FACTOIDS

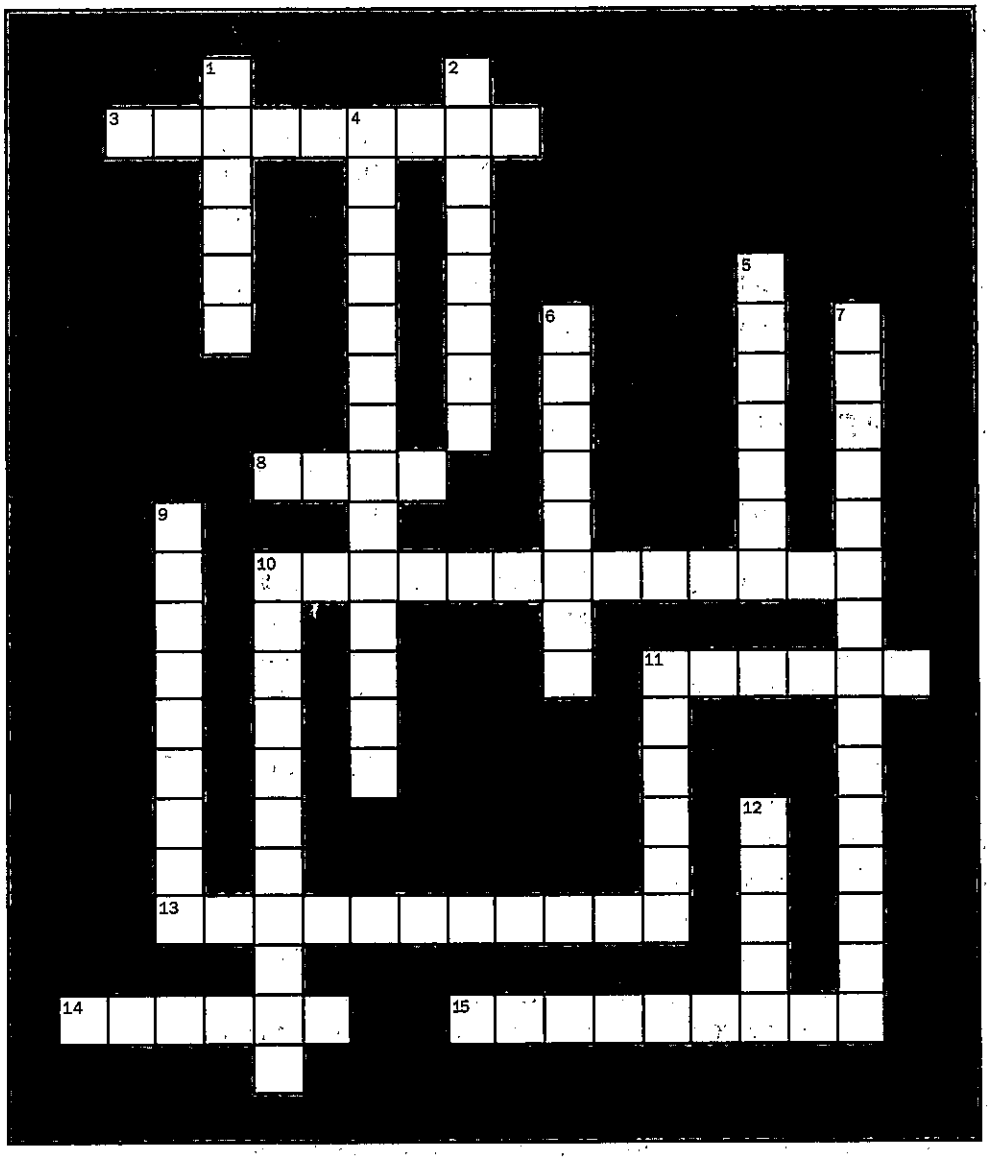
1. More than 60 million Americans have some form of cardiovascular disease. It is the leading cause of non-accidental death in this country. Major risk factors include high blood pressure, high cholesterol, diabetes, obesity and overweight, smoking, inactivity, heredity, age, and male gender. Contributing factors include stress, postmenopausal drops in hormonal levels, and heavy alcohol consumption. It has been shown that people who are overweight and carry most of their weight around their middle are at higher risk for heart attacks than those who carry their weight distributed over their frame.
2. Some patients have heart attacks without even being aware of it! This phenomenon, known as a silent MI, is usually discovered when a screening EKG shows evidence of an old heart attack. Diabetics are particularly susceptible to this phenomenon.
3. Deficient blood flow to the heart can not only cause heart attacks, it can also cause arrhythmias! When a portion of the ventricle gets hypoxic, it begins to get "twitchy," and may begin to beat very quickly. This rapid beating, called ventricular tachycardia, is independent of the rhythm ordered by the heart's pacemaker, and unfortunately, is not particularly effective at pumping blood. The condition can rapidly degrade into total cardiac arrest.
4. Some patients have coagulation problems and may be totally unaware of it! These subtle problems with blood clotting are very minor, and typically have no effect on everyday activities. However, they can cause significant problems in surgery. An important part of every pre-operative physical is screening for signs or symptoms of these subtle coagulopathies.

