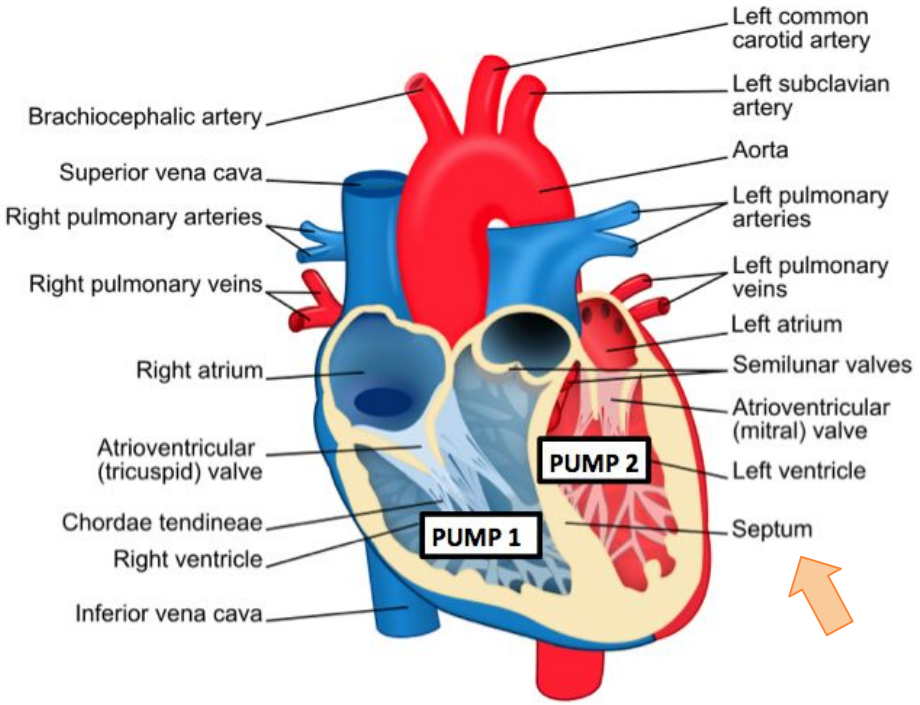
11.4 Cardiac Cycle and Circulation

Septum

A wall of **muscle** called the **septum** separates the heart into **two parallel pumps**, each with an atria and a ventricle.



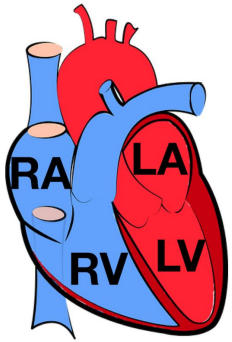
Atria and Ventricles

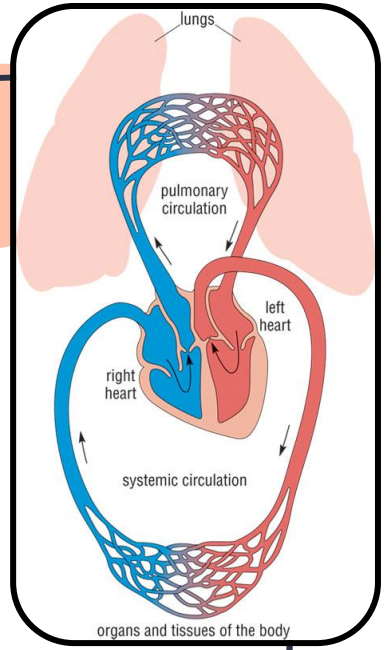
Atria

- ✗ located at the top of the heart
- ✗ receive blood and pump it into the ventricles.

Ventricles

- ✗ located at the bottom of the heart
- ✗ pump blood out into two circuits:
  1. pulmonary circuit
  2. systemic circuit

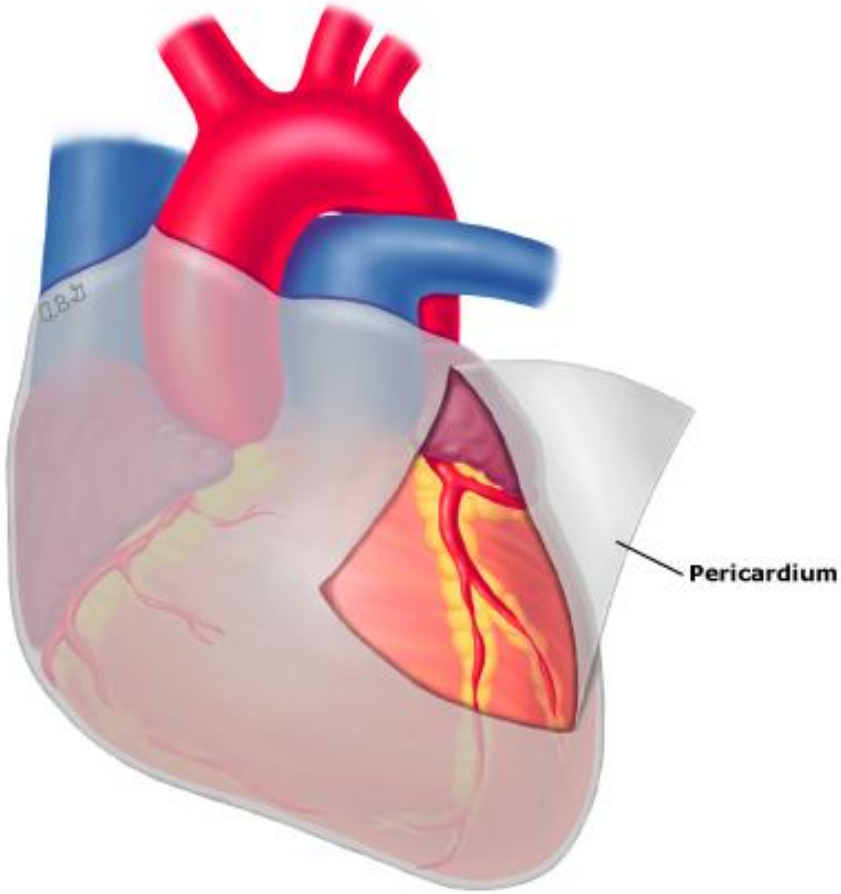




Pericardium

The heart is surrounded by the **pericardium.**

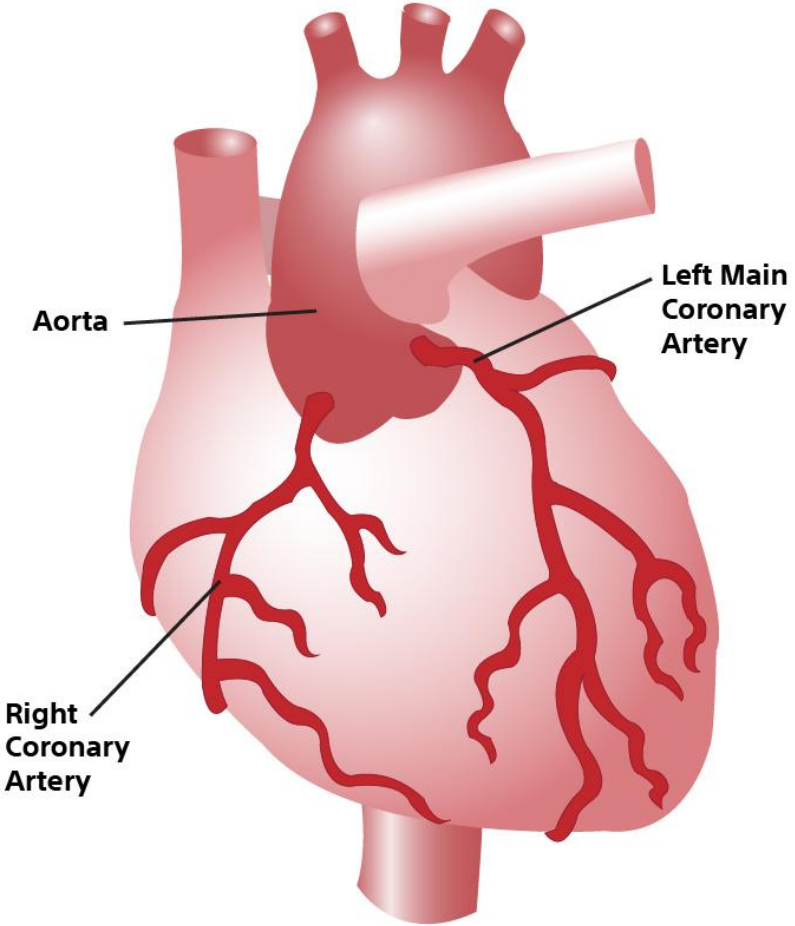
- ✗ a **two-layered membrane** that has **fluid** between the layers.
- ✗ Protects the heart **from friction** with other tissues and organs as the heart beats.



