CHAPTER SCOPE

Lub-dub, lub-dub, lub-dub! Seventy beats each minute, 4,200 beats each hour, 100,800 beats each day your heart contracts, ejecting blood into elastic blood vessels for distribution around the body. **Blood** is mostly water and proteins, with millions of red blood cells (*erythrocytes*) carrying oxygen, white blood cells (*leukocytes*) defending against infections, and platelets (*thrombocytes*) plugging vascular leaks. Platelets are intimately involved in blood clotting, or **coagulation** — a rapid series of complex *positive feedback* events that serve to stop bleeding. With the bleeding stopped, the disturbance has been corrected (*negative feedback*) and homeostasis has been restored.

The **heart** has blood receiving chambers (*atria*) and blood pumping chambers (*ventricles*) with valves at each exit to ensure the continuous flow of blood. Each complete cardiac cycle starts with a spontaneous electrical excitation followed shortly by a mechanical contraction of the myocardium. The *electrical* cycle originates from the pacemaker region and spreads throughout the heart, as recorded on the **electrocardiogram** (**ECG**). In this manner, both normal and abnormal (arrhythmia) cardiac cycles can be evaluated. Potential life-threatening interruption in blood flow to the myocardium (*ischemia*) is one example of cardiac conditions that reveals itself on the ECG. The *mechanical* cycle is characterized by pressure and volume changes within the heart that result in the ejection of blood and the formation of two valve sounds (lub-dub) that can be heard with a *stethoscope*.

Blood is forced out of the heart and into large **arteries**, which branch into smaller and smaller **arterioles**. Beyond arterioles, miles of capillaries cruising close to all living cells are active in the exchange of gases and nutrients for wastes. After this exchange, blood is drained away from tissue capillaries through **venules** and then larger **veins**, returning to the heart for another boost around the vascular network.

Since some fluid and other materials are forced out of capillaries, and others are released from neighboring cells, the lymph system vessels (**lymphatics**) provide a beautifully designed drainage system for the filtering and recycling of extracellular fluid that eventually returns to the blood. In the next chapter, the focus is on the arterioles, where blood pressure and the distribution of blood flow to various parts of the body such as the kidney, skin, and brain is regulated. These two chapters combine to provide a circulatory theme that helps us to better understand the following chapters that discuss the respiratory (chapter 15), urinary (chapter 16), digestive (chapters 17 and 18), and endocrine (chapters 11 and 20) systems.

I. FUNCTIONS AND COMPONENTS OF THE CIRCULATORY SYSTEM

Blood serves numerous functions, including the transport of respiratory gases, nutritive molecules, metabolic wastes, and hormones. Blood is transported through the body in a system of vessels leading from and returning to the heart.

A. Multiple Choice

___ 1. Which of the following is *not* a function of the circulatory system?
   a. respiration
   b. transportation
   c. regulation
   d. protection
   e. All of these are functions of the circulatory system.

___ 2. Which substances involved in cellular metabolism are not normally transported by the circulatory system?
   a. respiratory gas molecules, such as oxygen and carbon dioxide
   b. absorbed products of digestion
   c. Krebs cycle enzymes
   d. metabolic wastes
   e. water and ions

___ 3. How many liters of blood does the adult heart pump each minute?
   a. three
   b. five
   c. seven
   d. nine
   e. twelve

___ 4. The thinnest and most numerous of all blood vessels are the
   a. arteries.
   b. arterioles.
   c. capillaries.
   d. venules.
   e. veins.

B. True or False/Edit

___ 5. As blood flows through capillaries, the *hydrostatic* pressure of the blood forces some fluid out of the capillary walls and into the tissue spaces.

___ 6. Tissue fluid is the same as interstitial fluid; and may form lymph, returning to the venous blood through lymphatic vessels.

___ 7. The lymph nodes within the lymphatic system are considered part of the excretory system.

II. COMPOSITION OF THE BLOOD

Blood consists of formed elements that are suspended and carried in a fluid called plasma. The formed elements—erythrocytes, leukocytes, and platelets—function, respectively, in oxygen transport, immune defense, and blood clotting. Plasma contains different types of proteins and many water-soluble molecules.

A. Multiple Choice

___ 8. A normal *hematocrit* of 45 means that
   a. 45% of the formed elements are erythrocytes.
   b. there are 45 million formed elements per milliliter of blood.
   c. 45% of the total blood volume is formed elements.
   d. 45 milliliters of plasma is the standard volume measured.

___ 9. Much like extracellular fluid (ECF), the major solute dissolved in the plasma portion of the blood is
   a. glucose.
   b. Na^+.
   c. K^+.
   d. albumin.
   e. Ca^{2+}.

___ 10. Which of the following proteins is *not* considered a **plasma protein**?
   a. globulin
   b. insulin
   c. albumin
   d. fibrinogen

___ 11. Which statement about **erythrocytes** is *false*?
   a. They lack both a nucleus and mitochondria.
   b. They outnumber leukocytes by a large margin.
   c. They require dietary iron and vitamin B_{12}.
   d. Their circulating life span is about twelve months.
   e. All of these statements regarding erythrocytes are true.

___ 12. Which of the following is *not* a *granular leukocyte*?
   a. neutrophil
   b. basophil
   c. lymphocyte
   d. eosinophil
   e. All of these are granular leukocytes.