ETHICAL DILEMMAS

1. You are invited to a friend's house for Thanksgiving dinner. After dinner, your friend's father complains of "heartburn," saying his left arm is tingling and he feels short of breath. You're pretty sure he's having a heart attack and recommend he call 911. He says, "No, it will go away in a minute. I just ate too much." Do you override his wishes and call 911 anyway? What do you do?
2. This friend's father collapses. As you examine him, you realize he's not breathing and has no pulse. You have your friend call 911 (if you haven't called them already). As you prepare to do CPR, your friend tells you that this man is HIV positive. You don't have a one-way valve/mask with you, and will have to perform mouth-to-mouth directly. Do you perform CPR now, or do you wait for EMS to arrive? (Be sure to discuss the new recommendations that suggest even chest compressions alone are helpful in saving lives.)

Name _____

CIRULATORY ANATOMY AND PHYSIOLOGY



Across

3. The valve between the right atrium and right ventricle
8. A blood vessel that contains valves
10. The blood vessel that returns oxygenated blood fromt the lungs to the heart
11. A blood vessel that carries blood away from the heart
13. The inner lining of the heart
14. The tissue that divides the left and right sides of the heart
15. A tiny blood vessel that permits exchange of oxygen, nutrients, and waste products between the blood and the tissues

Down

1. The valve between the left atrium and left ventricle
2. The phase of the cardiac cycle where the heart is at rest
4. The pacemaker of the heart
5. The phase of the cardiac cycle where the heart contracts
6. A large blood vessel that returns deoxygenated blood the the right atrium
7. The only artery in the body that contains deoxygenated blood
9. A lower chamber of the heart
10. The serous membrane that surrounds the heart
11. An upper chamber of the heart
12. The large blood vessel that carries oxygenated blood from the left ventricle to the body

CHAMBERS OF THE HEART

CN: Use blue for A–A^4, red for H–H^4, and your lightest colors for B, C, I, and J. All dotted arrows (A^4) receive a blue color; all clear arrows (H^4) receive a red color. (1) Begin with the arrows A^4 above the title list and above the superior vena cava (A) in the illustration at upper right and color the structures in the order of the title list (A–H^3). (2) Color the circulation chart at lower right, beginning with the arrow A^4 leading into the right atrium (numeral 1). Color the numerals in order from 1 to 4 and related arrows. Do not color the chambers or the vessels in this drawing at lower right.

