

until birth. Shortly after birth, the bypass structures become blocked, and the special umbilical vessels stop functioning.



HOMEOSTATIC IMBALANCE

Congenital heart defects account for about half of infant deaths resulting from all congenital defects. Environmental interferences, such as maternal infection and ingested drugs during the first three months of pregnancy (when the embryonic heart is forming), seem to be the major causes of such problems. Congenital heart defects may include a ductus arteriosus that does not close, septal openings, and other structural abnormalities of the heart. Such problems can usually be corrected surgically. ▶

In the absence of congenital heart problems, the heart usually functions smoothly throughout a long lifetime for most people. Homeostatic mechanisms are so effective that we rarely are aware of when the heart is working harder. The heart will hypertrophy and its cardiac output will increase substantially if we exercise regularly and aerobically (that is, vigorously enough to force it to beat at a higher-than-normal rate for extended periods of time). The heart becomes not only a more powerful pump but also a more efficient one: pulse rate and blood pressure decrease. An added benefit of aerobic exercise is that it clears fatty deposits from the blood vessel walls, helping to slow the progress of atherosclerosis. However, let's raise a caution flag here: The once-a-month or once-a-year tennis player or snow shoveler has not built

up this type of heart endurance and strength. When such an individual pushes his or her heart too much, it may not be able to cope with the sudden demand. This is why many weekend athletes are myocardial infarction victims.

As we get older, more and more signs of cardiovascular system disturbances start to appear. In some, the venous valves weaken, and purple, snakelike varicose veins appear. Not everyone has varicose veins, but we all have progressive atherosclerosis. Some say the process begins at birth, and there's an old saying that goes, "You are only as old as your arteries," referring to this degenerative process. The gradual loss in elasticity in the blood vessels leads to hypertension and hypertensive heart disease. The insidious filling of the blood vessels with fatty, calcified deposits leads most commonly to **coronary artery disease**. Also, as described in Chapter 10, the roughening of the vessel walls encourages thrombus formation. At least 30 percent of the population in the United States has hypertension by the age of 50, and cardiovascular disease causes more than one-half of the deaths in people over age 65. Although the aging process itself contributes to changes in the walls of the blood vessels that can lead to strokes or myocardial infarctions, most researchers feel that diet, not aging, is the single most important contributing factor to cardiovascular diseases. There is some agreement that the risk is lowered if people eat less animal fat, cholesterol, and salt. Other recommendations include avoiding stress, eliminating cigarette smoking, and taking part in a regular, moderate exercise program.

Summary

➤ Access more review material and fun learning activities online—visit www.anatomyandphysiology.com and select Essentials of Human Anatomy & Physiology, 10th edition. In addition, references to Interactive Physiology are included below.

iP = Interactive Physiology

The Heart (pp. 357–370)

1. The heart, located in the thorax, is flanked laterally by the lungs and enclosed in a pericardium.
2. The bulk of the heart (myocardium) is composed of cardiac muscle. The heart has four hollow chambers—two atria (receiving chambers) and two ventricles (discharging chambers), each lined with endocardium. The heart is divided longitudinally by a septum.
 - iP** Cardiovascular System Topic: Anatomy Review: The Heart, pp. 3–5.
3. The heart functions as a double pump. The right heart is the pulmonary pump (right heart to lungs to left heart). The left heart is the systemic pump (left heart to body tissues to right heart).

- Four valves prevent backflow of blood in the heart. The AV valves (mitral and tricuspid) prevent backflow into the atria when the ventricles are contracting. The semilunar valves prevent backflow into the ventricles when the heart is relaxing. The valves open and close in response to pressure changes in the heart.

iP Cardiovascular System Topic: Cardiac Cycle, p. 3.

- The myocardium is nourished by the coronary circulation, which consists of the right and left coronary arteries and their branches, and is drained by the cardiac veins and the coronary sinus.
- Cardiac muscle is able to initiate its own contraction in a regular way, but its rate is influenced by both intrinsic and extrinsic factors. The intrinsic conduction system increases the rate of heart contraction and ensures that the heart beats as a unit. The SA node is the heart's pacemaker.

iP Cardiovascular System Topic: Intrinsic Conduction System, pp. 3–6.