___ 13. Which statement about **platelets** is *false*?
a. They have a life span of about 120 days.
b. They are the smallest of the formed elements, derived originally from megakaryocytes.
c. During blood clotting, they release a chemical called serotonin that constricts blood vessels in the injured area.
d. Phospholipids in their membranes activate clotting factors in the plasma.
e. They lack nuclei but are capable of ameboid movement.

___ 14. Which of the following cells has the *shortest* life span? (*Hint*: see table 13.2 in your text.)
a. erythrocytes
b. platelets
c. agranular leukocytes
d. granular leukocytes

___ 15. In the **ABO system** of red blood cell typing, which of the following genotypes is *not* possible?
a. ii
b. I^Ai
c. I^Bi
d. I^AI^B
e. All of these genotypes are possible.

___ 16. A person whose blood type is B has red blood cells with membrane-bound ____ antigens and anti-___ antibodies circulating in the plasma.
a. B; B
b. B; A
c. A; A
d. A; B

___ 17. In *erythroblastosis fetalis* (hemolytic disease of the newborn), the
a. baby is Rh positive and the mother is Rh negative.
b. mother has made antibodies against th Rh factor present on the baby's red blood cells.
c. baby has abnormally low numbers of red blood cells (anemia).
d. mother should have been given RhoGAM (antibodies) by injection.
e. All of these statements regarding erythroblastosis fetalis are correct.

___ 18. Which of the following events does *not* occur as blood clots within an injured blood vessel (*hemostasis*)?
a. The endothelial lining is damaged, exposing collagen proteins to the blood.
b. Newly released chemicals constrict smooth muscles located in the injured blood vessel wall.
c. Platelets become "sticky" and a platelet plug is formed near the injury.
d. A web of fibrin protein strands interweaves the platelet plug.
e. All of these events occur during hemostasis.

___ 19. The endothelial cells lining a *damaged* blood vessel secrete an important protein that binds to both exposed collagen and to incoming platelets, known as
a. serotonin.
b. von Willebrand's factor.
c. adenosine diphosphate (ADP).
d. thromboxane A_2.
e. Damaged endothelial cells secrete none of these chemicals.

___ 20. The ion most involved in blood clotting sequences, is
a. Na^+.
b. Ca^{2+}.
c. K^+.
d. H^+.
e. Fe^{3+}.

___ 21. The final step in blood clot formation is the conversion of
a. factor XII to factor XI.
b. factor VII to factor X.
c. fibrinogen to fibrin.
d. prothrombin to thrombin.

___ 22. The vitamin that converts glutamate amino acids in clotting factor proteins into gamma-carboxyglutamate, which can then effectively use Ca2+ during blood clotting, is vitamin ____.
a. K
b. C
c. B_{12}
d. D
e. A

___ 23. Which of the following chemicals is *not* an anticoagulant?
a. citrate
b. EDTA (chelating agent)
c. heparin
d. bradykinin
e. coumarin

B. True or False/Edit

___ 24. *Oxyhemoglobin* is the combination of oxygen with hemoglobin inside the erythrocytes, giving venous blood its blue color.

___ 25. Normal blood pH ranges from 7.35 to 7.45.

___ 26. The most common plasma protein is *albumin*, whose primary function is to draw water from the extracellular fluid (ECF) into the capillary plasma.

___ 27. Alpha, beta, and gamma globulins are all plasma proteins produced by the liver that all function as antibodies in immunity.

___ 28. *Diapedesis* is the amoeba-like movement of leukocytes (white blood cells) through pores in capillary walls to reach sites of infection.

___ 29. The most abundant type of leukocyte, comprising 50% to 70% of all white blood cells is the lymphocyte.

___ 30. Plasma cells are actually enlarged monocytes that produce and secrete large amounts of antibodies into the blood.

___ 31. Polycythemia is to anemia what leukocytosis is to leukemia.

___ 32. Red bone marrow (myeloid tissue) produces all of the different types of blood cells, while lymphoid tissue makes lymphocytes.

___ 33. *Erythropoietin* is a hormone secreted by the kidneys in response to lowered blood oxygen concentrations, thus stimulating erythrocyte stem cells in bone marrow to divide.

___ 34. People who are blood type O (or ii), have both anti-A and anti-B antibodies in their plasma.

___ 35. A and B antigens on red blood cells are sometimes called agglutinogens, and the plasma antibodies made against them are called agglutinins.

___ 36. A prostaglandin derivative secreted by intact blood vessel endothelium that normally prevents platelets from sticking to each other and to the lining of healthy blood vessels is *thromboxane* A_2.

___ 37. *Aspirin* is an inhibitor of both the COX-1 (and COX-2) isoenzymes that catalyze the synthesis of blood clotting prostaglandins and therefore would be expected to reduce platelet aggregation and to slow the clotting sequence.

___ 38. Plasma is actually serum minus the clotting factor called fibrinogen.

___ 39. When repairs have been made to a damaged blood vessel, the activated plasma enzyme that digests fibrin and thereby dissolves the clot is called plasmin.

III. STRUCTURE OF THE HEART

The heart contains four chambers: two atria, which receive venous blood, and two ventricles, which eject blood into arteries. The right ventricle pumps blood to the lungs, where the blood becomes oxygenated; the left ventricle pumps oxygenated blood to the entire body. The proper flow of blood within the heart is aided by two pairs of one-way valves.