→ A^4

SUPERIOR VENA CAVA A
INFERIOR VENA CAVA A'
RIGHT ATRIUM B

↓

RIGHT VENTRICLE C
- A-V TRICUSPID VALVE D
  - CHORDAE TENDINEAE E
  - PAPILLARY MUSCLE F

↓

PULMONARY TRUNK A^2
- PUL. SEMILUNAR VALVE G
- PUL. ARTERY A^3

→ H^4

PULMONARY VEIN H
LEFT ATRIUM I

↓

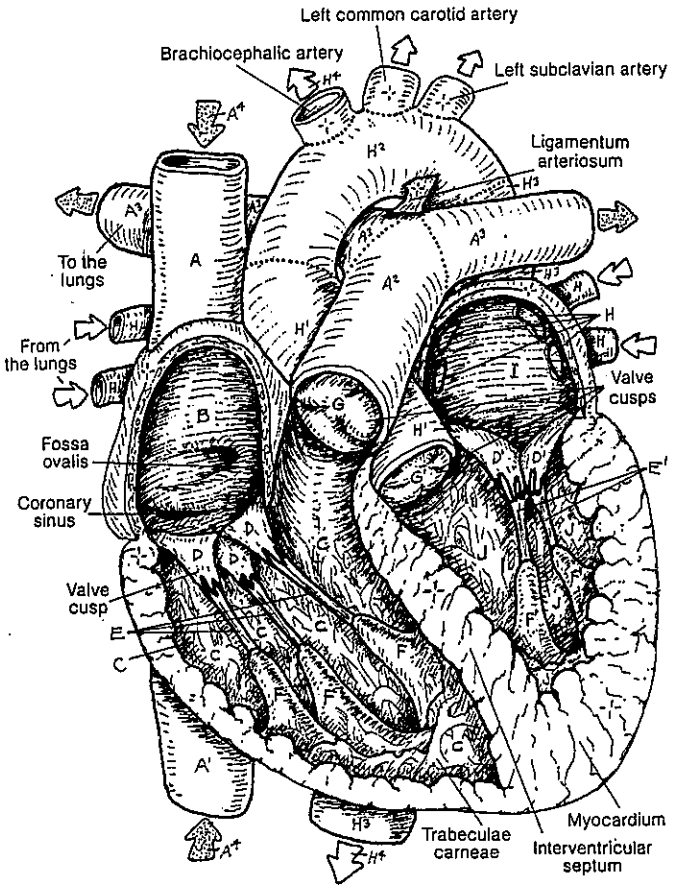
LEFT VENTRICLE J
- A-V BICUSPID (MITRAL) VALVE D'
  - CHORDAE TENDINEAE E'
  - PAPILLARY MUSCLE F'

↓

ASCENDING AORTA H'
- AORTIC SEMILUNAR VALVE G'
- AORTIC ARCH H^2
- THORACIC AORTA H^3

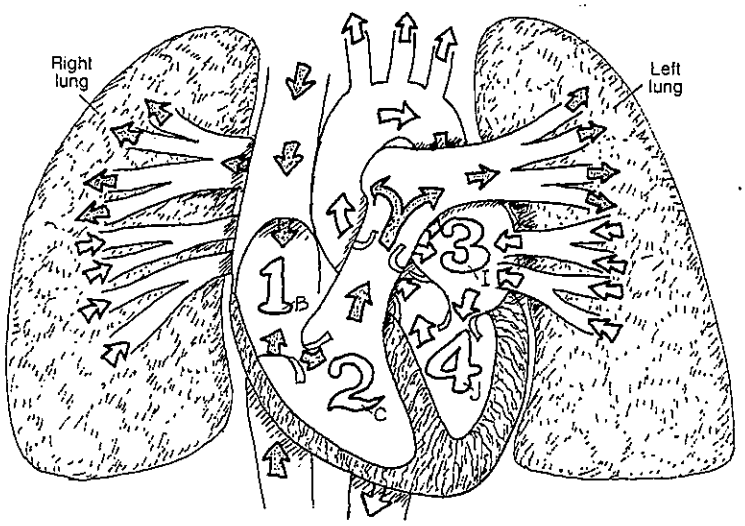
The heart is the muscular pump of the blood vascular system. It contains four cavities (chambers): two on the right side (pulmonary heart), two on the left (systemic heart). The pulmonary "heart" includes the right atrium and right ventricle. The thin-walled *right atrium* receives poorly *oxygenated blood* from the *superior* and the *inferior vena cava* and from the coronary sinus (draining the heart vessels). The thin-walled *left atrium* receives richly *oxygenated blood* from pulmonary veins. Atrial blood is pumped at a pressure of about 5 mm Hg into the *right and left ventricles* simultaneously through the atrioventricular orifices, guarded by the 3-cusp *tricuspid valve* on the right and the 2-cusp *bicuspid valve* on the left. The cusps are like panels of a parachute, secured to the *papillary muscles* in the ventricles by tendinous *chordae tendineae*. These muscles contract with the ventricular muscles, tensing the cords and resisting cusp over-flap as ventricular blood bulges into them during ventricular contraction (systole). The right ventricle pumps oxygen-deficient blood to the lungs via the *pulmonary trunk* at a pressure of about 25 mm Hg (right ventricle), and the left ventricle pumps oxygen-rich blood into the *ascending aorta* at a pressure of about 120 mm Hg simultaneously. This pressure difference is reflected in the thicker walls of the left ventricle compared to the right. The pocket-like *pulmonary and aortic semilunar valves* guard the trunk and aorta, respectively. As blood falls back toward the ventricle from the trunk/aorta during the resting phase (diastole), these pockets fill, closing off their respective orifices and preventing reflux into the ventricles.