- The time and events occurring from one heartbeat to the next are the cardiac cycle.
- As the heart beats, sounds resulting from the closing of the valves (“lub-dup”) can be heard. Faulty valves reduce the efficiency of the heart as a pump and result in abnormal heart sounds (murmurs).

iP Cardiovascular System Topic: Cardiac Cycle, pp. 4–10.

- Cardiac output, the amount of blood pumped out by each ventricle in one minute, is the product of heart rate (HR) \times stroke volume (SV). SV is the amount of blood ejected by a ventricle with each beat.
- SV rises or falls with the volume of venous return. HR is influenced by the nerves of the autonomic nervous system, drugs (and other chemicals), and ion levels in the blood.

Blood Vessels (pp. 370–391)

- Arteries, which transport blood from the heart, and veins, which carry blood back to the heart, are conducting vessels. Only capillaries play a role in actual exchanges with tissue cells.
- Except for capillaries, blood vessels are composed of three tunics: The tunica intima forms a friction-reducing lining for the vessel. The tunica media is the bulky middle layer of muscle and elastic tissue. The tunica externa is the protective, outermost connective tissue layer. Capillary walls are formed of the tunica intima only.

iP Cardiovascular System Topic: Anatomy Review: Blood Vessel Structure and Function, pp. 3–5.

- Artery walls are thick and strong to withstand pressure fluctuations. They expand and recoil as the heart beats. Vein walls are thinner; their lumens are larger, and they are equipped with valves. These modifications reflect the low-pressure nature of veins.

iP Cardiovascular System Topic: Anatomy Review: Blood Vessel Structure and Function, pp. 20–22.

- Capillary beds have two types of vessels—a vascular shunt and true capillaries, the entrances to which are guarded by precapillary sphincters. Exchanges with tissue cells occur across the walls of the true capillaries. When the precapillary sphincters are closed, blood bypasses the local area via the vascular shunt.
- Varicose veins, a structural defect due to incompetent valves, is a common vascular problem, especially in the obese and people who stand for long hours. It is a predisposing factor for thrombophlebitis.
- All the major arteries of the systemic circulation are branches of the aorta, which leaves the left ventricle. They branch into smaller arteries and then into the arterioles, which feed the capillary beds of the body tissues. For the names and locations of the systemic arteries, see pp. 374–375.
- The major veins of the systemic circulation ultimately converge on one of the venae cavae. All veins above the diaphragm drain into the superior vena cava, and those below the diaphragm drain into the inferior vena cava. Both venae cavae enter the right atrium of the heart. See pp. 376–377 for the names and locations of the systemic veins.
- The arterial circulation of the brain is formed by branches of paired vertebral and internal carotid arteries. The circle of Willis provides alternate routes for blood flow in case of a blockage in the brain's arterial supply.
- The fetal circulation is a temporary circulation seen only in the fetus. It consists primarily of three special vessels: the single umbilical vein that carries nutrient- and oxygen-laden blood to the fetus from the placenta, and the two umbilical arteries that carry carbon dioxide and waste-laden blood from the fetus to the placenta. Shunts bypassing the lungs and liver are also present.
- The hepatic portal circulation is formed by veins draining the digestive organs, which empty into the hepatic portal vein. The hepatic portal vein carries the nutrient-rich blood to the liver, where it is processed before the blood is allowed to enter the systemic circulation.

11. The pulse is the alternate expansion and recoil of a blood vessel wall (the pressure wave) that occurs as the heart beats. It may be felt easily over any superficial artery; such sites are called pressure points.
12. Blood pressure is the pressure that blood exerts on the walls of the blood vessels. It is the force that causes blood to continue to flow in the blood vessels. It is high in the arteries, lower in the capillaries, and lowest in the veins. Blood is forced along a descending pressure gradient. Both systolic and diastolic pressures are recorded.

iP Cardiovascular System Topic: Measuring Blood Pressure, pp. 3–8.