Coronary Blood Vessels

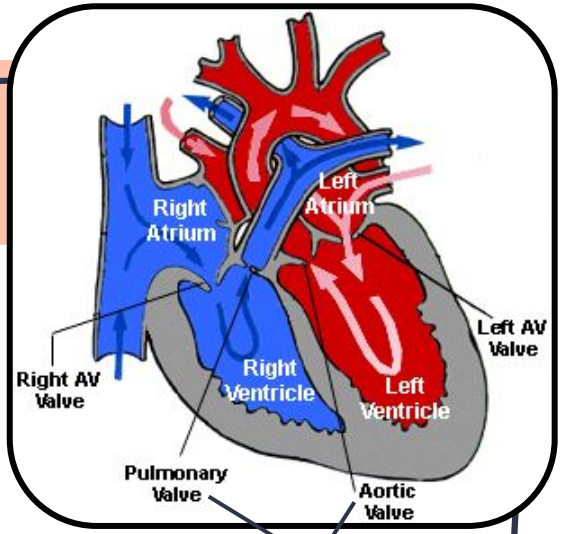
The heart has its own supply of blood vessels, known as the **coronary blood** vessels.

- ✗ Extend from the aorta
- ✗ Provide nutrients and oxygen to the heart tissue.



Heart Valves

There are **four valves** in the heart that ensure blood flows in **only one direction.**



Atrioventricular (AV) valves

- Between the atria and ventricles
- Prevent the backflow of blood from the ventricles into the atria

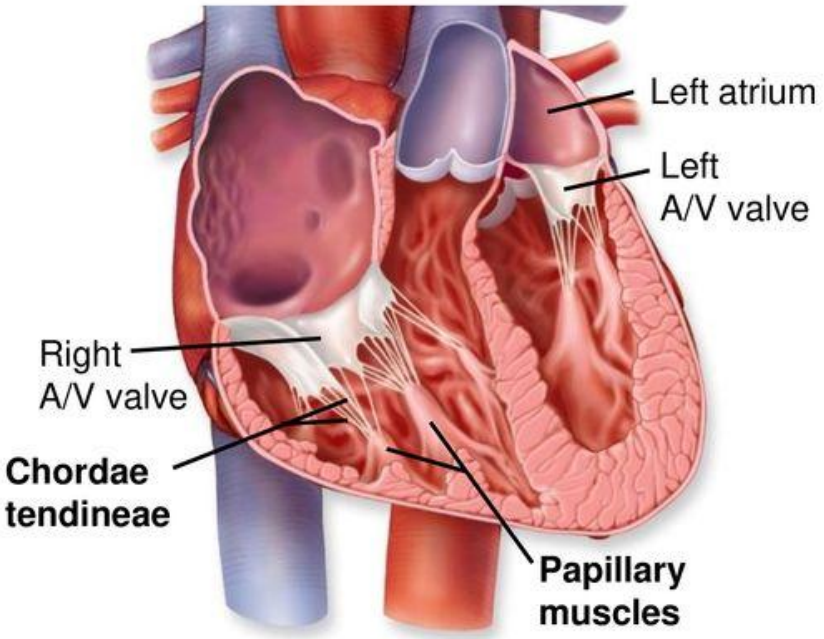
Semilunar valves

- Where the ventricles meet the pulmonary arteries and aorta
- Prevents backflow of blood when the ventricles relax

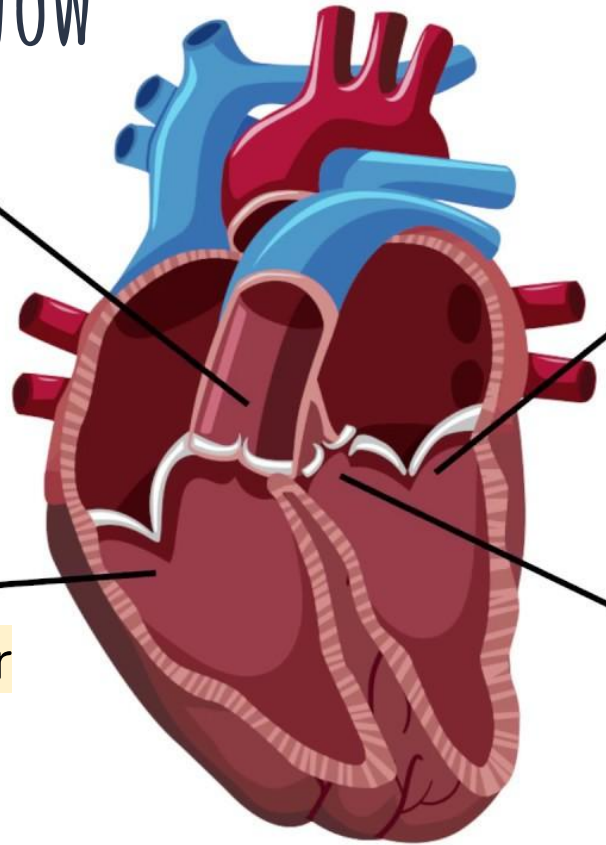
Chordae Tendineae

AV valves are attached to the inside of ventricles by chordae tendineae

- ✗ The chordae tendineae attach specifically to papillary muscles inside ventricle
- ✗ Prevents inversion of valve flaps