A. Multiple Choice

___ 40. In the pulmonary circulation, the
  a. pulmonary artery carries oxygen-poor blood.
  b. pulmonary vein carries blood toward the lung capillaries.
  c. blood returning to the left atrium of the heart is oxygen-poor.
  d. oxygen from the blood diffuses into the air sacs (alveoli) of the lungs.
  e. blood leaves the left ventricle and returns to the right atrium.

___ 41. The atrioventricular (*AV*) *valve*
  a. between the right atrium and ventricle is the bicuspid.
  b. between the left atrium and ventricle is the tricuspid.
  c. called the mitral valve, is also known as the bicuspid valve.
  d. normally prevents blood flow from the atria to the ventricles.

___ 42. The semilunar valves
  a. prevent the backward flow of blood into the atria of the heart.
  b. are open during relaxation of the ventricles.
  c. are held tightly by papillary muscles and chordae tendinae.
  d. direct blood ejected from the ventricles into the pulmonary artery and the aorta.

B. True or False/Edit

___ 43. A muscular wall called a septum prevents the mixture of blood between the left and right sides of the heart.

___ 44. The myocardial cells of the atria and ventricles are structurally and functionally separated from each other.

___ 45. The work performed by the right ventricle is five to seven times greater than that performed by the left ventricle.

___ 46. The cardiac valves open and close due to changes in pressure on either side of the valves.

C. Sequencer – Pathway of Circulating Blood

47. You are a red blood cell entering the heart from the superior vena cava! Test your understanding of cardiac structures by tracing your route through the entire heart, past the valves, and into the aorta. Starting with number 1, write the numerical sequence of the following structures on the left in the spaces provided. On the right side of the page, write out the name of the structure that corresponds to the numerical sequence from 1 to 12 that you have chosen. The last one, number 12 (aorta), has been done for you. Notice that the pulmonary circulation is included. Completion of figure 13.1 should be of further help in learning these structures.

Notice that the pulmonary circulation is included. Now label the figure in the next section.

____ pulmonary capillary	1.
____ mitral valve	2.
____ aortic semilunar valve	3.
____ tricuspid valve	4.
____ pulmonary vein	5.
12 aorta	6.
____ left ventricle	7.
____ right ventricle	8.
____ right atrium	9.
____ pulmonary semilunar valve	10.
____ left atrium	11.
____ pulmonary artery	12. aorta

D. Label the Figure — The Heart

Study figure 13.1 and label all structures of the heart, including the four valves. When finished, check your work with figure 13.11 in your text.