ANTERIOR VIEW OF HEART CAVITIES AND GREAT VESSELS



CIRCULATION THROUGH THE HEART

OXYGEN-RICH BLOOD H^4 →
OXYGEN-POOR BLOOD A^4 →



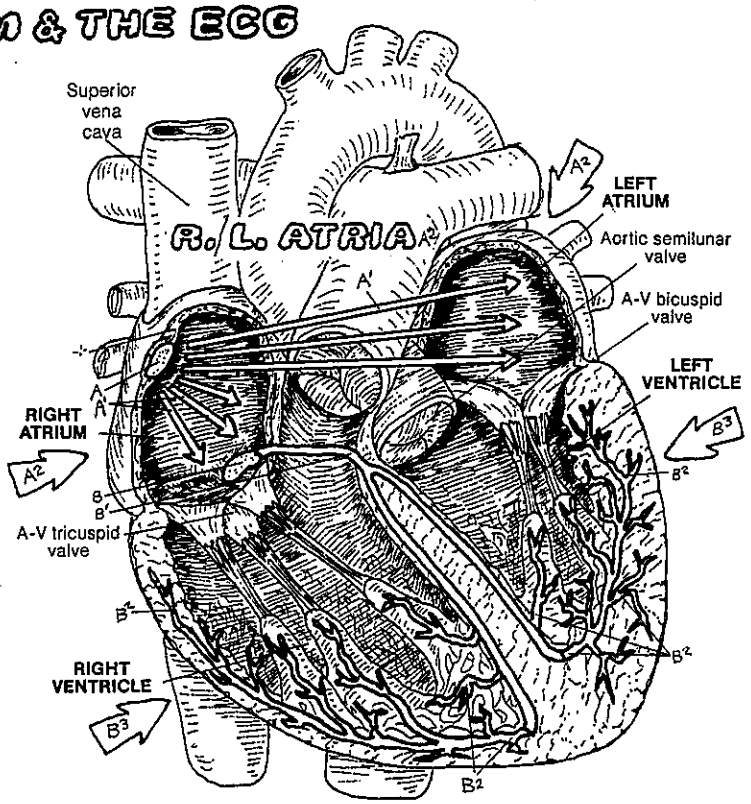
CARDIAC CONDUCTION SYSTEM & THE ECG

CN: Use blue for D and red for E. Use a very light color for B so that the patterns of dots identifying the segments (B–B^3) of the ECG remain visible after coloring. (1) Begin at upper right and color the four large arrows identifying the atria (A^2) and ventricles (B^3), as well as their titles. The atria and ventricles are not to be colored. (2) In the middle of the page, color the stages of blood flow through the heart, and related letters. These stages relate to voltage changes in the ECG below. (3) Color the ECG and related letters, starting at the left and working to the right. The parts of the ECG are related to the activity of the conduction system or related myocardial activity. (4) Color the horizontal bar below the time line.

CONDUCTION SYSTEM

- SA (SINOATRIAL) NODE A
- INTERNODAL PATHWAY A'
- AV (ATRIOVENTRICULAR) NODE B
- AV BUNDLE / BRANCHES B'
- PURKINJE PLEXUS B^2

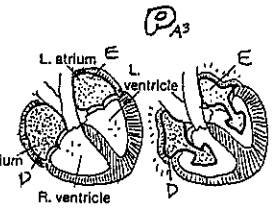
Cardiac muscle cells contract spontaneously. They do not require motor nerves to shorten. However, the intrinsic contraction rate of these cells is too slow and too unorganized for effective pumping of the heart. Happily, groups of more excitable but non-contractile cardiac cells take responsibility for initiating and conducting electrochemical impulses throughout the cardiac musculature. Such cells effect a coordinated, rhythmic sequence of cardiac muscle contractions that result in blood being moved through the cavities of the heart with appropriate volumes and pressures. These cells constitute the *cardiac conduction system*. Impulses generated at the *sinoatrial (SA) node* are distributed throughout the atria and to the *atrioventricular (AV) node* by way of non-discrete *internodal pathways*. Impuses travel from the AV node, down the *AV bundle and its branches*, to the *Purkinje plexus* of cells embedded in the ventricular musculature.

