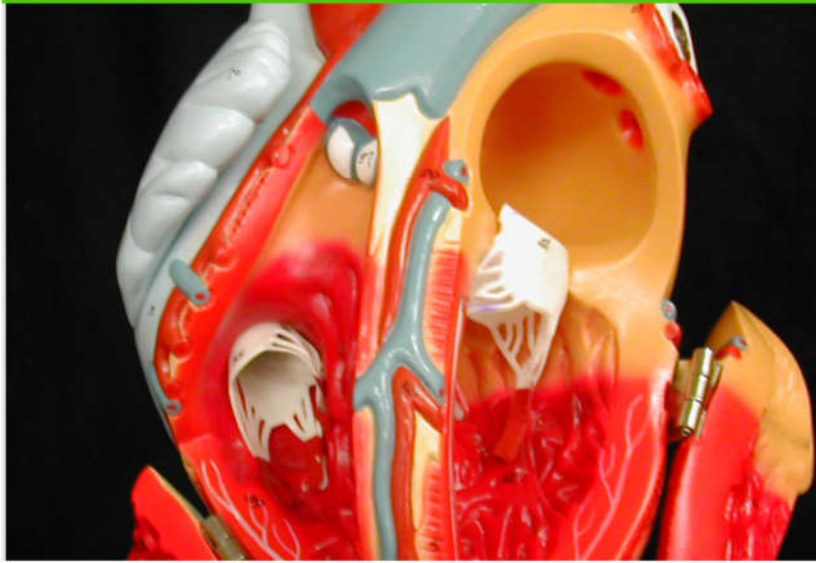


# Circulatory system

Transporting gases, nutrients, wastes, and hormones

## Features and Functions



## Features

- Circulatory systems generally have three main features:
  - Fluid (blood or hemolymph) that transports materials
  - System of blood vessels
  - A heart to pump the fluid through the vessels

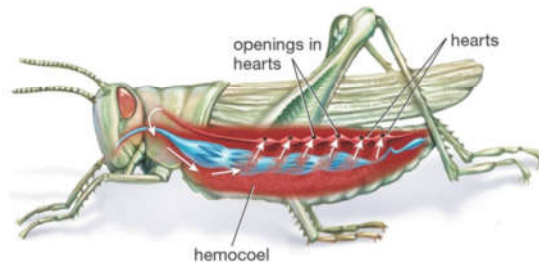
## Types of circulatory systems

- Animals that have a circulatory system have one of two kinds:
  - Open: fluid is circulated through an open body chamber.
  - Closed: fluid is circulated through blood vessels.

# Open system

- Arthropods and most mollusks have an open circulatory system.
- Hemolymph is contained in a body cavity, the hemocoel. A series of hearts circulates the fluid.

(a) Open circulatory system

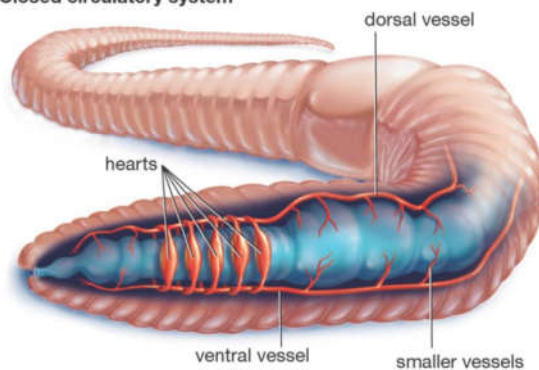


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# Closed system


- Vertebrates, annelid worms, and a few mollusks have a closed circulatory system.
- Blood is moved through blood vessels by the heart's action. It does not come in direct contact with body organs.