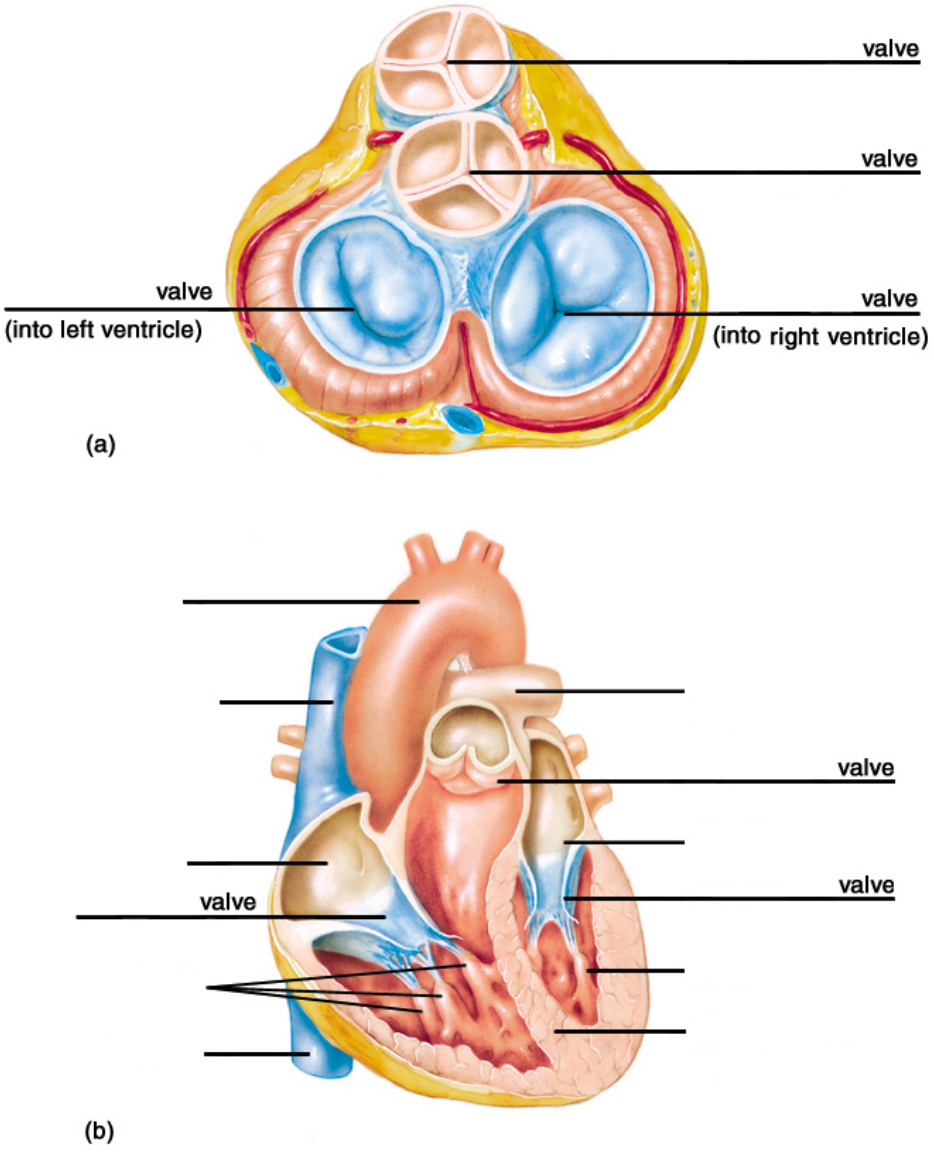

Figure 13.1

IV. CARDIAC CYCLE AND HEART SOUNDS

The two atria fill with blood and then contract simultaneously. This is followed by simultaneous contraction of both ventricles, which sends blood through the pulmonary and systemic circulations. Contraction of the ventricles closes the AV valves and opens the semilunar valves; relaxation of the ventricles causes the semilunar valves to close. The closing of first the AV valves and then the semilunar valves produces the "lub-dub" sounds heard with a stethoscope.

A. Multiple Choice

___ 48. The terms *systole* and *diastole* refer, respectively, to the
a. contraction phase and relaxation phase of the atria.
b. relaxation phase and contraction phase of the atria.
c. contraction phase and relaxation phase of the ventricles.
d. relaxation phase and contraction phase of the ventricles.
e. the simultaneous contraction and relaxation phases of both the atria and the ventricles.

___ 49. During normal ventricular contraction, what *fraction* of the end-diastolic volume is ejected as the stroke volume?
a. one-fourth
b. one-third
c. one-half
d. two-thirds
e. three-fourths

___ 50. At rest, each cardiac cycle lasts about 0.8 seconds; of which systole lasts ___ seconds, and diastole lasts ____ seconds.
a. 0.3; 0.5
b. 0.4; 0.4
c. 0.1; 0.7
d. 0.6; 0.2
e. 0.2; 0.6

___ 51. During one cardiac cycle, the major difference between the left and the right halves of the heart is that the
a. left heart pumps a greater volume of blood than the right heart.
b. right heart contracts shortly before the left heart.
c. right heart pumps blood with less force (at lower pressure) than the left heart.
d. left heart has a shorter cardiac cycle duration than the right heart.

___ 52. The *first* heart sound results from vibrations generated by the
a. opening of the AV valves.
b. closing of the AV valves.
c. opening of the semilunar valves.
d. closing of the semilunar valves.
e. Both b and d are correct.

B. True or False/Edit

___ 53. Normally, both atria contract at the same time, followed shortly by both ventricles contracting at the same time.

___ 54. Venous blood returning to fill the heart (venous return) is greatest during systole.

___ 55. The contraction of both atria is essential for life because it delivers about 80% of the total volume of blood to the ventricles for subsequent ejection.

___ 56. During both isovolumetric contraction and isovolumetric relaxation phases, all four valves in the heart (2 AV and 2 semilunar) are closed.

___ 57. During inhalation particularly, the first heart sound may be "split" into two separate sounds as the tricuspid and mitral heart valves close individually.

___ 58. A streptococcus bacterial throat infection in susceptible persons may lead to rheumatic fever and rheumatic endocarditis, resulting in damage to the heart valves and detectable murmurs.

___ 59. Simple septal defects are usually congenital (from birth), resulting in the flow of blood from the right side of the heart to the left side of the heart since the pressure is higher on the right side.

V. ELECTRICAL ACTIVITY OF THE HEART AND ELECTROCARDIOGRAM

The pacemaker region of the heart (SA node) exhibits a spontaneous depolarization that causes action potentials, resulting in the automatic beating of the heart. Electrical impulses are conducted by myocardial cells in the atria and are transmitted to the ventricles by specialized conducting tissue. Electrocardiogram waves correspond to the electrical events in the heart as follows: P wave (depolarization of the atria); QRS wave (depolarization of the ventricles); and T wave (repolarization of the ventricles).

A. Multiple Choice

___ 60. The *sinoatrial (SA) node* region of the right atrium is the normal pacemaker of the heart because this region
   a. demonstrates spontaneous electrical activity.
   b. depolarizes to threshold before other cardiac regions.
   c. has Ca^{2+} diffusing through Ca^{2+} channels into the cardiac fibers.
   d. develops pacemaker potentials during diastole.
   e. All of these statements are correct.

___ 61. Action potentials in myocardial cells (not SA node fibers) have a characteristic *plateau phase*, which is caused primarily by the
   a. slow outward diffusion of Na^{+}.
   b. fast inward diffusion of Na^{+}.
   c. fast outward diffusion of Ca^{2+}.
   d. slow inward diffusion of Ca^{2+}.

___ 62. Which statement about the normal *electrocardiogram* (ECG) tracing is *false*?
   a. Lead I is a recording from the right arm to the left arm.
   b. The unipolar leads are found only on the chest.
   c. There are a total of twelve standard ECG leads that "view" the changing pattern of the heart's electrical activity.
   d. There are six unipolar chest leads.
   e. Lead III is a recording from the left arm to the left leg.

___ 63. Which statement about the normal *electrocardiogram* (ECG) tracing is *false*?
   a. The T wave represents depolarization of the atria.
   b. The QRS wave represents depolarization of the ventricles.
   c. The repolarization of the atria is hidden by the QRS wave.
   d. The P wave occurs shortly before the QRS wave.
   e. All of these statements about the ECG are true.

