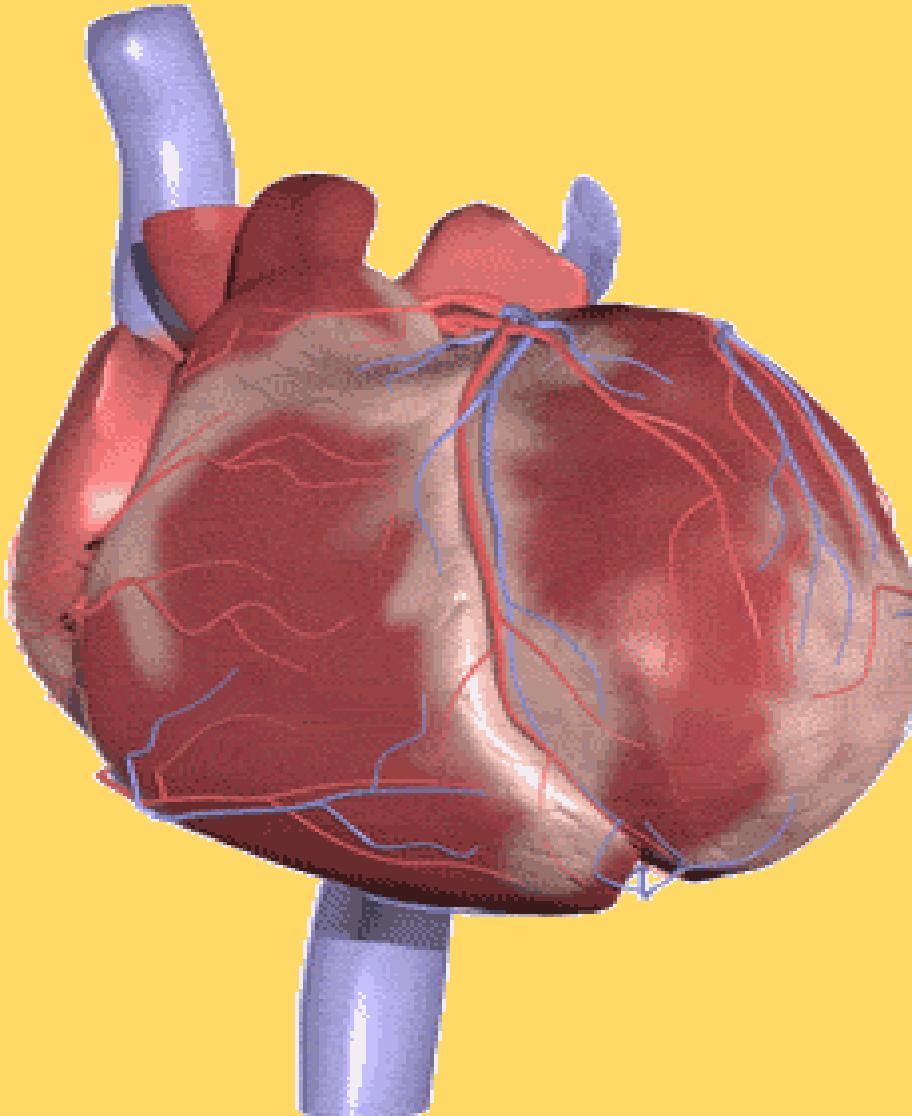


T  
H  
E



H  
E  
A  
R  
T

The circulatory system and respiratory system work together to supply cells with the **nutrients** and **oxygen** they need to stay alive.

a) The **respiratory system**:

- picks up the oxygen and absorbs it into the blood.
- It changes oxygen-poor blood (**deoxygenated**) into oxygen-rich blood (**oxygenated**)

b) The **circulatory system**:

- then pumps the blood to the lungs & rest of body

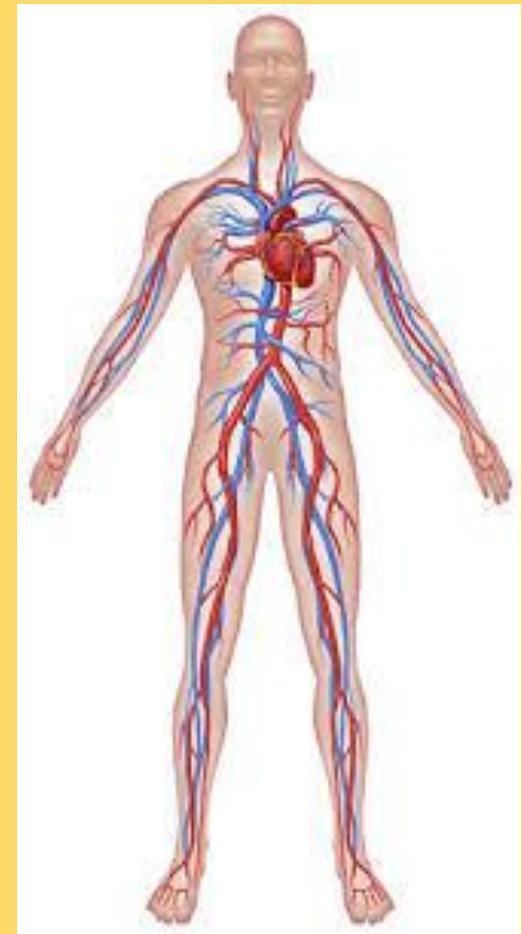
# Functions of the Circulatory System

Organisms with many cells need a way to get oxygen & nutrients to each and **every** cell of their body. The circulatory system is the transport system of the body that can do this.

Humans and other vertebrates have a **closed** circulatory system, meaning that the blood is always contained within a system of vessels.

The human circulatory system consists of:

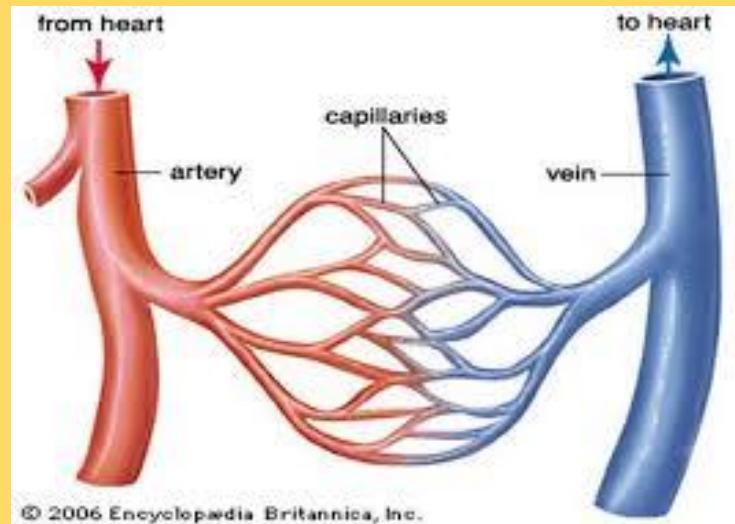
- the heart
- blood vessels
- blood



**As blood flows through the circulatory system, it moves through three types of blood vessels:**



- arteries
- capillaries
- veins



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# Arteries

Large vessels that carry blood AWAY from the heart to the tissues of the body are called arteries.

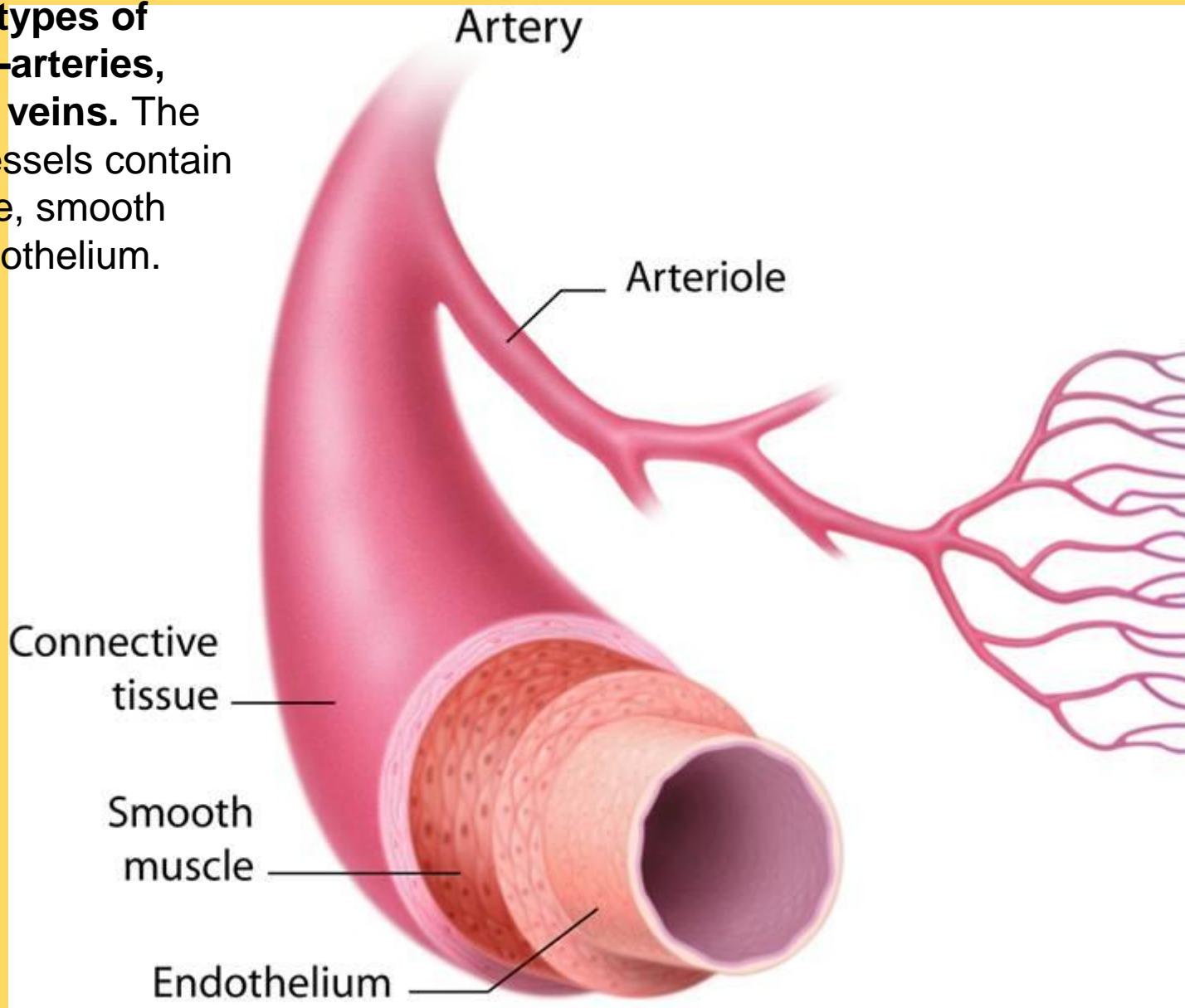
Except for the pulmonary arteries, all arteries carry oxygenated blood.

Arteries have thick muscular walls.

They contain the following tissues from outside to inside: connective tissue, smooth muscle, and endothelium.

## Blood Vessels

In the circulatory system, there are three types of blood vessels—arteries, capillaries, and veins. The walls of these vessels contain connective tissue, smooth muscle, and endothelium.



# Capillaries

The smallest of the blood vessels are the **capillaries**. No cells are far from a capillary.

Their walls are only **one cell thick**, and most are so narrow that only one red blood cell can pass through at a time.

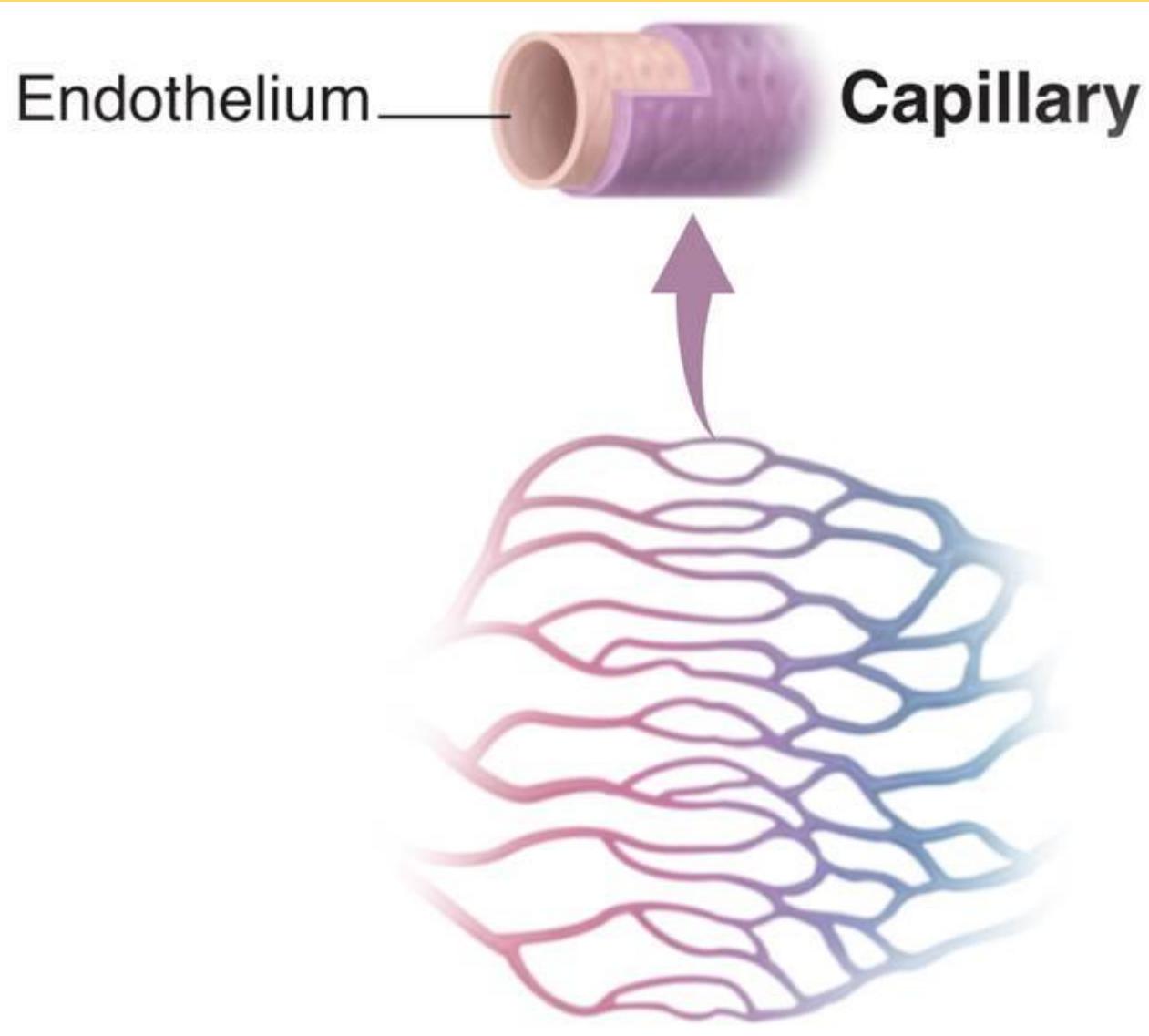
The capillaries are exchange vessels:

They bring nutrients and oxygen to the tissues of body

They absorb carbon dioxide and other waste products from body cells and bring these compounds away from cells so the body can dispose of them.

## Blood Vessels

In the circulatory system, there are three types of blood vessels—arteries, capillaries, and veins. The walls of these vessels contain connective tissue, smooth muscle, and endothelium.



# Veins

Blood vessels that carry blood back to the heart are called **veins**.

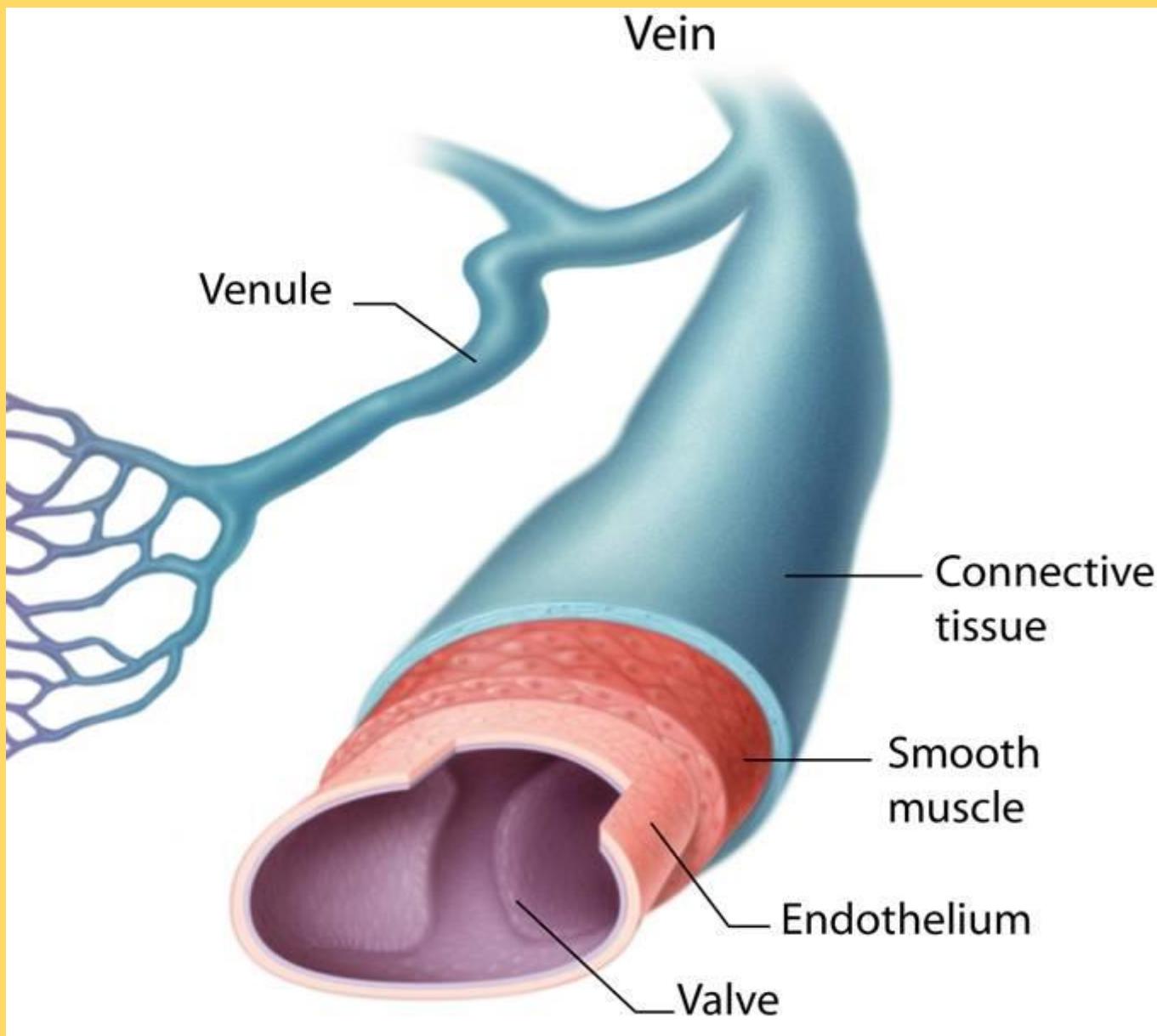
Except for the pulmonary veins, all veins carry **deoxygenated blood**.

Veins have thinner walls than arteries, containing less muscle than arteries.

The walls of veins contain connective tissue, smooth muscle and endothelium.

## Blood Vessels

In the circulatory system, there are three types of blood vessels—arteries, capillaries, and veins. The walls of these vessels contain connective tissue, smooth muscle, and endothelium.

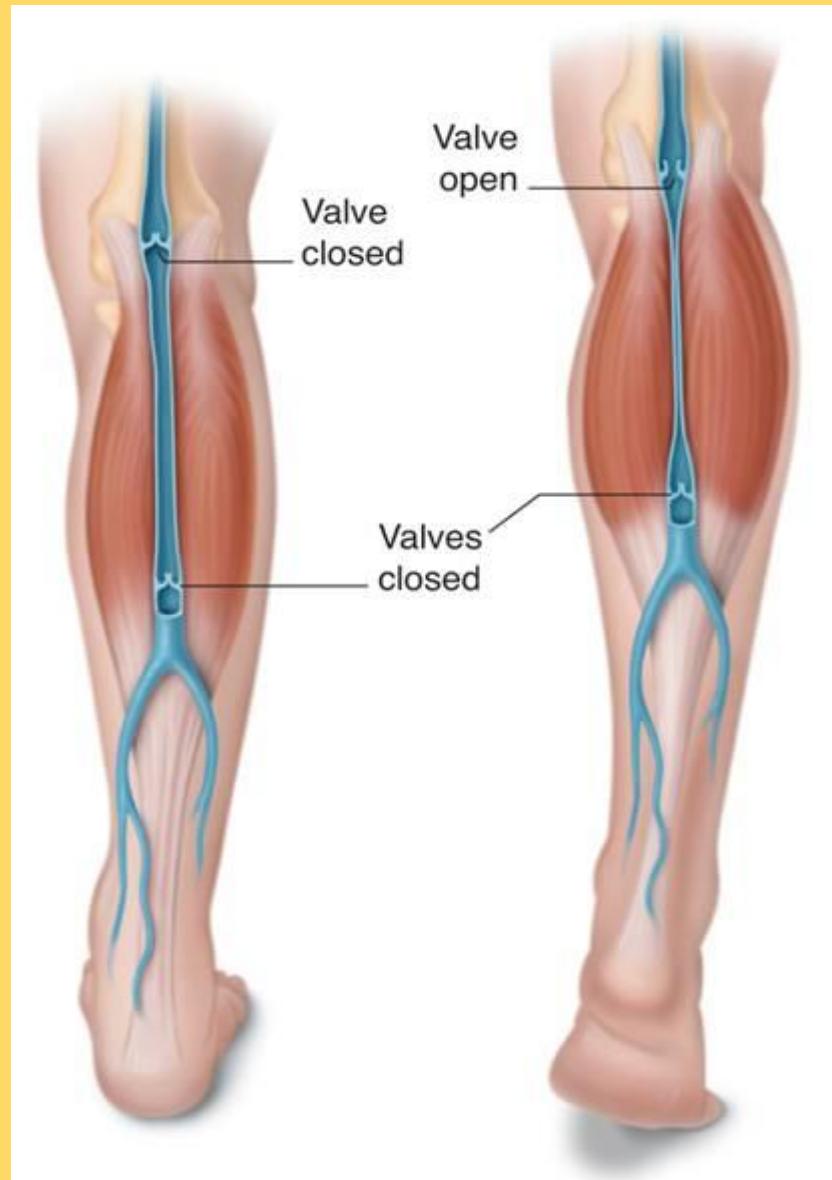


## Blood Vessels

Large veins contain one-way **valves** that keep blood moving toward the heart.