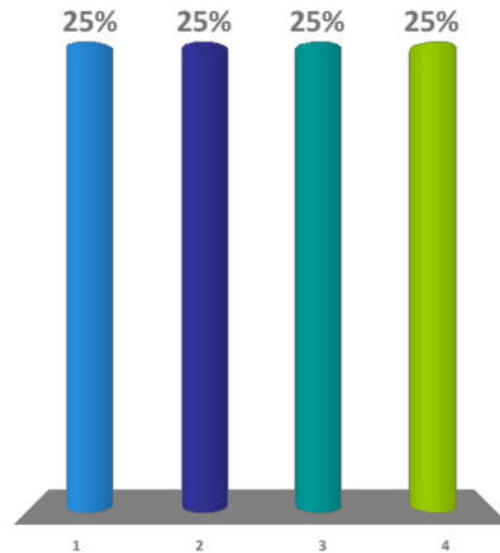
(b) Closed circulatory system



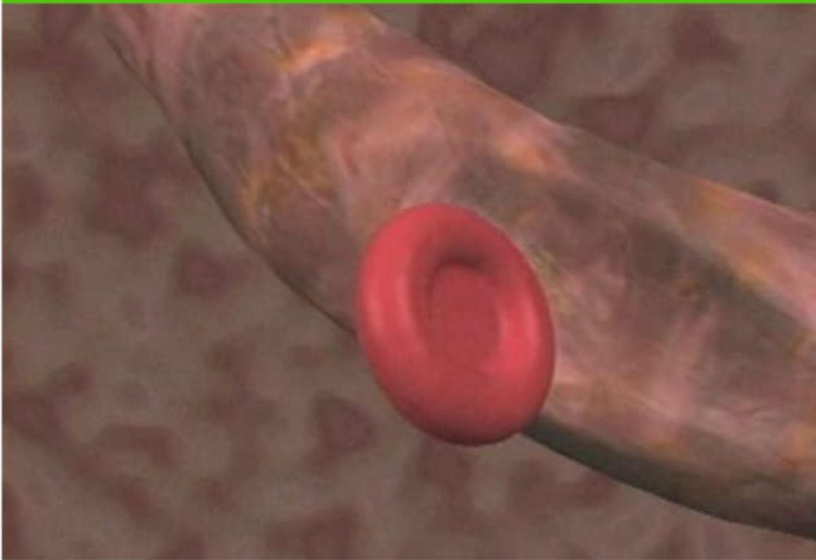
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## Why does an open circulatory system limit body size?

1. Hearts are too small for growth.
2. Too little blood to support a larger animal.
3.  Less efficient in moving oxygen to body tissues.
4. Hemocoel must be shed for growth.



## Blood

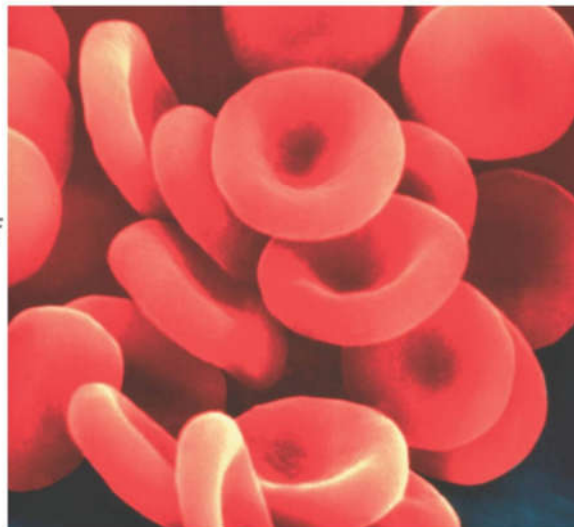


# Components

- Blood is made up of four major components. What do each of these do?
  - Plasma: the liquid portion.
  - Red blood cells.
  - White cells.
  - Platelets.

# Red blood cells

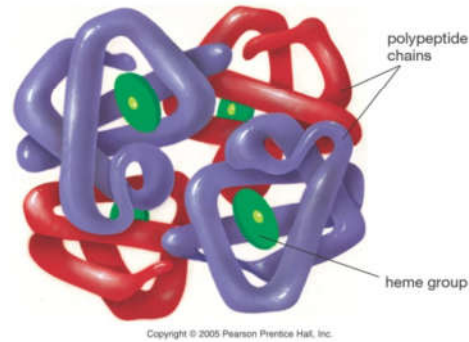
- RBCs lose their nucleus at maturity.
- Make up about 99% of the blood's cellular component.
- Red color is due to hemoglobin.



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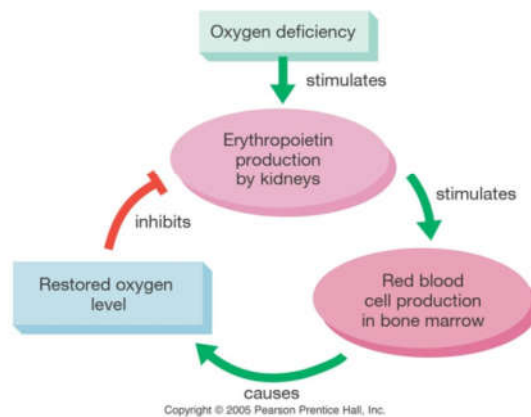
# Hemoglobin

- Hemoglobin is a complex protein made up of four protein strands, plus iron-rich heme groups.
- Each hemoglobin molecule can carry four oxygen atoms. The presence of oxygen turns hemoglobin bright red.