Valve Names to Know



Pulmonary
Semilunar

Mitral
Bicuspid
Atrioventricular

Tricuspid
Atrioventricular

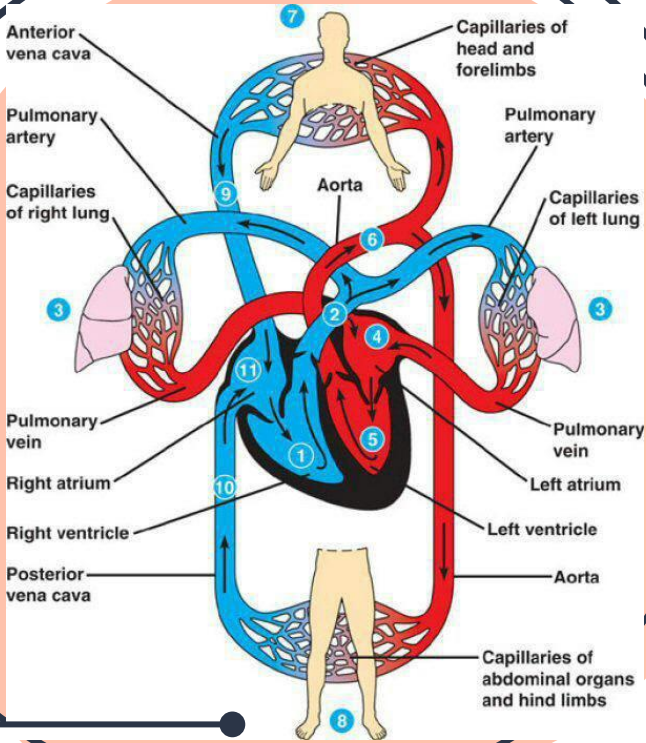
Aortic
Semilunar

Journey of a red blood cell

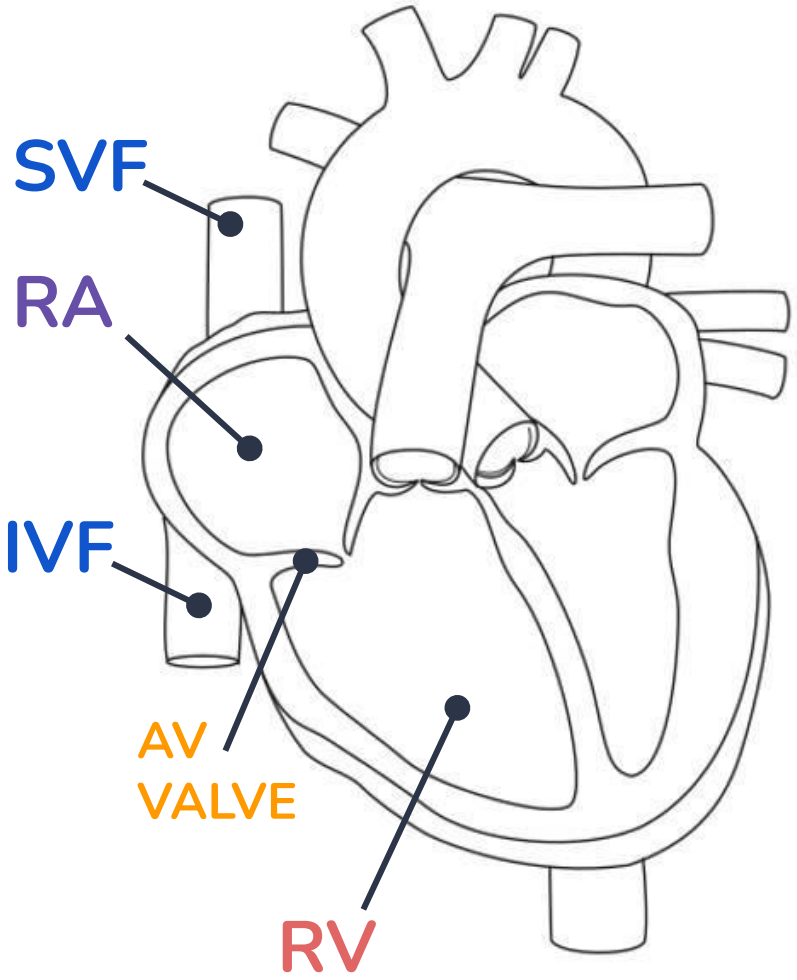
You are a red blood cell, draw your path through the human heart!

- ✗ You are a red blood cell coming from your **little toe** where you just gave up your oxygen (for **<u>cellular respiration</u>**)

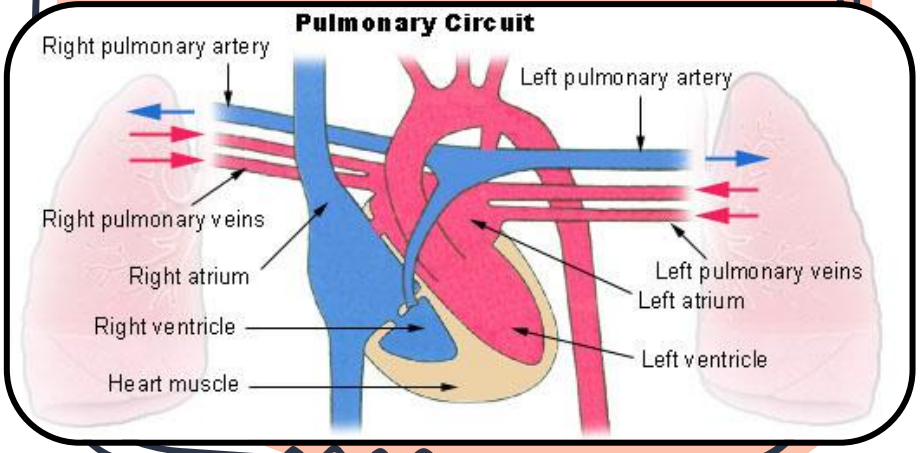
- ✗ You are deoxygenated
  - ✗ CO_2 is bound to you instead of O_2

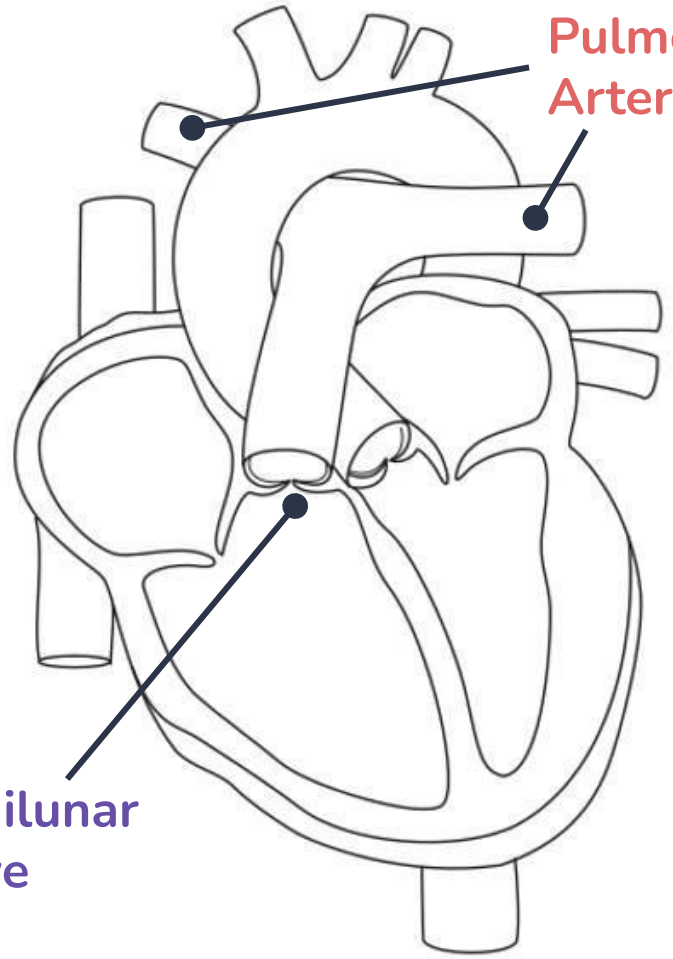


- ✗ You enter the right atrium (RA) of the heart by the inferior vena cava (IVF).
- ✗ Contraction of the right atrium and gravity force you past the atrioventricular valve and into the right ventricle.