13. Arterial blood pressure is directly influenced by heart activity (increased heart rate leads to increased blood pressure) and by resistance to blood flow. The most important factors increasing the peripheral resistance are a decrease in the diameter or stretchiness of the arteries and arterioles and an increase in blood viscosity.
14. Many factors influence blood pressure, including the activity of the sympathetic nerves and kidneys, drugs, and diet.
15. Hypertension, which reflects an increase in peripheral resistance, strains the heart and damages blood vessels. In most cases, the precise cause is unknown.
16. Substances move to and from the blood and tissue cells through capillary walls. Some substances are transported in vesicles, but most move by diffusion—directly through the endothelial cell plasma membranes, through intercellular clefts, or through fenestrations. Fluid is forced from the bloodstream by blood pressure and drawn back into the blood by osmotic pressure.

Developmental Aspects of the Cardiovascular System (pp. 391–393)

1. The heart begins as a tubelike structure that is beating and pumping blood by the fourth week of embryonic development.
2. Congenital heart defects account for half of all infant deaths resulting from congenital problems.
3. Arteriosclerosis is an expected consequence of aging. Gradual loss of elasticity in the arteries leads to hypertension and hypertensive heart disease, and clogging of the vessels with fatty substances leads to coronary artery disease and stroke. Cardiovascular disease is an important cause of death in individuals over age 65.
4. Modifications in diet (decreased fats, cholesterol, and salt), stopping smoking, and regular aerobic

exercise may help to reverse the atherosclerotic process and prolong life.

Review Questions

Multiple Choice

More than one choice may apply.

1. Freshly oxygenated blood transported from the lungs is first received by the
 - a. right ventricle.
 - b. left ventricle.
 - c. right atrium.
 - d. left atrium.
2. Given an end-diastolic volume of 150 ml, an end-systolic volume of 50 ml, and a heart rate of 60 bpm, the cardiac output is
 - a. 600 ml/min.
 - b. 6 liters/min.
 - c. 1200 ml/min.
 - d. 3 liters/min.
3. Which of the following depolarizes next after the AV node?
 - a. Atrial myocardium
 - b. Ventricular myocardium
 - c. Bundle branches
 - d. AV bundle
4. During atrial systole,
 - a. the atrial pressure exceeds ventricular pressure.
 - b. 70 percent of ventricular filling occurs.
 - c. the AV valves are open.
 - d. valves prevent backflow into the great veins.
5. Atrial repolarization coincides in time with the
 - a. P wave.
 - b. T wave.
 - c. QRS wave.
 - d. P-Q interval.
6. Soon after the onset of ventricular systole, the
 - a. AV valves close.
 - b. semilunar valves open.
 - c. first heart sound is heard.
 - d. aortic pressure increases.
7. The base of the heart is its _____ surface.
 - a. diaphragmatic
 - b. superior
 - c. anterior
 - d. inferior
8. In comparing a parallel artery and vein, you would find that
 - a. the artery wall is thicker.
 - b. the artery diameter is greater.
 - c. the artery lumen is smaller.
 - d. the artery endothelium is thicker.

9. Which of these vessels is bilaterally symmetrical (i.e., one vessel of the pair occurs on each side of the body)?
 - a. Internal carotid artery
 - b. Brachiocephalic trunk
 - c. Azygos vein
 - d. Renal vein
10. A stroke that occludes a posterior cerebral artery will most likely affect
 - a. hearing.
 - b. vision.
 - c. smell.
 - d. higher thought processes.
11. Vessels involved in the circulatory pathway to and/or from the brain are the
 - a. brachiocephalic artery.
 - b. subclavian artery.
 - c. internal jugular vein.
 - d. internal carotid artery.
12. Which layer of the artery wall thickens most in atherosclerosis?
 - a. Tunica media
 - b. Tunica intima
 - c. Tunica adventitia
 - d. Tunica externa
13. Which of the following are associated with aging?
 - a. Increasing blood pressure
 - b. Weakening of venous valves
 - c. Arteriosclerosis
 - d. Collapse of the ductus arteriosus
14. An increase in BP would be caused by all of the following except
 - a. increase in SV.
 - b. increase in heart rate.
 - c. hemorrhage.
 - d. vasoconstriction of the arterioles.
15. The most external part of the pericardium is the
 - a. parietal layer of serous pericardium.
 - b. fibrous pericardium.
 - c. visceral layer of serous pericardium.
 - d. epicardium.
16. Which heart chamber pumps blood with the greatest amount of force?
 - a. Right atrium
 - b. Right ventricle
 - c. Left atrium
 - d. Left ventricle
17. How many cusps does the right atrioventricular valve have?
 - a. Two
 - b. Three
 - c. Four
 - d. Six