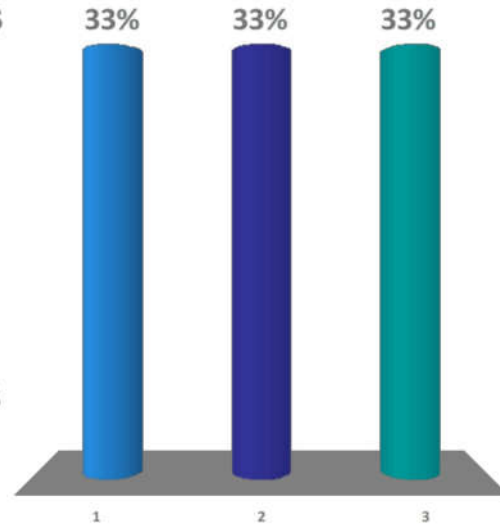
# RBC lifespan

- RBCs live about 4 months. Iron from hemoglobin is recycled in the liver and spleen.
- The hormone erythropoietin, made by the kidneys, stimulates the production of RBCs in red bone marrow.



## If your diet is poor in iron, what will happen to your RBCs?

1. You will make fewer because there is less iron to make hemoglobin.
2. You will make more to make up for the lack of iron in hemoglobin.
3. You will make just as many.

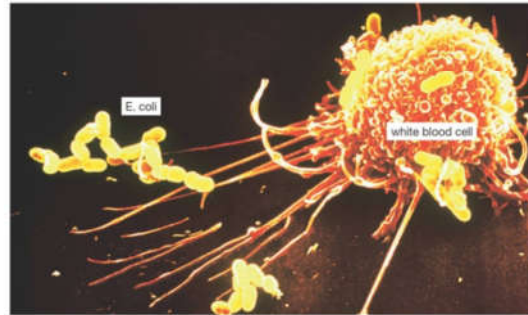


- One of the illegal drugs that some top Olympic athletes have been caught using is erythropoetin. What would this hormone do that would give athletes an edge in competitions?

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## White cells

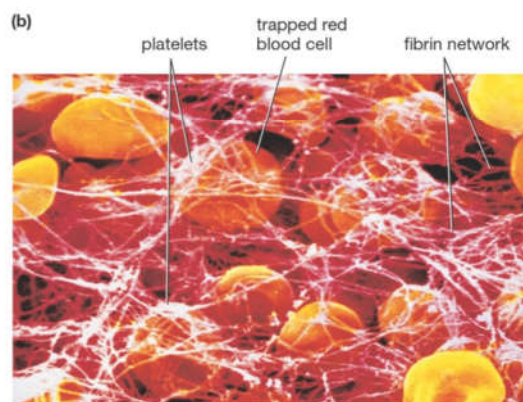
- White blood cells defend against disease by recognizing proteins that do not belong to the body.
- White cells are able to ooze through the walls of capillaries to patrol the tissues and reach the lymph system.



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## Platelets

- Platelets are cell fragments used in blood clotting.
- Platelets are derived from megakaryocytes. Because they lack a nucleus, platelets have a short lifespan, usually about 10 days.

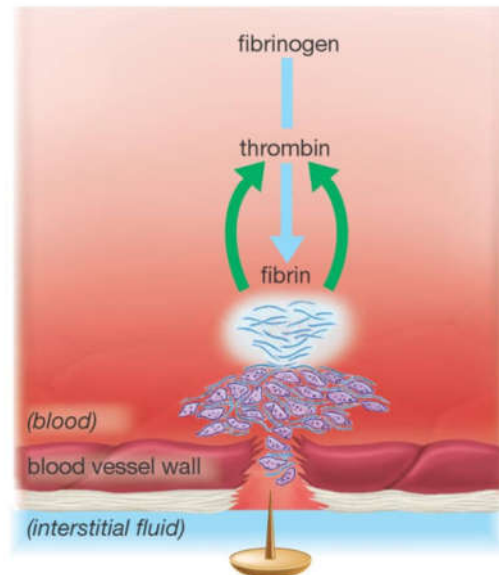


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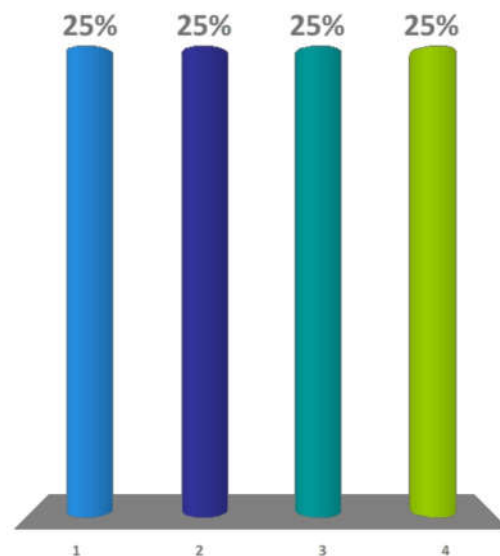
# Blood clotting

- Platelets aggregate at the site of a wound.
- Broken cells and platelets release chemicals to stimulate thrombin production.
- Thrombin converts the protein fibrinogen into sticky fibrin, which binds the clot.