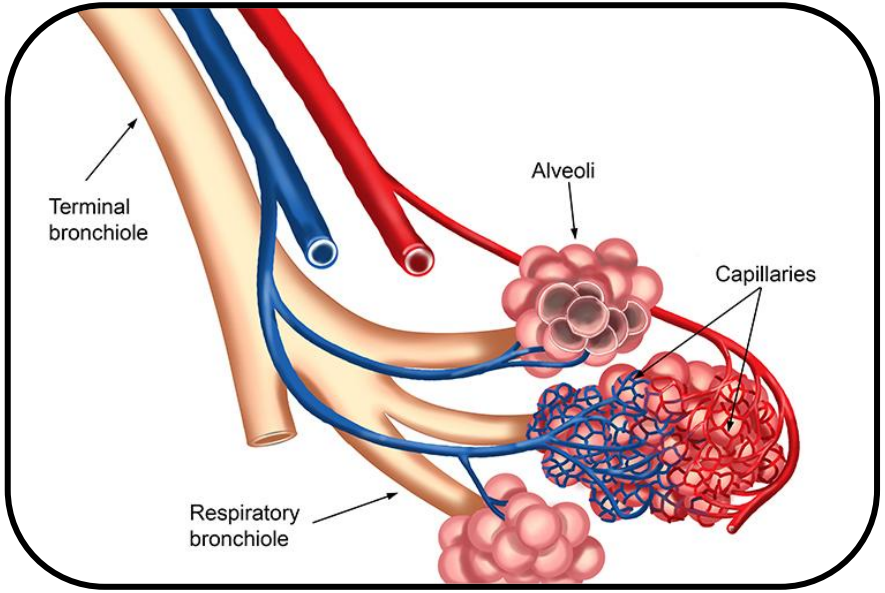


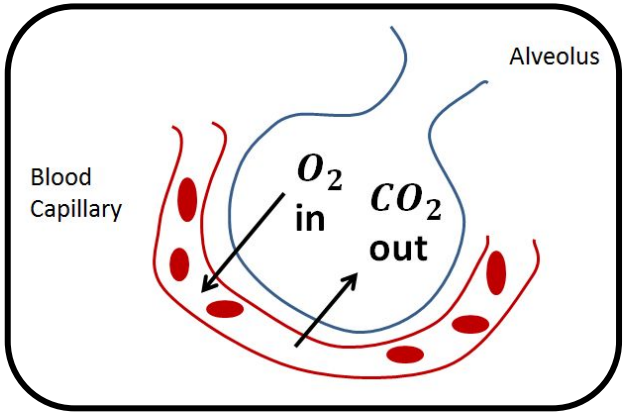
- The heart contracts using a wringing motion which forces you past the semilunar valve and into the pulmonary arteries.



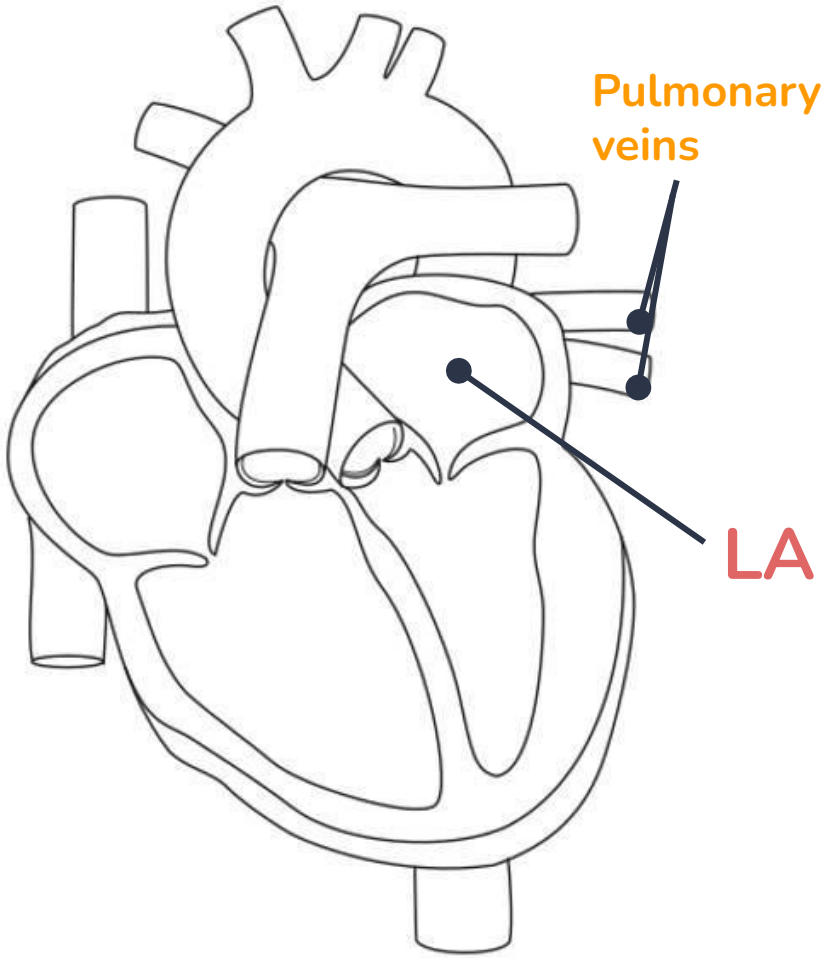


- ✗ You are transported to the **lungs** where you enter smaller and smaller vessels until you reach a **pulmonary capillary** surrounding an **alveolus**.
- ✗ This is where you and the plasma give up carbon dioxide in exchange for **oxygen**.
  - ✗ You are now **oxygenated**!