___ 64. The *second* heart sound (S_2) is heard while the ECG is recording the corresponding
   a. P wave.
   b. P-R interval.
   c. QRS wave.
   d. T wave.
   e. S-T segment.

B. True or False/Edit

___ 65. Since a fibrous skeleton separates the atria from the ventricles of the heart, the electrical excitation and mechanical contraction of the ventricle is separate from that of the atria.

___ 66. In the SA node region of the heart, spontaneous, automatic depolarization of the pacemaker fibers (*diastolic depolarization*) results from the more rapid entry of K^{+} ions down their electrochemical gradient.

___ 67. As the pacemaker fibers of the atria depolarize to threshold, the inward current of Ca^{2+} produces not only the upward phase of the action potential but also the mechanical contraction that follows.

___ 68. Diastolic depolarization occurs faster in response to epinephrine and norepinephrine (catecholamines) because stimulation of the β_1-adrenergic receptors produces cAMP second messengers that keep the HCN channels open.

___ 69. An ectopic pacemaker (or ectopic focus) is a cluster of myocardial cells located away from the SA node that take over and regulate the cardiac pace.

___ 70. The rate of impulse conduction from the SA node is slowed as it passes through the AV node, causing a time delay before the ventricles are excited.

___ 71. The electrical depolarization of myocardial cells during the cardiac cycle stimulates the opening of voltage-gated Ca^{2+} channels in the sarcolemma that allows calcium ions to diffuse down its concentration gradient and into the cells.

___ 72. The excitation-contraction coupling in myocardial cells depends on the *calcium-stimulated-calcium-release* mechanism that releases stored Ca^{2+} from the sarcoplasmic reticulum, which joins the Ca^{2+} that has already entered from outside the cells in response to depolarization.

___ 73. During the excitation of myocardial cells the rapid entry of Ca^{2+} into the cytoplasm stimulates contraction by binding directly to myosin filaments.

___ 74. Unlike skeletal muscles, heart muscle cannot maintain a sustained maximal contraction (tetany).

___ 75. The summation of myocardial cell contractions is prevented primarily by their relatively short refractory period.

___ 76. The body is a good conductor of electricity because tissue fluids contain a high concentration of ions that move in response to changes in the membrane potential differences, thereby creating current.

___ 77. The electrocardiogram (ECG) wave patterns that are designated P, QRS, and T represent recordings of single action potentials from specific regions in the heart.

C. Label the Figure — The Conduction System of the Heart

Study the drawing of the electrical conduction pathway of the heart in figure 13.2. Then write the words that best describe the conduction pathway structures indicated by the blank lines on the figure. Remember this is the pathway for *electrical* excitation — the *mechanical* contraction of cardiac muscle fibers will follow shortly. See figure 13.20 in the text to check your work.

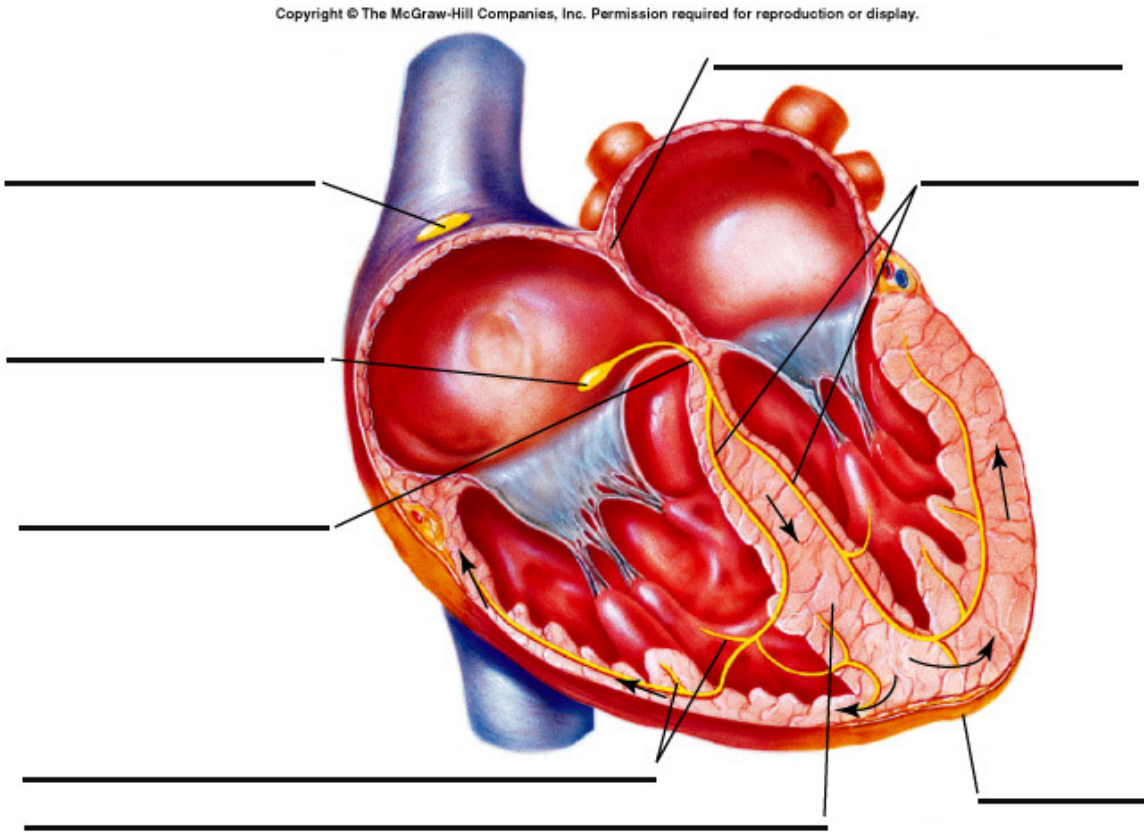

Figure 13.2 The conduction system of the heart.