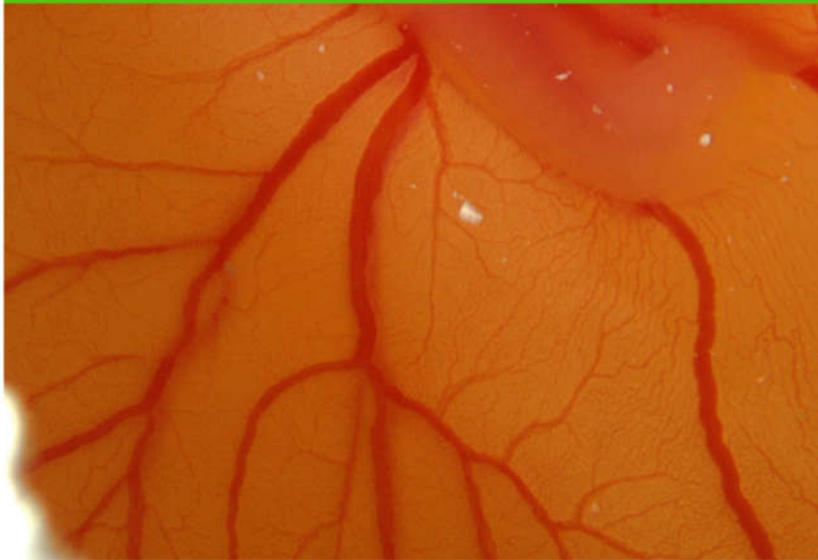
## Which blood cells transport oxygen?

1. White cells
- ★ 2. Red cells
3. Platelets
4. All blood cells



- If a person had a defect in the gene for fibrinogen, what health problems could this cause?

## Blood Vessels

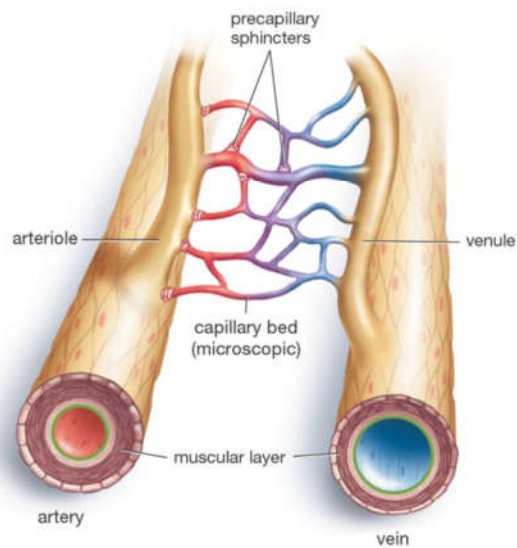


## Classes of blood vessels

- Blood vessels fall into three major classes:
  - Arteries and arterioles carry blood away from the heart.
  - Veins and venules carry blood to the heart.
  - Capillaries allow exchange of nutrients, wastes and gases.

## Arteries

- Arteries are thick-walled, and lined with smooth muscle.
- How does the structure of an artery help with its function?



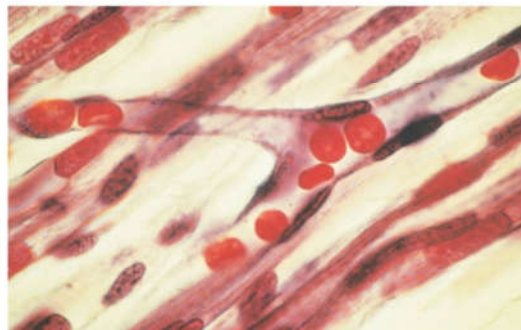
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## Arterioles

- Arterioles branch off of arteries.
- Arterioles can constrict to direct and control blood flow. They may, for example, increase or decrease blood supply to the skin.
- How might arterioles be involved when:
  - Your skin turns red when you are hot.
  - A person's face turns pale with fright.

## Capillaries

- Body tissues contain a vast network of thin capillaries.
- Capillary walls are only one cell thick, allowing exchange of gases, nutrients, and wastes.
- Capillaries are so fine that RBCs must line up single-file to go through them.



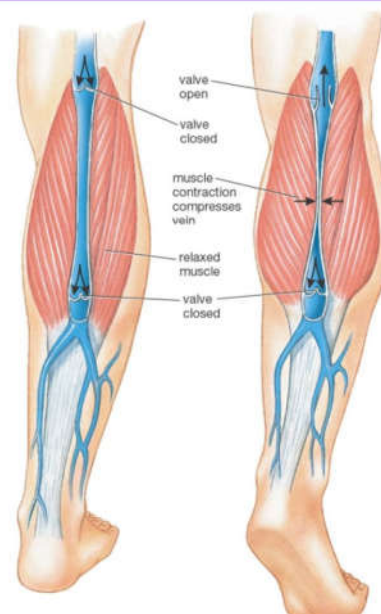
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# Venules

- Venules are thin-walled collectors of blood.
- Low pressure in the venules allows the capillary beds to drain into them.