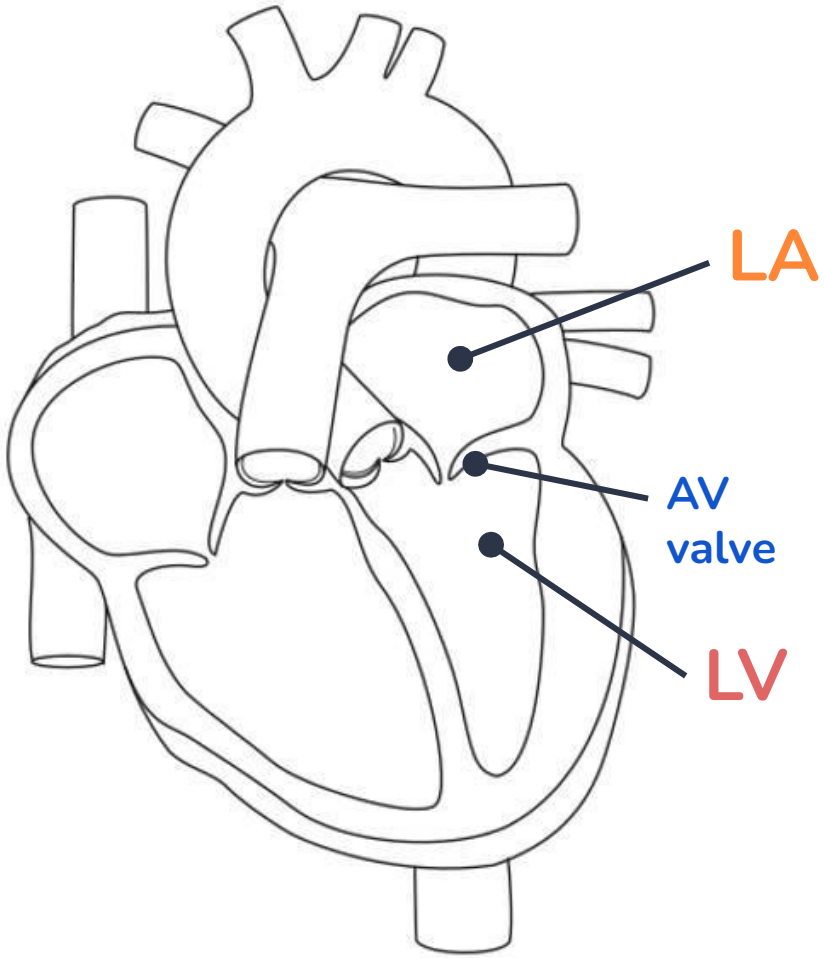




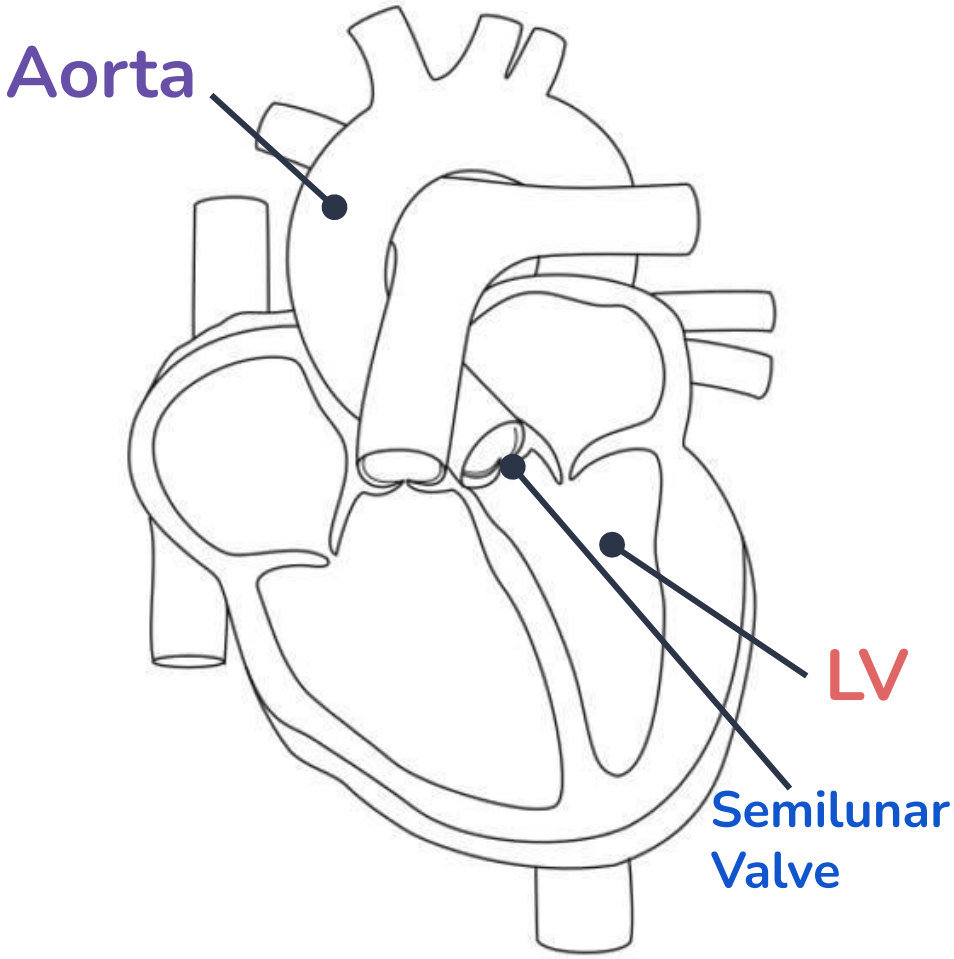
- ✗ Now you can start your return journey to the heart via larger and larger vessels which eventually become the right and left pulmonary veins.
- ✗ The pulmonary veins dump you into the **left atrium**.

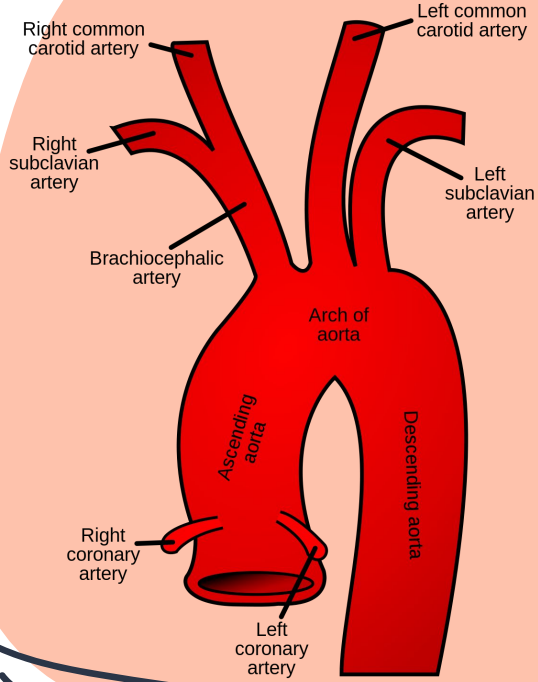


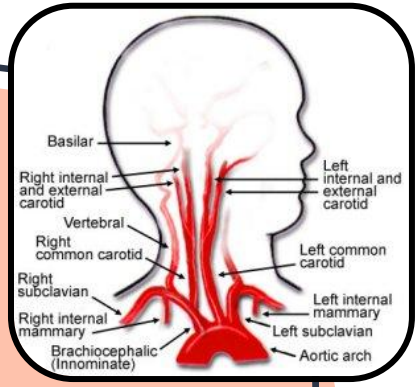
✗ The left atrium contracts forcing you into the **left ventricle** past the **atrioventricular** valve (mitral/bicuspid valve).



- Finally, the ventricle **contracts** and you are pushed out of the left ventricle into the aorta after passing through the semilunar (aortic) valve.





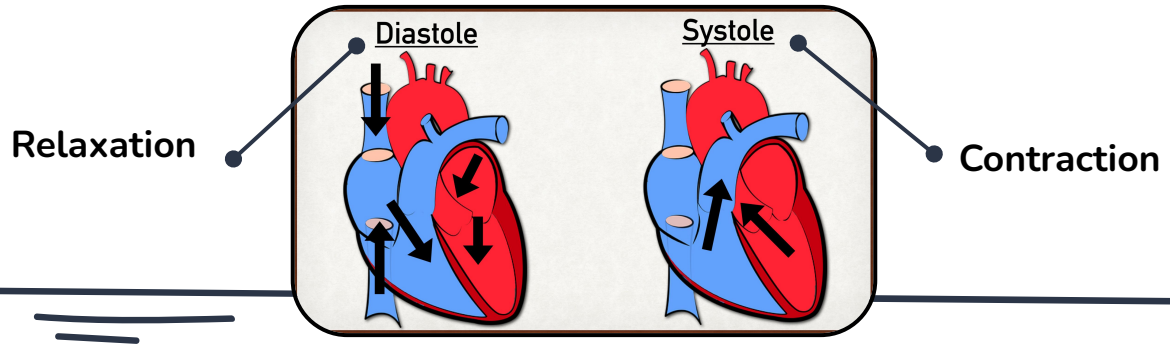


This time your journey takes you to the head, but in less than a minute, you are back at the heart to start the cycle again.

The Cardiac Cycle

The cardiac cycle refers to a complete heartbeat.

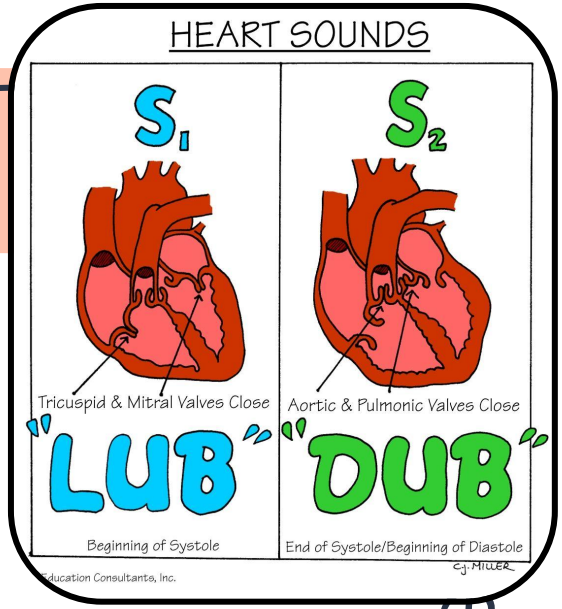
- Takes about 0.8 seconds
- Is divided into two phases: diastole and systole
  - **Diastole:** when ventricles relax and fill with blood
  - **Systole:** when ventricles contract and empty



Heart Sounds

- **“LUB-DUB”** due to closing of the valves

  Heard using a **stethoscope**

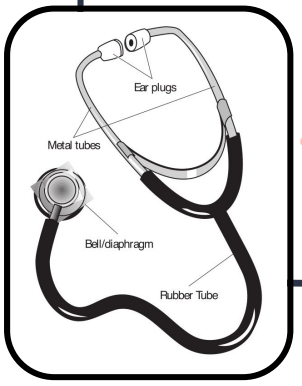


“LUB”

- **AV valves close** as the ventricles begin to contract
- Prevents blood flowing back into atria

“DUB”