Many veins are located near and between skeletal muscles.

The movement of these skeletal muscles helps to return the blood to our hearts when we are standing.



Contraction of skeletal muscles helps move blood in veins toward the heart.

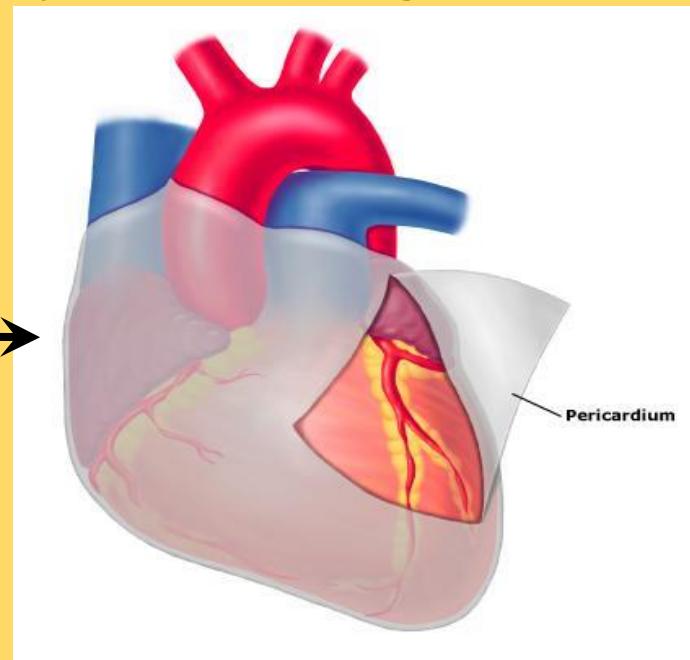
# The Heart



# Structure of the Heart

- The heart is a muscle that contracts to pump blood throughout the body.
- The heart is enclosed in a protective sac called the **PERICARDIUM**.

-Keeps the heart contained in the chest cavity.  
-Prevents the heart from over-expanding when blood volume increases.  
-Limits heart motion.  
-made up of three layers Fibrous Pericardium, Parietal Pericardium, Visceral Pericardium



- In most animals, the heart is located between the 3<sup>rd</sup> and 7<sup>th</sup> rib in the ventral chest cavity.
- The pointed end of the heart- APEX
- The flattened end of the heart- BASE.

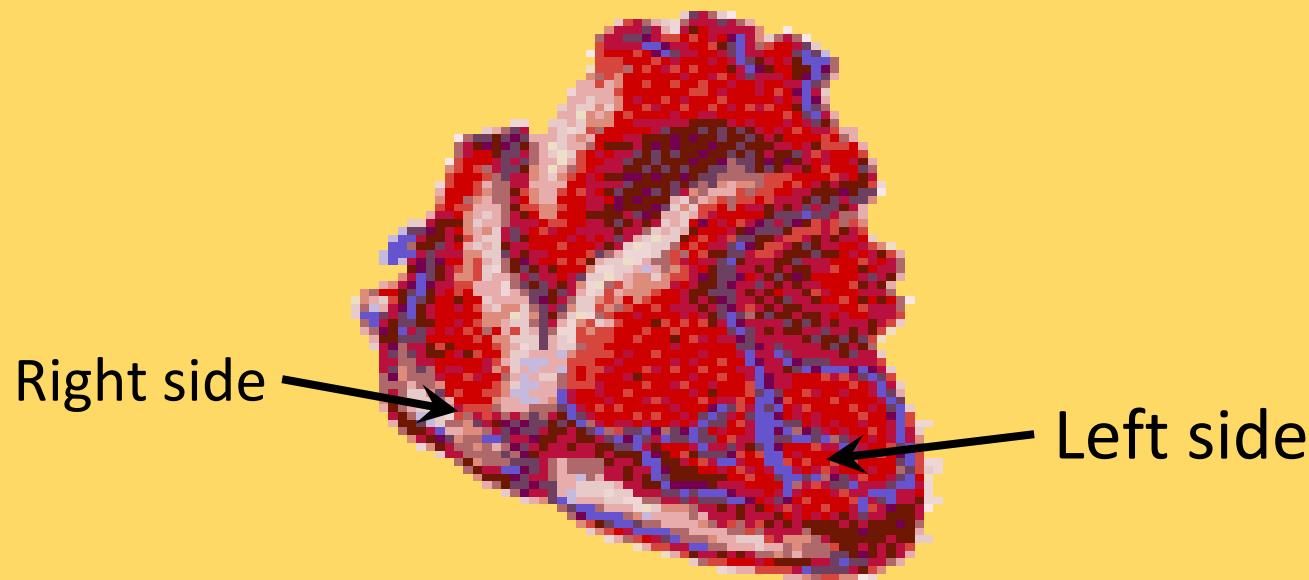
# The Heart

In the walls of the heart, two layers of epithelial and connective tissue form around a thick layer of muscle called the **myocardium**.

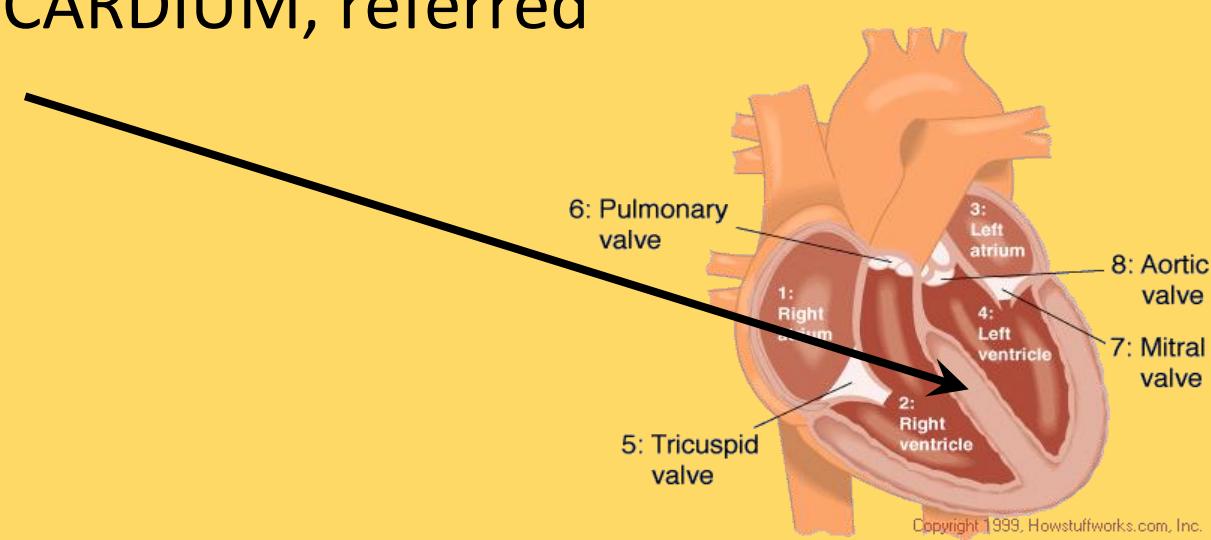
Contractions of the myocardium pump blood.



- When referring to the heart, always refer to it from the animal's point of view. SO.....

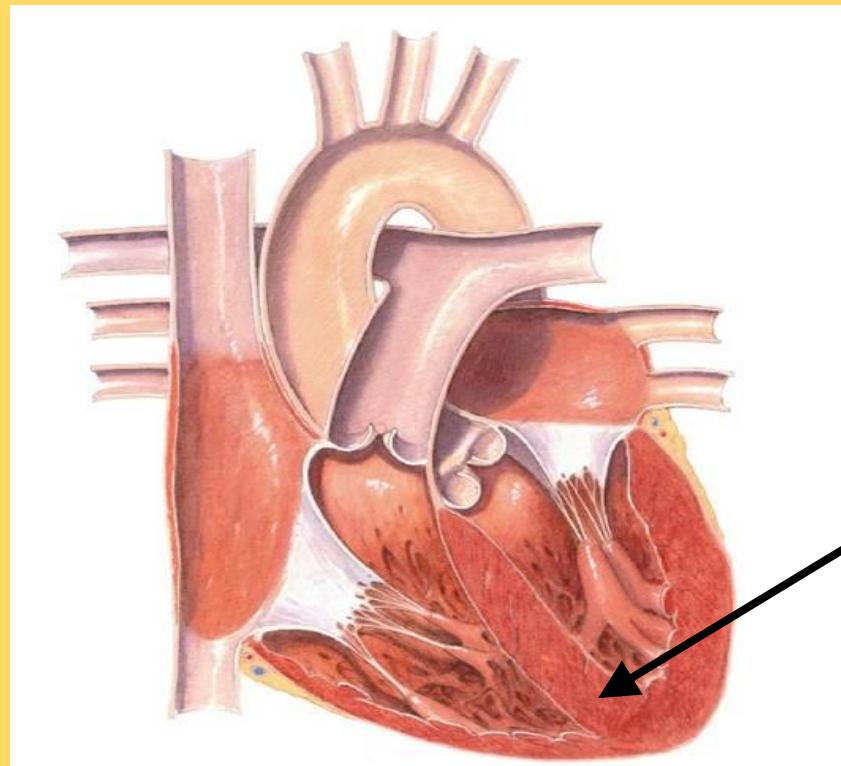


- A thick wall of MYOCARDIUM, referred to as the SEPTUM,

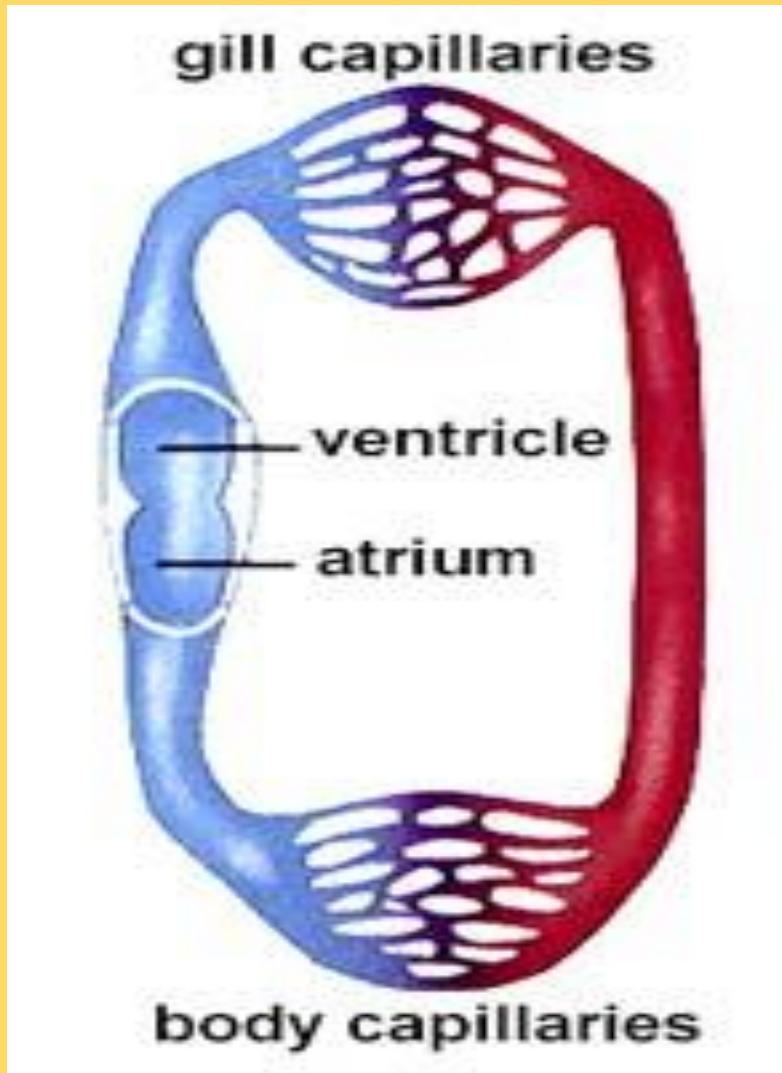


The **septum** divides the right side of the heart from the left.

It prevents the mixing of deoxygenated and oxygenated blood.

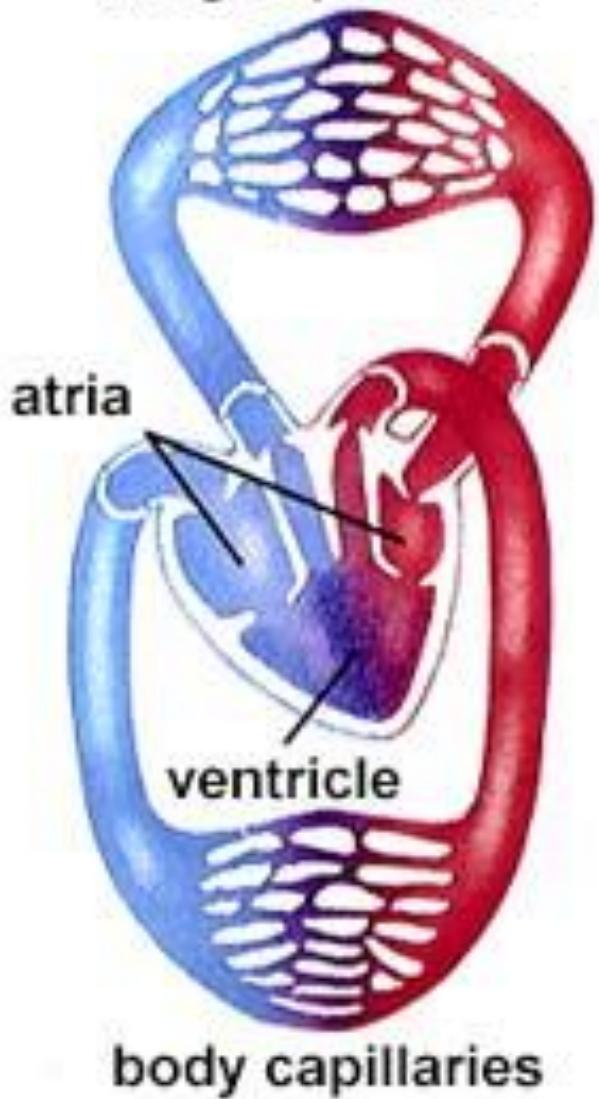


The heart is divided into chambers and valves that help pump the blood and prevent backflow.

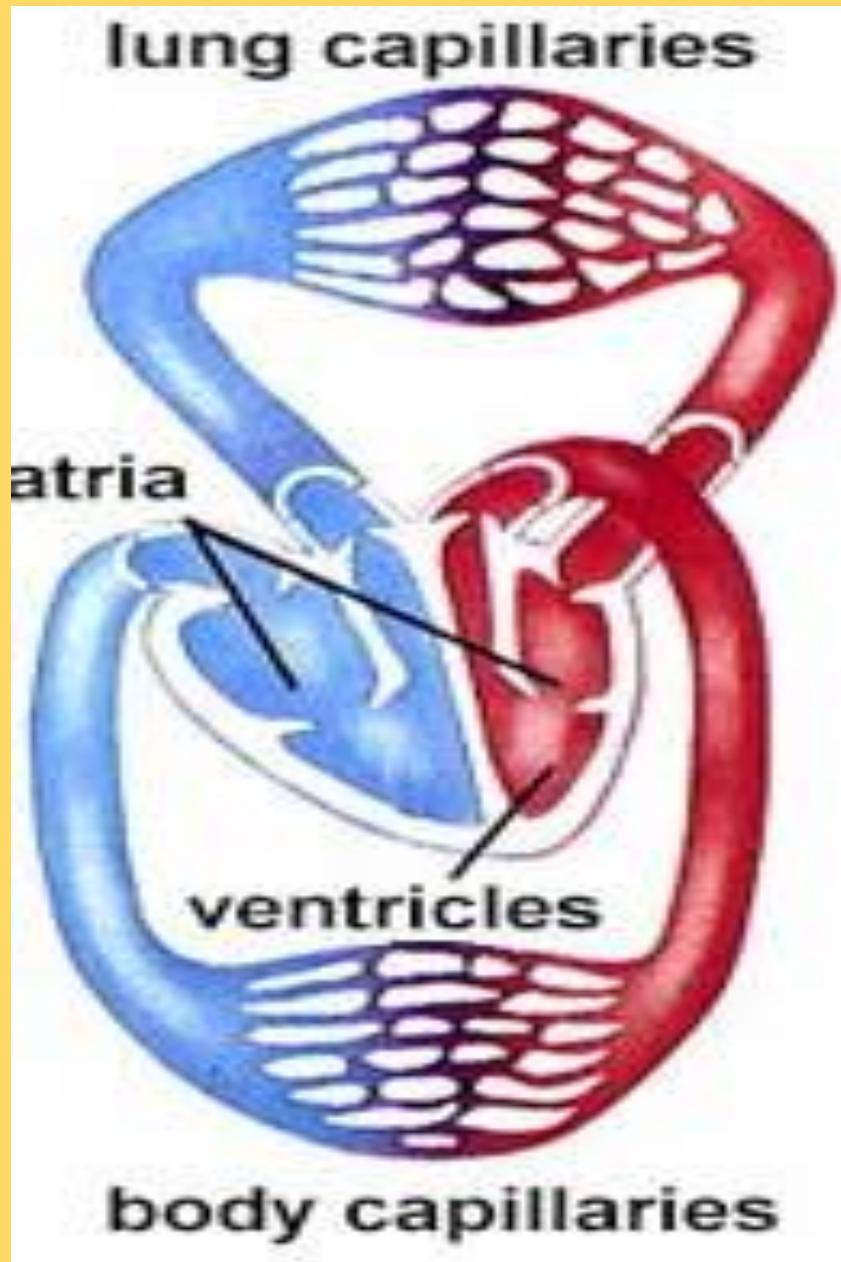


Fish have a 2-chambered heart:  
1 atrium receives blood  
1 ventricle pumps blood

lung capillaries



Amphibians and Reptiles:  
Have a 3-chambered heart:  
2 Atria  
1 Ventricle



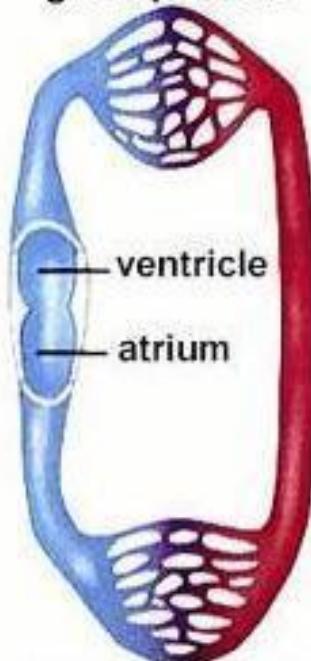
Birds and Mammals:  
Have 4-chambered hearts:  
2- Atria  
2- Ventricles

We will be focusing on the  
mammalian heart!!

a)

Fish Heart:  
One Atrium,  
One Ventricle,  
"Single Circulation"

gill capillaries

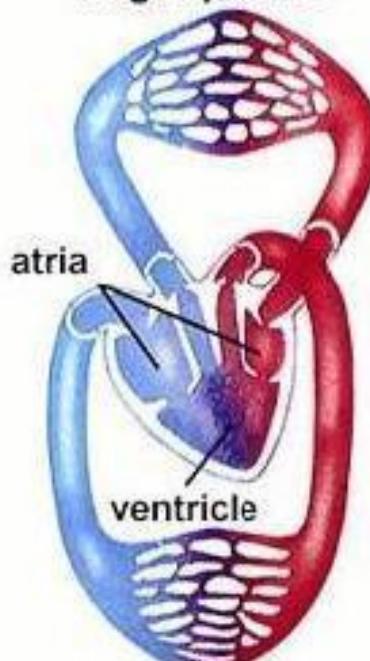


**2 CHAMBERED  
HEART**

b)

