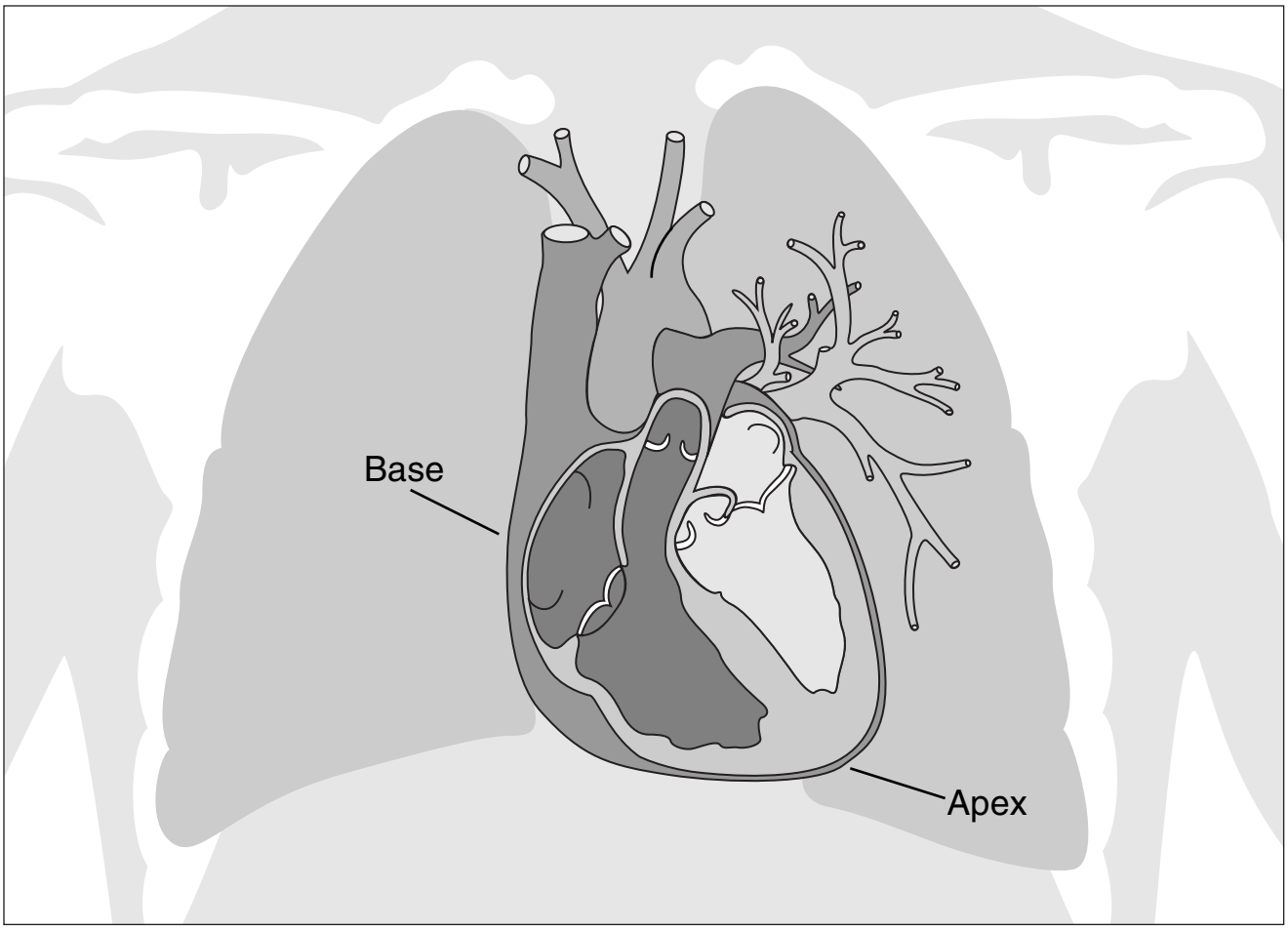
Anatomy of the Heart

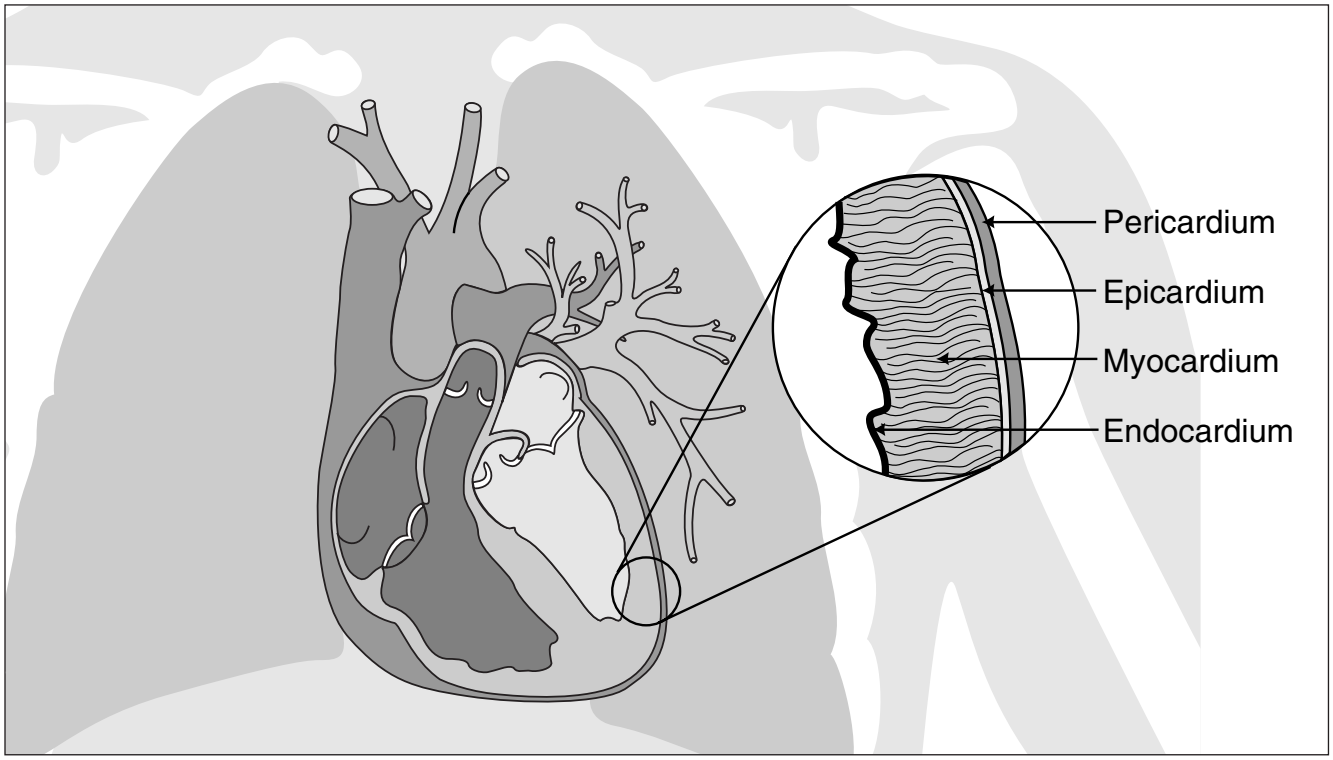


The heart is the central organ of circulation. It lies in the middle of the chest, between the lungs and slightly left of midline. The top is called the base; the bottom the apex.