VI. BLOOD VESSELS

The thick muscle layer of arteries allows them to transmit blood ejected from the heart under high pressure, and the elastic recoil of the large arteries further contributes to blood flow. The thinner muscle layer of veins allows them to distend when an increased amount of blood enters them, and their one-way valves ensure that blood flows back to the heart. Capillaries are composed of only one layer of endothelium, which facilitates the rapid exchange of materials between the blood and tissue fluid.

A. Multiple Choice

___ 78. The blood vessel layer composed primarily of smooth muscle is called the tunica _____.
- a. externa
- b. media
- c. interna
- d. endothelium

___ 79. Which of the following statements about arteries and veins is *false*?
a. Arteries have more smooth muscle than comparable veins.
b. Arteries carry blood under higher pressure.
c. Veins have one-way valves, promoting flow in only one direction.
d. Veins collapse thereby providing the greatest resistance to blood flow in the circulatory system.
e. All of these statements regarding arteries and veins are true.

___ 80. The "business ends" of the circulatory system in which the exchanges of gases and nutrients occur, are important blood vessels known as
a. arteries.
b. arterioles.
c. capillaries.
d. venules.
e. veins.

___ 81. In the central nervous system (CNS), the type of capillary that lacks intercellular channels and helps form the blood-brain barrier, is called a
a. continuous capillary.
b. discontinuous capillary.
c. fenestrated capillary.

___ 82. Which of the following mechanisms does *not* play an important role in the normal return of venous blood to the heart?
a. the inhalation (inspiratory) phase of normal breathing
b. large skeletal muscle contractions (pump)
c. the higher average hydrostatic pressure in the veins than that found in the heart
d. standing upright, perfectly still

B. True or False/Edit

___ 83. Compared to larger arteries, smaller arteries and arterioles are less elastic and have a thicker layer of smooth muscle for their diameters.

___ 84. In skeletal muscle at rest, the relatively high resistance to blood flow in the small arteries and arterioles reduces capillary blood flow to about 5%-10% of its maximum capacity.

___ 85. *Fenestrated capillaries* of the kidneys, endocrine glands, and intestines have wide intercellular pores or "windows" which are covered by a mucoprotein layer that restricts the passage of certain molecules (especially proteins) that might otherwise pass through the large capillary pores.

___ 86. Exposed to cytokines such as *vascular endothelial growth factor* (VEGF) and *fibroblast growth factor* (FGF), new blood vessels can form from pre-existing blood vessels – a process known as **angiogenesis**.

___ 87. Varicose veins can result from extra blood accumulating in large veins over a long period of time, thereby stretching these vessels and making venous valves less efficient — no longer able to ensure the one-way flow of blood to the heart.

VII. ATHEROSCLEROSIS AND CARDIAC ARRHYTHMIAS

Atherosclerosis is a disease process that can lead to obstruction of coronary blood flow. As a result, the electrical properties of the heart and its ability to function as a pump may be seriously compromised. Abnormal cardiac rhythms, or arrhythmias, can be detected by the abnormal electrocardiogram patterns they produce.

A. Multiple Choice

___ 88. Which of the following events is *not* considered part of the progression that occurs during the development of long-term atherosclerosis?
   a. Monocytes, attracted to the tunica intima region of the damaged endothelium, engulf lipids and take on a "foamy cells" appearance.
   b. Gray-white "fatty streaks" formed by lipid-filled macrophages, protrude into the lumen of arteries and thus reduce blood flow.
   c. White blood cells (phagocytes) attempt to attack and reject the developing atheroma as a foreign substance.
   d. Fibrous plaques may form, composed of accumulated lipids, white blood cells, and debris, covered by a cap of connective tissue and smooth muscle cells.
   e. All of these events are part of the long-term progression in atherosclerosis.

___ 89. Which of the following is *not* considered a risk factor in the development of atherosclerosis?
   a. advanced age
   b. smoking
   c. high blood HDL — cholesterol
   d. hypertension
   e. high blood LDL — cholesterol

___ 90. Which of the following statements about **low-density lipoproteins** (LDLs) is *false*?
   a. In the liver, LDL consists of droplets of cholesterol, neutral fat, free fatty acids, and phospholipids surrounded by an outer layer of protein molecules.
   b. LDL levels are typically higher in females and in exercising males than in those who are inactive.
   c. The apolipoproteins molecules in LDLs are recognized by specific receptors located on various body cells resulting in attachment and ingestion of the LDLs by receptor-mediated endocytosis.
   d. Persons with high blood LDL levels usually have a low number of LDL receptors in their livers.
   e. LDL blood levels rise in persons with high cholesterol, in those eating high-fat diets, and in people with familial hypercholesteremia.