# Veins

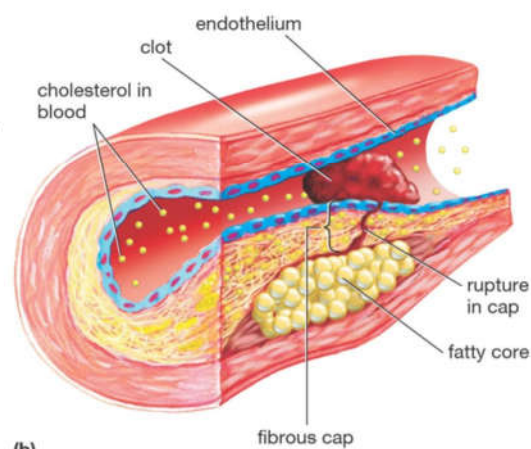
- Veins have thinner walls than arteries.
- Veins have fewer smooth muscle cells, but do have valves. How do valves and the skeletal muscles help veins function?



- Besides the ability to contract and move blood, why do arteries need to be so thick and strong?
- Varicose veins are veins in the legs that are swollen, stretched, and painful. What factors could lead to this condition, and how can varicose veins be prevented?

## Atherosclerosis

- LDL cholesterol forms plaques in arteries, triggering inflammation.
- The immune system forms a hard cap over the plaque, partially blocking the artery. Caps can rupture, creating clots that can close off an artery.



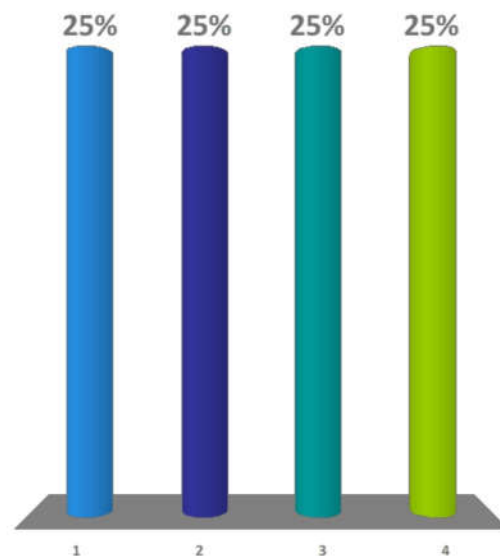
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## Preventing heart attacks

- Both genetic and environmental factors contribute to atherosclerosis.
- Blood LDL cholesterol can be reduced by a low-fat diet that emphasizes high-fiber foods, antioxidants, and “good” fats (monounsaturated fats, omega-3 oils), and reduce trans-fats.
- Regular exercise also contributes significantly to LDL cholesterol reduction.

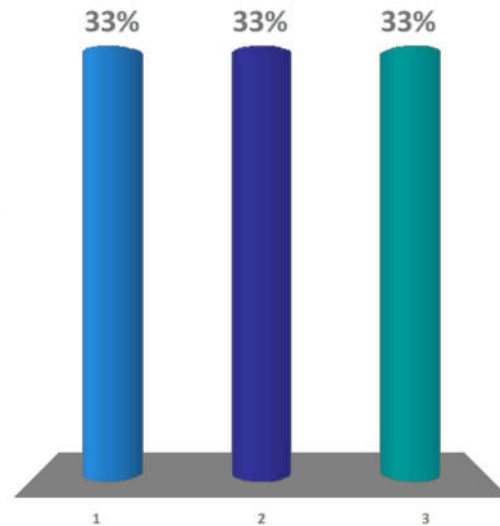
## What is always true of arteries?

1. Always carry oxygenated blood.
2. Always carry deoxygenated blood.
3. Always carry blood to the heart.
- ★ 4. Always carry blood away from the heart.




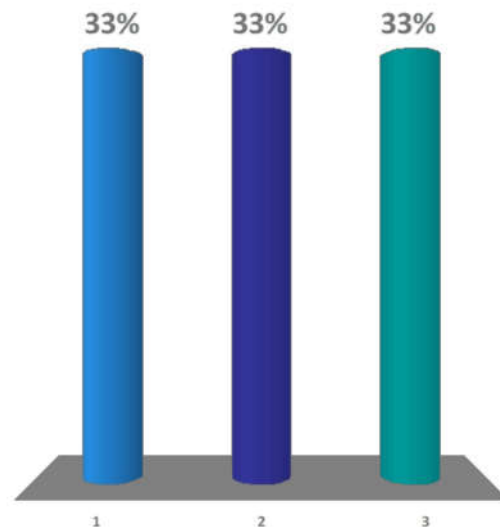
## Besides having to constrict to move blood, why are artery walls so thick and strong?