The base is broader than the apex, which makes the ***heart*** look somewhat like an inverted cone. The tip points down and to the left side of the chest.

Notes

Heart Layers



The heart is surrounded by a thin, fluid-filled sac called the pericardium. The wall of the heart has three layers.

The pericardial sac contains a small amount of fluid that lubricates the heart and allows it to beat in a frictionless environment. The thin and fibrous outer surface of the heart is called the ***epicardium***. The middle and thickest layer is the ***myocardium***, the heart muscle that enables the heart to beat and pump blood. The inner lining, the ***endocardium***, is made of flat, closely joined cells that provide a smooth surface for blood flow.

Notes

The heart has three layers of tissue - epicardium, myocardium, and endocardium - and is surrounded by the pericardium.

Questions:

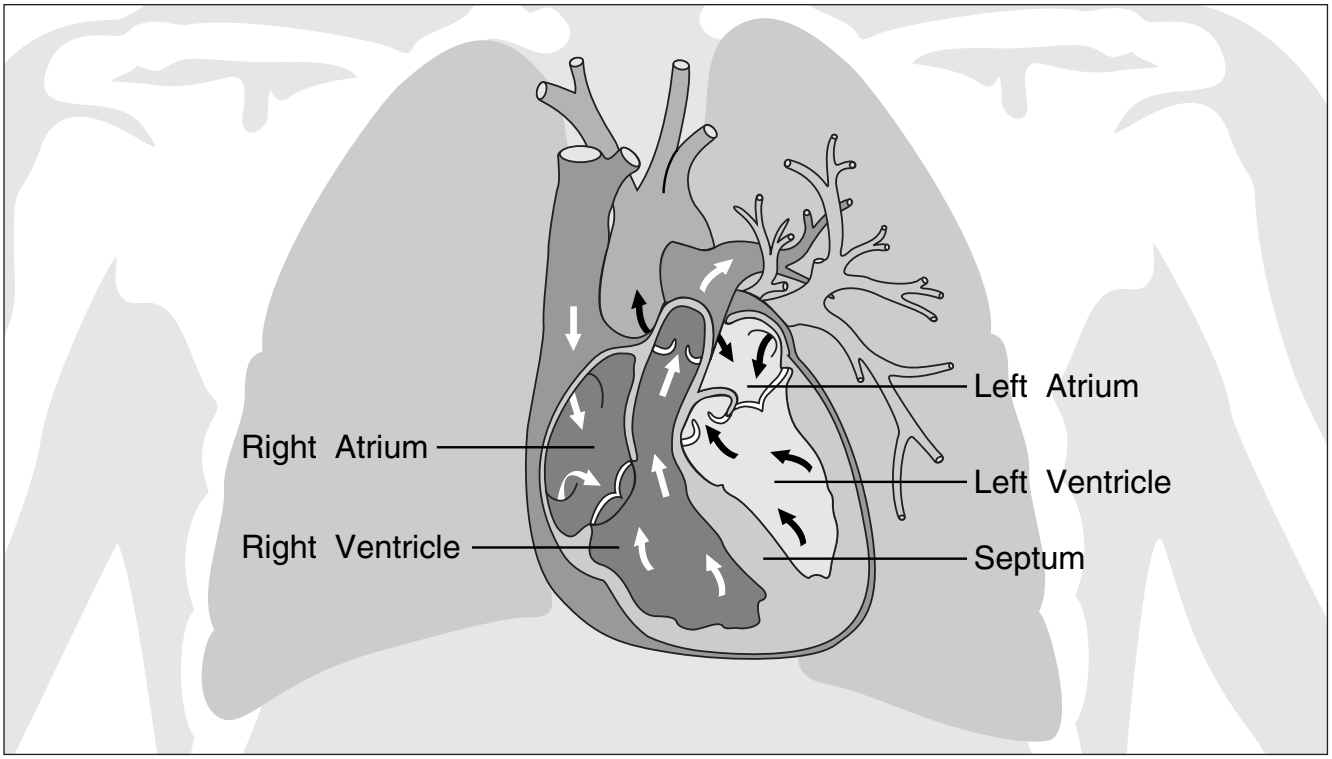
The *outer* heart layer is the _____.

The *muscular* layer is the _____.

The *inner* lining is the _____.

Answers: epicardium / myocardium / endocardium

Heart Chambers



The heart has two sides and four chambers. The right-sided chambers circulate oxygen-depleted blood. The left-sided chambers circulate oxygen-rich blood.

The atria are the small receiving chambers. The ***right atrium*** receives oxygen-depleted blood from the body. The ***left atrium*** receives oxygen-rich blood from the lungs.

The ventricles are the pumping chambers. The ***right ventricle*** pumps oxygen-depleted blood to the lungs (pulmonary circulation). The ***left ventricle*** pumps oxygen-rich blood to the body (systemic circulation).

The two sides of the heart are separated by a wall called the ***septum***, which keeps oxygen-rich blood from mixing with oxygen-depleted blood.

Notes

The heart has a right and left side, separated by the septum, and four chambers: right atrium, left atrium, right ventricle, and left ventricle.

Questions:

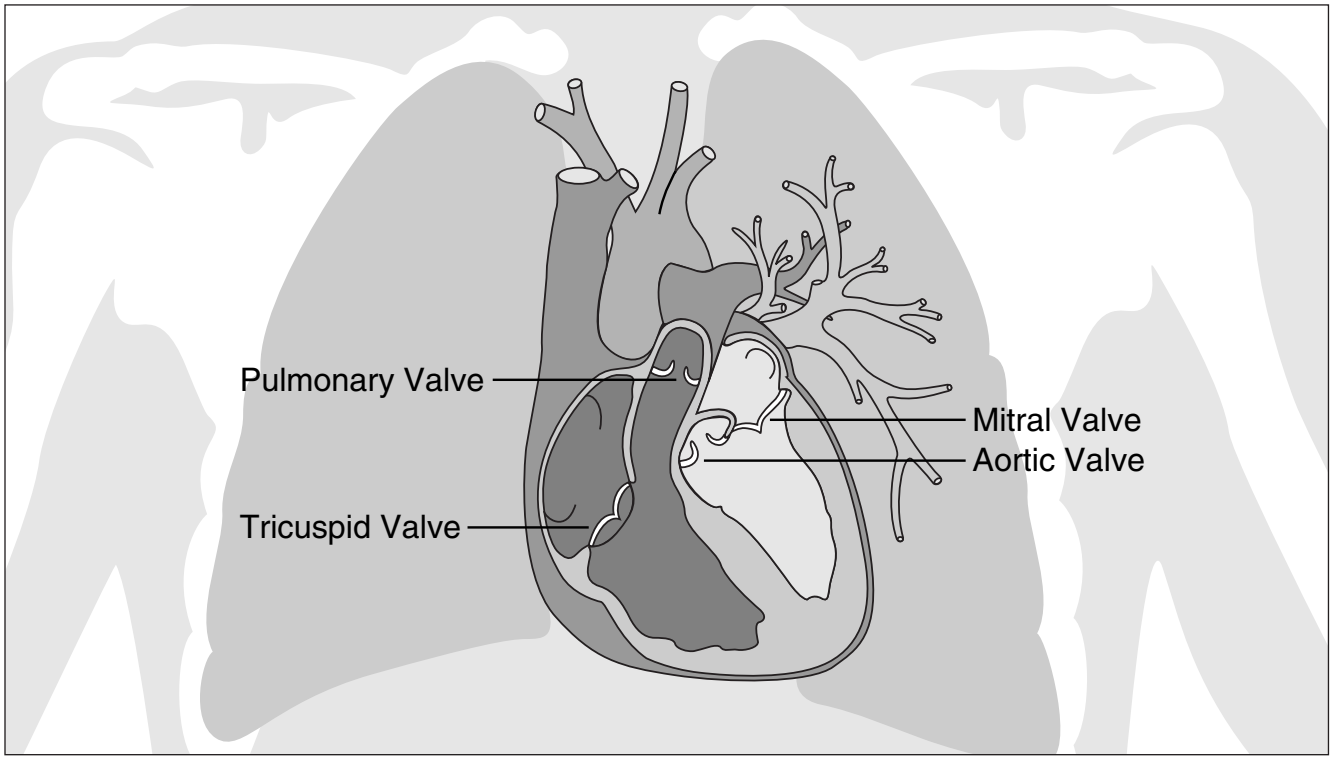
The *receiving* chambers are the _____.