Reptile/Amphibian Heart:  
Two Atria, One Ventricle  
(both oxygenated and  
deoxygenated blood  
are mixed),  
"Double Circulation"

lung capillaries

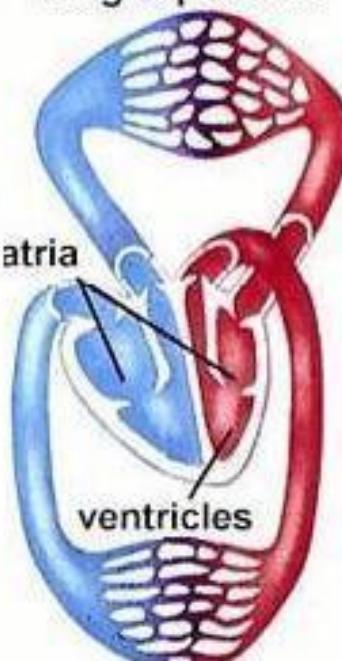


**3 CHAMBERED  
HEART**

c)

Mammalian Heart:  
Two Atria, Two Ventricles  
(oxygenated and  
deoxygenated blood  
separate),  
"Double Circulation"

lung capillaries



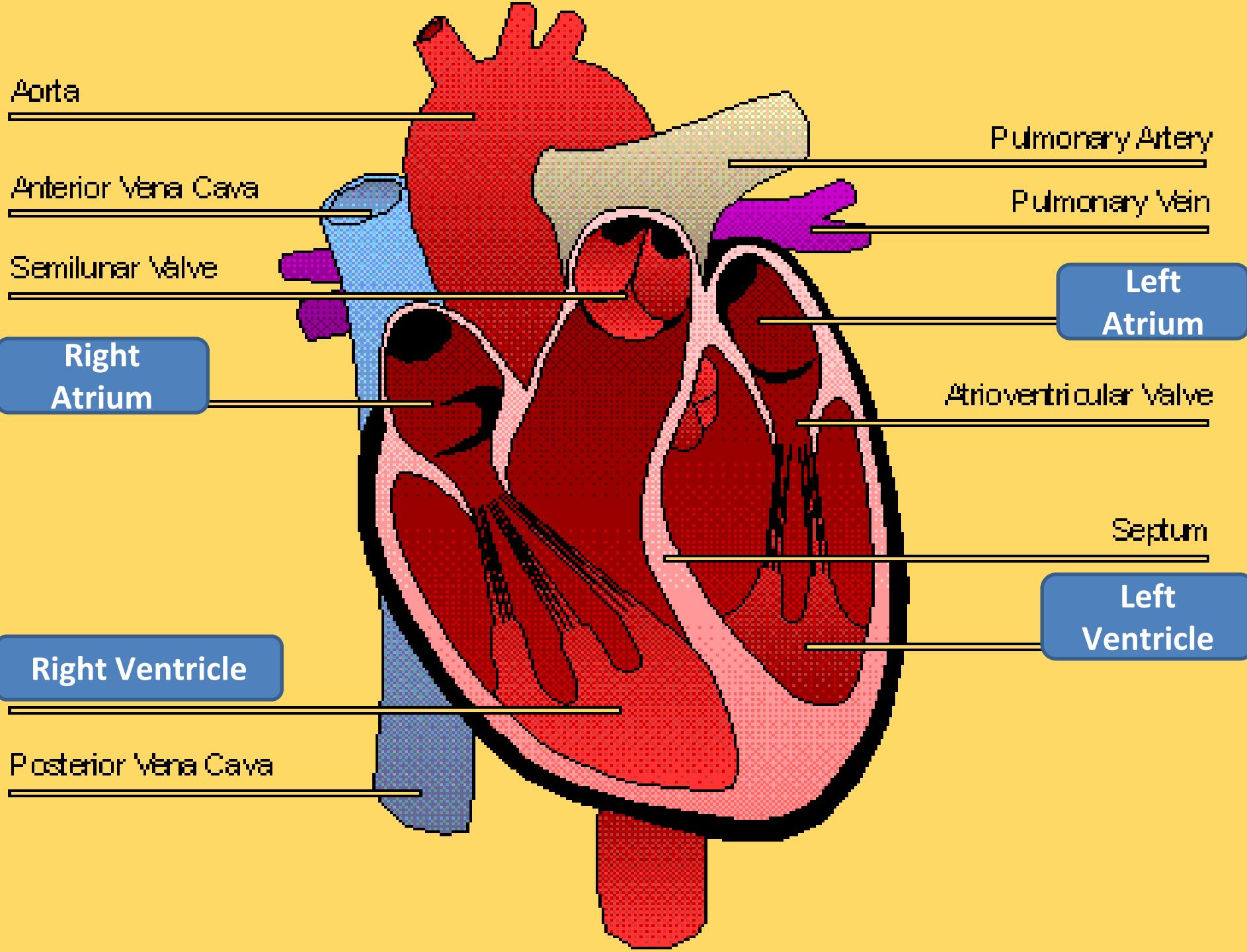
**4 CHAMBERED  
HEART**

The heart has **four chambers** — two atria and two ventricles.

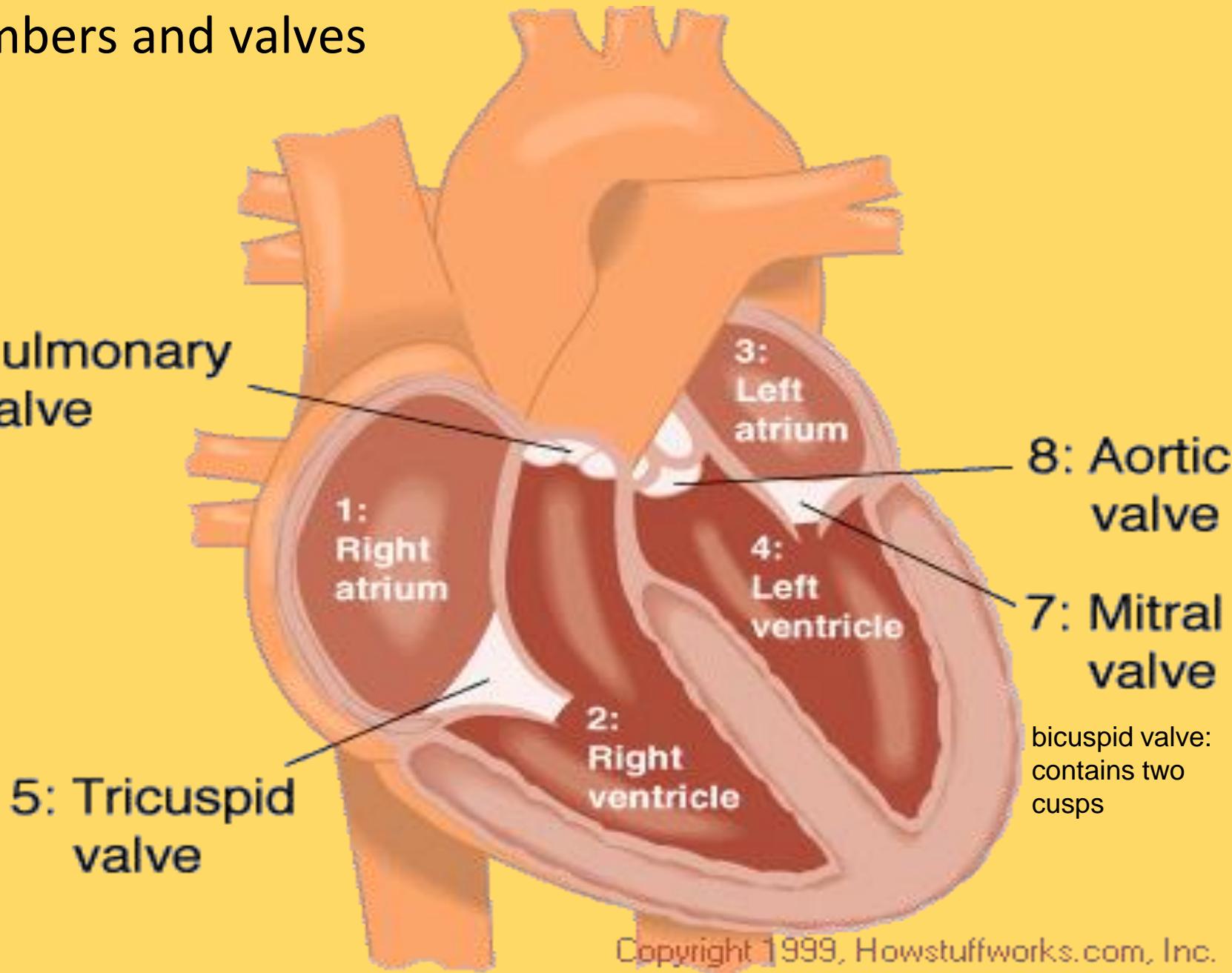
There are two chambers on each side of the septum.

The upper chamber, which receives the blood, is the **atrium**.

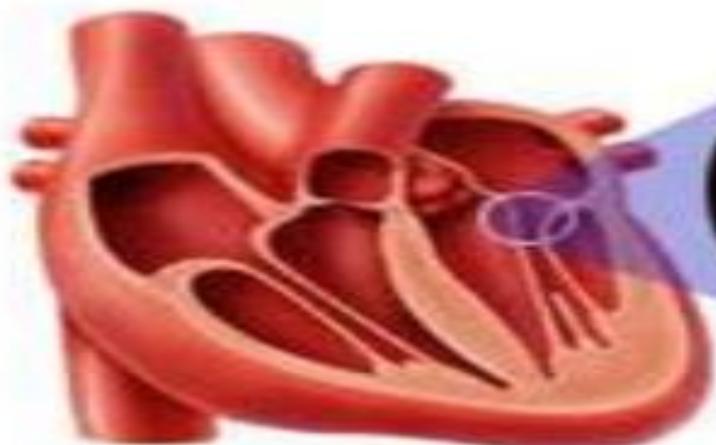
The lower chamber, which pumps blood out of the heart, is the **ventricle**.



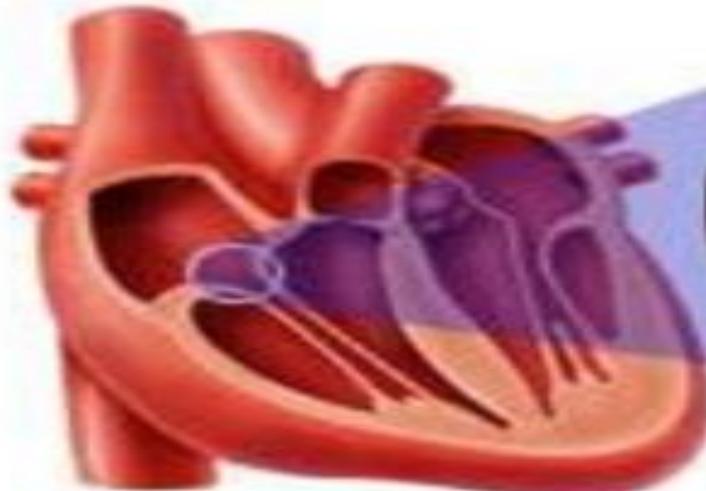
# Chambers and valves



# Valves



**Bicuspid Valve**



**Tricuspid Valve**

# Circulation Through the Heart

Large veins, the **vena cava**, bring blood back to the heart from the rest of the body. These enter either the right atrium.

**There are 2 vena cava:**

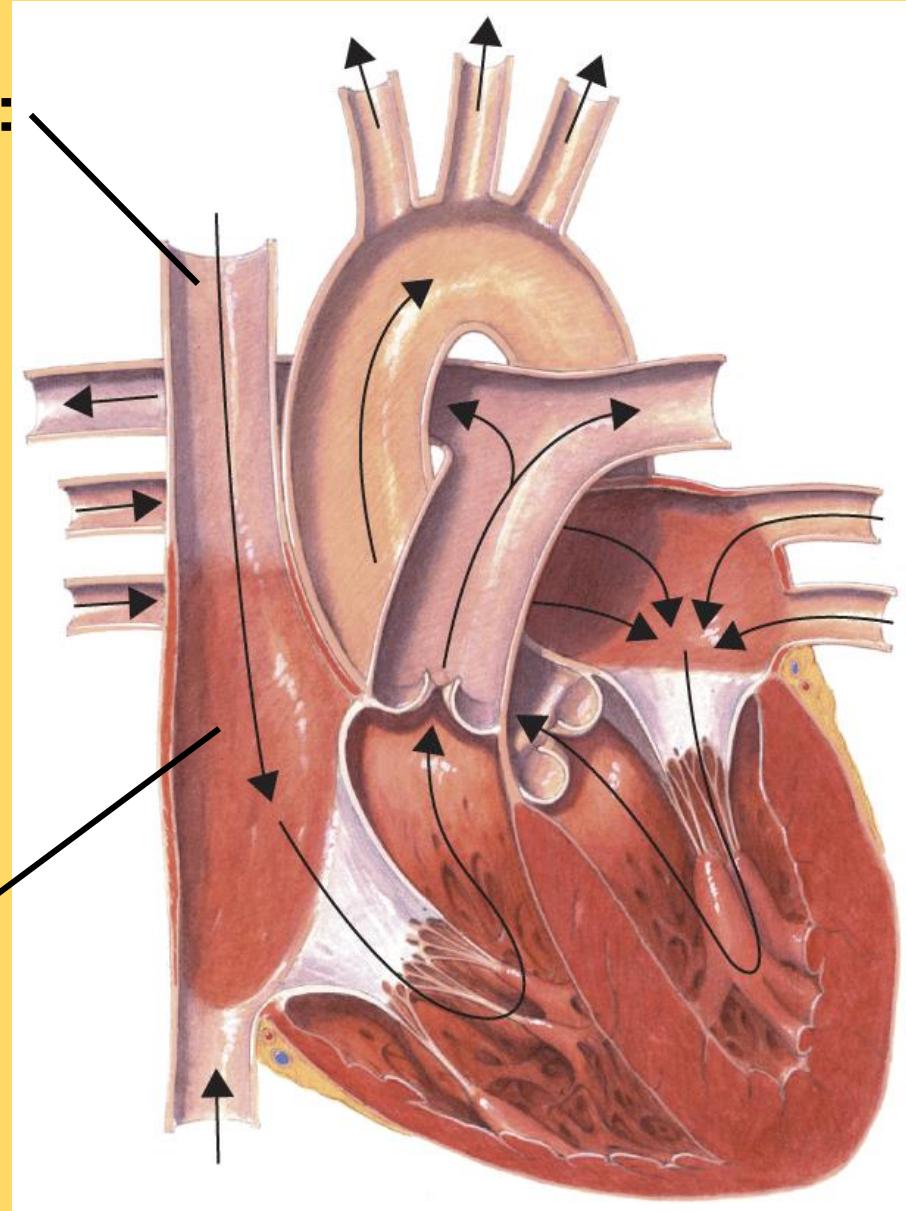
Superior (from head region)

Inferior (from lower body)

## Superior Vena Cava:

Large vein that brings deoxygenated blood from the upper part of the body to the right atrium

## Right Atrium

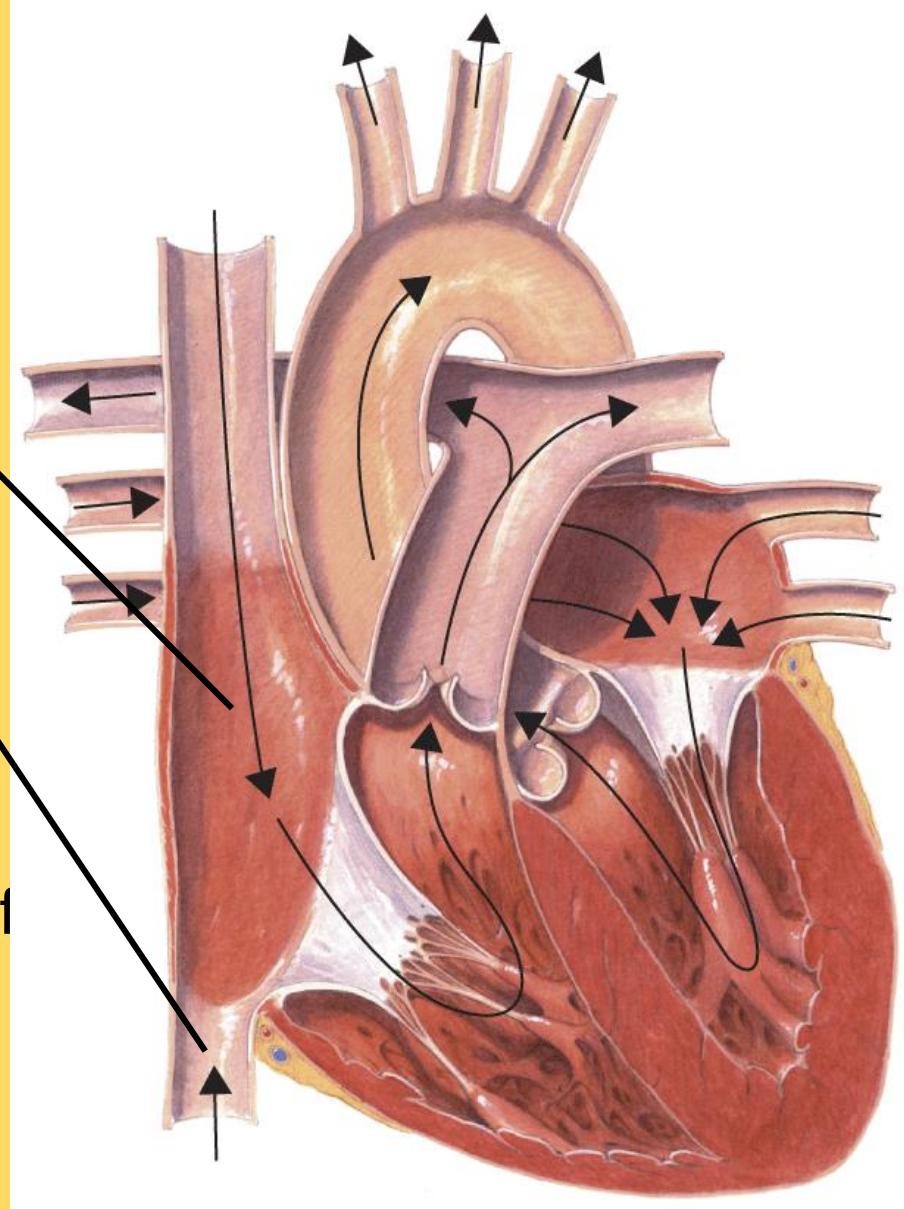


# The Heart

**Right Atrium**

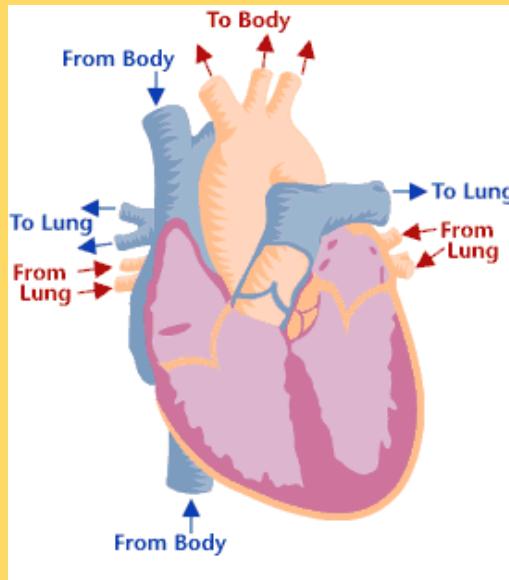
**Inferior Vena Cava:**

Vein that brings deoxygenated blood from the lower part of the body to the right atrium.



As the heart contracts, blood flows from the **atria** into the **ventricles**.

Then the ventricles pump the blood out of the heart into **two large arteries** (aorta & pulmonary artery). Blood then moves to either the body or the lungs.



There are flaps of connective tissue called **valves** between the atria and the ventricles.

Valve on left side is called the mitral or bicuspid valve.