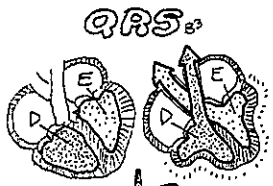


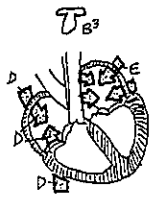
R_o/L_o VENTRICLES B^3

BLOOD FLOW

- OXYGEN-POOR D
- OXYGEN-RICH E

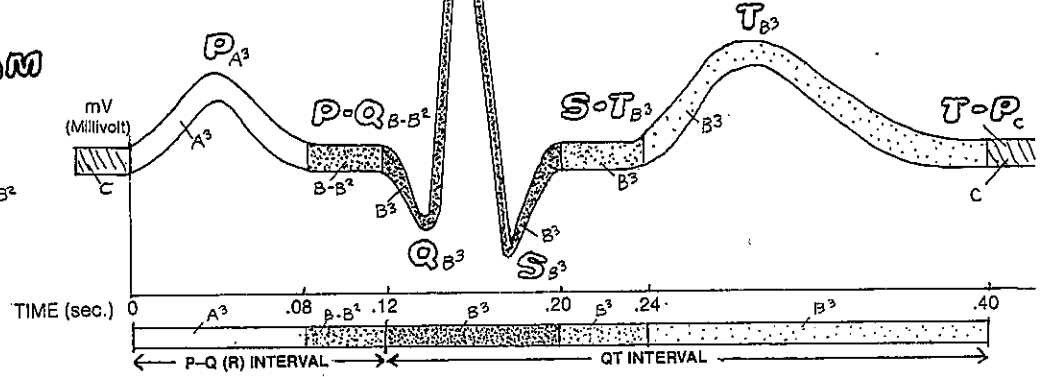






ELECTROCARDIOGRAM (ECG)

- P WAVE A^3
- P-Q (P-R) SEGMENT B-B^2
- QRS COMPLEX B^3
- S-T SEGMENT B^3
- T WAVE B^3
- T-P SEGMENT C



The cardiac conduction system generates voltage changes about the heart, some of which can be monitored, assessed, and measured by *electrocardiography (ECG)*. An ECG is essentially a voltmeter reading. It does not measure hemodynamic changes. Electrodes are placed on a number of body points on the skin. Recorded data (various waves of varying voltage over time) are displayed on an oscilloscope or a strip of moving paper. The shape and direction of wave deflections are dependent upon the spatial relationship of the electrodes (leads) on the body surface.

When the SA node fires, excitation/depolarization of the atrial musculature spreads out from the node. This is reflected in the ECG by an upward deflection of the resting (isoelectric) horizontal line (*P wave*). This deflection immediately precedes the contraction of the atrial musculature and filling of the ventricles. The *P-Q interval* (P-R interval in the absence of a Q wave) reflects conduction of excitation from the atria to the Purkinje cell plexus in the ventricular myocardium. Prolongation of this interval beyond .20 seconds may reflect an AV conduction block. The *QRS complex* reflects depolarization of the ventricular myocardium. This complex of deflections immediately precedes ventricular contraction, wherein blood is forced into the pulmonary trunk and ascending aorta. The *S-T segment* reflects a continuing period of ventricular depolarization. Myocardial ischemia may induce a deflection of this normally horizontal segment. The *T wave* is an upward, prolonged deflection and reflects ventricular repolarization (recovery), during which the atria passively fill with blood from the vena cavae and pulmonary veins. The QT interval, corrected for heart rate (QTc), reflects ventricular depolarization and repolarization. Prolongation of this segment may suggest abnormal ventricular rhythms (arrhythmias). In a healthy heart at a low rate of beat, the P-Q, S-T, and T-P segments all are isoelectric (horizontal).