1. Arteries must move oxygenated blood.
2.  Arteries must withstand very high blood pressure when the heart contracts.
3. Arteries must move blood out to all parts of the body.



## Why are capillary walls so thin?

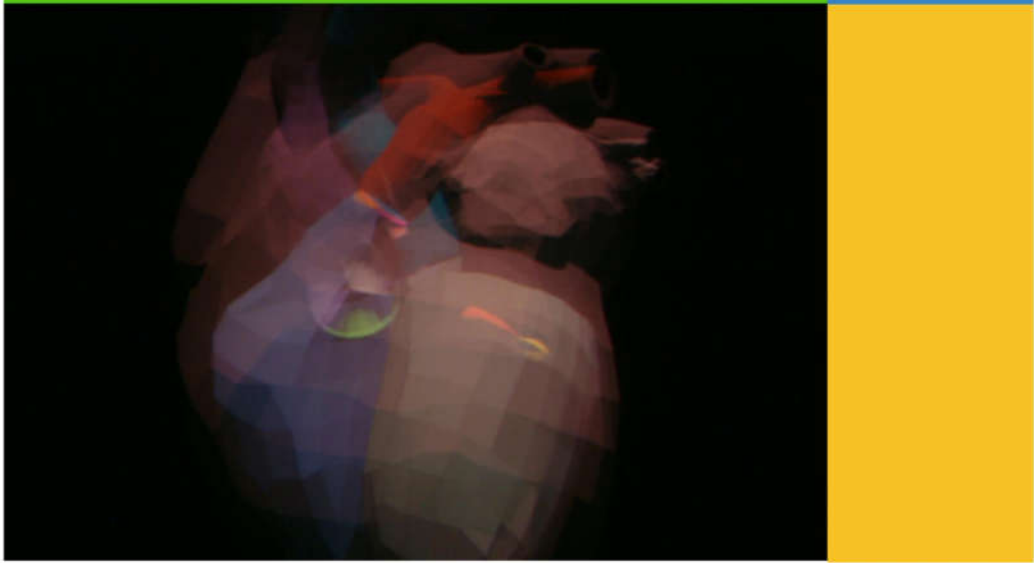
1. Because capillaries are thin and narrow
2.  To allow exchange of gases and nutrients.
3. To force RBCs to move through in single file.





- Some people who are at high risk for heart attacks may be advised by their doctors to take low doses of aspirin daily. What effects does aspirin have that would help prevent heart attacks?

# Heart

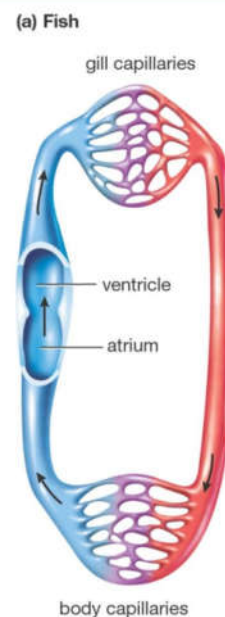


## The Vertebrate Heart

- Vertebrate hearts are separated into two types of chambers
- Atria (singular: atrium): receive blood from body or lungs. Contractions of the atria send blood through a valve to the ventricles.
- Ventricles: receive blood from atria, contract to send blood to body or lungs.

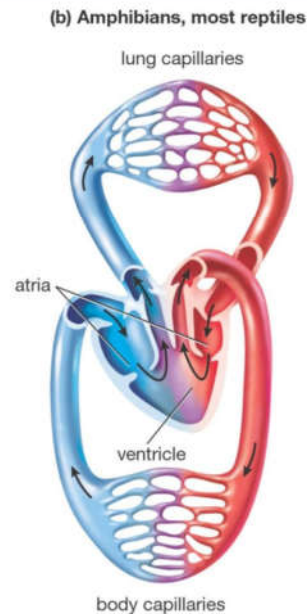
## Two-chambered heart

- The simplest vertebrate heart is the two-chambered heart, seen in fishes.
- A single atrium receives blood from the body cells. A ventricle sends blood to the gills to collect oxygen.



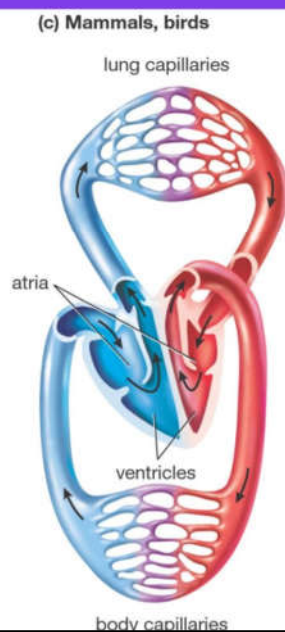
## Three-chambered heart

- Separate atria allow some separation of oxygenated and deoxygenated blood, which was an advantage for land organisms (reptiles, amphibians).
- Though blood can mix in the ventricle, mixing is minimal. Some reptiles have partial separation of the ventricle.