The *pumping* chambers are the _____.

The *wall* separating the sides of the heart is the _____.

Answers: atria / ventricles / septum

Heart Valves



The heart has two sets of valves that ensure blood flows in and out of the heart in one direction.

Atrioventricular valves control the flow of blood from the atria to the ventricles. The ***tricuspid*** valve is on the right side of the heart and the ***mitral*** valve on the left side.

Semilunar valves control the flow of blood leaving the heart. The ***pulmonary*** valve lies between the right ventricle and pulmonary artery; the ***aortic*** valve between the left ventricle and aorta.

Valves open and close in response to pressure that builds up in the heart chambers.

Notes

Atrioventricular and semilunar valves ensure that blood flows through the heart in one direction.

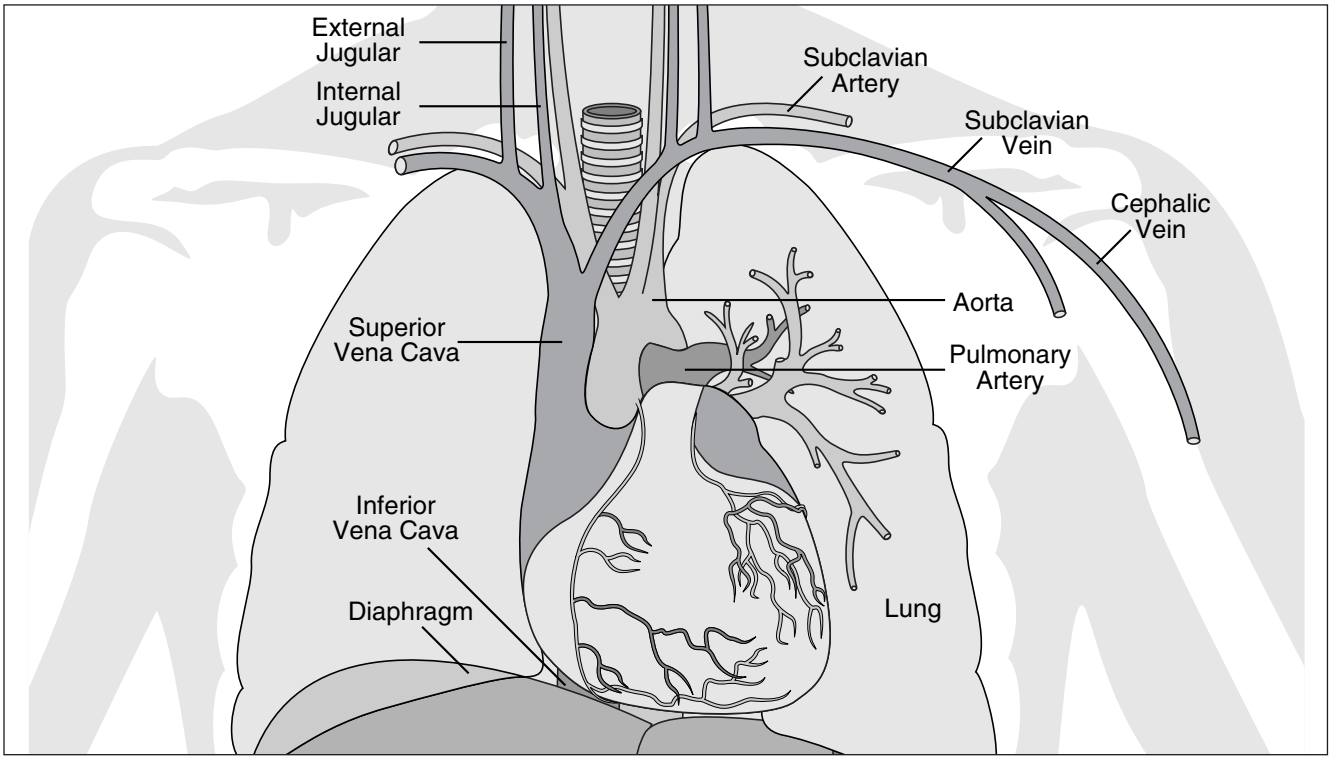
Questions:

The *atrioventricular* valves are _____.

The *semilunar* valves are _____.

Answers: tricuspid and mitral / pulmonary and aortic

Blood Vessels



The heart pumps blood to the body through a network of blood vessels.

Arteries carry blood away from the heart to body tissue. Arteries are thick-walled and elastic because they carry blood under high pressure. With one exception, arteries carry oxygen and nutrients. The exception is the pulmonary artery, which carries oxygen-depleted blood to the lungs.

Veins carry blood from body tissues to the heart. Veins have thin walls because they carry blood under less pressure. With one exception, veins carry cellular waste, including carbon dioxide. The exception is the pulmonary veins, which carry oxygen-rich blood to the left atrium.

The exchange of oxygen and nutrients for carbon dioxide and cellular waste occurs in the ***capillaries***, tiny vessels with thin walls.

Notes

Questions:

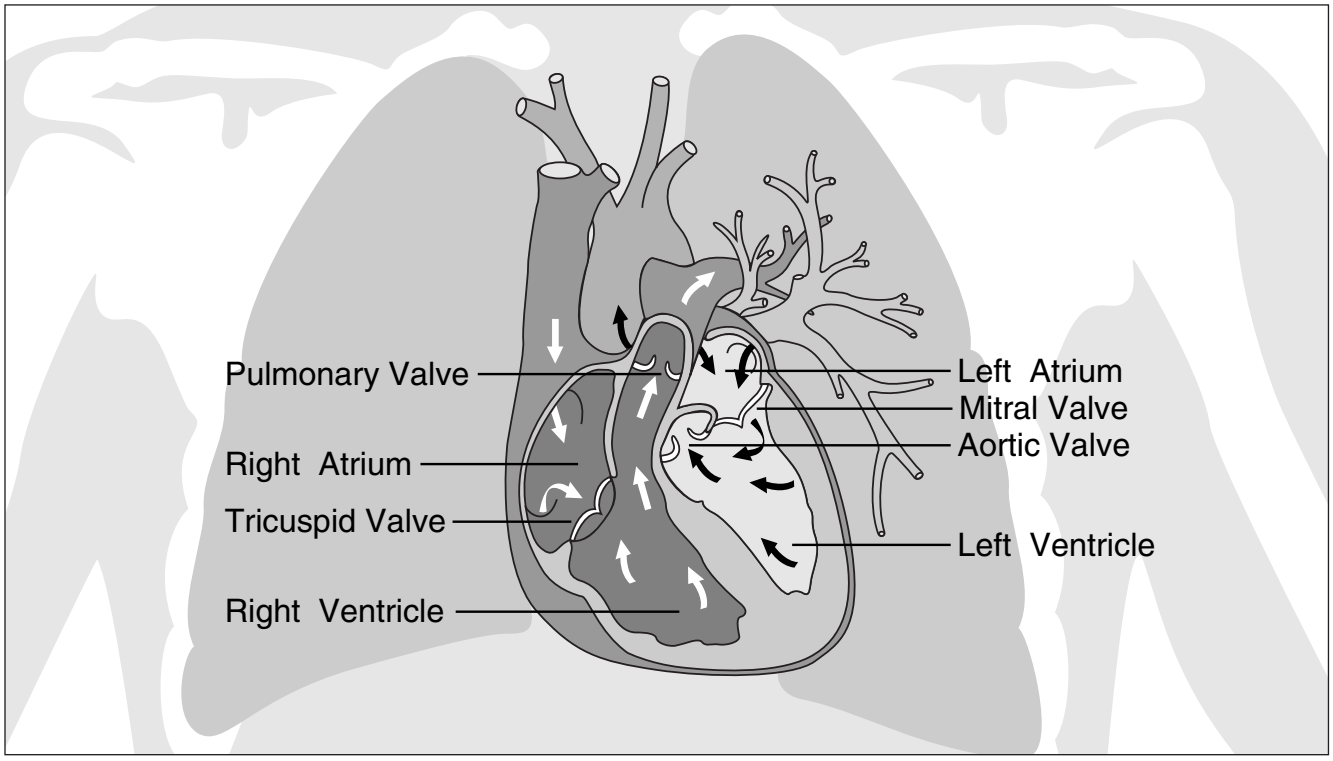
Vessels that carry blood *away from the heart* are _____.

Vessels that carry blood *to the heart* are _____.

Vessels that *exchange* nutrients for cellular waste are _____.

Answers: arteries / veins / capillaries

Blood Flow through the Heart



This illustration shows how blood flows through the heart.

The *right ventricle* pumps blood through the *pulmonary valve* into the **pulmonary artery** and to the lungs. The blood is oxygenated in the lungs, then returned to the *left atrium* through the **pulmonary veins**. When the left atrium contracts, blood passes through the *mitral valve* to fill the left ventricle.

The *left ventricle* pumps blood through the *aortic valve* into the **aorta** and out to the body. The blood nourishes body tissue then returns to the heart via the venous system, entering the *right atrium* by way of the **superior vena cava** (upper body) and **inferior vena cava** (lower body). When the right atrium contracts, blood passes through the *tricuspid valve* to fill the right ventricle.

Notes

Questions:

Deoxygenated blood is pumped from the heart to the lungs via the _____.

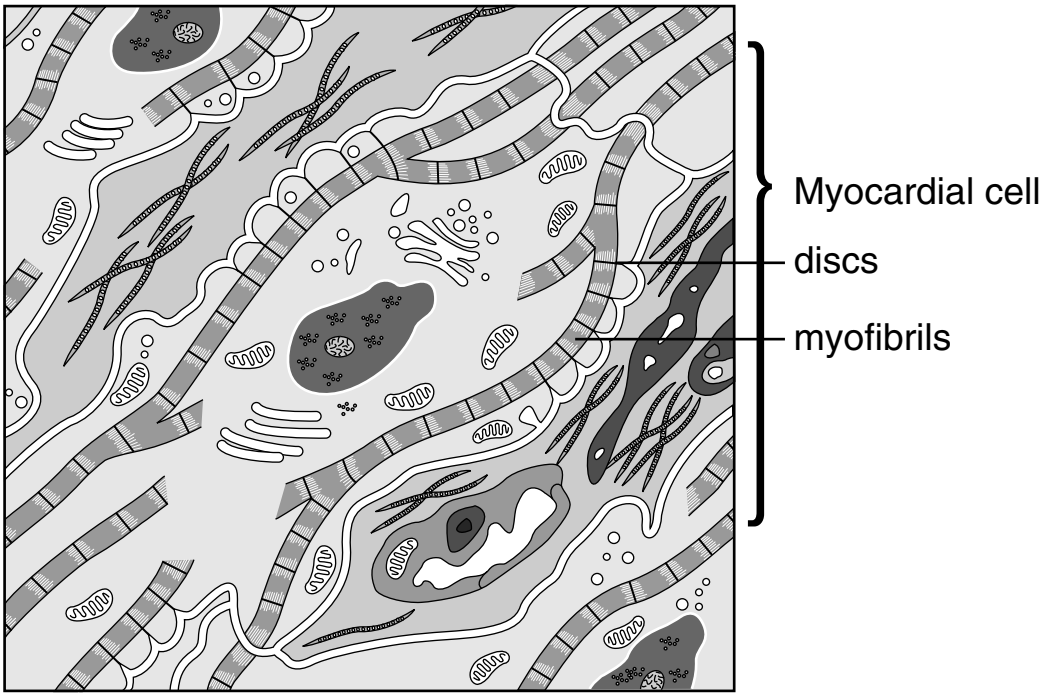
Oxygenated blood is carried from the lungs to the heart via the _____.

Oxygenated blood is pumped from the heart to the body via the _____.

Deoxygenated blood is returned from the body to the heart via the _____.

Answers: pulmonary artery / pulmonary veins / aorta / superior and inferior vena cava

Myocardial Cells



Myocardial cells are the basic units of the myocardium. They initiate and conduct electrical impulses at varying rates to ensure heart contractions are coordinated and efficient.

Myocardial cells branch and interlock so that when one cell is stimulated to contract, so are the adjacent cells. The cells are separated by discs that allow fast conduction of impulses. They contain many myofibrils, strings of protein that shorten when stimulated to contract the heart muscle. Cell membranes are thin and pliable.

A heart contraction is a wringing, twisting motion of the myocardium. It begins at the apex of the heart and works up toward the base, squeezing blood out of the heart into blood vessels.

