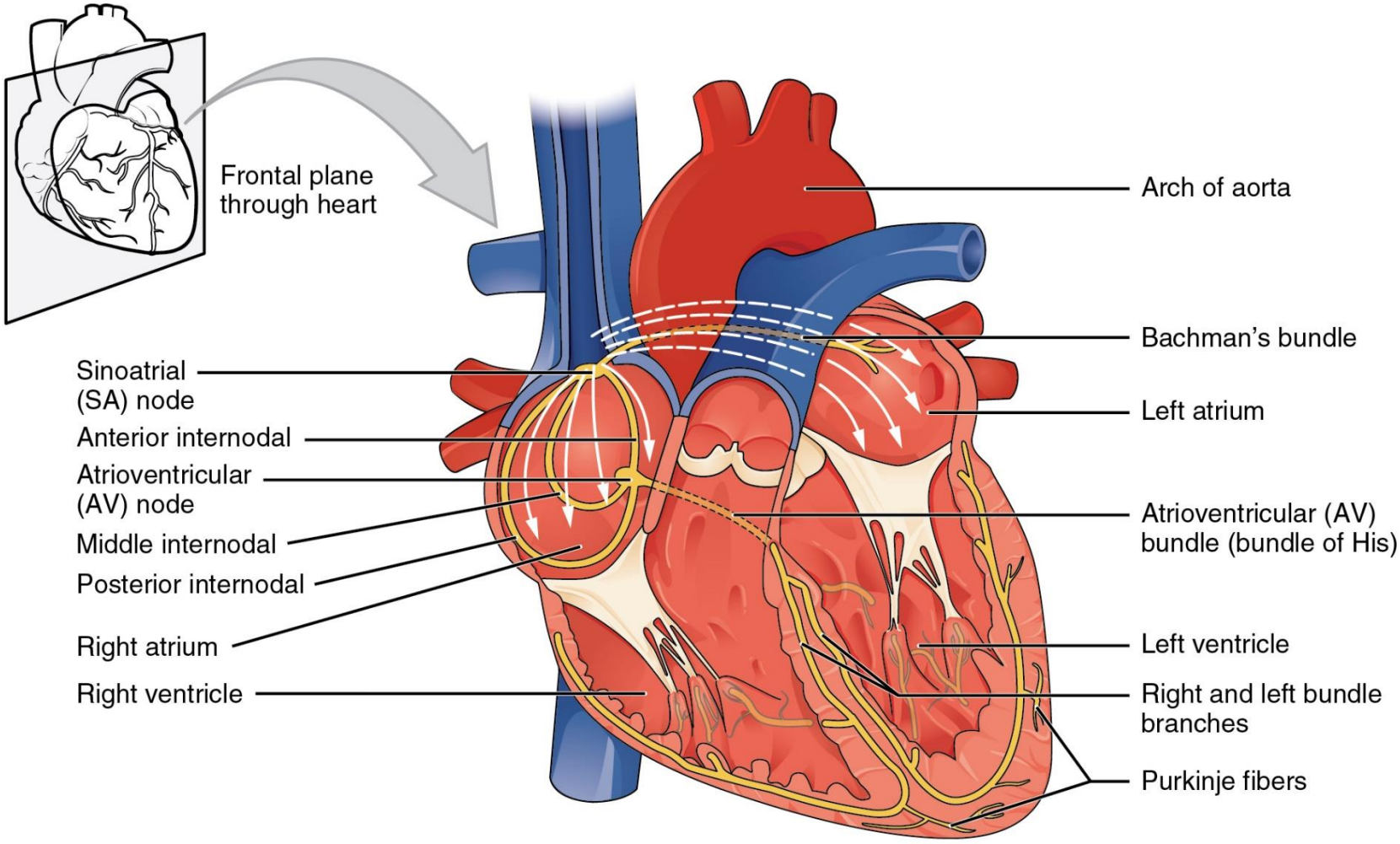
Neural conduction

The **sinoatrial node** is a group of pacemaker cells located at the superior wall of the right atrium.