CORONARY ARTERIES & CARDIAC VEINS

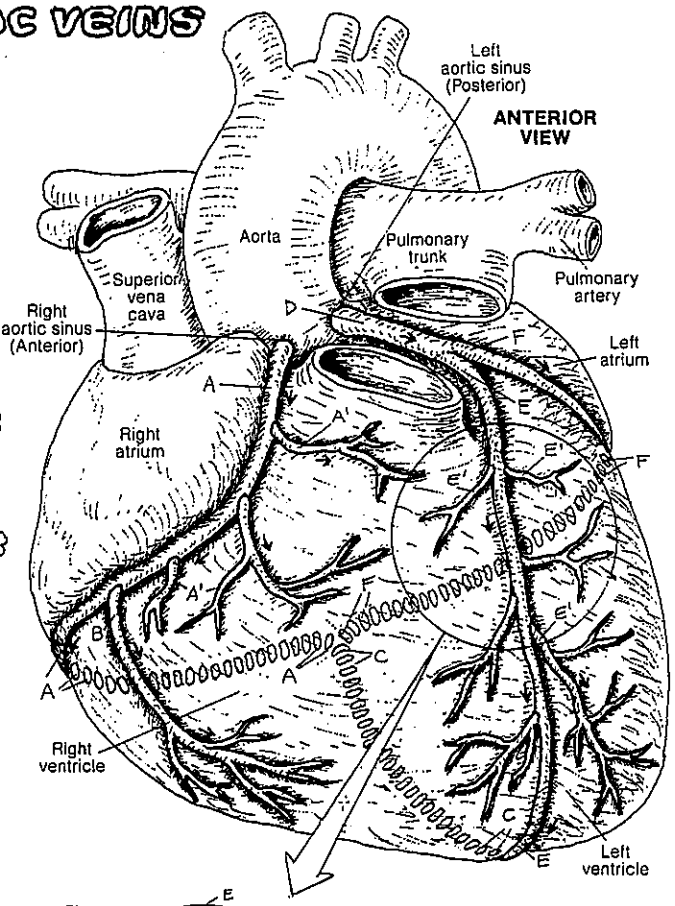
CN: Use your brightest colors for A, D, and L. (1) When coloring the arteries, include the broken lines that represent vessels on the posterior surface of the heart. (2) Do the same with the veins. (3) Color the artery in front of the plaque in the circled view; color the vessel after the plaque a lighter shade of the same color or do not color it at all.

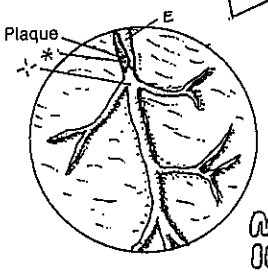
CORONARY ARTERIES

- RIGHT CORONARY A
  - MUSCULAR BRANCH A'
  - MARGINAL BRANCH B
  - POSTERIOR INTERVENTRICULAR (DESCENDING) BRANCH C
- LEFT CORONARY D
  - ANTERIOR INTERVENTRICULAR (DESCENDING) BRANCH E
    - MUSCULAR BRANCH E'
  - CIRCUMFLEX BRANCH F

The coronary arteries form an upside-down crown (L. corona) about or just deep to the surface of the heart. The arteries lie in grooves, or sulci, often covered over by the epicardium and sometimes the myocardium as well.

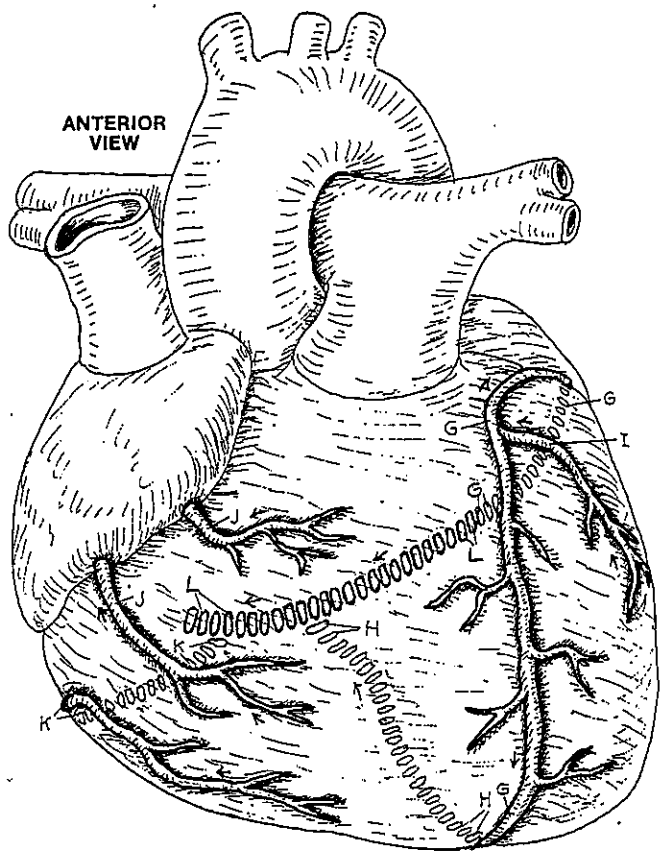
Both left and right arteries arise from small openings (aortic sinuses) just above the two aortic semilunar valve cusps. Generally, the left coronary artery is somewhat larger than the right; during the cardiac cycle, the flow rate through the left is greater in most people than that through the right. There may be considerable variation in the anastomotic pattern of the left and right arterial branches. These branches terminate in multitudes of arterioles supplying the vast capillary network among the muscle fibers. The apparent multiple communications among the left and right coronary arteries notwithstanding, varying degrees of vascular insufficiency occur when there is significant obstruction of one or both coronary arteries. There is some extra-coronary arterial supply to the heart from the epicardial vessels (branches of internal thoracic arteries) and aortic vasa vasorum.