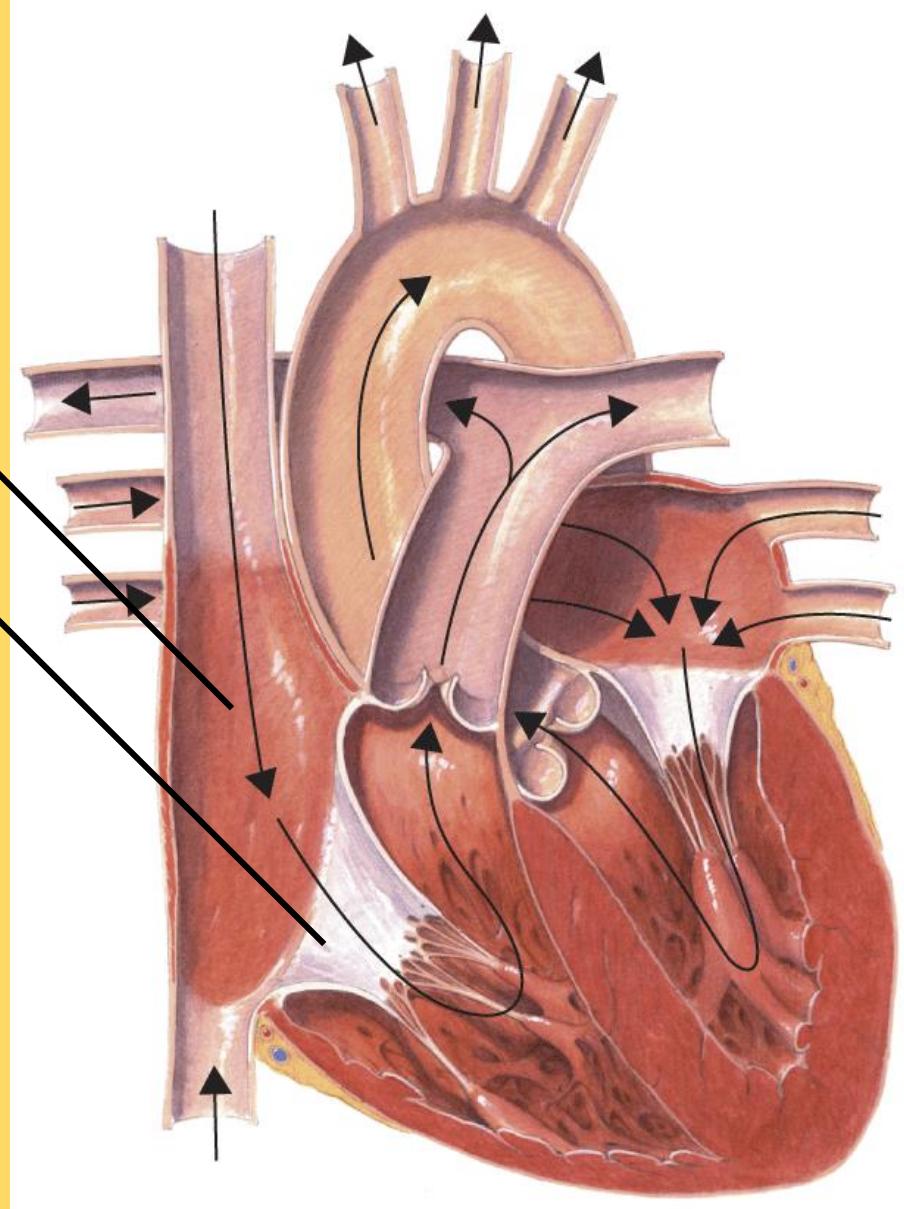
Valve on the right side is called the tricuspid valve.

When the ventricles contract, the valves close, which prevents blood from flowing back into the atria.

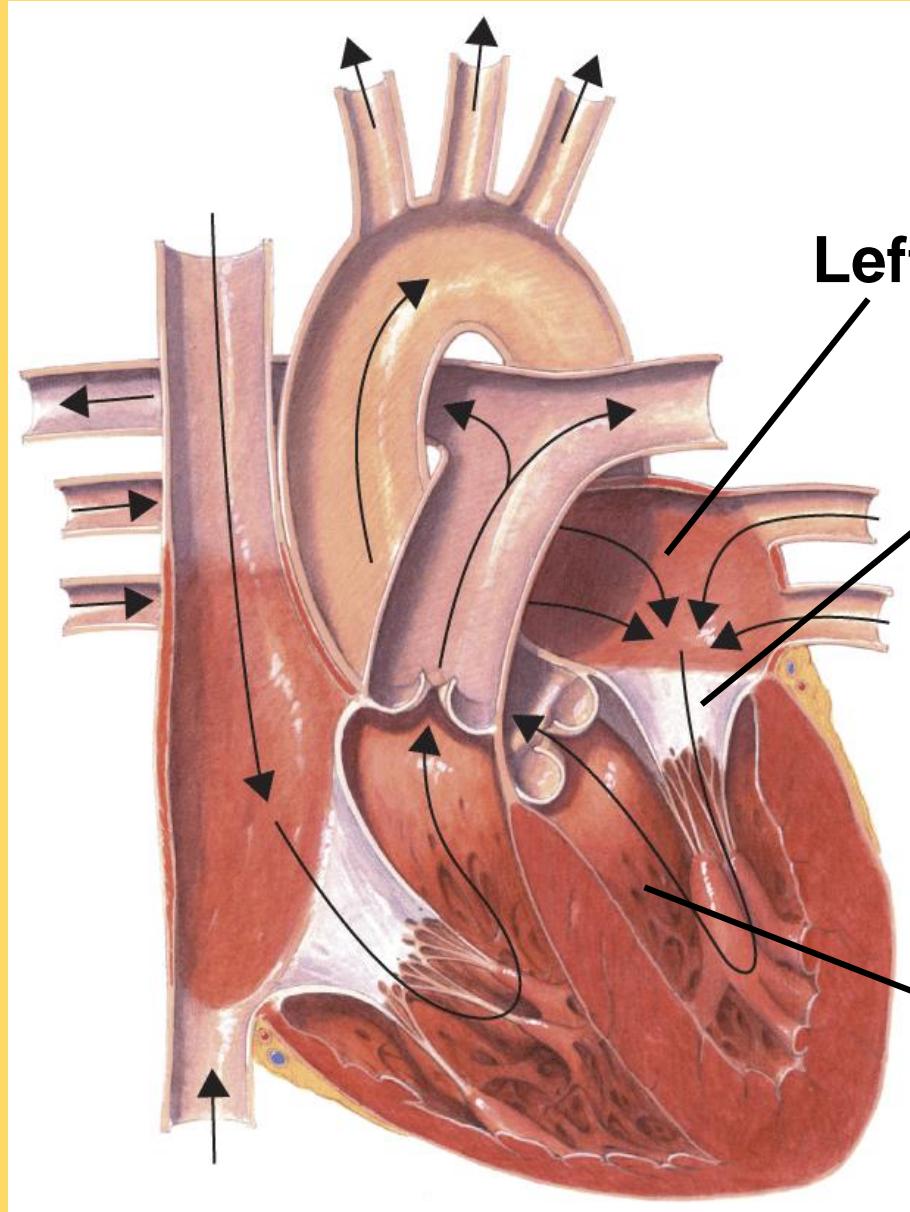
**Right Atrium**

**Tricuspid Valve:**

Prevents blood from flowing back into the right atrium after blood has entered the right ventricle



# The Heart



**Left Atrium**

**Mitral Valve:**  
Prevents blood  
from flowing back  
into the left atrium  
after blood has  
entered the left  
ventricle

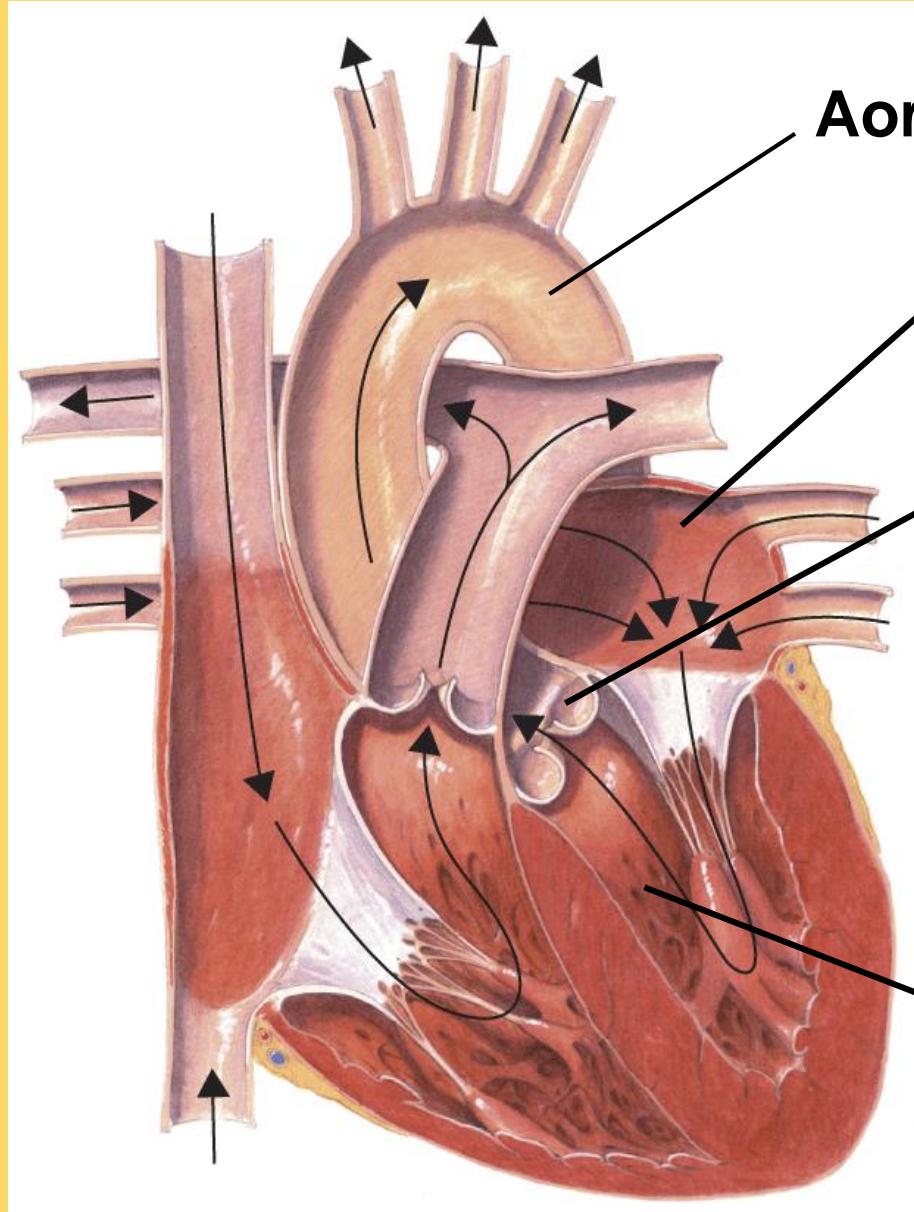
**Left Ventricle**

At the exits from the right and left ventricles, different valves prevent blood that flows out of the heart from flowing back in.

Blood leaves the left ventricle, and enters the **aorta**. This is the largest artery in your body and begins the blood's journey to the rest of the body.

- Valve at base the aorta is called the aortic valve.

# The Heart



Aorta

Left Atrium

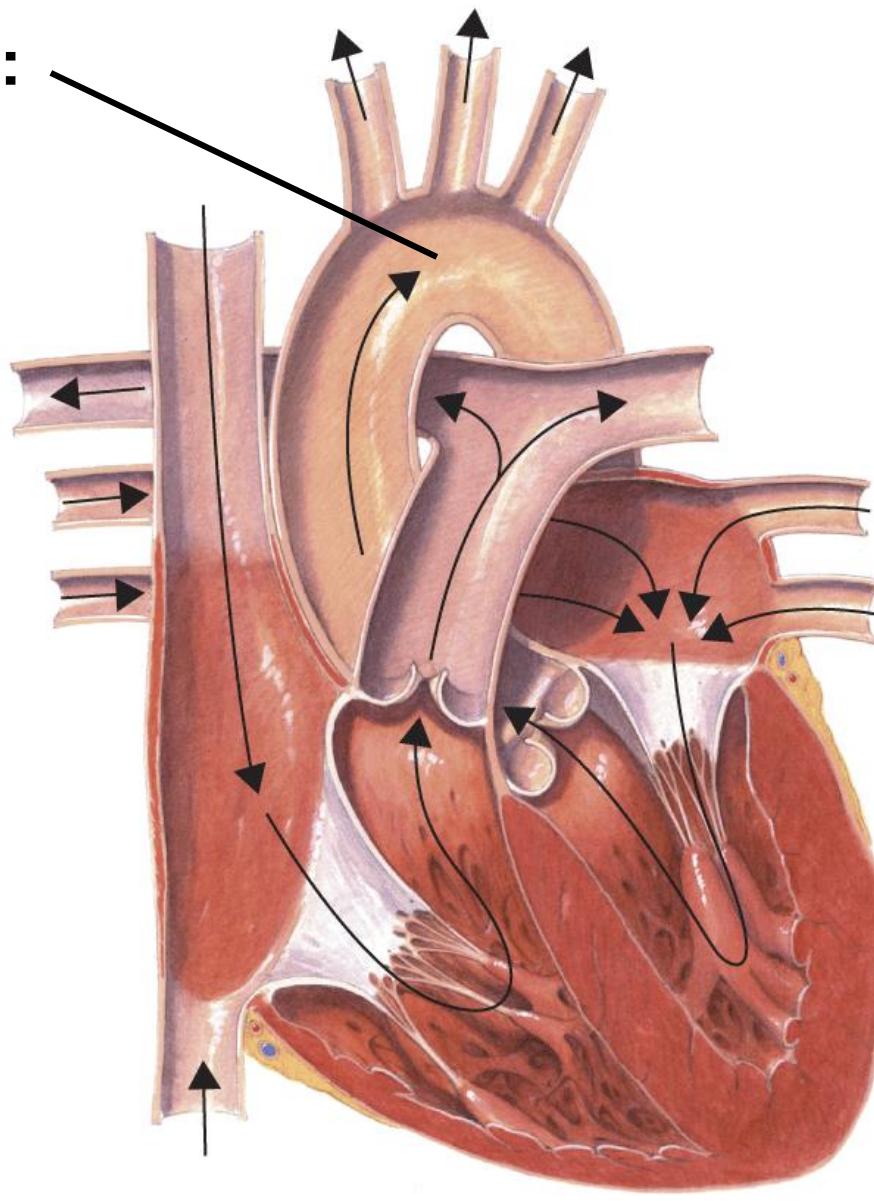
**Aortic Valve:**  
Prevents blood  
from flowing  
back into the left  
ventricle after it  
has entered the  
aorta

Left Ventricle

# The Heart

## Aorta:

Brings oxygenated blood from the left ventricle to the body



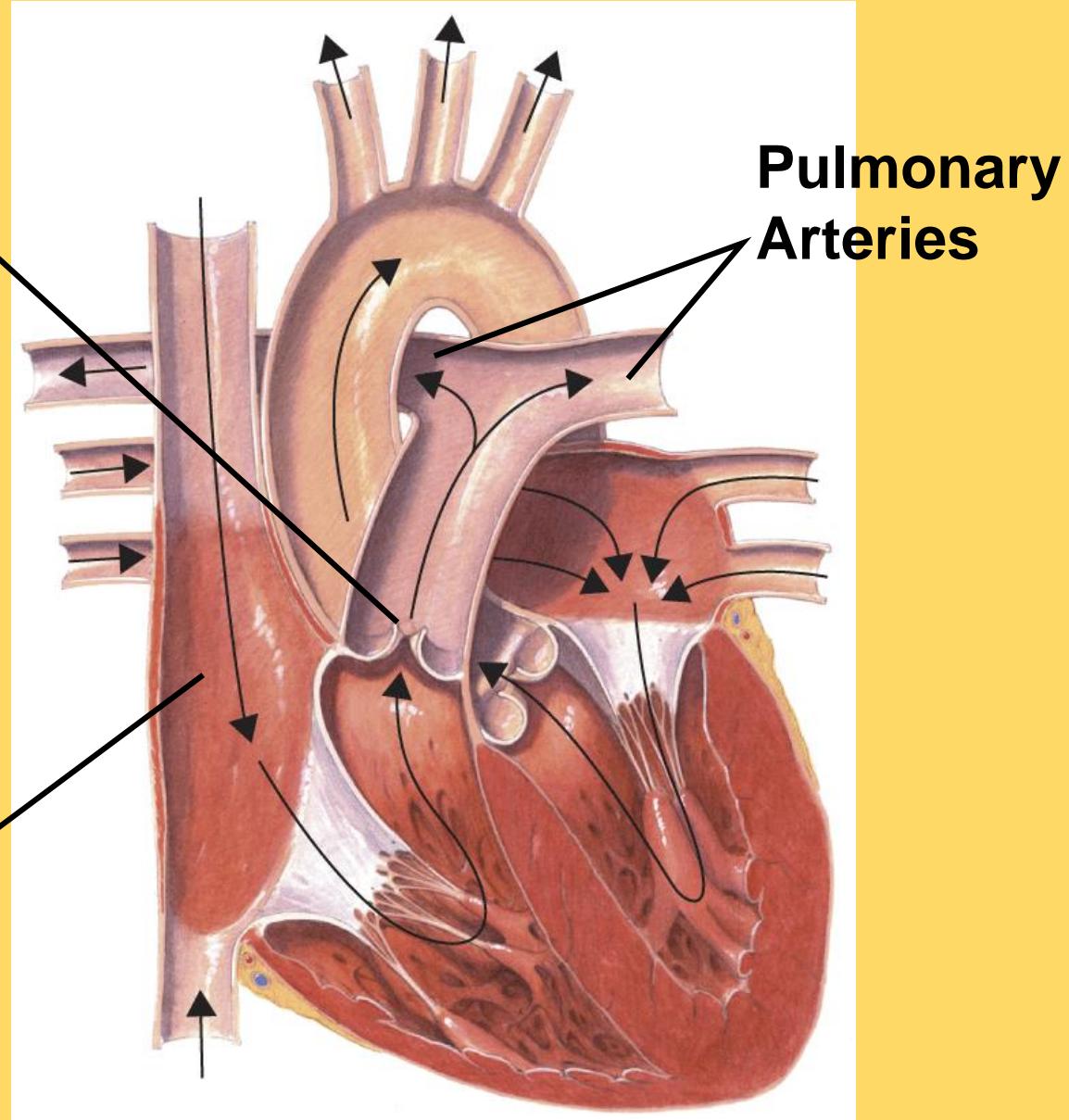
Blood leaves the right ventricle, and enters the **pulmonary artery**. This goes to the lungs to pick up oxygen and drop off carbon dioxide.

- Valve at base of the pulmonary artery is called the pulmonary valve.

## Pulmonary Valve:

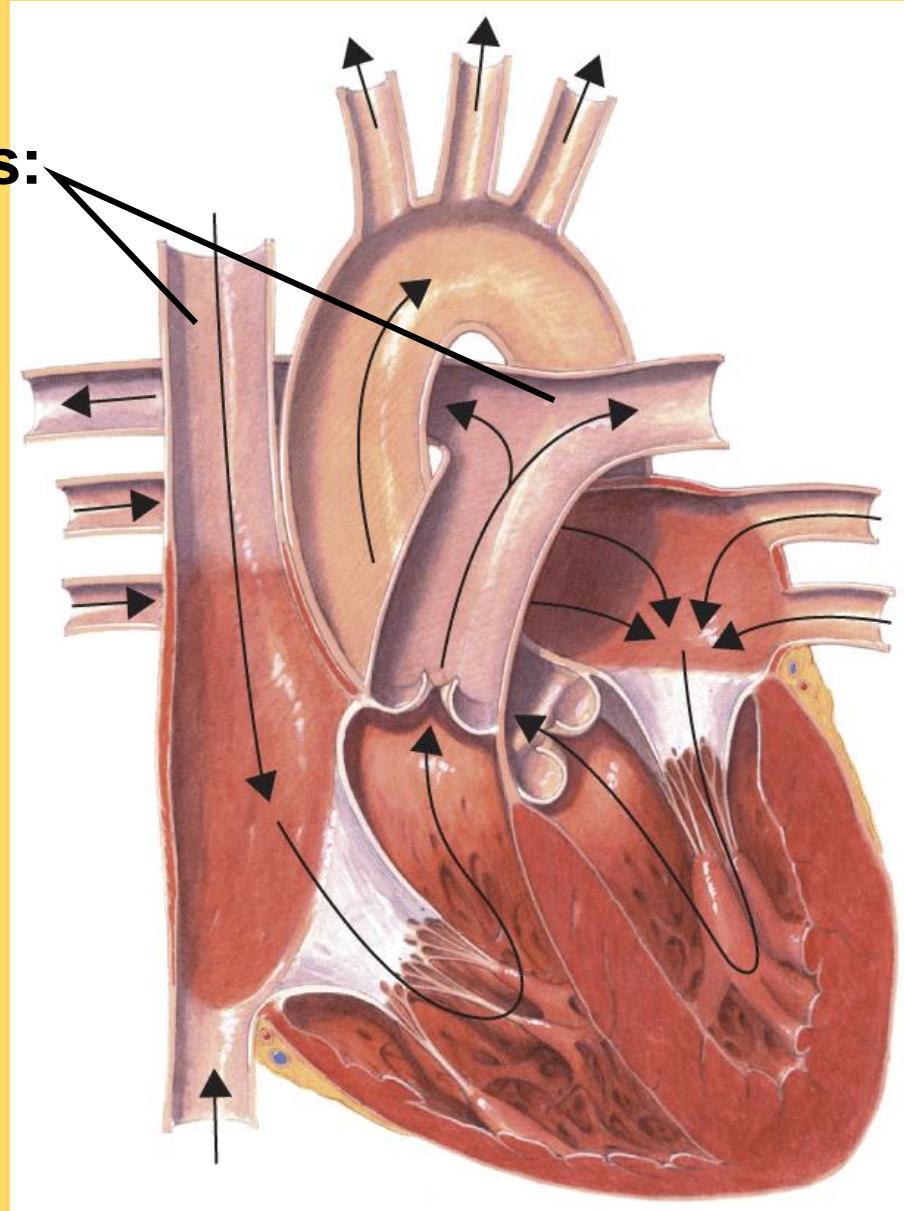
Prevents blood from flowing back into the right ventricle after it has entered the pulmonary artery.