Its signal contracts the atria, and then reaches the **atrioventricular node** near the inferior part of the interatrial septum.

This node slightly delays the signal, allowing the atria to fully contract, before conducting the signal through the **Bundle of Hiss** and the **Purkinje fibers** into the ventricular walls, which then contract.

Neural conduction



Anterior view of frontal section

Heart rate

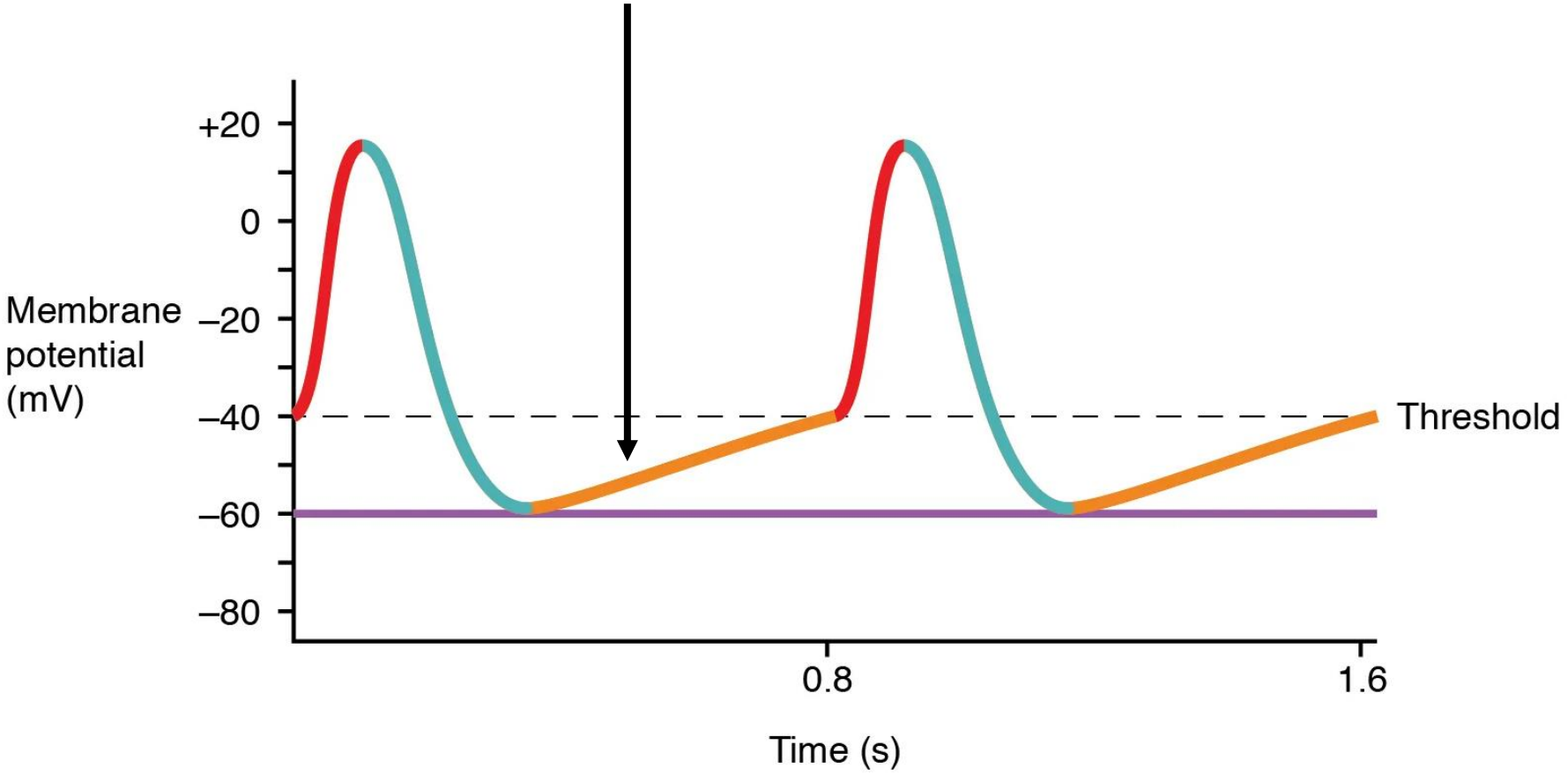
The SA node is the primary pacemaker, with the AV node yoked to its **sinus rhythm**.