- Ventricles relax and the **semilunar valves** snap shut
- Prevents blood from flowing back into the ventricles

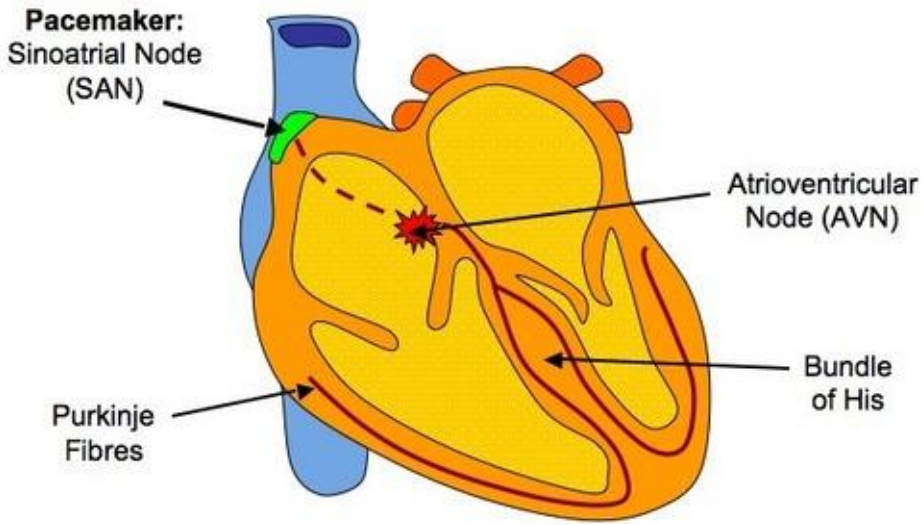


If a heart valve fails to close properly or completely, the sound of **blood leaking past or through the valve** can be heard.

This condition is known as a heart murmur.

The Heart is a Myogenic* Muscle And it has an intrinsic nervous system

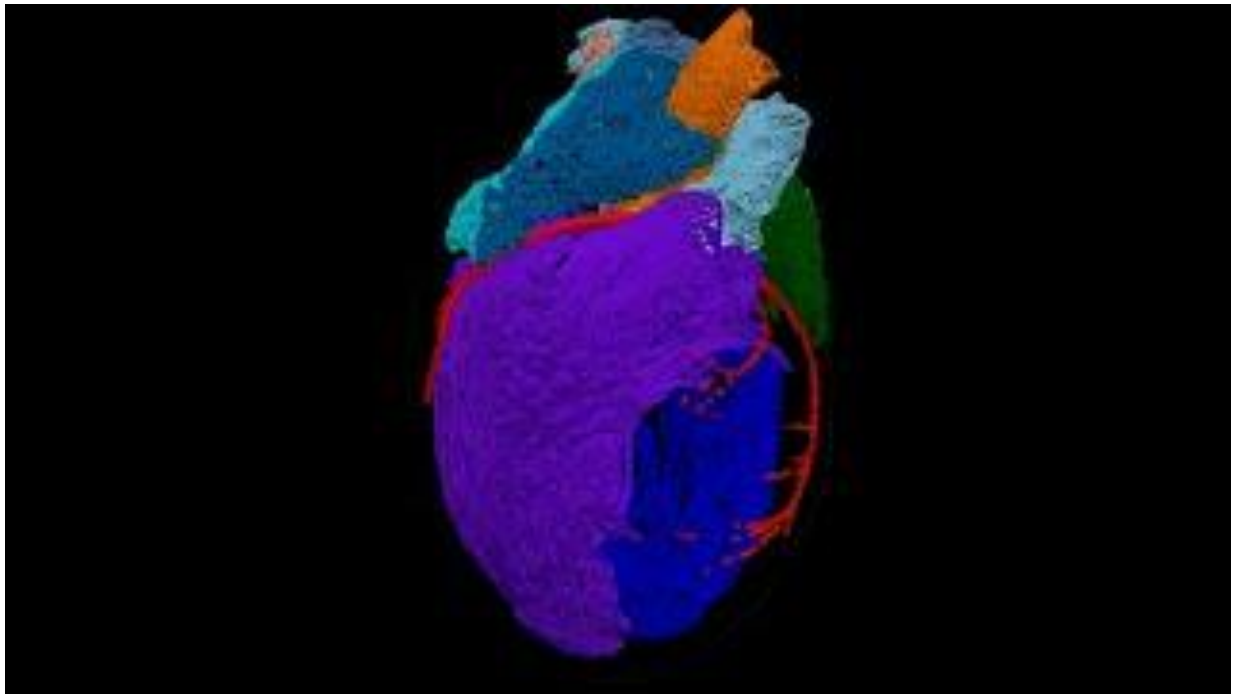
- ✗ Called the '**Cardiac Conduction System**'
- ✗ The heart has the ability to contract and relax on its own



This explains why...

... the heart continues to beat for a short period of time when taken out of an animal

... a person's heart who is pronounced "brain dead" continues to beat for a short period of time

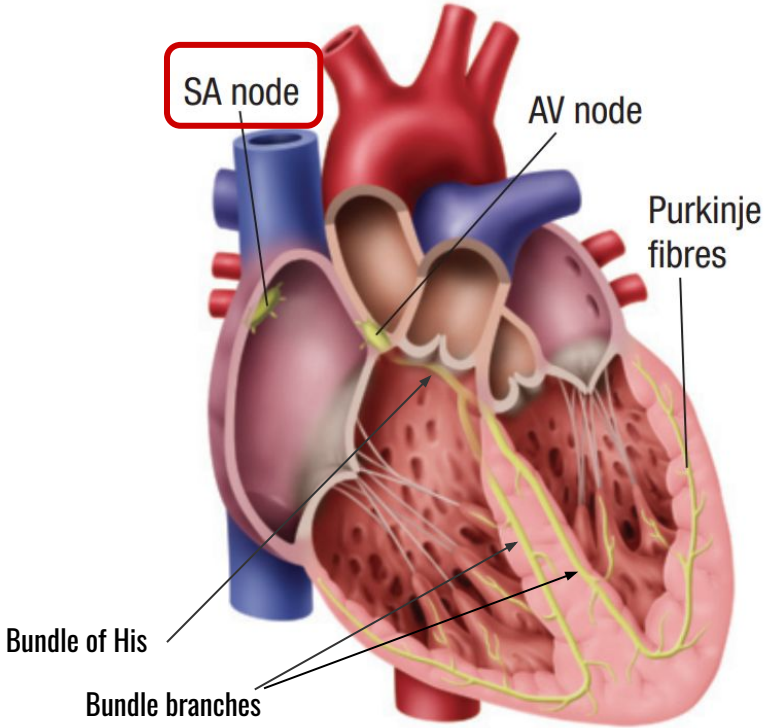


3D Model of the Heart’s ‘Brain’ - (Inside Science, 2020)

Regulation of Heart Rhythm

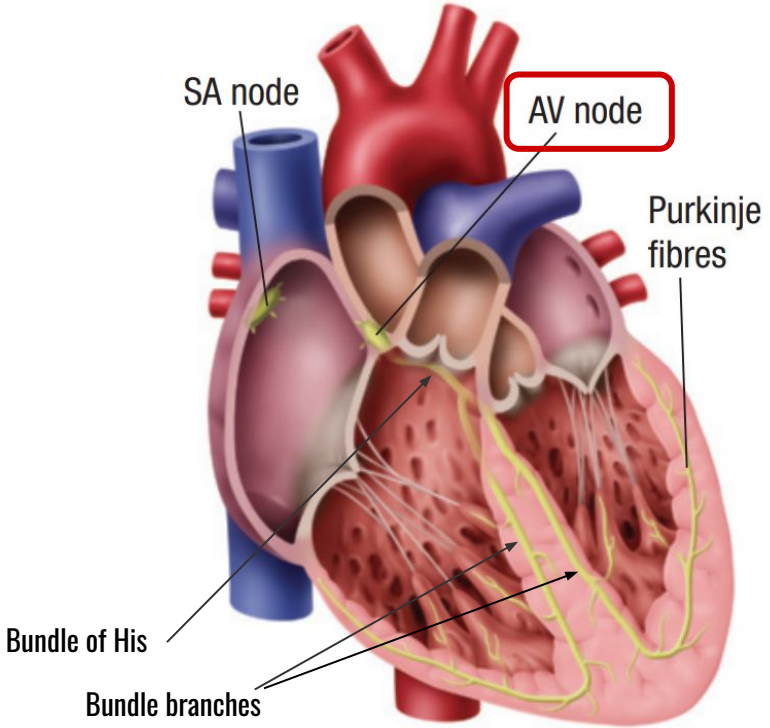
These components make up parts of the **cardiac conduction system**