## Right Atrium

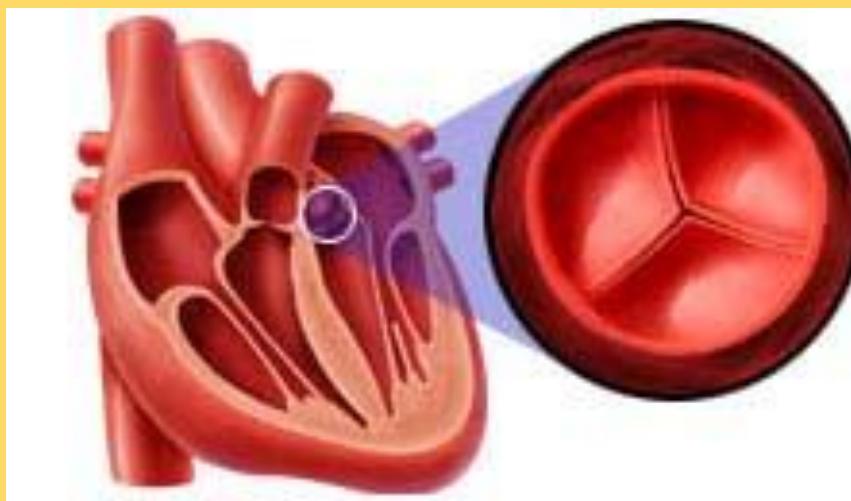


## Pulmonary Arteries:

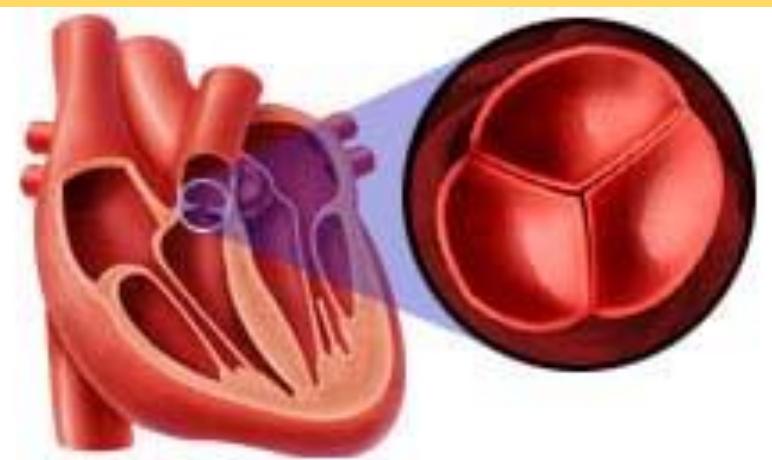
Bring oxygenated blood to the right or left lung



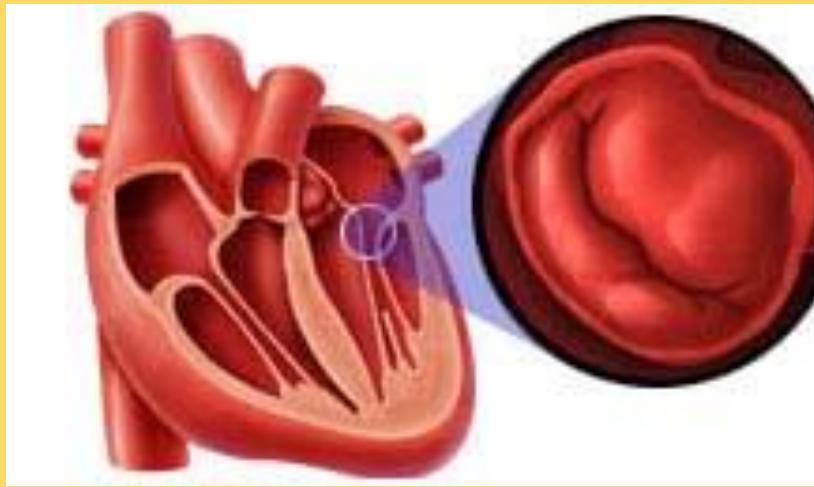
## Aortic Valve



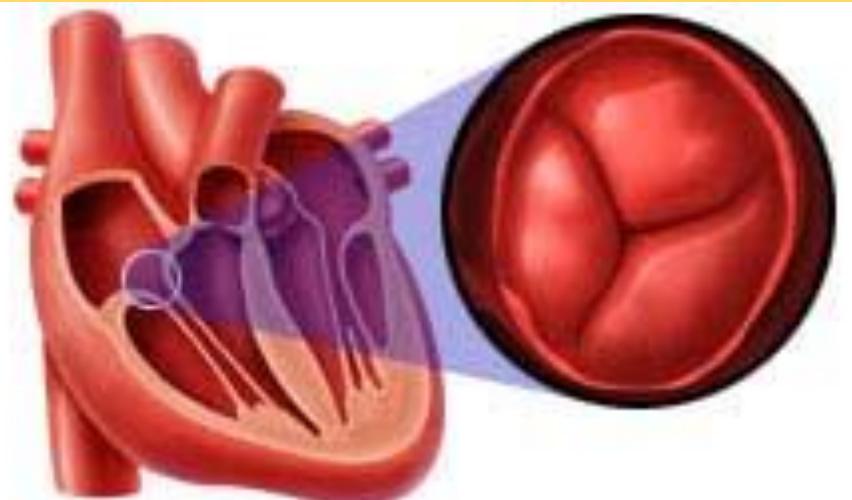
## Pulmonary Valve



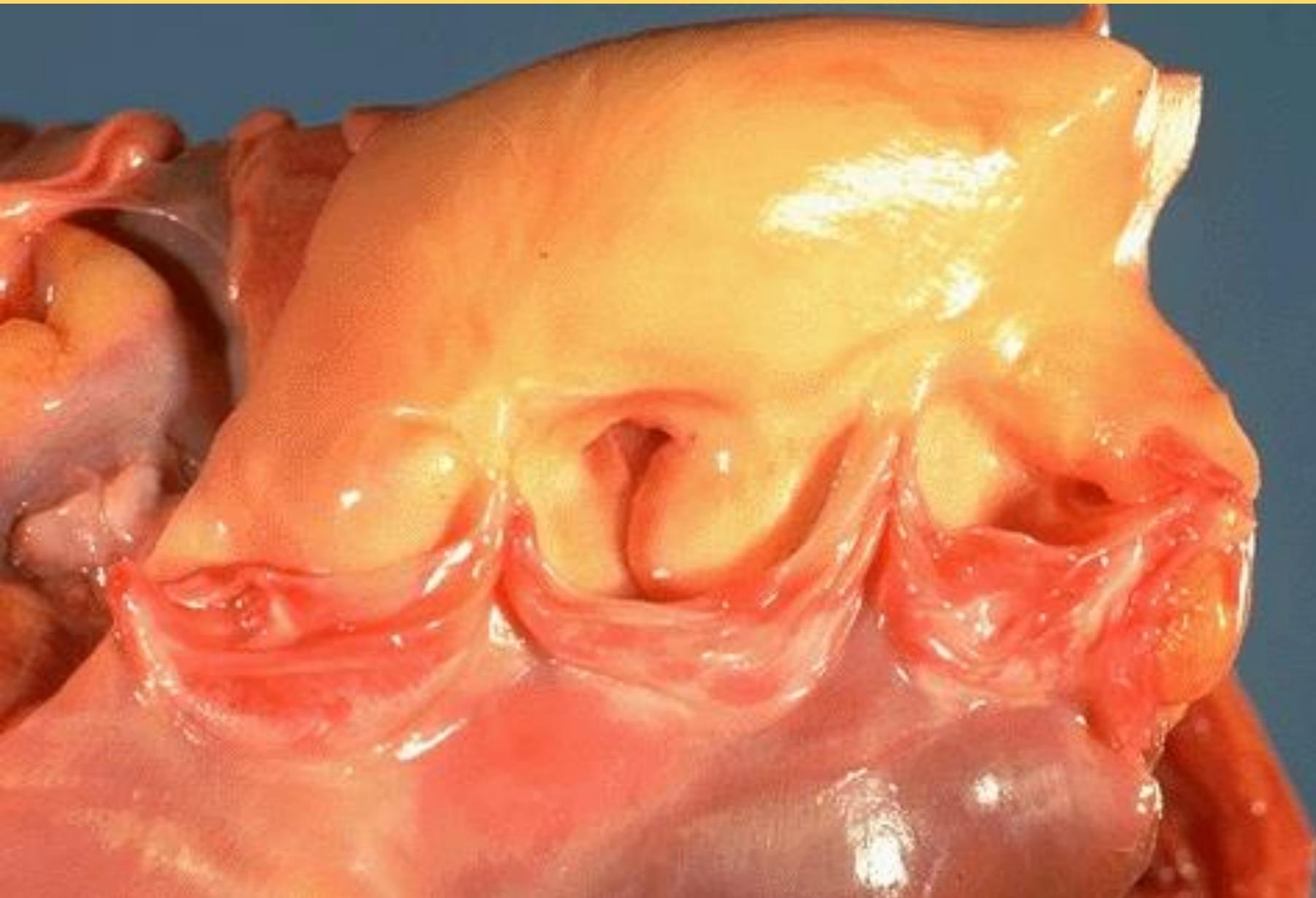
## Bicuspid Valve



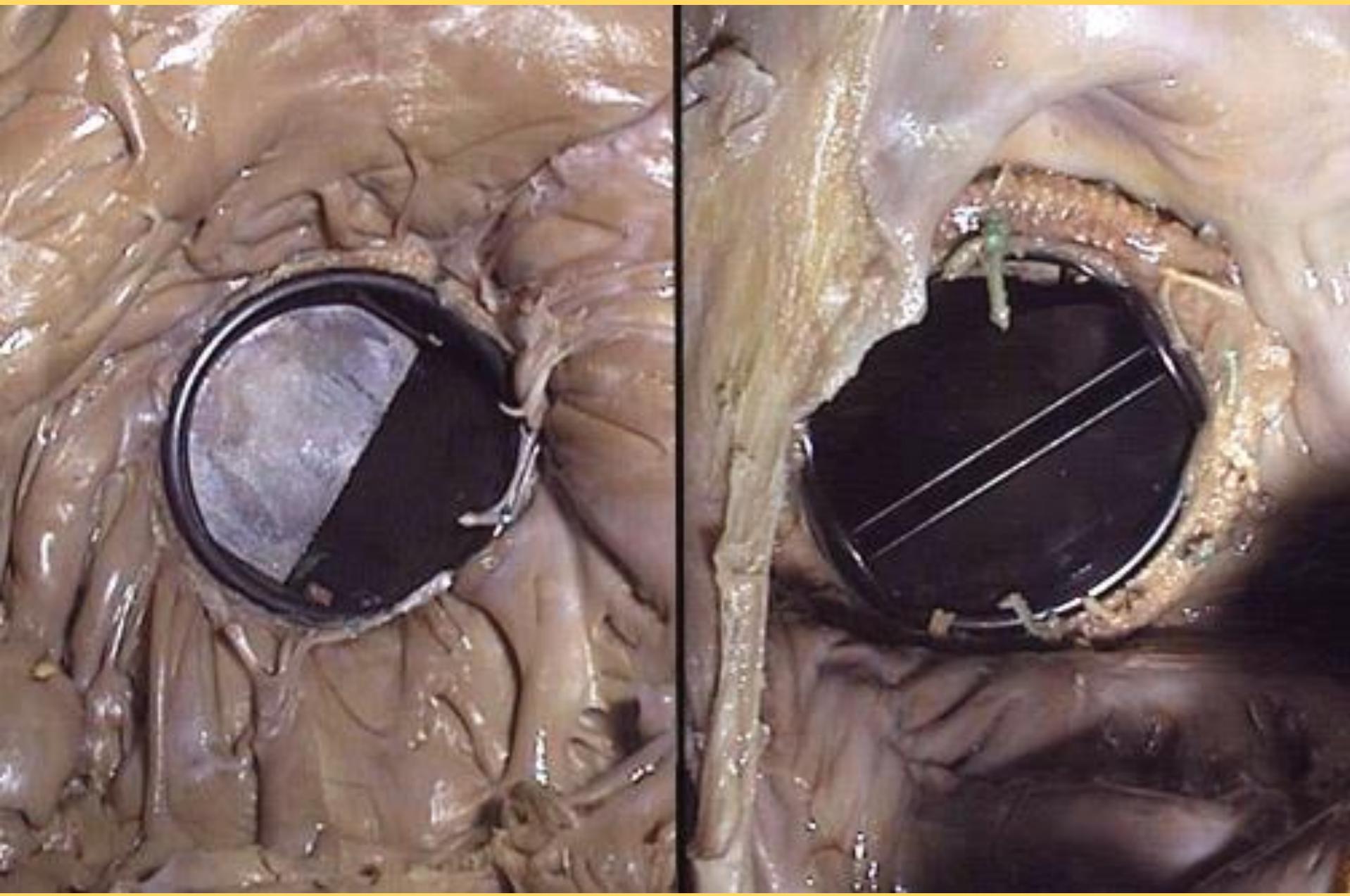
## Tricuspid Valve



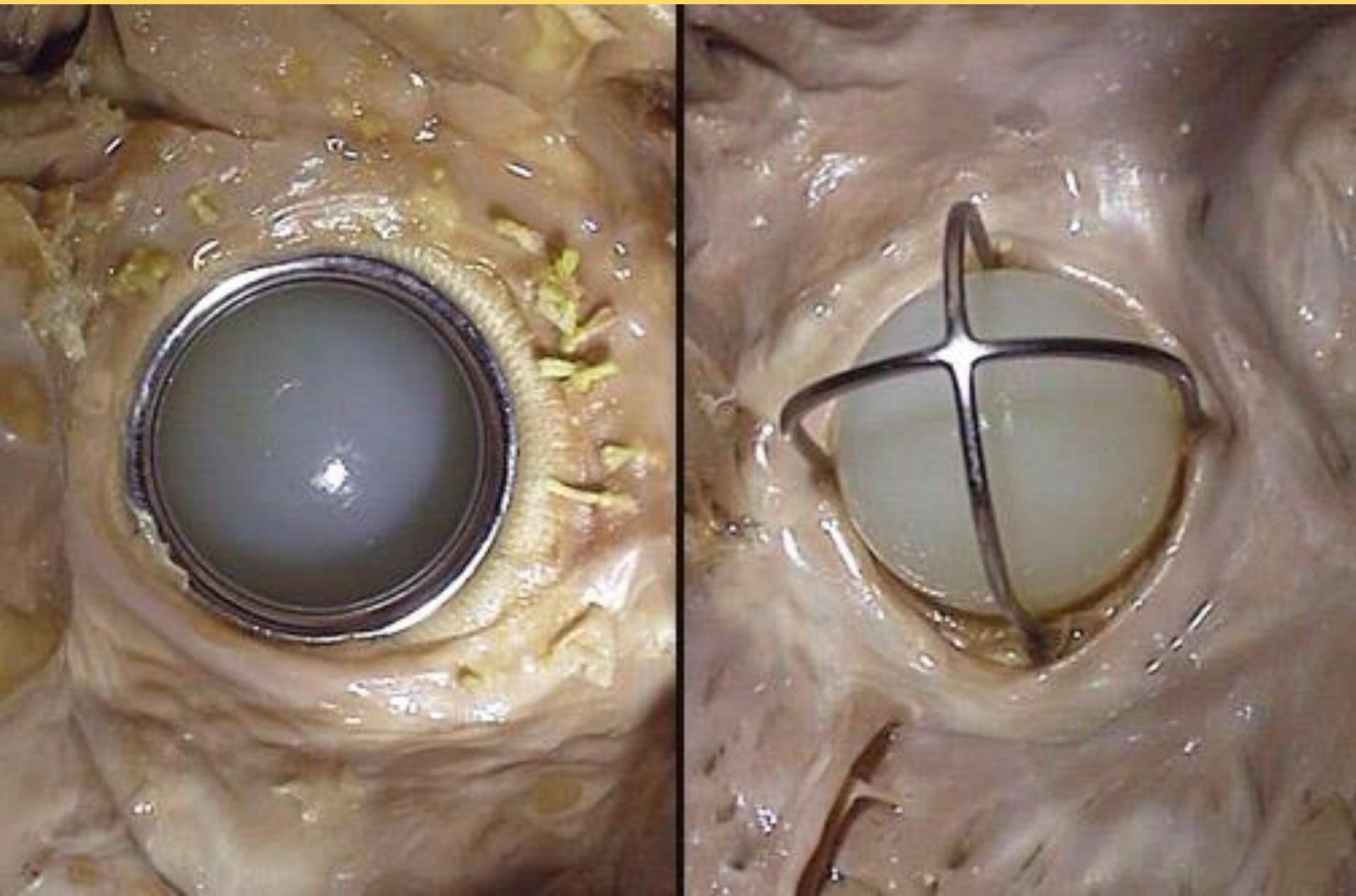
# The Aortic Valve



# Mechanical Heart Valves



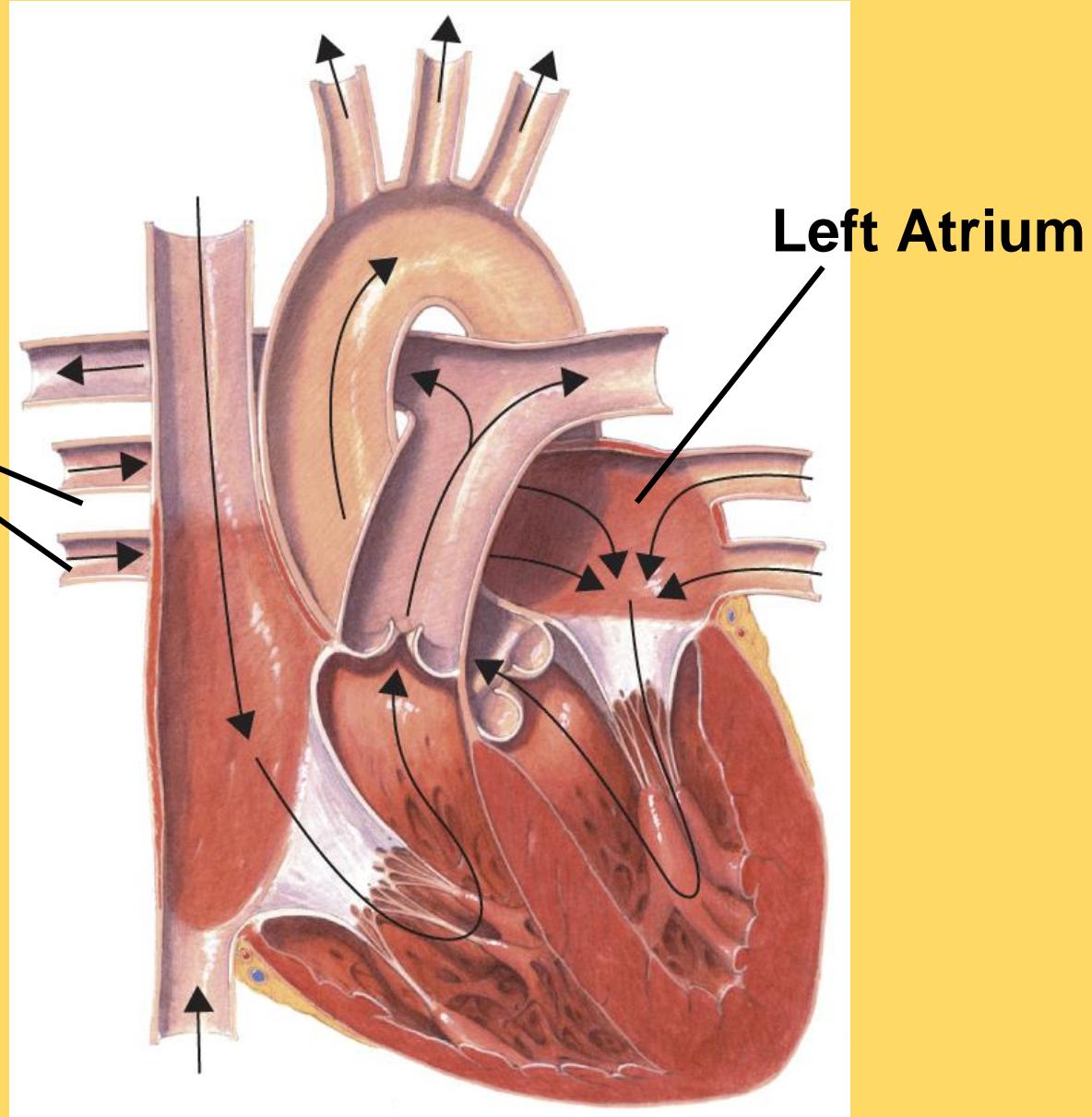
# Mechanical Heart Valves



Blood returns to the heart from the lungs in the **pulmonary veins**. This brings back oxygenated blood to the left atrium for distribution to the rest of the body.