Notes

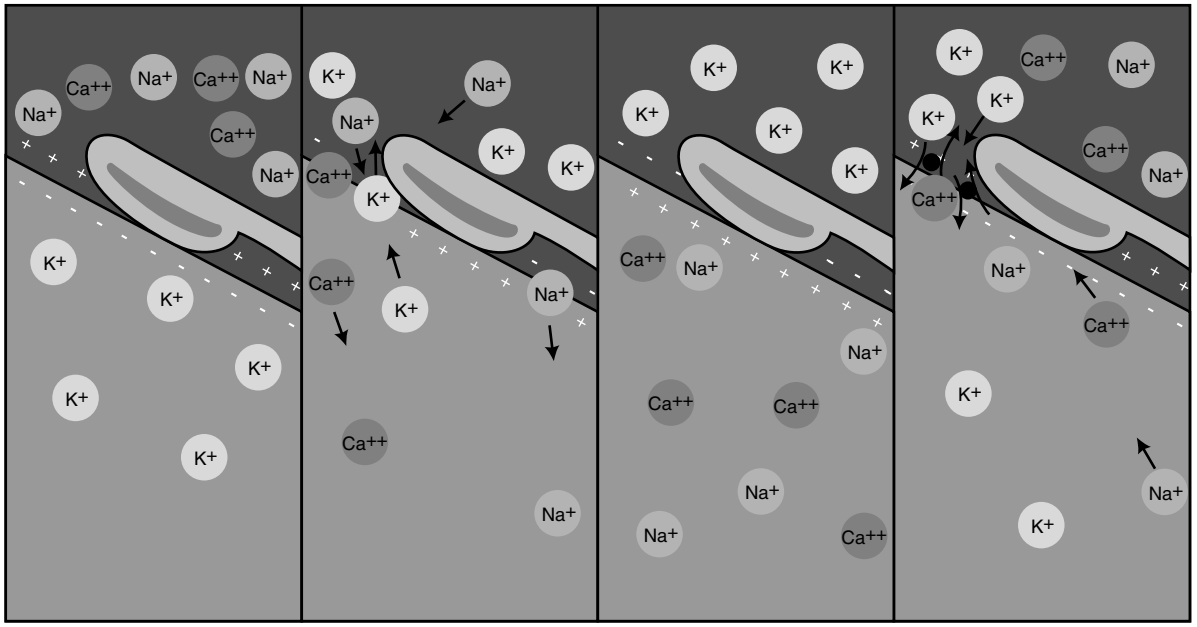
The unique structure of myocardial cells allows the healthy heart to contract in a smooth and coordinated sequence.

Question:

Cells that initiate and *conduct electrical impulses* are _____.

Answers: myocardial cells

Ions



Ions are electrically-charged particles that move in and out of a myocardial cell to produce heart contractions.

Three ***ions*** – sodium (Na+), potassium (K+), and calcium (Ca++) - are responsible for heart contractions. Their movement in and out of a myocardial cell creates differences in the electric charge of the cell*. The flow of ions is regulated by channels (small pores) in the cell membrane. The channels open in response to stimuli (electrical, mechanical, or chemical), allowing the ions to travel back and forth. As the concentration of ions changes, so does the electric charge inside the cell.

* In a normal resting state, the inside of a cell has a negative (-) charge and the outside a positive (+) charge.

Notes

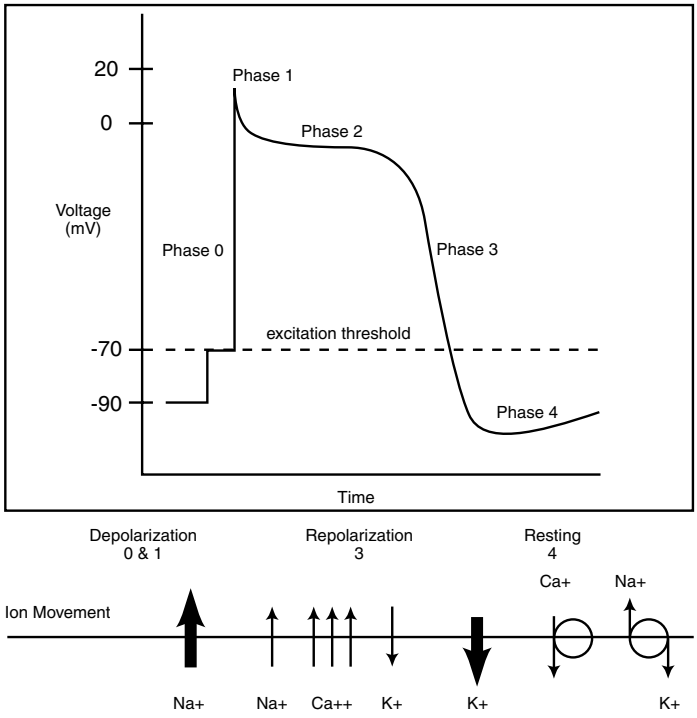
The changing concentration of ions inside and outside a myocardial cell produces changes in the electric charge of the cell. This results in a heart contraction.

Question:

Electrically-charged particles responsible for heart contractions are _____.

Answers: ions

Action Potential



Action potential is the cycle of electrical activity in a myocardial cell. It has three general phases.

Depolarization is the stimulation phase. Sodium ions (Na^+) rush into the cell, creating a positive charge and a strong electric current (voltage spike on the graph). When one cell depolarizes, the adjacent cells are stimulated to depolarize. Thus, a heart contraction is a wave of positive electrical charges moving through the myocardium.

Repolarization is the recovery phase. Ions return to their starting point, and the myocardial cell to its negatively-charged state. During this time, the cell does not respond to stimuli (it does not depolarize) and is said to be *refractory*.

Resting is the phase of electrical stability. During the ***resting phase***, the inside of a cell has a negative charge and no electrical impulses are conducted. Some myocardial cells (pacemaker cells) do not rest. Ions leak out and gradually increase the internal voltage of the cell. When the voltage is high enough (at its threshold), the next depolarization wave begins. This is called *automaticity*, the ability of the normal heart to depolarize spontaneously at regular intervals.

Notes

The three phases of electrical activity in the myocardial cell are depolarization, repolarization, and resting.

Questions:

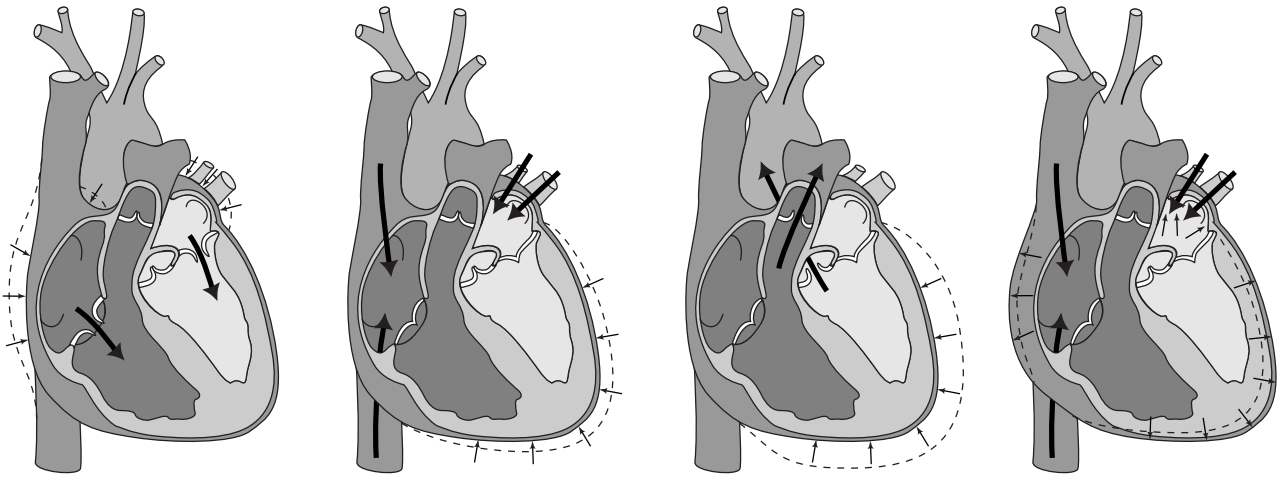
An advancing wave of *myocardial stimulation* is called _____.