MYOCARDIAL INFARCTION*

Damage to the intimal layer of coronary arteries can occur with lipid deposition or inflammation. Platelet aggregation at these sites contributes to the formation of plaque (cell material, lipid, platelet, fibrin). Plaque builds up within the vessels, forming thrombi that occlude the vessels in progressively greater degrees. Significantly reduced blood flow to the myocardium (ischemia) can cause sharp pain (angina) to the chest, back, shoulder, and arm as well as permanent damage to the myocardium (infarction).



CARDIAC VEINS

- GREAT CARDIAC V. G
- MIDDLE CARDIAC V. H
- MARGINAL V. I
- ANTERIOR CARDIAC V. J
- SMALL CARDIAC V. K

CORONARY SINUS L

The cardiac veins travel with the coronary arteries, but incompletely. Vast anastomoses of veins occur throughout the myocardium; most drain into the right atrium by way of the coronary sinus. The anterior cardiac veins conduct blood directly into the right atrium. Other small veins may drain directly into the right atrium as well. Some deep (arteriosinusoidal) veins drain directly into the atria and ventricles. Extracardiac venous drainage can also occur through the vasa vasorum of the vena cavae.

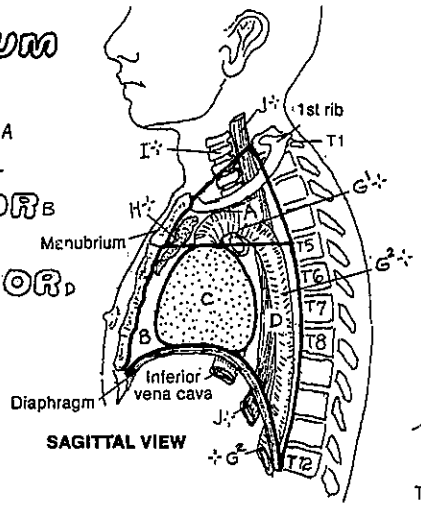
MEDIASTINUM, WALLS & COVERINGS OF THE HEART

CN: Use blue for F, red for G, and your lightest colors for A–D. (1) Begin with the regions of the mediastinum at upper left and color over all the structures within the dark outline. (2) Color the major structures within the mediastinum in the anterior view. Note that the lungs, not being in the mediastinum, remain uncolored. Note that the thymus, which can be seen in the sagittal view, has been deleted here to show the great vessels covered by it. (3) Finally, color the walls of the heart and layers of pericardium at lower left. The pericardial cavity has been greatly exaggerated for coloring. It is normally only a potential space.