The SA node has an intrinsic rhythmicity of about 100 bpm; the AV node of about 40-60 bpm, the Bundle of His 20-40. The fastest available rhythm dominates the others.

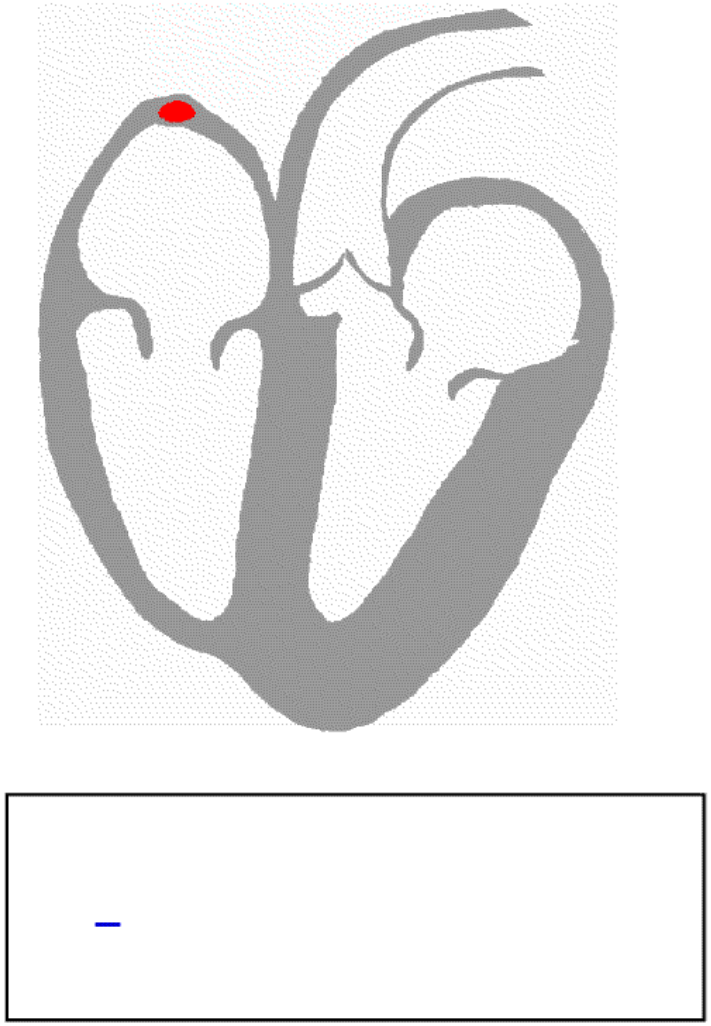
A denervated heart would beat on its own at around 100 bpm. The autonomous nervous system can modulate the cardiac autorhytmicity, both to slow it down (parasympathetic) and to speed it up (sympathetic) as needed.

Autonomic influence

Neurotransmitters open additional Na^+ and Ca^{2+} channels (sympathetic), or open additional K^+ channels (parasympathetic), influencing the rate of depolarization.



Neural conduction and the ECG



The cardiovascular system

The cardiovascular system contains a pulmonary and a systemic circulation, driven by two each of the four chambers of the heart: the right and left, respectively, atria and ventricles.

The myocardium contains pacemaker cells with an instable resting potential, producing autorhythmicity. Neural conduction, also enabled by the gap junctions between the cardiomyocites, spreads throughout the heart and causes sequential contractions.

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