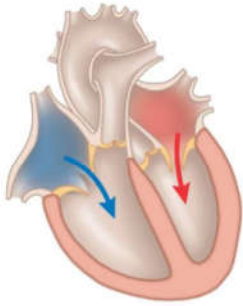


## Four-chambered heart

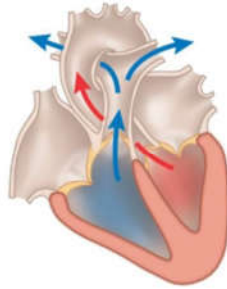
- The four-chambered heart, seen in birds and mammals, allows complete separation of oxygenated and deoxygenated blood.
- Complete separation is necessary to support a fast metabolism found in homeotherms.



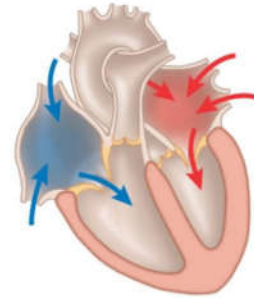
# “Dual pump” operation



① Atria contract, forcing blood into the ventricles.

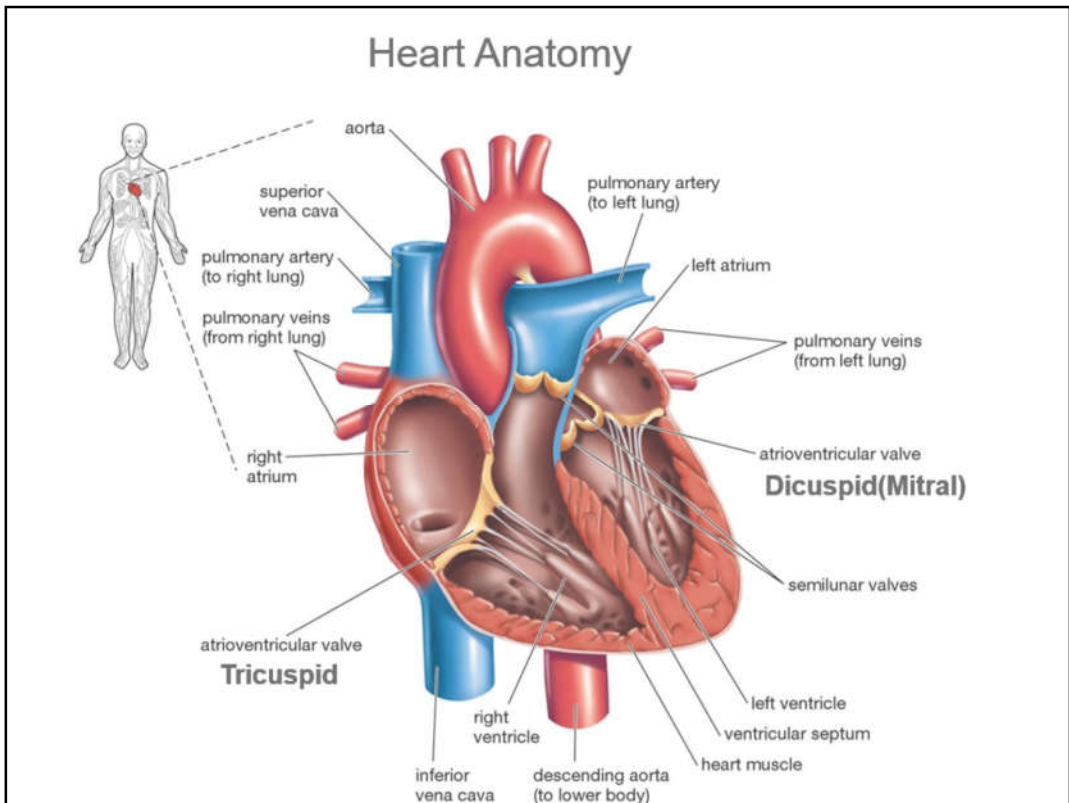


② Then the ventricles contract, forcing blood through arteries to the lungs and the rest of the body.



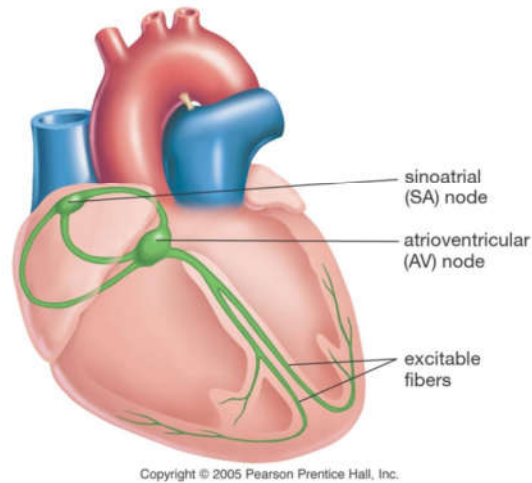
③ The cycle ends as the heart relaxes.