- ✗ **Sinoatrial Node:** a mass of muscle and nerve cells in the right atrium; initiates the heartbeat and maintains the regular rhythm



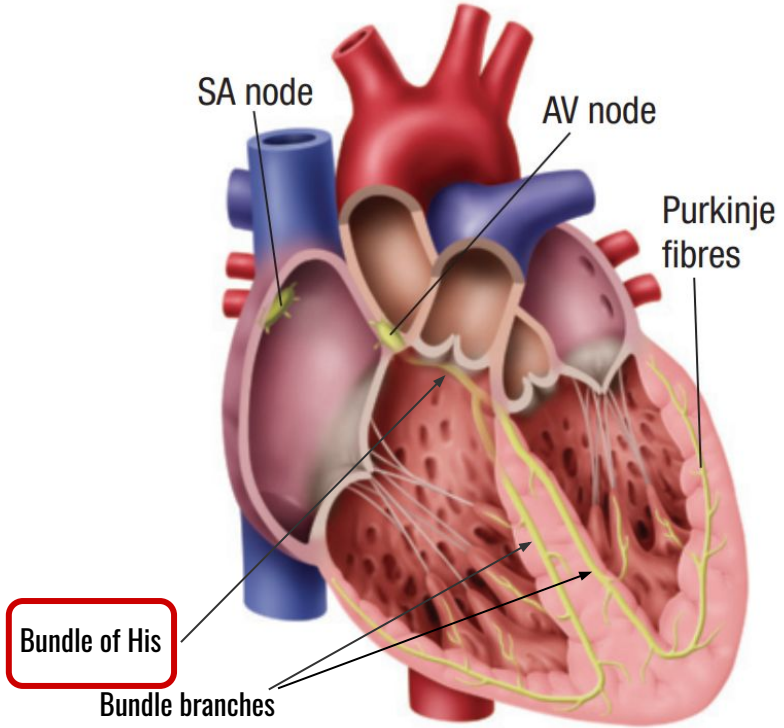
Regulation of Heart Rhythm

- **Atrioventricular (AV) Node:** a mass of conducting cells that transmits the signals from the SA node to the muscles of the ventricles



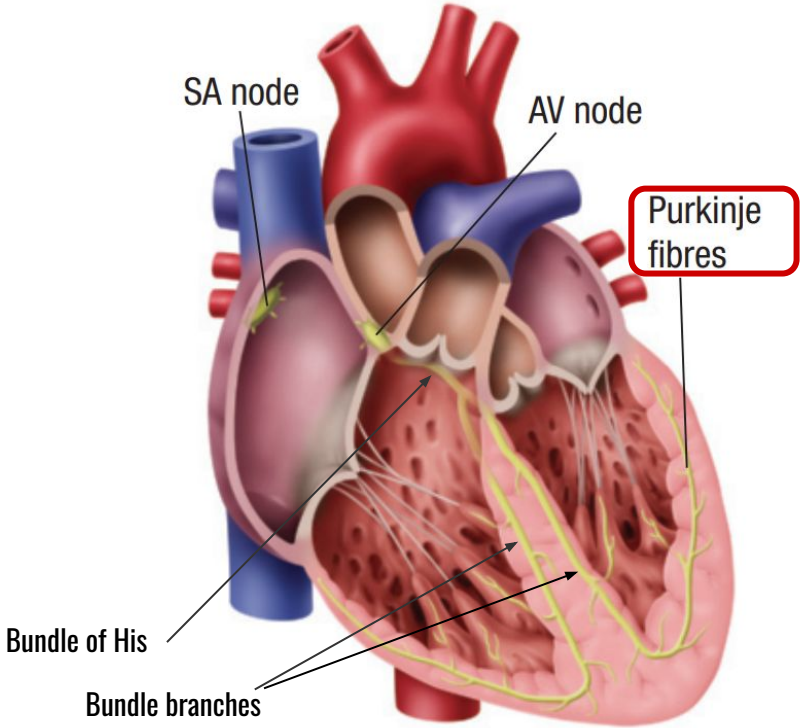
Regulation of Heart Rhythm

- **Bundle of His:** A collection of specialized muscle cells that, along with its branches, carry the electrical signals from the AV node to the Purkinje fibers in the ventricles



Regulation of Heart Rhythm

- **Purkinje Fibres:** extend from bundle branches and conduct electrical signals to the muscle cells of the ventricles

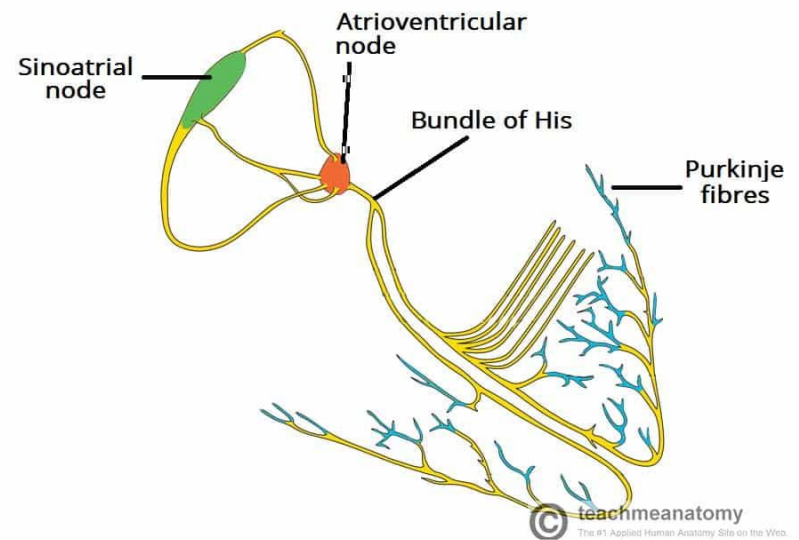


The heartbeat is initiated in a cluster of cells in the right atrium called the sinoatrial (SA) node.

The SA node acts as a pacemaker, and its signals set the **normal rhythm of the heartbeat.**

The signals then reach a second **mass of cells** called the atrioventricular (AV) node.

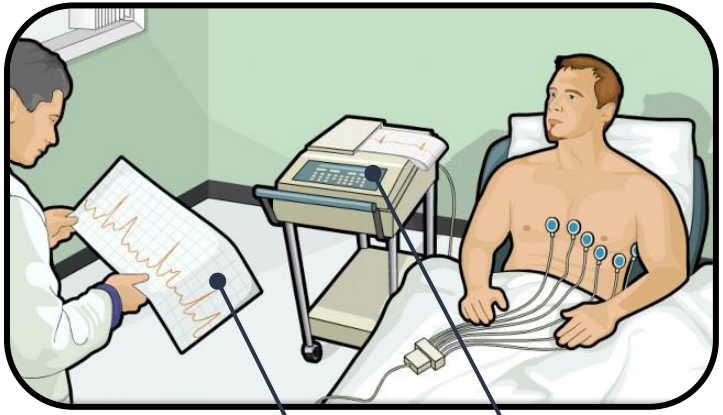
From the AV node, fast conducting muscle fibres (bundle of His) and special conducting fibres (Purkinje) cause the cardiac muscles to contract.