The *recovery phase* of action potential is _____.

The period of *electrical stability* is the _____.

Answers: depolarization / repolarization / resting

Cardiac Cycle



The cardiac cycle is one complete heartbeat. It consists of periods of cardiac contraction and relaxation, which are controlled by flowing electrical impulses.

During the ***cardiac cycle***, electrical impulses are converted into mechanical contractions that pump blood out of the heart in a coordinated sequence.

The period of contraction is called ***systole***. The period of relaxation is ***diastole***. The atria contract when the ventricles relax and relax when the ventricles contract.

Notes

One cardiac cycle consists of one complete heartbeat. Thus, if the heart beats sixty times per minute *(60 bpm)*, a complete heart beat occurs every second.

Questions:

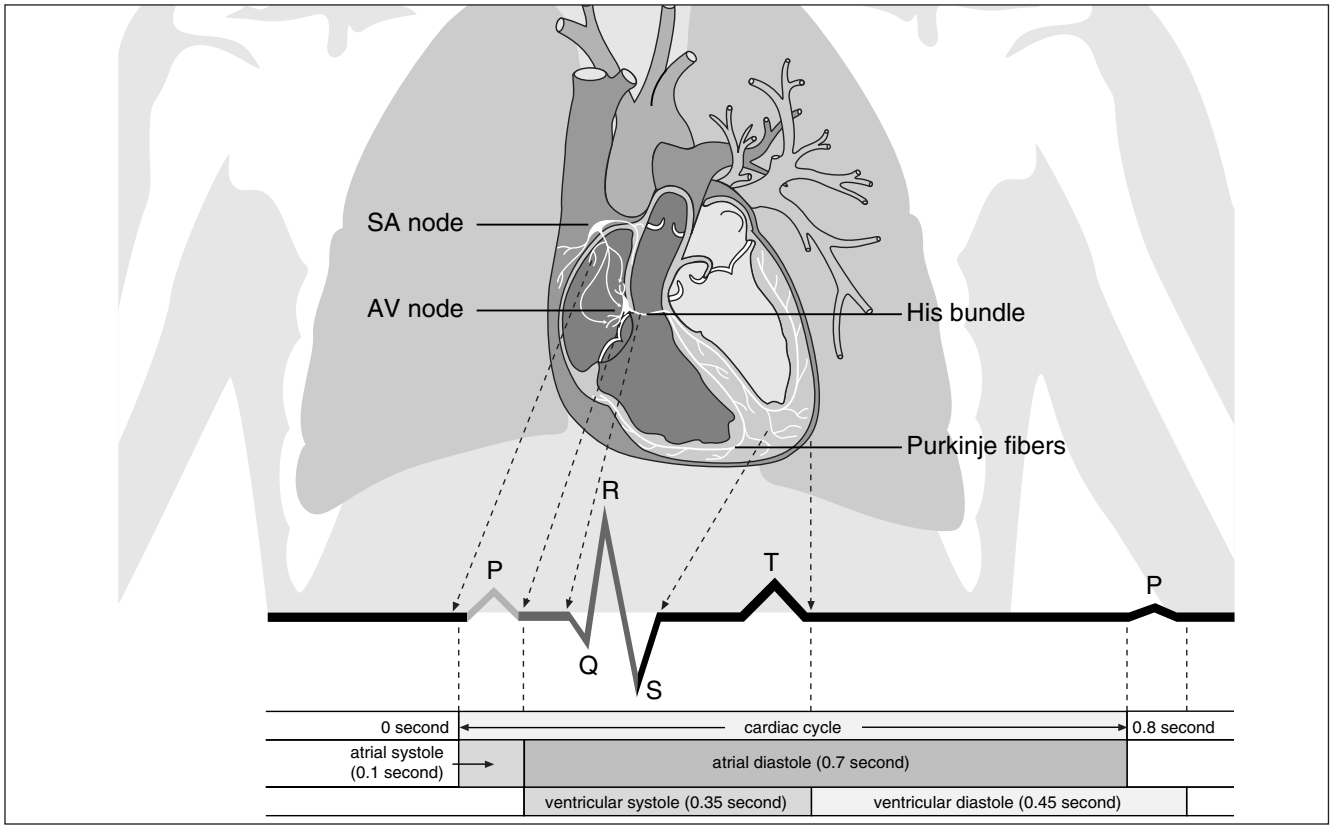
The cycle of electrical and mechanical activity in the heart is called the _____.

Cardiac contraction is called _____.

Cardiac relaxation is called _____.

Answers: cardiac cycle / systole / diastole

Conduction Pathway



An electrical impulse starts at the sinoatrial node, pauses at the atrioventricular node, then proceeds rapidly along the conduction pathway to the ventricles.

The ***sinoatrial (SA) node*** is at the junction of the right atrium and superior vena cava. It is a cluster of cells that generates electrical impulses on its own at a rate needed to pump sufficient blood to the body. An electrical impulse proceeds outward from the sinoatrial node, producing a depolarization wave and atrial contraction.

The ***atrioventricular (AV) node*** is in the lower portion of the right atrium, near the ventricular septum. When a depolarization wave reaches this junction, there is a slight pause. This gives the atria time to completely contract and fill the ventricles with blood. The delay mechanism ensures *atrioventricular synchrony*.

The *His bundle* descends into the ventricular septum, divides into branches, and terminates in *Purkinje fibers*, which penetrate the ventricular myocardium. After leaving the atrioventricular node, electrical impulses travel rapidly along these fibers, producing strong ventricular contractions and the forceful expulsion of blood from the heart.

Notes

The conduction system controls the speed and rhythm of a heart contraction.

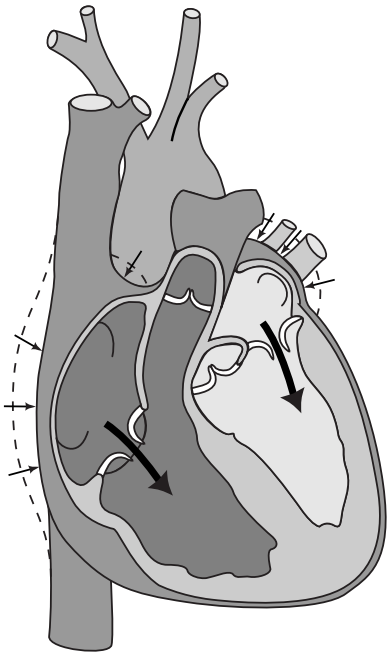
Questions:

The *pace of a heartbeat* is set by the _____.

A conduction delay occurs at the _____.

Answers: sinoatrial node / atrioventricular node

Atrial Systole



Atrial Systole

Atrial systole begins with electrical stimulation of the atrial muscle. During this phase, the atria contract and the ventricles are relaxed.

During ***atrial systole***, both atria contract to push blood through the atrioventricular valves (mitral and tricuspid) into the ventricles. Atrial pressure rises during the contraction, then quickly lowers as blood flows into the ventricles.* The conduction delay at the atrioventricular node allows time for increased filling of the ventricles. This atrial contribution to ventricular filling is called *atrial kick*. It accounts for 20 to 30% of the blood volume of the ventricles at the end of diastole.

* The changing pressure inside a chamber acts to open and close the heart valves. Blood flows from an area of high pressure to an area of low pressure.