# The Heart

**Pulmonary Veins:**  
Bring deoxygenated blood from each of the lungs to the left atrium



## Circuits Through the Body

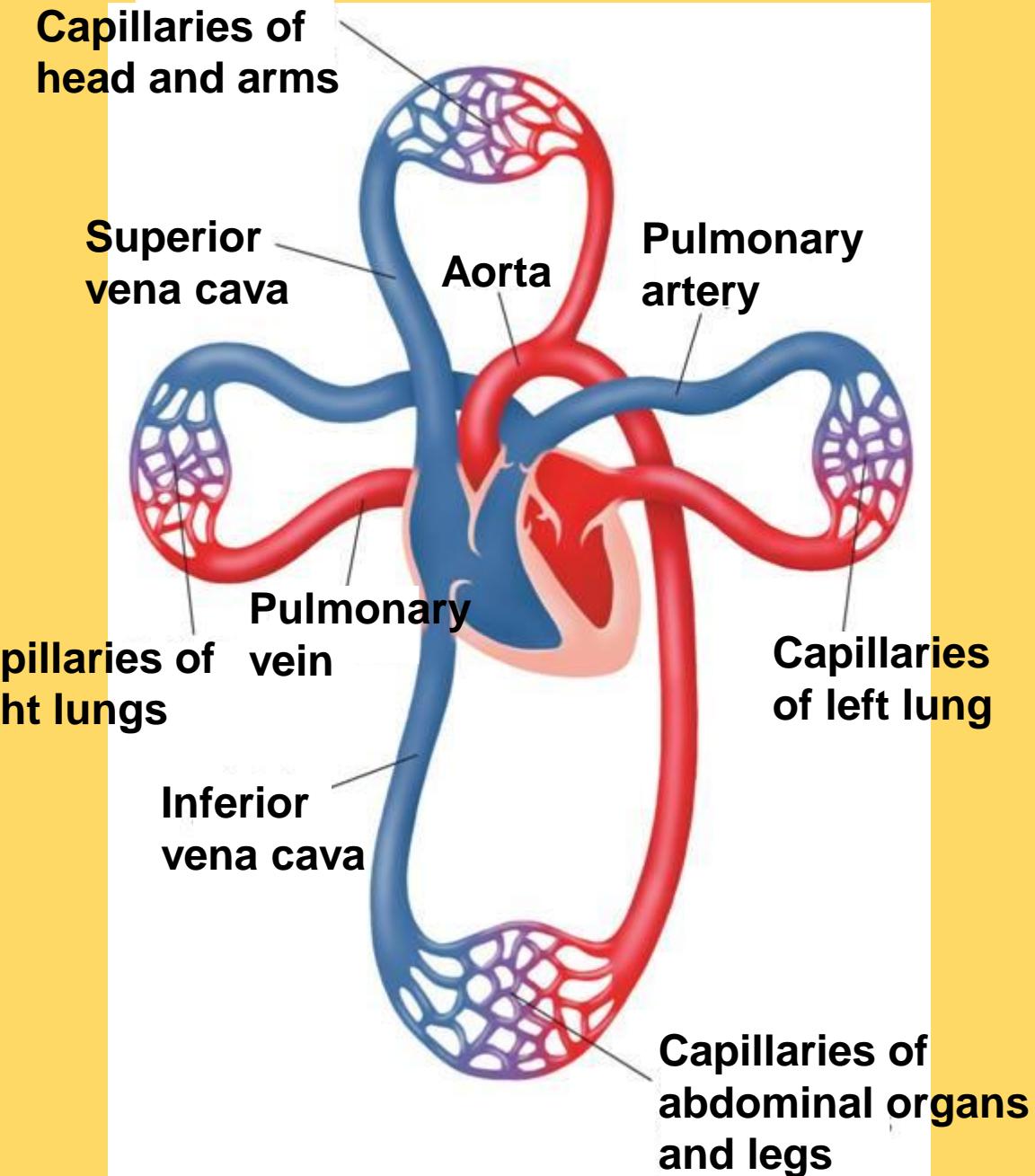
The heart functions as two separate pumps:

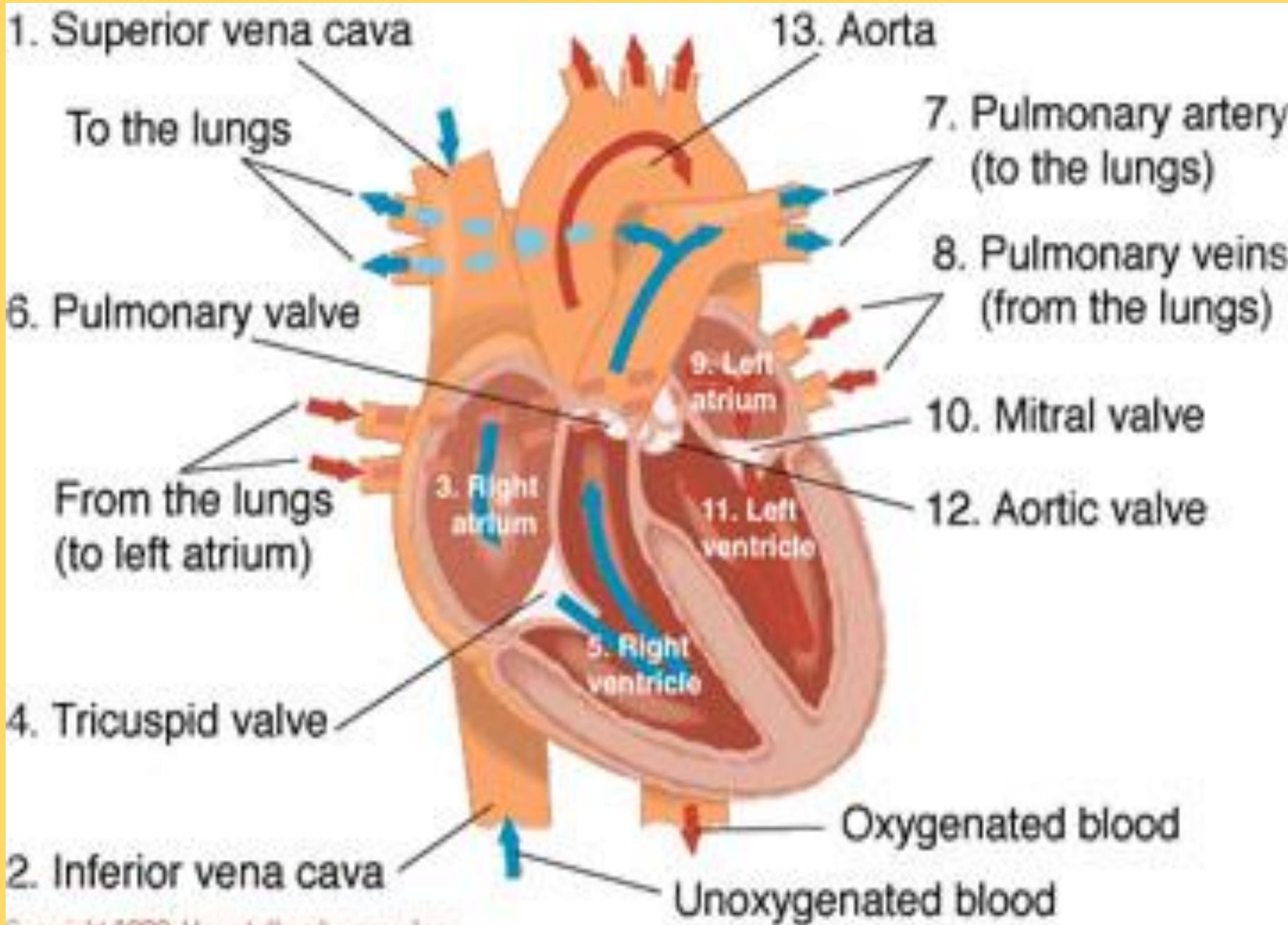
One pumps deoxygenated blood from the right side of the heart to the lungs and back to the left side of the heart. This is called the **pulmonary circuit**.

The other pumps oxygenated blood from the left side of the heart to the cells of the body and then back to the right side of the heart. This is called the **systemic circuit**.

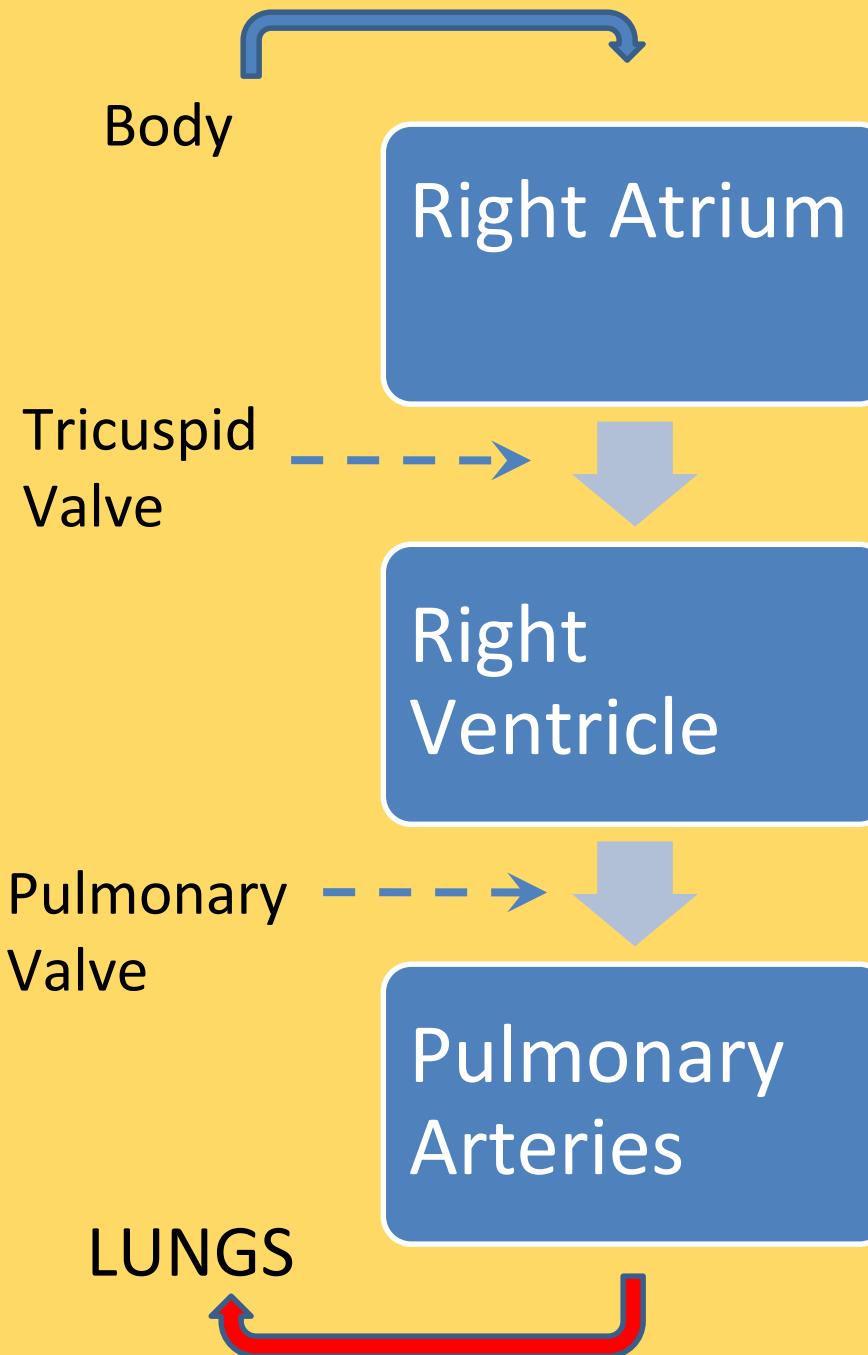
# Circulation of Blood through the Body

## The Heart



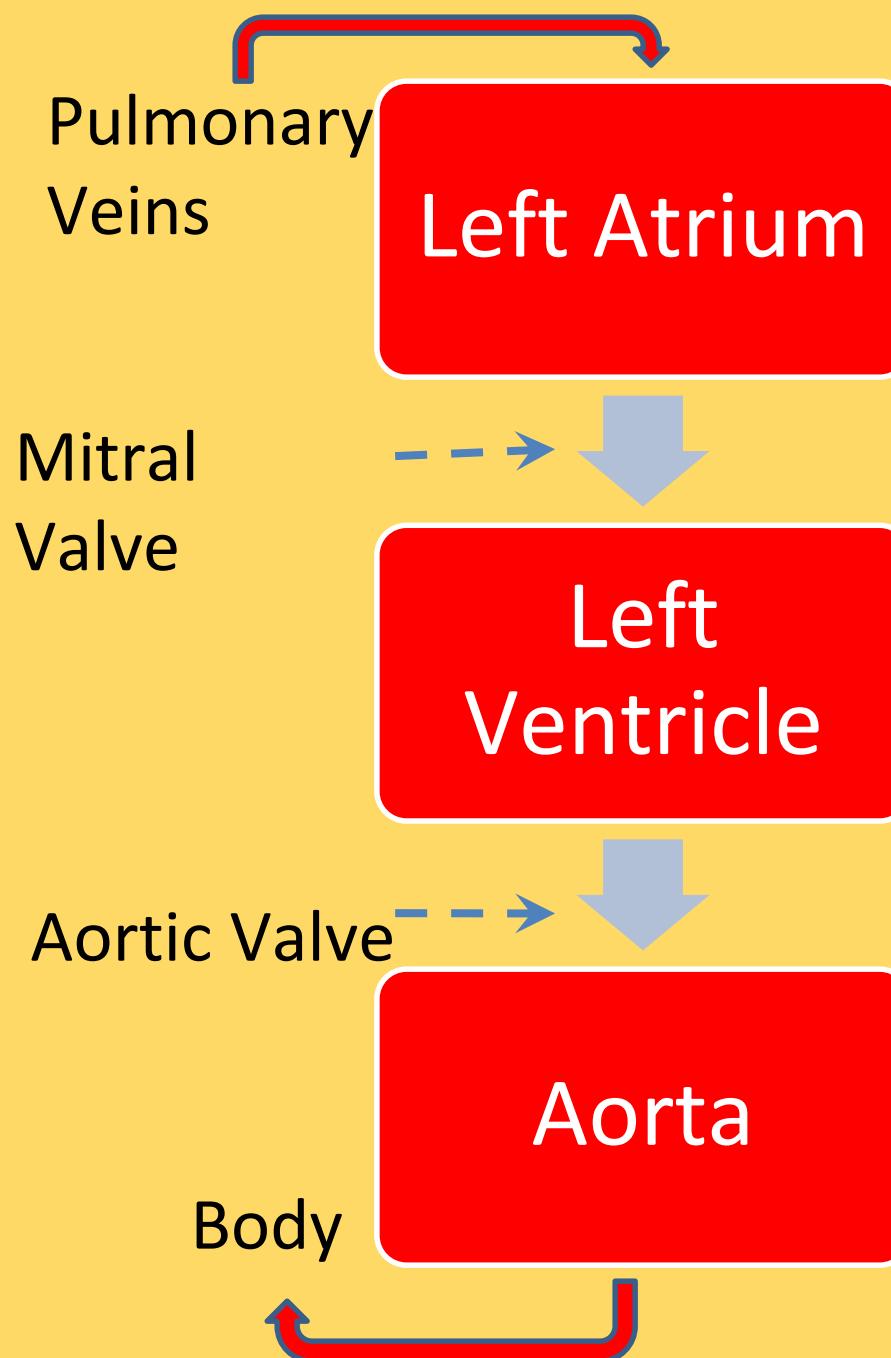


# F L O W O F B L O O D



Deoxygenated blood returns to the heart via veins and enters the Right Atrium

# F L O W O F B L O O D



Oxygenated blood from the lungs returns to the heart and enters the Left Atrium.



# Blood Pathway:

Here is a listing of all of the places that the blood flows as it moves through the heart and body in order:

Vena cava, right atrium, tricuspid valve, right ventricle, pulmonary valve, pulmonary artery, lungs, pulmonary veins, left atrium, bicuspid (mitral) valve, left ventricle, aortic valve, aorta, body tissues, vena cava

# Heart Conduction

- The cardiac muscle has the ability to expand and contract and is regulated by the heart's own conduction system.
- The conduction system is similar to an electrical outlet: Once “plugged in” electricity flows through the heart causing it to beat.
- The sounds of the heart “lub dub” are actually the heart valves opening and closing with each electrical impulse.

# Heartbeat

Each contraction begins in a small cluster of cells in the right atrium called the **sinoatrial (SA) node**.

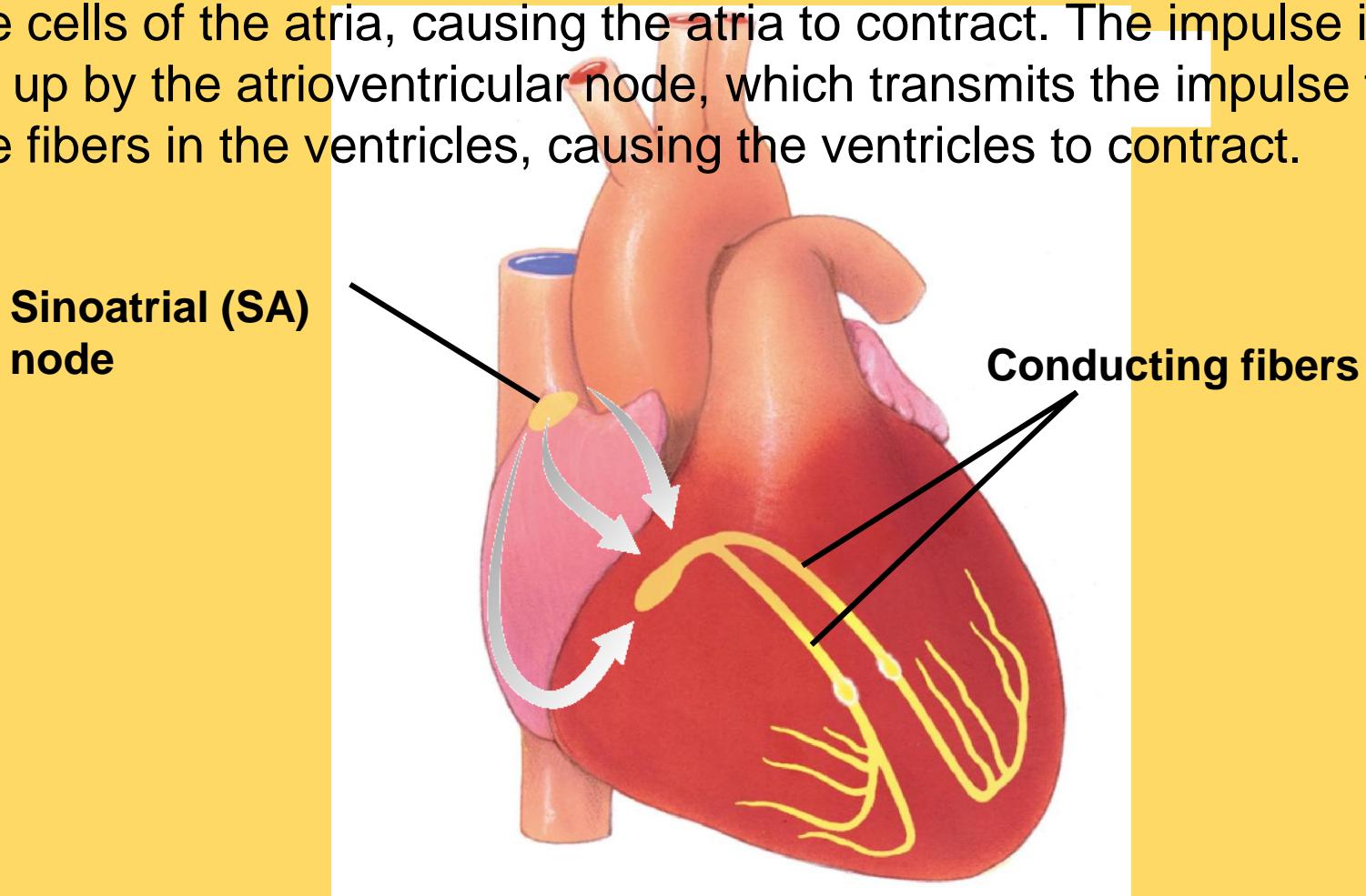
- Cells act like a pacemaker
- Spontaneously sets off impulses, about **72 beats/minute**

Contraction spreads quickly from atria to ventricles.

- Spread by a system of fibers called the **Purkinje fibers**.