___ 91. Which of the following statements about *myocardial infarction* (MI) is *false*?
   a. An MI is commonly referred to by the general public as a "heart attack."
   b. An MI may be detected by changes in the S-T segment of the ECG.
   c. Since myocardial cells are adapted to respire anaerobically for several hours, an MI takes time to develop.
   d. An MI can be diagnosed by the abnormal release of *creatine phosphokinase* (CPK) and *lactate dehydrogenase* (LDH) enzymes released from the infarcted cells.
   e. All of these statements regarding an MI are true.

___ 92. Which of the following arrhythmias is best diagnosed by following changes in the P-R interval of the electrocardiogram (ECG)?
   a. flutter
   b. fibrillation
   c. tachycardia
   d. bradycardia
   e. AV node block

B. True or False/Edit

___ 93. Atherosclerosis, accompanied by heart disease and stroke, is responsible for about 50% of the deaths in the United States, Europe, and Japan.

___ 94. "Fatty streaks" are gray-white areas that protrude from the tunica intima into the lumen of arteries; and are even present in children to a small degree in the aorta and coronary arteries of children aged 10 to 14.

___ 95. During the progression of atherosclerosis, lymphocytes may engulf lipids while passing through the endothelium of arteries, developing into "foamy cells."
___ 96. The measurement of *C-reactive protein* levels in the blood appears to be a stronger predictor of atherosclerotic heart disease than the blood LDL cholesterol level..
___ 97. People who eat a diet high in cholesterol and saturated fat, and people with familial hypercholesterolemia, have a high blood HDL concentration because their livers have a low number of HDL receptors.
___ 98. Drugs known as **statins** can lower the blood levels of LDL-cholesterol because they function as inhibitors of the enzyme *HMG-Coenzyme A reductase*, resulting in a decrease in the synthesis of cholesterol by the liver.
___ 99. The antioxidant property of vitamins C, E, and beta-carotene as well as the drug *probucol* appear important due to the ability of these substances to inhibit the oxidation of LDL that contributes to the progression of atherosclerosis.
___ 100. Persons having higher plasma LDL-cholesterol concentrations and lower plasma HDL-cholesterol concentrations appear to have a lower risk of developing atherosclerosis.
___ 101. About 40%-50% of the calories eaten in a typical fast-food meal are derived from the ingestion of fat; whereas eating one meal of oily fish such as salmon a week can significantly reduce the risk of myocardial infarction.
___ 102. *Ischemia* is an inadequate flow of blood (and an inadequate supply of oxygen) to any tissue, including the myocardium.
___ 103. Myocardial infarction (MI) resulting from occlusion of the coronary arteries is the leading cause of death in the western world.
___ 104. Following coronary bypass surgery and restoration of coronary blood flow, dead myocardial cells (necrosis) can be replaced by mitosis of neighboring healthy cells.
___ 105. The very serious, even lethal heart rhythm characterized by circus rhythms in which electrical waves are recycled around continuously changing pathways in the heart, best describes third degree, or complete, AV node block.

VIII. LYMPHATIC SYSTEM

Lymphatic vessels absorb excess tissue fluid and transport this fluid — now called lymph — to ducts that drain into veins. Lymph nodes, and lymphoid tissue in the thymus, spleen, and tonsils produce lymphocytes, which are white blood cells involved in immunity.

A. Multiple Choice

___ 106. Which of the following is *not* a basic function of the lymphatic system?
a. transport interstitial (tissue) fluid back to the blood
b. transport lymph via thoracic ducts to the right and left subclavian veins
c. transport fat absorbed from the small intestine to the blood
d. help in the immunological defense against disease-causing agents
e. All of these are lymphatic system functions.

___ 107. Due to the unique structure of lymph capillaries, lymph contains all of the following substances, *except*
a. interstitial proteins.
b. interstitial microorganisms.
c. interstitial RBCs and WBCs.
d. interstitial fluid.
e. absorbed fat.

___ 108. Lymph fluid from around the body eventually flows into lymphatics that merge and drain directly into the
a. right and left subclavian veins.
b. superior and inferior vena cavae.
c. aorta.
d. right atrium.
e. right and left pulmonary veins.

___ 109. Which of the following is *not* considered a lymphoid organ since it does *not* contain phagocytic cells and germinal centers for the production of lymphocytes?
a. the thymus gland
b. the thyroid gland
c. the tonsils
d. the spleen
e. All of these are considered lymphoid organs.

B. True or False/Edit

___ 110. Like veins, lymphatic vessels have the same three vessel layers and one-way valves to prevent the backward flow of lymph.
___ 111. Lymph is formed by the filtration of blood plasma from capillaries, forming filtrate that ultimately returns to the blood to complete the cycle.
___ 112. Lymph nodes germinal centers contain phagocytic cells that help to remove pathogens from lymph.
___ 113. The lymphatic system may contribute to the spread of cancer (metastasis) since cancer cells can enter and later exit the porous lymphatic capillaries.

CHAPTER REVIEW

B. Essay

Essay Tutorial

This essay tutorial will answer the first essay question found in the "**Review Activities**" section of your *Human Physiology* textbook. Please read *Essay Question* 1 in the "**Test Your Understanding of Concepts and Principles"** section located at the end of chapter 13 and let me guide you through one possible answer. Watch for key terms in boldface type, helpful tips and general suggestions on writing the essay or short-answer questions. Enjoy!