Notes

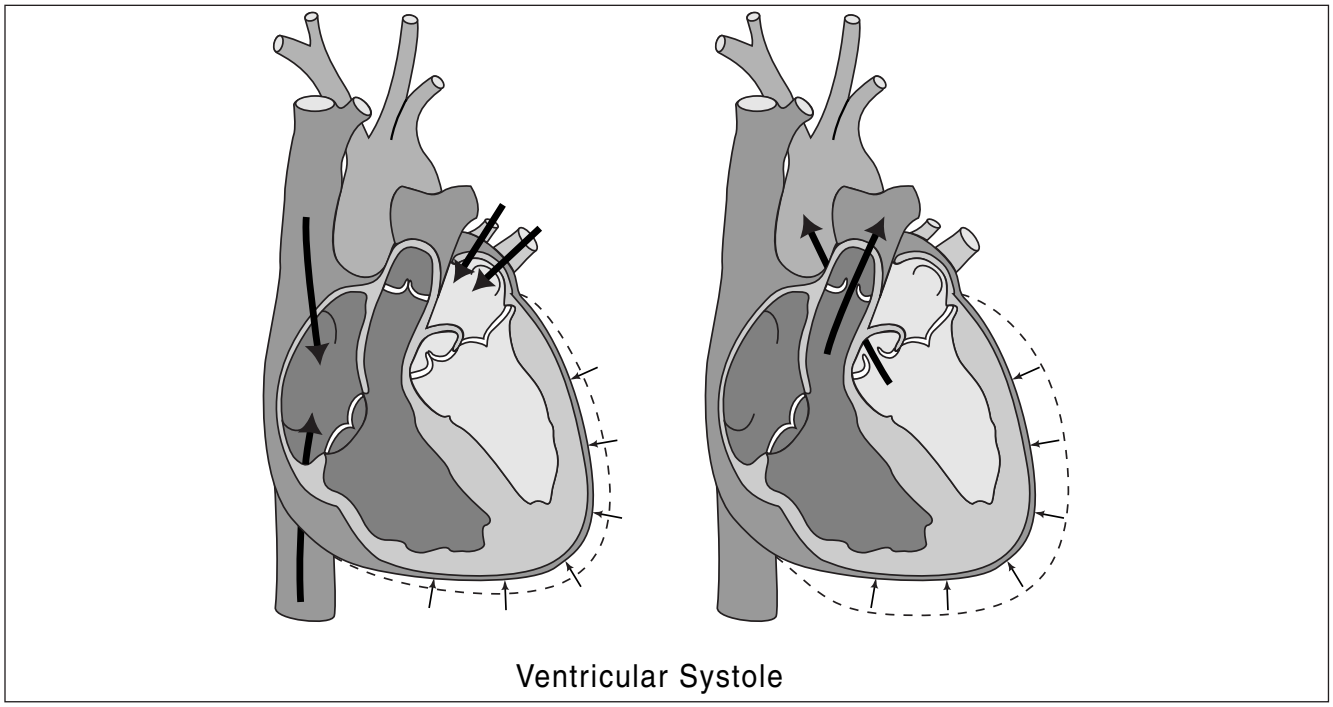
Atrial systole is the period during which the atria contract to fill the ventricles.

Question:

Atrial depolarization and contraction occur during _____.

Answers: atrial systole

Ventricular Systole



Ventricular Systole

Ventricular systole begins with electrical stimulation of ventricular muscle.

During ***ventricular systole***, the ventricles contract to eject blood into circulation. Contraction occurs in phases as pressures change:

1) Ventricular pressure builds until the atrio-ventricular valves shut. The semilunar valves are not yet open, so for a moment, each ventricle is a closed chamber. This is *isovolumetric contraction*.

2) Ventricular pressure continues to rise until the semilunar valves are forced open and blood is quickly ejected.* This is *rapid ejection*.

3) As the ventricles empty, ventricular pressure falls and blood flow decreases. This is *reduced ejection*. When pressure in the ventricles is less than that in the aorta and pulmonary arteries, the semilunar valves close. This marks the end of ventricular systole and the beginning of ventricular diastole.

When the ventricles are in systole, the atria are in diastole, filling passively with blood from the venae cavae and pulmonary veins.

* Though the left and right ventricles beat at the same time, the left ventricle contracts with more force because it pumps blood farther - into systemic circulation. For this reason, the left ventricular myocardium is about three times more muscular than the right.

Notes

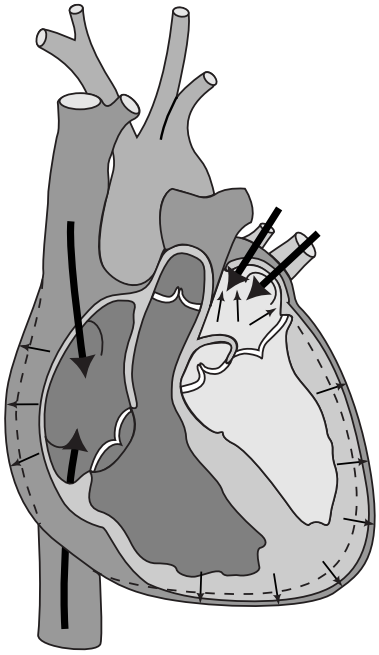
Ventricular systole is the period during which the ventricles contract to eject blood.

Question:

Blood is ejected from the heart during _____.

Answer: ventricular systole

Ventricular Diastole



Ventricular Diastole

During ventricular diastole, the ventricles fill with blood from the atria.

Ventricular diastole occurs in phases as pressure changes:

1) Ventricular pressure falls as the ventricular wall relaxes. The semilunar valves are closed and the atrioventricular valves are not yet open. For a moment, each ventricle is a closed chamber. This is *isovolumetric relaxation*.
2) When ventricular pressure is lower than atrial pressure, the atrioventricular valves open and blood flows quickly from the atria to the ventricles. This is *rapid filling*.
3) As the ventricles fill, ventricular pressure starts rising and filling slows - called *reduced filling*.
4) Diastolic ventricular filling ends with atrial kick: The atria eject an additional volume of blood into the ventricles just before the ventricles contract again.

Systole corresponds to the depolarization and repolarization phases of action potential. Diastole, which takes up about 2/3 of the cardiac cycle, corresponds to resting potential.