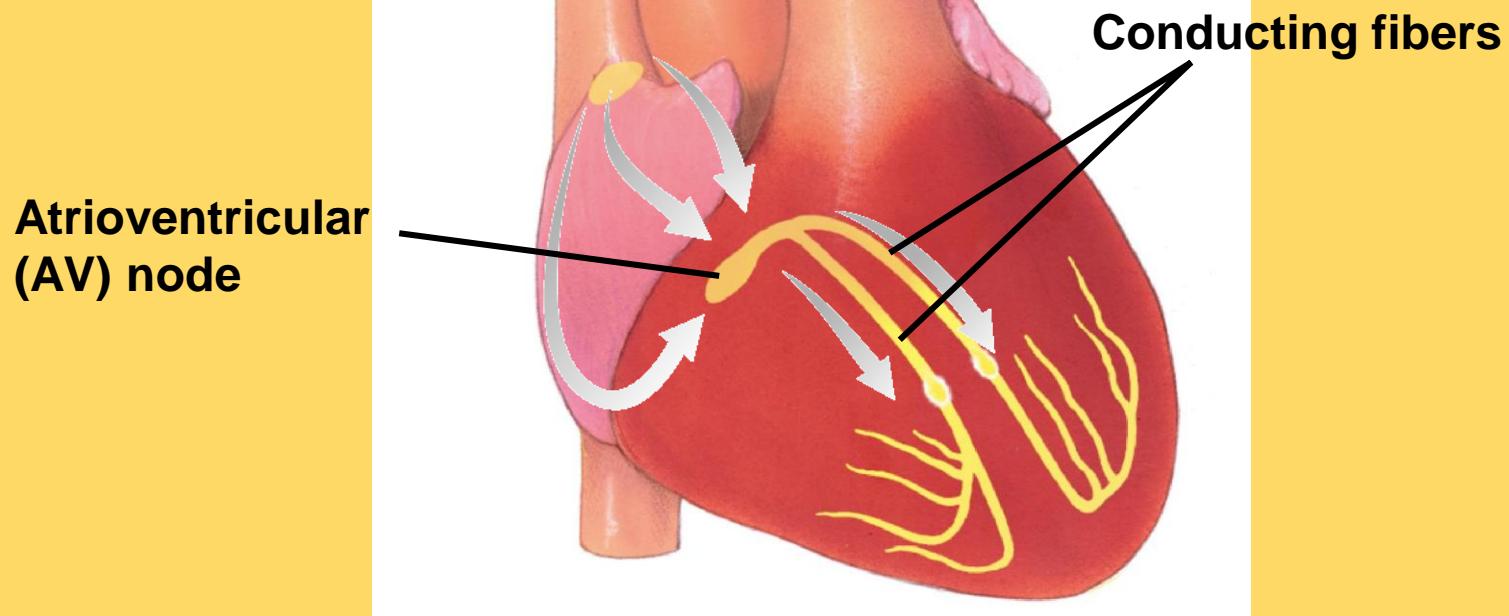
# The impulse spreads from the pacemaker (SA node) to a network of fibers in the atria.

The signal to contract spreads from the sinoatrial node to the cardiac muscle cells of the atria, causing the atria to contract. The impulse is picked up by the atrioventricular node, which transmits the impulse to muscle fibers in the ventricles, causing the ventricles to contract.

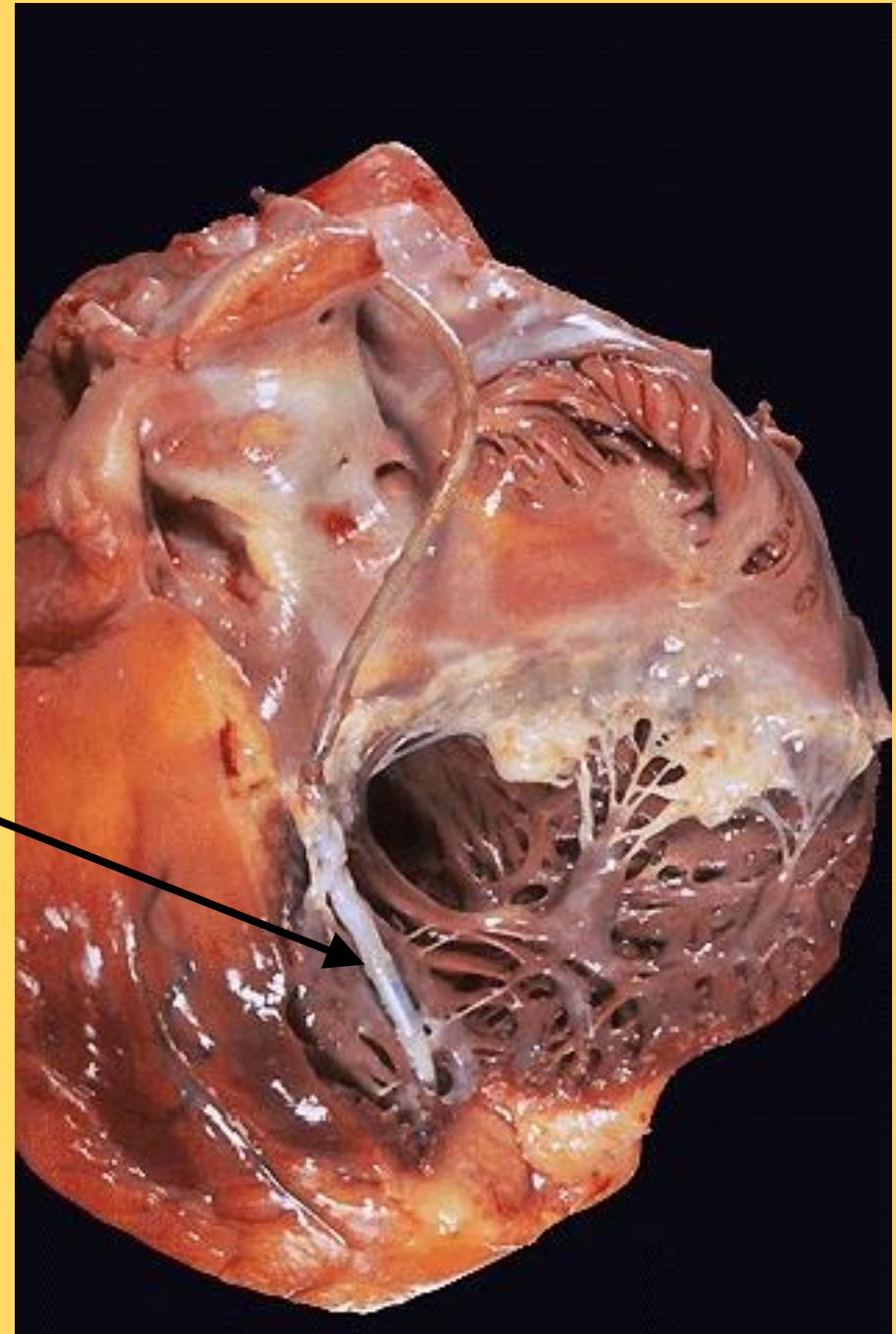


The impulse is picked up by a bundle of fibers called the **atrioventricular (AV) node** and carried to the network of Purkinje fibers in the ventricles.

The signal to contract spreads from the sinoatrial node to the cardiac muscle cells of the atria, causing the atria to contract. The impulse is picked up by the atrioventricular node, which transmits the impulse to muscle fibers in the ventricles, causing the ventricles to contract.



**Artificial  
Pacemaker**



# Heart Rate

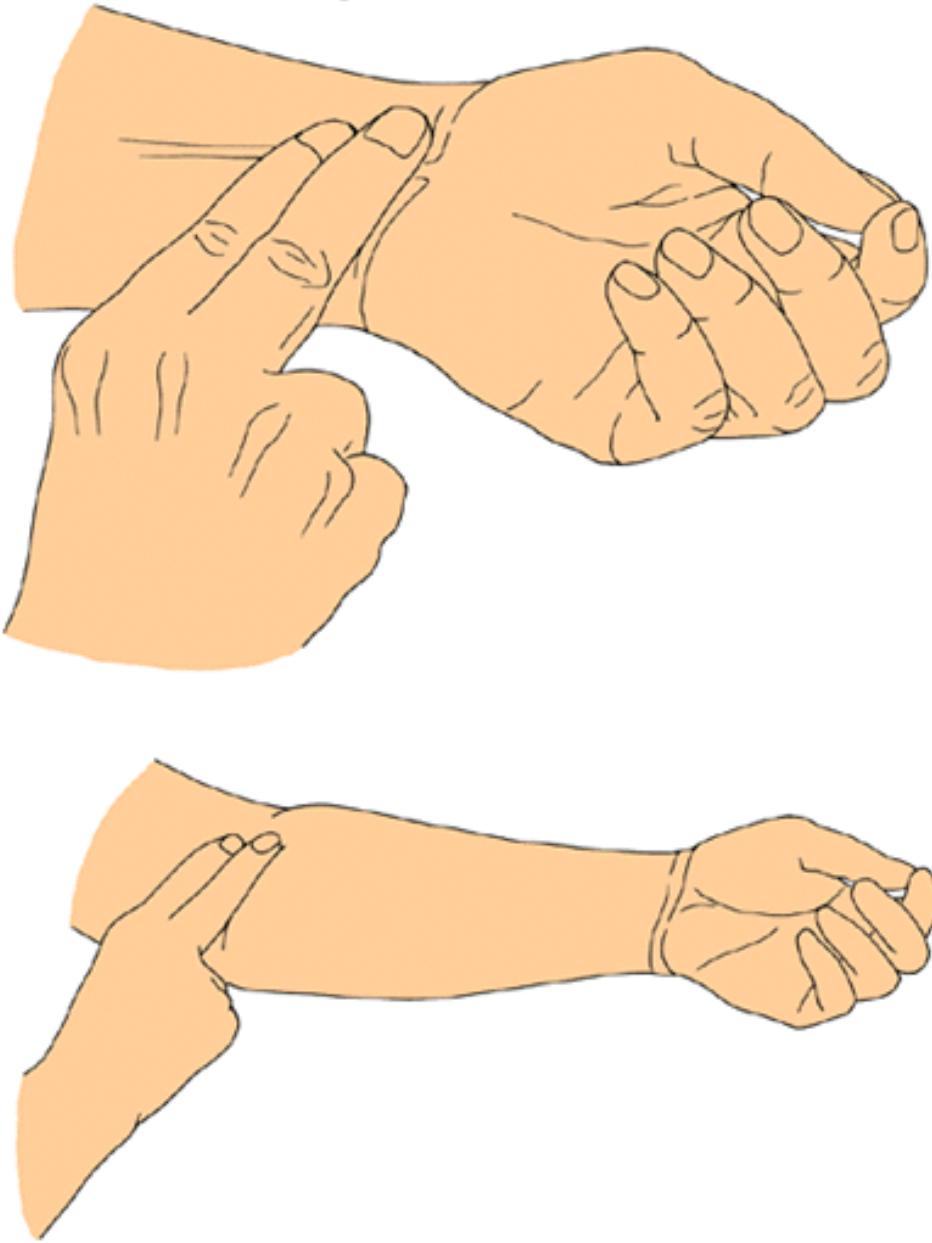
Your pulse is actually caused by pressure waves within an artery during systole (contraction of ventricles)

Can be felt near surface of body because the walls of arteries expand

Can easily be felt in:

- ♥ radial artery in wrist
- ♥ carotid artery in neck

## Taking Your Own Pulse

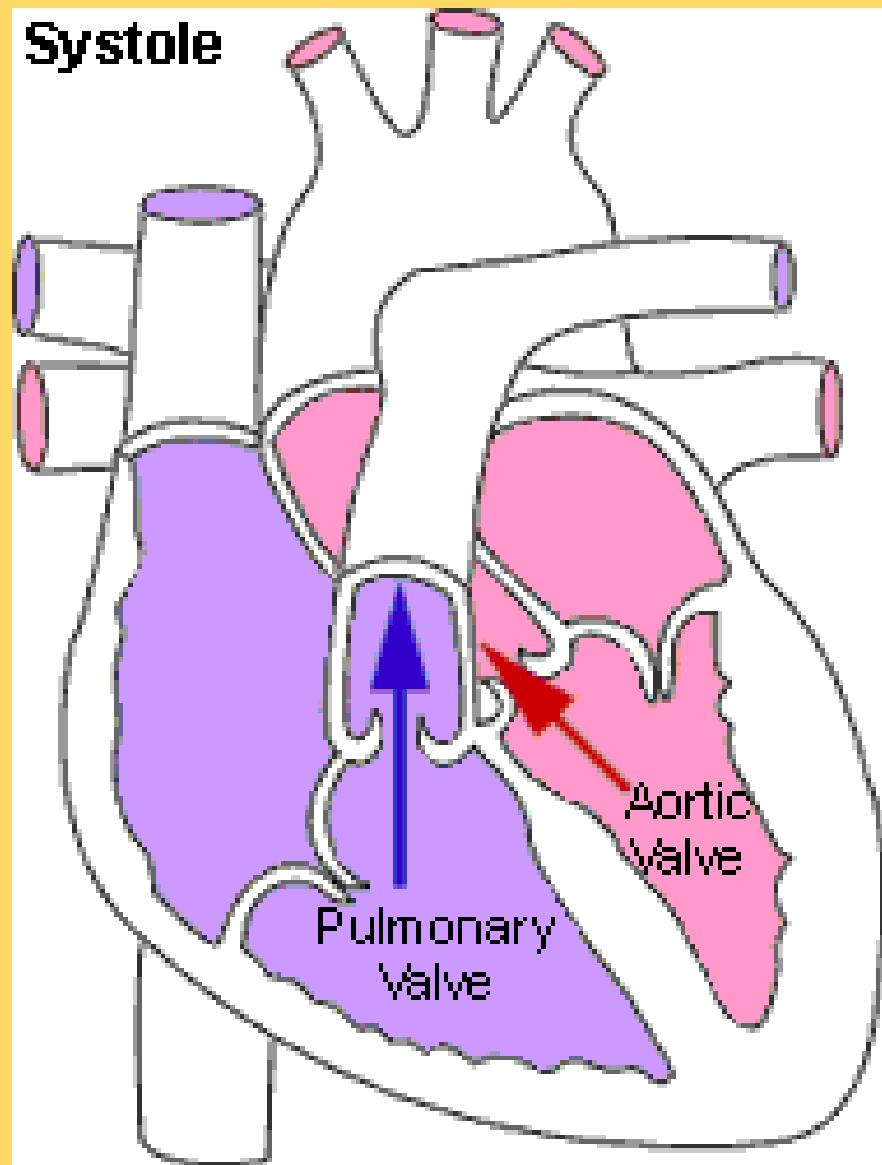


[Finding Heart with a Virtual Stethoscope](#)

# Contraction Phases of Heartbeat

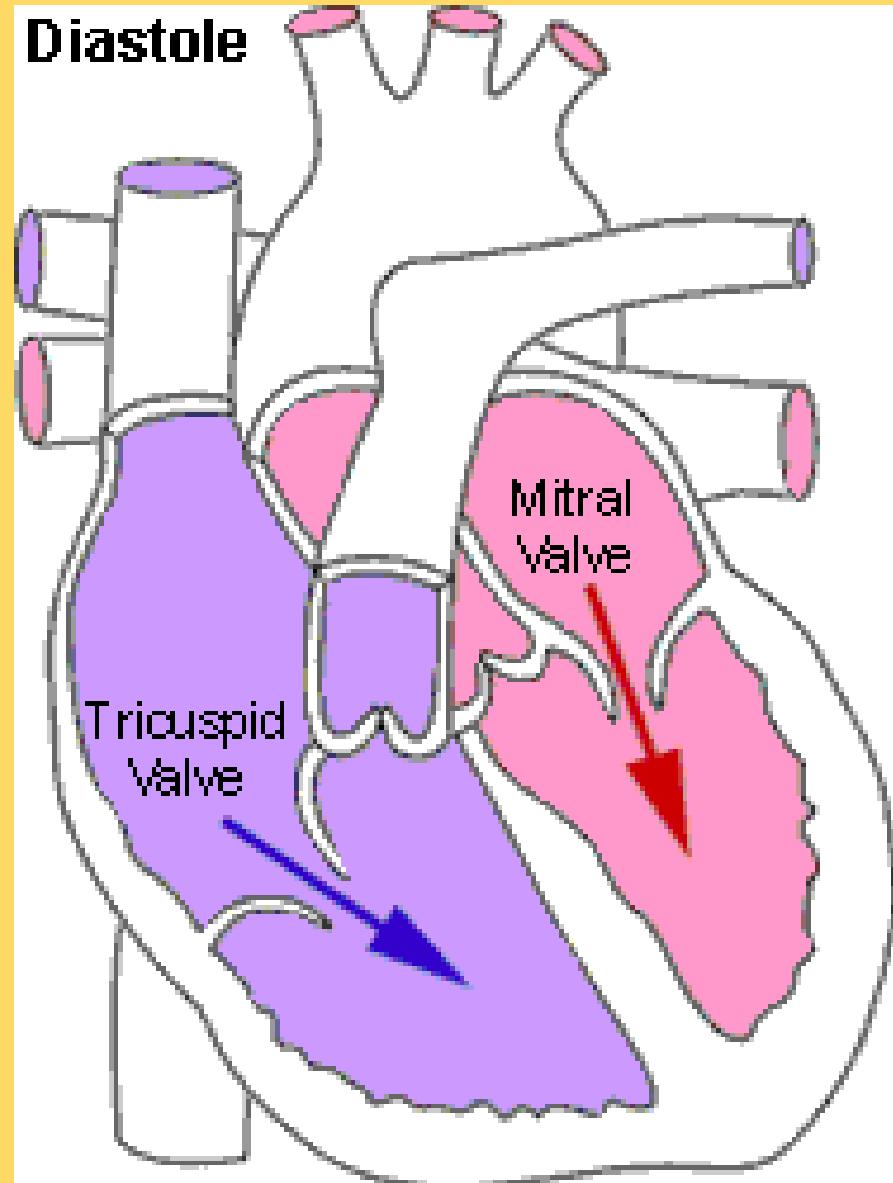
## Systole

- The contraction phase of the heart cycle
- When the ventricles actively pump the blood

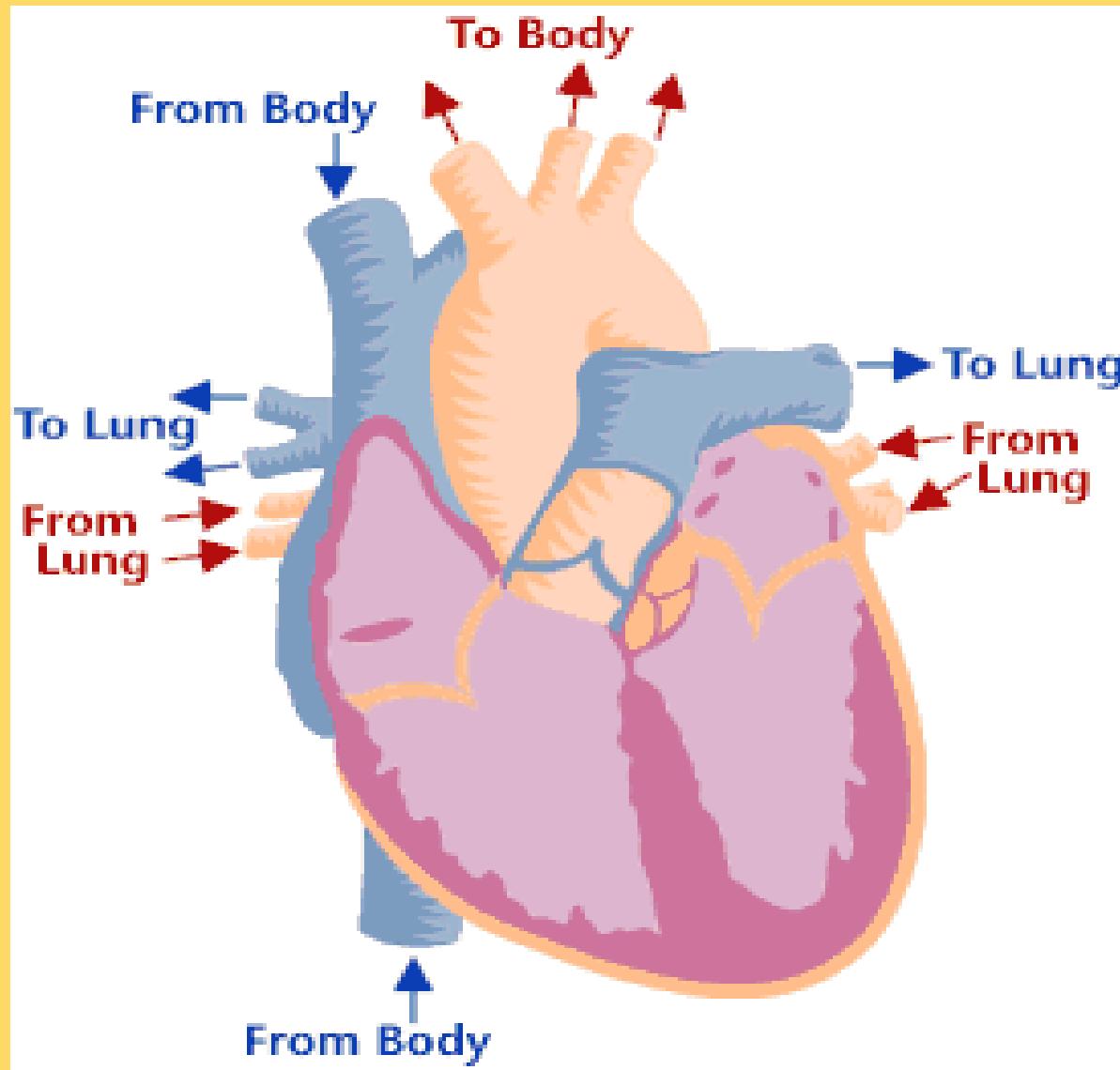


# Diastole

- The relaxation phase of the heart cycle
- When the ventricles fill with blood



# Heart Contraction & Blood Flow



# Blood Pressure

When the ventricle of the heart contracts, it produces a wave of fluid pressure in the arteries.

The force of the blood on the arteries' walls is **blood pressure**.

Blood pressure keeps blood flowing through the body.

## Blood Pressure

Blood pressure is measured with a machine called a:  
**sphygmomanometer.**

A typical blood pressure for a healthy person is 120/80.