Electrocardiograph

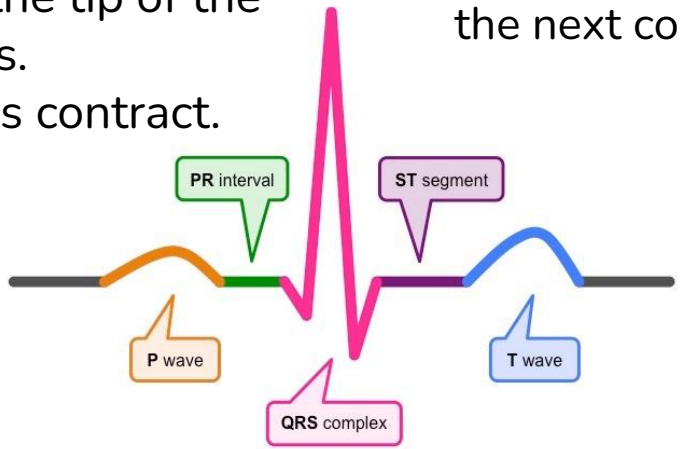
Electrocardiograph (ECG or EKG)

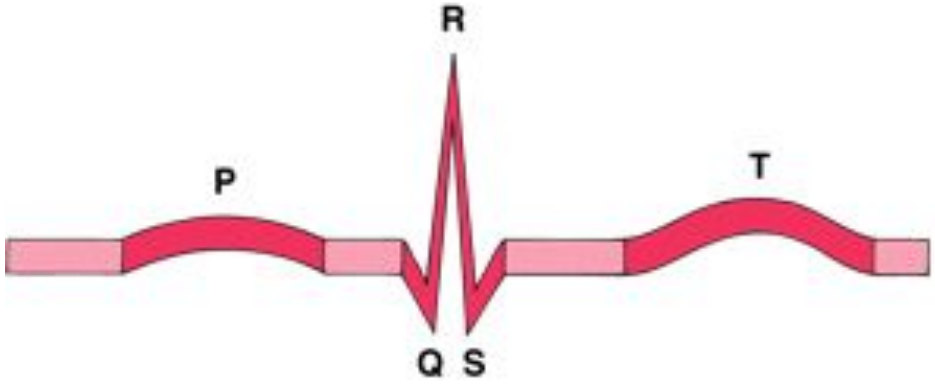
Measures the electrical signals and records them as an **electrocardiogram**.

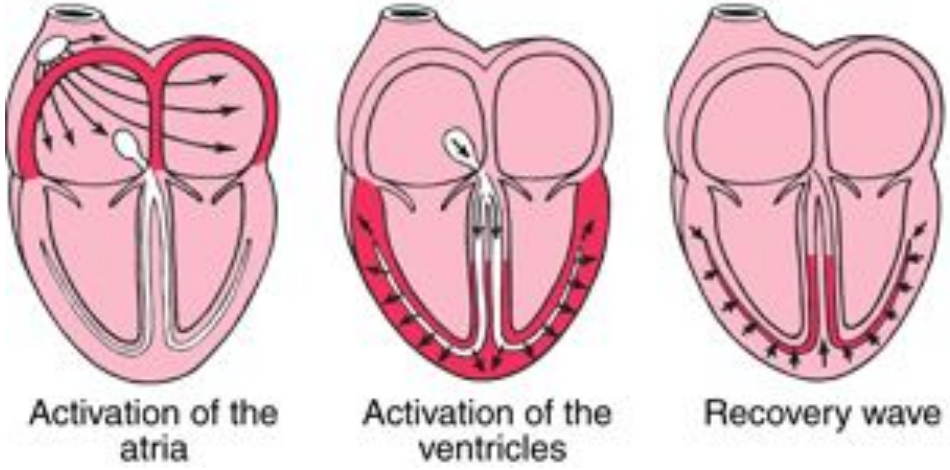


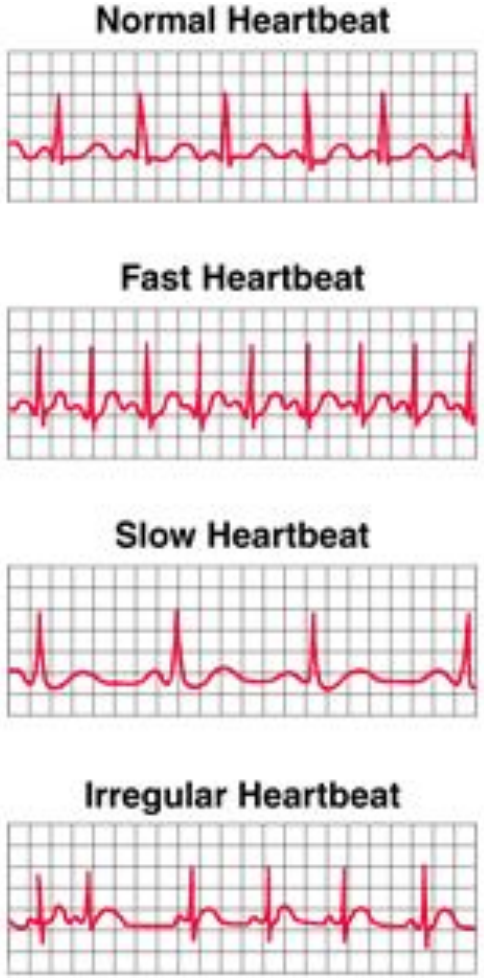
Analysis of an electrocardio**gram** can provide evidence for the presence of abnormal heart conditions.

- A normal heartbeat starts with an electrical stimulus from the SA node.
- This stimulus spreads and causes the contraction of the atria, creating the P wave on the ECG.
- The signal moves to the AV node and then the QRS complex follows, during which the electrical stimulus moves from the AV node to the tip of the ventricles.
- Ventricles contract.
- After the QRS complex, there is another slight delay.
- The recovery period produces the T wave on the ECG (ventricles relax and prepare for the next contraction).




R
P
T
Q S


P Wave
QRS Complex
T Wave
Activation of the atria
Activation of the ventricles
Recovery wave


Normal Heartbeat
Fast Heartbeat
Slow Heartbeat
Irregular Heartbeat

11.4 Summary

- The human heart is a four-chambered double pump that pumps blood through two separate circuits: the pulmonary circuit and systemic circuit.
- Two atrioventricular valves and two semilunar valves in the heart ensure that blood flows in only one direction.
- The cardiac cycle has two main phases—diastole and systole. Diastole begins when the ventricles begin to relax and ends when the ventricles are filled with blood. Systole begins when the ventricles begin to contract and ends when the blood is forced out of the ventricles.
- Heart sounds, which can be heard with the use of a stethoscope, are produced by the closing of the heart valves.
- Cardiac muscle is myogenic, which means it can contract and relax without input from external nerve stimuli. The rate of contraction and relaxation, however, can be adjusted by the nervous system.
- The sinoatrial (SA) node initiates the heartbeat by sending electrical signals and maintains the regular rhythm of contraction and relaxation.
- An electrocardiograph can be used to monitor the cardiac cycle. The printout from the electrocardiograph, called an electrocardiogram, can be analyzed to diagnose abnormal heart conditions.

Homework:
P. 500 # 1 - 7

11.4 Notes (Pg. 495 - 500)

Functions of:

Septum:

Pericardium:

AV valves:

Chordae tendineae:

Semilunar valves:

Coronary arteries:

Stethoscope::

ECG:

Other important definitions

Heart murmur:

Myogenic muscle:

Aorta:

Pulmonary arteries:

Direction of blood flow

IVF/SVF → RA → tricuspid valve →

Pulmonary vs. Systemic Circuits

Names for valves:

Diastole vs. systole:

Sketch of ECG wave. Describe what is happening at each section.

Why does the heart makes a "lub-dub" sound?

Any other information?