Notes

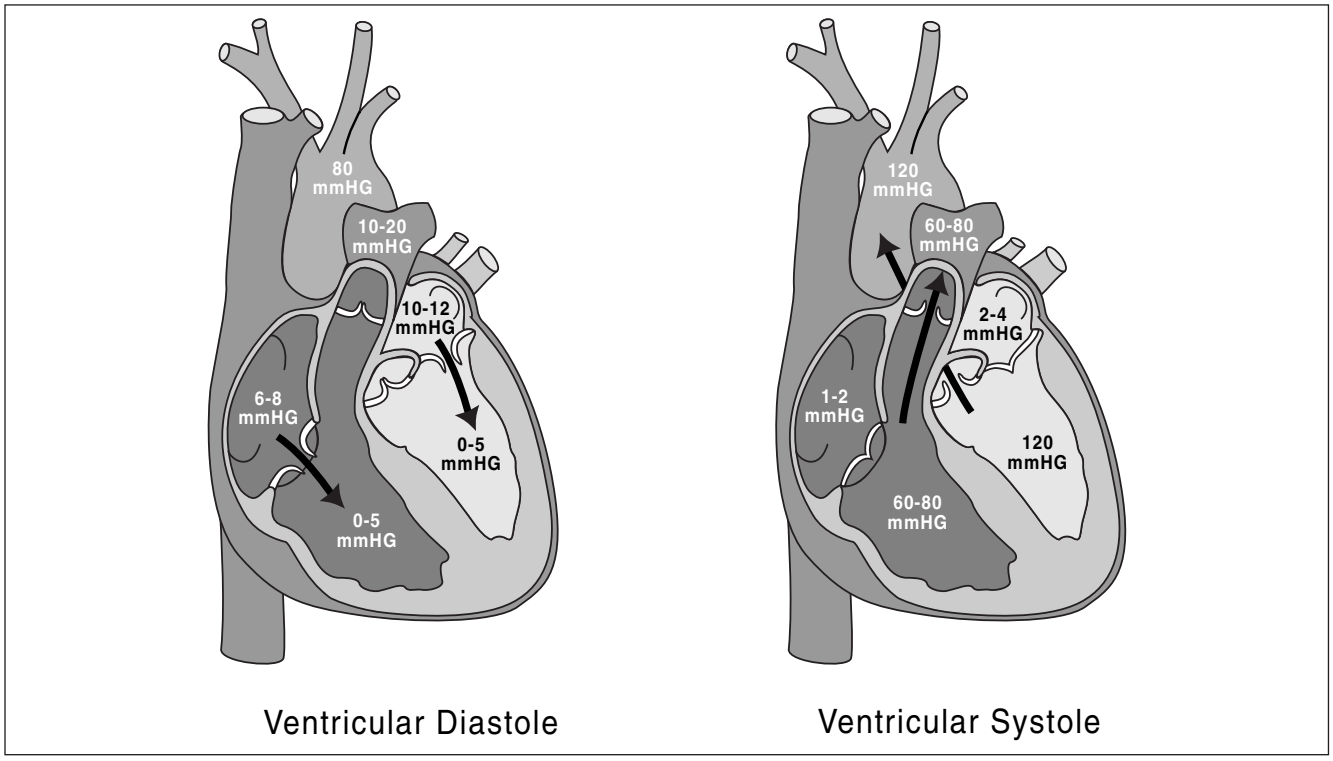
Ventricular diastole is the period during which the ventricles relax to fill with blood.

Question:

The ventricles fill during _____.

Answer: ventricular diastole

Normal Cardiac Pressures



This diagram shows how pressures change during the cardiac cycle. (In millimeters of mercury [mn HG]).

Notes

Recall that changing pressures in the heart chambers and great vessels act to open and close the heart valves. Blood flows from an area of high pressure to an area of low pressure.

Questions:

When ventricular pressure rises above atrial pressure, the mitral valve _____.

When ventricular pressure exceeds aortic pressure, the aortic valve _____.

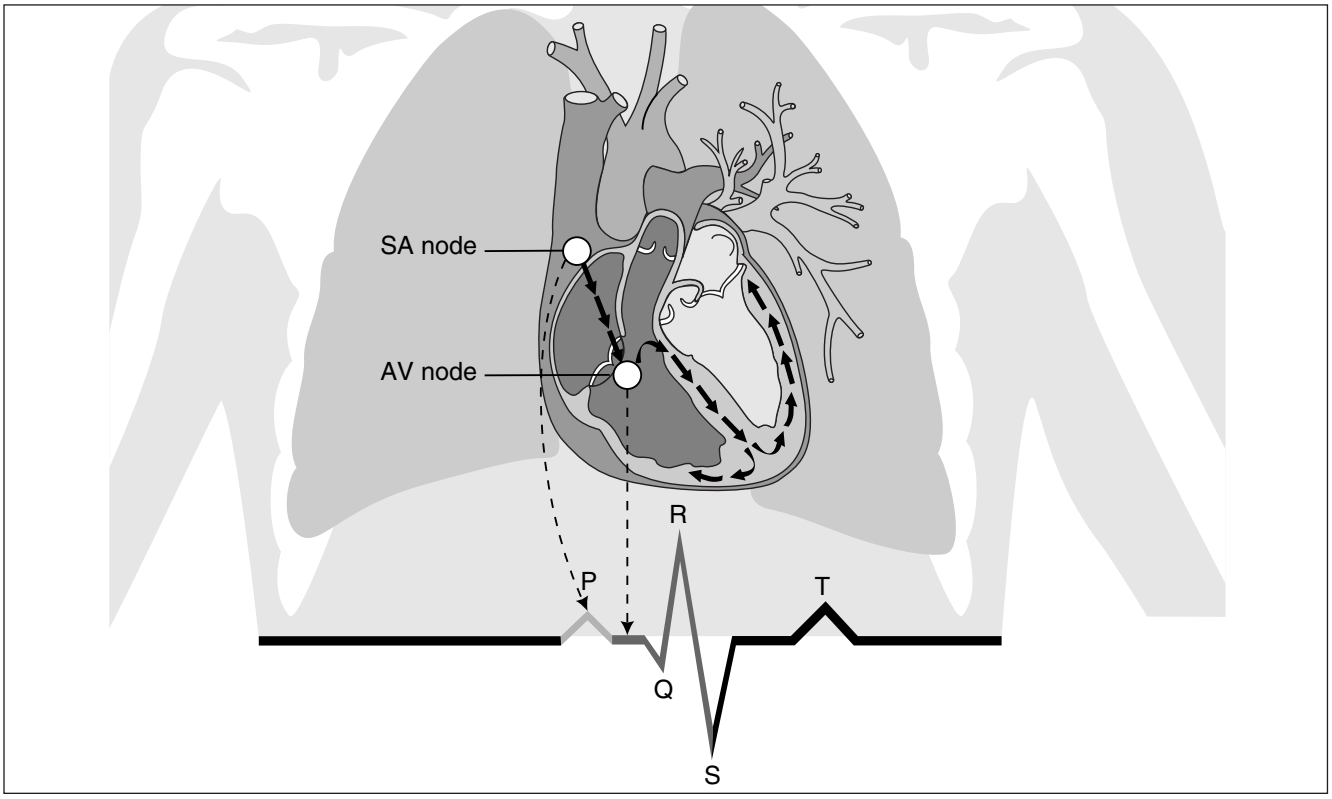
Ventricular pressure is highest during _____.

When ventricular pressure falls below aortic pressure, the aortic valve _____.

When ventricular pressure is less than atrial pressure, the mitral valve _____.

Answers: closes / opens / rapid ejection / closes / opens

ECG Rhythms



An electrocardiogram (ECG) is a record of the electrical activity in the heart. Electrical impulses are shown as a series of distinct waves in repeating cycles.

The ***P-wave*** represents atrial depolarization and contraction. The ***QRS complex*** represents ventricular depolarization and contraction. The ***T-wave*** represents ventricular repolarization and relaxation.*

An ECG is recorded from the body's surface, using an electrocardiograph. It is used to determine if the heart's electrical activity is normal or abnormal.

* Atrial repolarization waves are small and occur during ventricular depolarization (QRS complex), so they are usually not seen on an ECG.

Notes

An ECG is a graphic representation of the heart's electrical activity.

Questions:

Atrial depolarization is represented by a _____.

Ventricular depolarization is represented by a _____.

Ventricular repolarization is represented by a _____.

Answers: P-wave / QRS complex / T-wave