- 1<sup>st</sup> # = systolic pressure

Pressure during systole

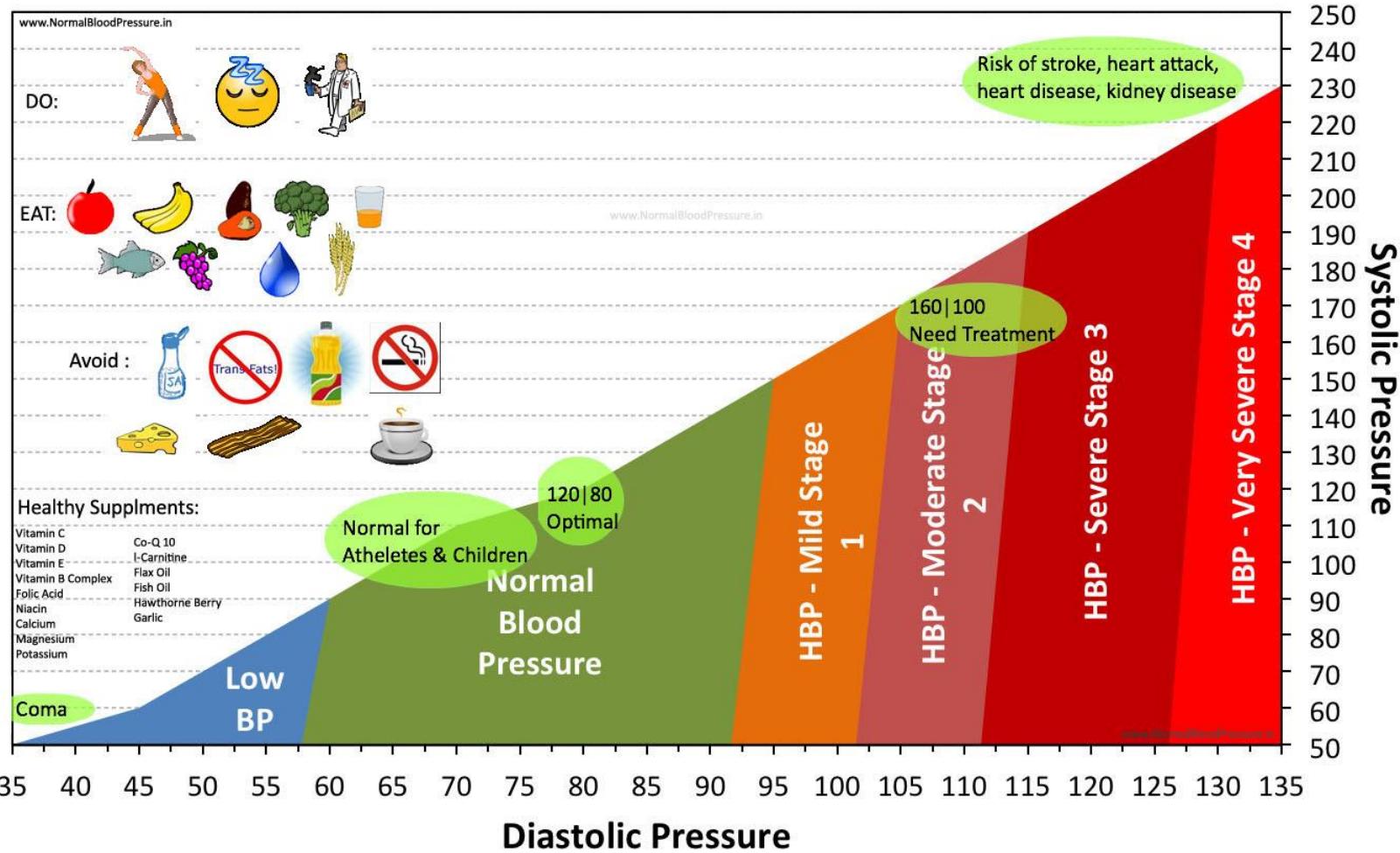
- 2<sup>nd</sup> # = diastolic pressure

Pressure during diastole



<b>Age</b>	<b>Min</b>	<b>Normal</b>	<b>Max</b>
1 to 12 months	75 / 50	90 / 60	100 / 75
	1 to 5 years	80 / 55	95 / 65
	6 to 13 years	90 / 60	105 / 70
	14 to 19 years	105 / 73	117 / 77
	20 to 24 years	108 / 75	120 / 79
	25 to 29 years	109 / 76	121 / 80
	30 to 34 years	110 / 77	122 / 81
	35 to 39 years	111 / 78	123 / 82
	40 to 44 years	112 / 79	125 / 83
	45 to 49 years	115 / 80	127 / 84
	50 to 54 years	116 / 81	129 / 85
	55 to 59 years	118 / 82	131 / 86
	60 to 64 years	121 / 83	134 / 87

# BLOOD PRESSURE CHART



# Electrocardiograms (EKGs)

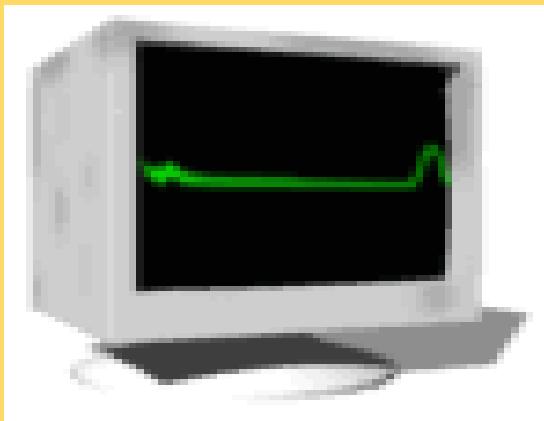
Can measure tiny electrical impulses  
that are produced by the heart

Electrocardiograph is an instrument that  
can measure these impulses

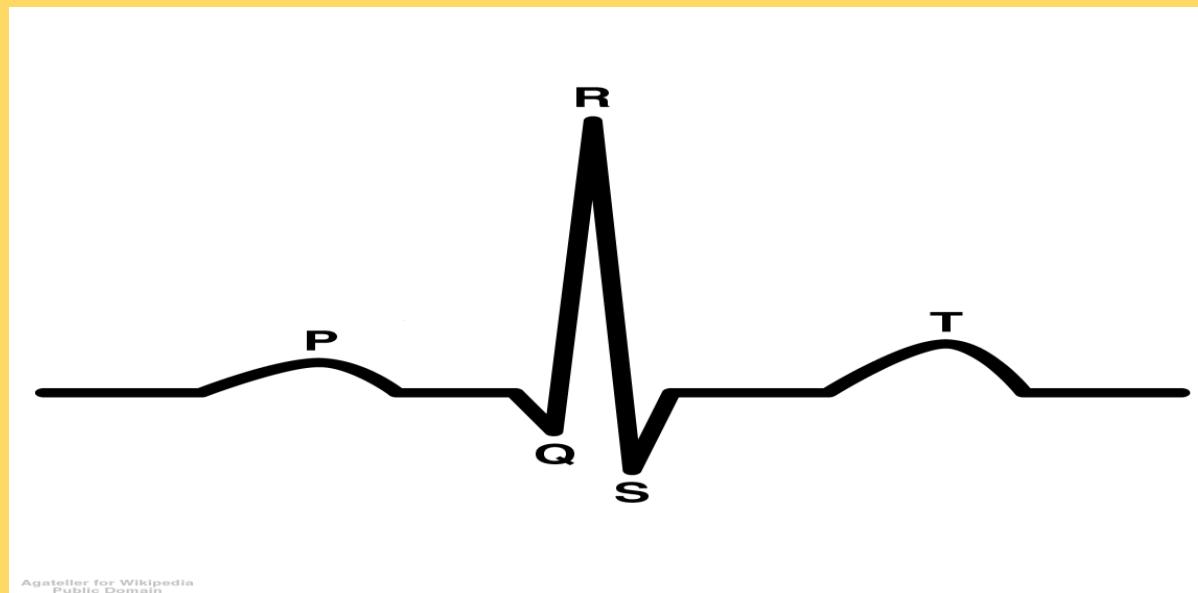
The written record is called an  
electrocardiogram (EKG or ECG)



# Electrocardiogram (ECG or EKG)



A test used to measure the electrical activity of the heart. Informs us if the heart is beating too fast, too slow, normally or irregularly.



## How to read an EKG

To briefly summarize the features used in reading EKGs, they consist of waveform components which indicate electrical events during one heartbeat. These waveforms are labeled P, Q, R, S, and T .

P wave is the first short upward movement of the EKG tracing. It indicates that the atria are contracting, pumping blood into the ventricles.

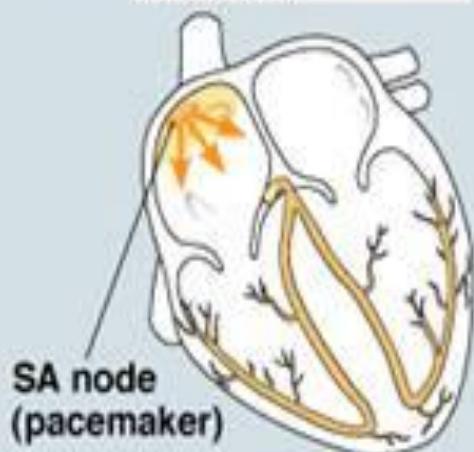
The QRS complex, normally beginning with a downward deflection, Q; a larger upwards deflection, a peak (R); and then a downwards S wave. The QRS complex represents ventricular depolarization and contraction.

The PR interval indicates the transit time for the electrical signal to travel from the AV node to the ventricles.

T wave is normally a modest upwards waveform representing ventricular repolarization

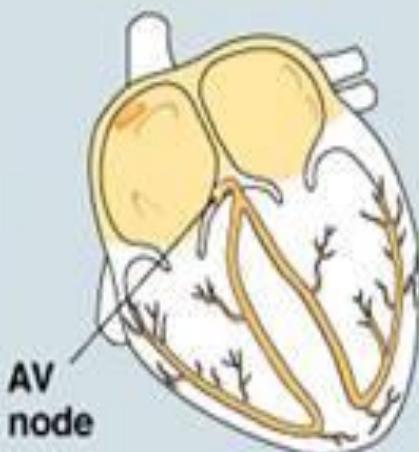


**1** Pacemaker generates wave of signals to contract



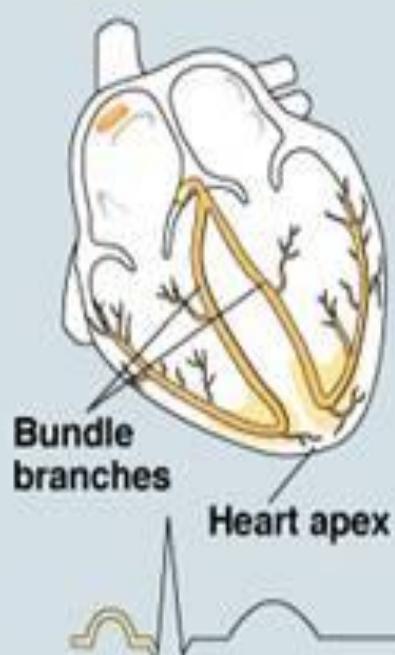
SA node  
(pacemaker)

**2** Signals delayed at AV node



AV node

**3** Signals pass to heart apex



Bundle  
branches

Heart apex

ECG

**4** Signals spread throughout ventricles

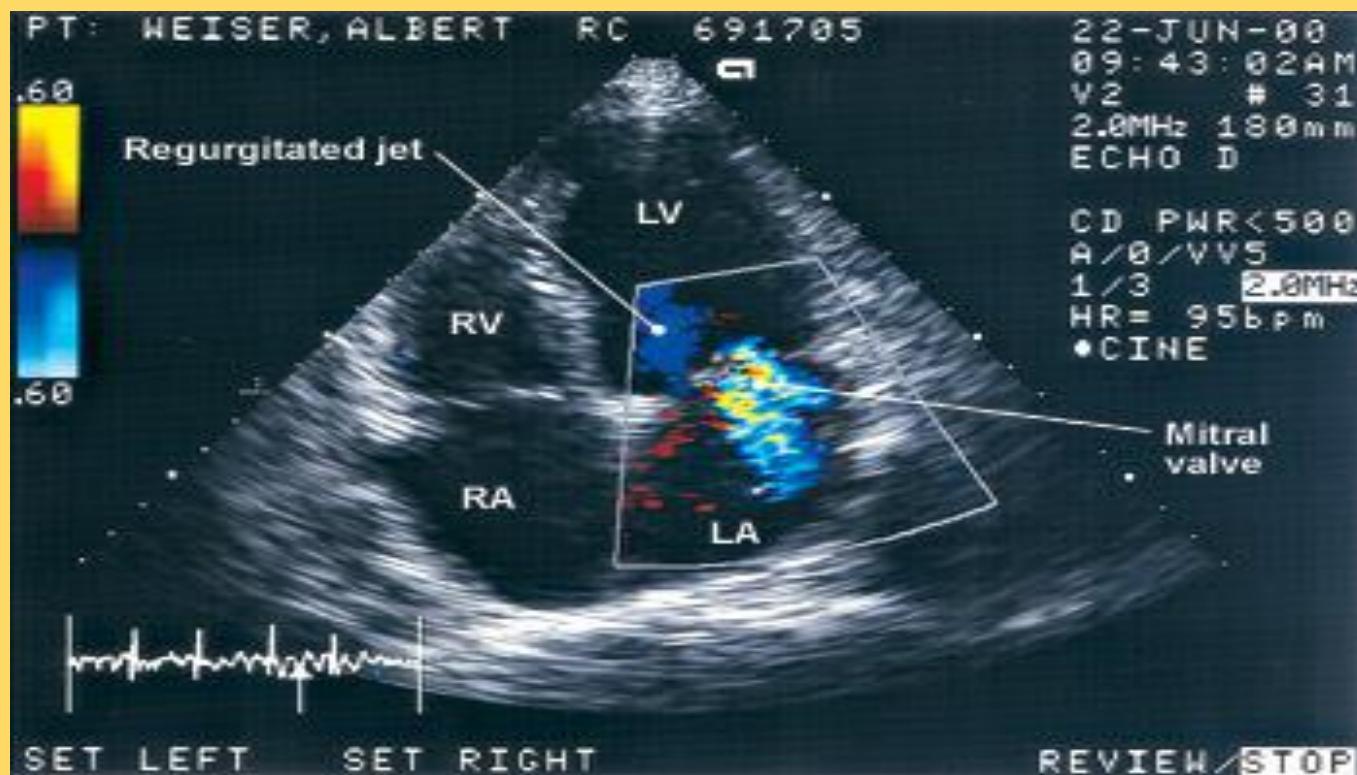


Purkinje  
fibers

©1999 Addison Wesley Longman, Inc.



# Echocardiogram



A test in which ultrasound, a type of sound wave, is used to obtain detailed images of the heart structure and function.

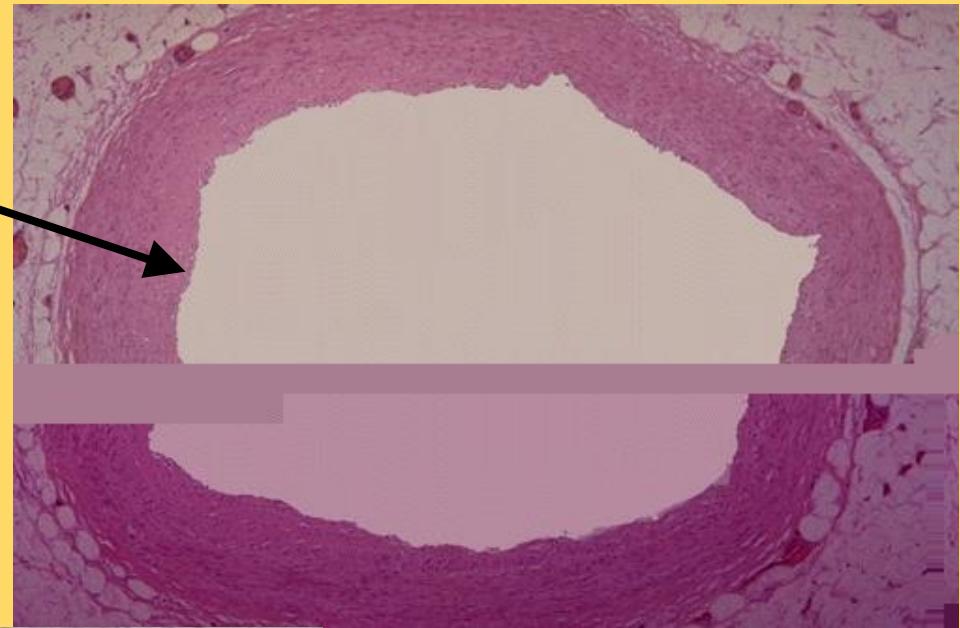
# Diseases of the Circulatory System

Cardiovascular diseases are among the leading causes of death and disability in the U.S.

**Atherosclerosis** is a condition in which fatty deposits called **plaque** build up on the inner walls of the arteries.

Atherosclerosis can lead to heart attacks and strokes in the brain.

Normal  
Coronary  
Artery



Atherosclerosis

Clogging of the  
arteries

← Artery with  
plaque



## Heart Attack and Stroke

If one of the **coronary arteries** in heart becomes blocked, part of the heart muscle may begin to die from a lack of oxygen.

If enough heart muscle is damaged, a **heart attack** occurs.

If a blood clot gets stuck in a blood vessel leading to the brain, a **stroke** occurs.

Brain cells die and brain function in that region may be lost.

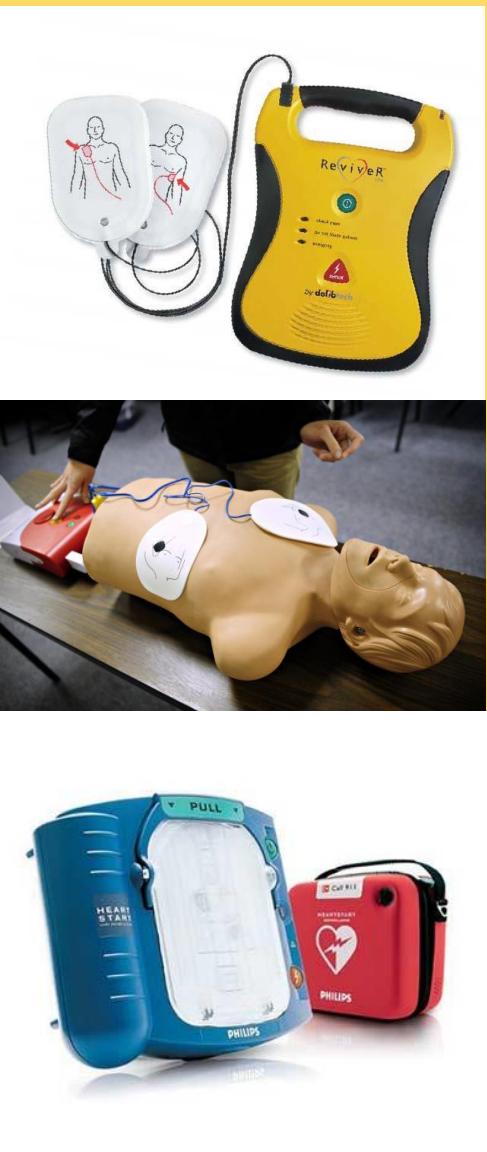
**Hypertension**, commonly called **high blood pressure**, is a serious problem.

- It puts strain on walls of arteries & increases chances they might burst
- It makes the heart work too hard
- It can lead to heart damage, brain damage and kidney failure

# Circulatory System Health

Ways of avoiding cardiovascular disease include:

- getting regular exercise.
- eating a balanced diet.
- avoiding smoking.

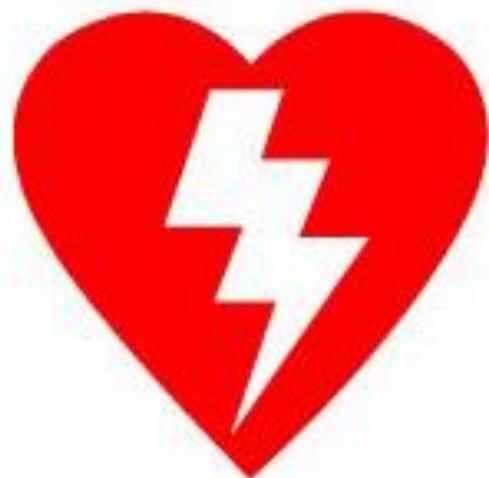


# CPR/AED

Sometimes when the heart stops, it can be restarted. Professionals are taught to read the rhythms of an EKG and decide if the heart is in a rhythm that can be restarted. An Automatic External Defibrillator or AED is also programmed to read these specific rhythms.

# AED

Automated External Defibrillator



While waiting for an AED to arrive, to give the person the best possible chance of surviving, Cardio Pulmonary Resuscitation or CPR should be performed. CPR keeps the heart pumping and the oxygenated blood circulating.



# HANDS-ONLY<sup>TM</sup> CPR

**TWO STEPS TO  
STAYING ALIVE**



CPR & First Aid



# Two steps to save a life:

1



Call Right Away!

2



Push Hard & Fast in  
the Center of the Chest!



I. Send someone to call 911 or,  
if alone, call 911 yourself



2. Push hard and fast in the middle  
of the chest

**CPR is as easy as**  
**C-A-B**



**Compressions**

Push hard and fast  
on the center of  
the victim's chest



**Airway**

Tilt the victim's head  
back and lift the chin  
to open the airway



**Breathing**

Give mouth-to-mouth  
rescue breaths

American Heart  
Association 

*Learn and Live*