MEDIASTINUM

REGIONS

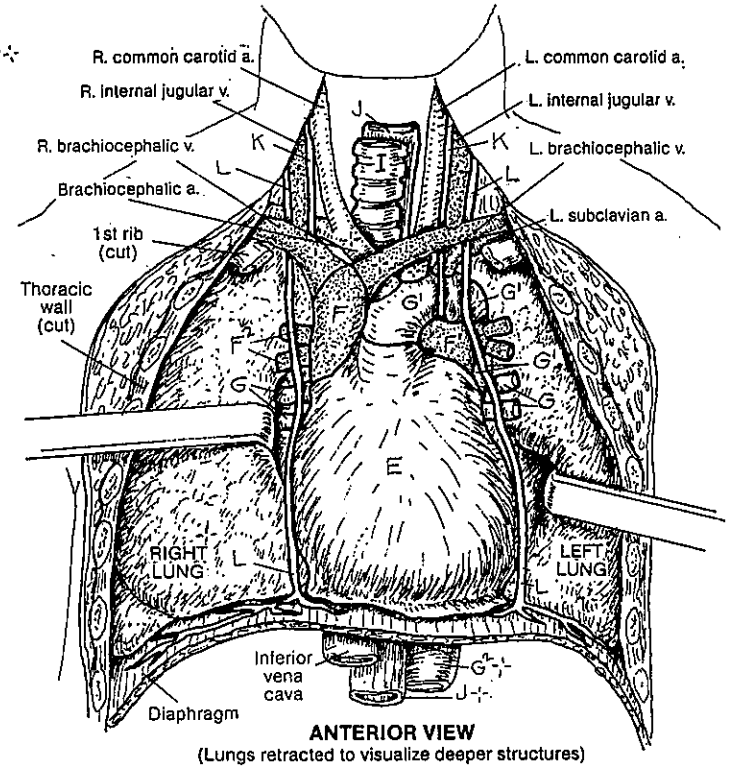
- SUPERIOR A
- INFERIOR
  - ANTERIOR B
  - MIDDLE C
  - POSTERIOR D



SAGITTAL VIEW

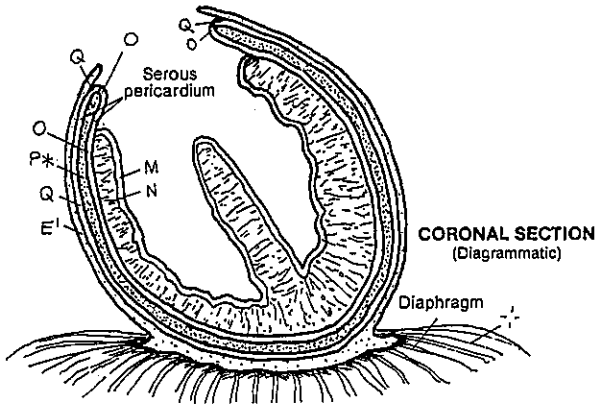
STRUCTURES

- PERICARDIUM-LINED HEART E
- GREAT VESSELS
  - SUPERIOR VENA CAVA F
  - PULMONARY TRUNK F¹
  - PULMONARY ARTERY F²
  - PULMONARY VEIN G
  - AORTIC ARCH G¹
  - THORACIC AORTA G²
- THYMUS H
- TRACHEA I
- ESOPHAGUS J
- VAGUS NERVE K
- PHRENIC NERVE L



ANTERIOR VIEW
(Lungs retracted to visualize deeper structures)

The mediastinum (median septum or partition) is a highly populated region between and excluding the lungs. A variety of passageways, nerves, and vessels enter, pass through, and exit the mediastinum. For descriptive purposes, the mediastinum is divided into the subdivisions (regions) illustrated. The *superior mediastinum* is remarkable for the array of *great vessels of the heart* and the *trachea*, *esophagus*, and *vagus* and *phrenic nerves*. At the level of the T4–T5 vertebrae (superior/inferior mediastinal border), the trachea bifurcates into the main bronchi (see Plate 133) posterior to the great vessels, and the *aorta* makes its *arch*. The *posterior mediastinum* includes the inferior continuation of the esophagus embraced by a fine network of vagal nerve fibers, the thoracic duct (see Plate 121), and the descending (*thoracic*) aorta. The floor of the mediastinum is the diaphragm, penetrated by the thoracic aorta, esophagus, and inferior vena cava.



CORONAL SECTION
(Diagrammatic)

WALLS OF THE HEART / PERICARDIUM

- ENDOCARDIUM M
- MYOCARDIUM N
- VISCERAL PERICARDIUM O
  - PERICARDIAL CAVITY P*
- PARIETAL PERICARDIUM Q
- FIBROUS PERICARDIUM E¹

The heart wall consists of an inner layer of simple squamous epithelium (*endocardium*) overlying a variably thick *myocardium* (cardiac muscle). External to the myocardium is a three-layered sac (*pericardium*). The innermost layer of this sac is the *visceral pericardium* (epicardium), clothing the heart. At the origin of the aortic arch, this layer turns (reflects) outward to become the *parietal pericardium* (imagine a fist clutching the edges around the opening of a paper bag; now push the fist into the closed bag still clutching the edges; as you do so, note that your fist becomes surrounded by two layers of the paper bag, yet is not inside the bag itself). The relationship of your fist to the two layers of the bag is the relationship of the heart to the visceral and parietal pericardium. The cavity of the bag is empty—the fist is not in the bag (if you did it right!). Similarly, the *pericardial cavity* between the two pericardial layers is empty as well, except for serous fluid that makes for friction-free movement of the heart in its sac.

The fibrous pericardium is the outer surface of the parietal pericardium; it is fibrous and fatty and is strongly attached to the sternum, the great vessels, and the diaphragm. It keeps the twisting, contracting, squeezing heart within the middle mediastinum.