114. Describe how the pacemaker cells produce a spontaneous *diastolic depolarization*, and how this leads to the production of action potentials**.**

Answer. During the resting period (diastole) of the heart, the fibers of the sinoatrial (SA) node region of the right atrium have unique channels that open in response to membrane *hyperpolarization* (approaching –60 mV) left over from the previous action potential. Since these channels are permeable to both Na^+ and K^+, the predominate entry of Na^+ results in the net depolarization of these pacemaker cells producing spontaneous diastolic depolarization. Once threshold is reached, voltage-gated Ca^{2+} channels in the plasma membrane open resulting in the influx of Ca^{2+} that produces the upward phase of the action potential tracing and also results in contraction of these myocardial cells. After the spike, voltage-gated K^+ channels open and the outward diffusion of K^+ produces repolarization of the membranes that once again approach –60 mV with hyperpolarization that follows to repeat the cycle. The term "spontaneous" refers to the inherent property of myocardial pacemaker cells to beat automatically and on their own without the assistance of nerves or hormones. This property is known as *automaticity.*

OK, now that wasn't so hard was it? Here are some more.

115. Draw and label two consecutive heart beats as recorded on the electrocardiogram (ECG). In sequence describe what occurs in the heart to create each electrical event. (*Hint*: This is a favorite test question!)

116. In three columns compare and contrast the structure and related functions of (a) arteries, (b) veins, and (c) lymph vessels. (*Hint*: Use a table format here, OK?)

117. Describe the first two events that occur when blood begins to clot starting from both the *intrinsic* pathway and the *extrinsic* pathway. State the important differences in these two pathways. Then, write the final *two* enzymatic steps in the formation of a fibrin clot (notice that these last steps are the same for both pathways).

118. Trace the recycling pathway of plasma fluid from capillary blood, through the extracellular (interstitial) spaces, its conversion to lymph fluid, and transport through lymph vessels to become part of blood once again. Name all structures involved and the forces (or pressures) that keep the fluids moving continuously. (*Hint*: Work slowly, this is difficult, but the result will give you an excellent overview of the lymphatic system.)

119. Describe the *ABO blood typing system* — including the genotypes responsible, the synthesis of A and B antigens from the DNA code, and the differences between the antibodies which are found in the plasma and the A and B antigens which are found on the red blood cell membrane.

Answers — Chapter 13

I. Functions and Components of the Circulatory System
   A. 1. a, 2. c, 3. b, 4. c,
   B. 5. T, 6. T, 7. F—Replace "excretory" with "circulatory"

II. Composition of the Blood
   A. 8. c, 9. b, 10. b, 11. d, 12. c, 13. a, 14. d, 15. e, 16. b, 17. e, 18. e, 19. b, 20. b, 21. c, 22. a, 23. d,
   B. 24. F—Replace "venous" with "arterial" and "blue" with "red," 25. T, 26. T, 27. F—Only gamma globulins are antibodies; alphas and betas transport lipids 28. T, 29. F—Replace "lymphocyte" with "neutrophil," 30. F—Replace "monocytes" with "lymphocytes," 31.F—Leukemia represents abnormal WBCs, 32. T, 33. T, 34. T, 35. T, 36. F—Replace "thromboxane A_s" with "prostacyclin," 37. T, 38. F—Switch "plasma" and "serum," 39. T

III. Structure of the Heart
   A. 40. a, 41. c, 42. d
   B. 43. T, 44. T, 45. F—Switch "right" and "left," 46. T
   C. 47. 6, 9, 11, 2, 7, 12, 10, 3, 1, 4, 8, 5
   D. Label the Figure — The Heart; See figure 13.11 in the text.

IV. Cardiac Cycle and Heart Sounds
   A. 48. c, 49. d, 50. a 51. c, 52. b
   B. 53. T, 54. F—Replace "systole" with "diastole," 55. F—Atrial contraction is *not* essential for life, 56. T, 57. T, 58. T, 59. F—Switch "right" and "left;" replace "higher" with "lower"

V. Electrical Activity of the Heart and the Electrocardiogram
   A. 60. e, 61. d, 62. b, 63. a, 64. d
   B. 65. F-Excitation-contraction starts in the atria; spreads by gap junctions to the ventricles, 66. F—Replace K with Na, 67. T, 68. T, 69. T, 70. T, 71. T, 72. T, 73. F—Replace "myosin" with "troponin," 74. T 75. F—Replace "short" with "long," 76. T, 77. F—The ECG represents total potential changes of *all* myocardial cells in the heart
   C. Label the Figure—The Conduction System of the Heart; See figure 13.20 in the text.

VI. Blood Vessels
   A. 78. b, 79. d, 80. c, 81. a, 82. d
   B. 83. T, 84. T, 85. T, 86. T, 87. T

VII. Atherosclerosis and Cardiac Arrhythmias
   A. 88. c, 89. c, 90. b, 91. c, 92. e
   B. 93. T, 94. T, 95. F—Replace "lymphocytes" with "monocytes," 96. T, 97. F—Replace "HDL" with "LDL" (twice), 98. T, 99. T, 100. F—Switch "LDL" and "HDL" 101. T, 102. T, 103. T, 104. F—myocardial necrosis is permanent, 105. F—Replace "third-degree, or complete AV block" with "ventricular fibrillation"

VIII. Lymphatic System
   A. 106. e, 107. c, 108. a, 109. b
   B. 110. T, 111. T, 112. F—Germinal centers produce lymphocytes, 113. T