The four-chambered heart acts as two pumps.



## Keeping Time

- The sinoatrial (SA) node is nervous tissue that times heart beats.
- The SA node causes atria to contract, and sends the signal to the atrioventricular (AV) node to signal the ventricles to contract.



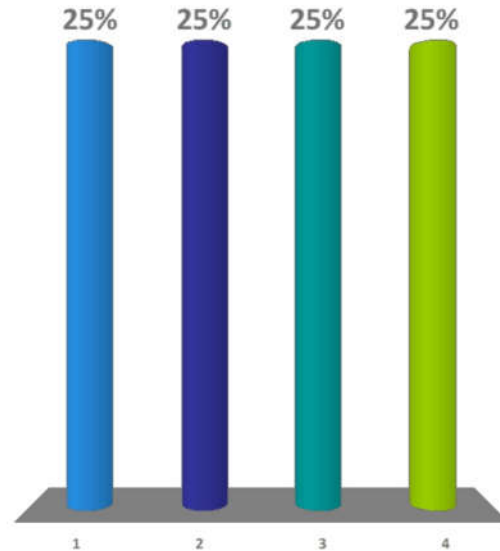
## Blood pressure

- Systolic pressure = pressure when the heart contracts.
- Diastolic pressure = pressure between heart beats.



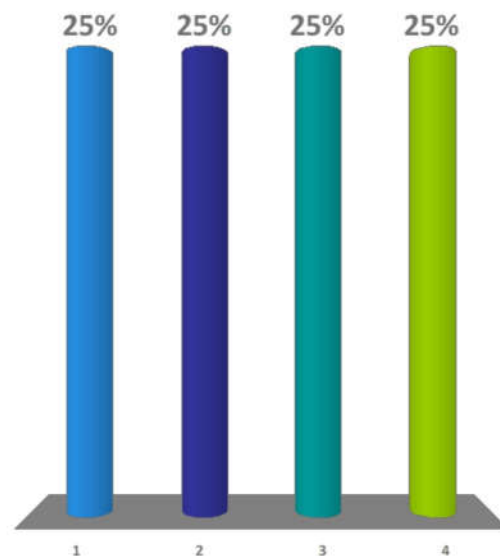
Which set of heart vessels moves deoxygenated blood from the body to the lungs?

- ★ 1. Right atrium, right ventricle
- 2. Right atrium, left atrium
- 3. Left atrium, left ventricle
- 4. Right ventricle, left ventricle



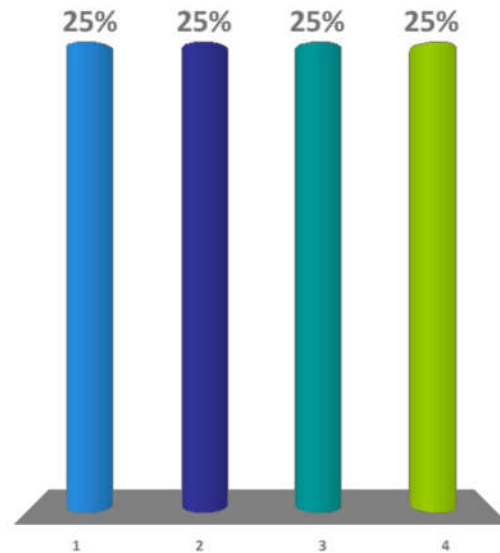
If your blood pressure is 90/70, the 70 represents:

- 1. Systolic pressure – heart contracts
- 2. Systolic pressure – heart is relaxed
- 3. Diastolic pressure – heart contracts
- ★ 4. Diastolic pressure – heart is relaxed

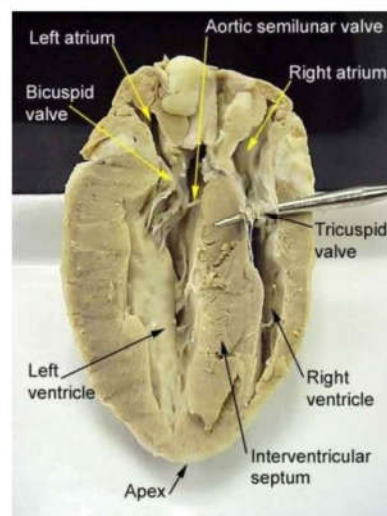


An electric pacemaker can be connected to the heart to replace a faulty:

1. AV node
2. Bicuspid valve
3. SA node
4. Tricuspid valve



Application: Dissection of The Sheep Heart For Gross Anatomical Examination



Source: <https://www.mikrora.com/sheep-heart-diagram/>

Source: <https://slideplayer.com/slide/6975278/>