18. Which layer of the heart wall is an endothelium?
 - a. Endocardium
 - b. Myocardium
 - c. Epicardium
 - d. Pericardium

Short Answer Essay

19. Draw a diagram of the heart showing the three layers composing its wall and its four chambers. Label each. Show where the AV and semilunar valves are. Show and label all blood vessels entering and leaving the heart chambers.
20. Trace one drop of blood from the time it enters the right atrium of the heart until it enters the left atrium. What is this circuit called?
21. What is the function of the fluid that fills the pericardial sac?
22. Define *systole* and *diastole*.
23. Define *stroke volume* and *cardiac cycle*.
24. How does the heart's ability to contract differ from that of other muscles of the body?
25. Name the elements of the intrinsic conduction system, *in order*, beginning with the pacemaker.
26. Name three different factors that increase heart rate.
27. Name and describe from the inside out the three tunics making up the walls of arteries and veins, and give the most important function of each layer.
28. Describe the structure of capillary walls.
29. Why are artery walls so much thicker than those of corresponding veins?
30. Name three factors that are important in promoting venous return.
31. Arteries are often described as vessels that carry oxygen-rich blood, and veins are said to carry oxygen-poor (carbon dioxide-rich) blood. Name two sets of exceptions to this rule that were discussed in this chapter.
32. Trace a drop of blood from the left ventricle of the heart to the wrist of the right hand and back to the heart. Now trace it to the dorsum of the right foot and back to the right heart.
33. What is the function of the hepatic portal circulation? In what way is a portal circulation a "strange" circulation?
34. In a fetus, the liver and lungs are almost entirely bypassed by blood. Why is this? Name the vessel that bypasses the liver. Name two lung bypasses. Three vessels travel in the umbilical cord; which of these carries oxygen- and nutrient-rich blood?

35. Define *pulse*. Palpate your pulse. Which pulse point did you use?
36. Which artery is palpated at the front of the ear? At the back of the knee?
37. Define *systolic* pressure and *diastolic* pressure.
38. Two elements determine blood pressure—the cardiac output of the heart and the peripheral resistance, or friction, in the blood vessels. Name two factors that increase cardiac output. Name two factors that increase peripheral resistance.
39. In which position—sitting, lying down, or standing—is the blood pressure normally highest? Lowest? Explain why.
40. What is different about the capillary exchanges seen in a capillary with fenestrations and intercellular clefts and the exchanges seen in a capillary lacking those modifications?
41. What are varicose veins? What factors seem to promote their formation?
42. Explain why blood flow in arteries is pulsatile and blood flow in veins is not.
43. What is the relationship between cross-sectional area of a blood vessel and velocity (speed) of blood flow in that vessel?
44. Which type of blood vessel is most important in regulating vascular resistance, and how does it achieve this?
45. John is a 30-year-old male who is overweight and smokes. He has been diagnosed with *hypertension* and *arteriosclerosis*. Define each of these conditions. How are they often related? Why is hypertension called the “silent killer”? Name three changes in your lifestyle that might help prevent cardiovascular disease in your old age.
46. Mrs. Hamad, a middle-aged woman, is admitted to the coronary care unit with a diagnosis of left ventricular failure resulting from a myocardial infarction. Her chart indicates that she was awakened in the middle of the night by severe chest pain. Her skin is pale and cold, and moist sounds of pulmonary edema are heard over the lower regions of both lungs. Explain how failure of the left ventricle might cause these signs and symptoms.
47. Linda, a 14-year-old girl undergoing a physical examination before being admitted to summer camp, was found to have a loud heart murmur at the second intercostal space on the left side of the sternum. The murmur takes the form of a swishing sound with no high-pitched whistle. What, exactly, is producing the murmur?
48. Mrs. Johnson is brought to the emergency room after being involved in an auto accident. She is hemorrhaging and has a rapid, thready pulse, but her blood pressure is still within normal limits. Describe the compensatory mechanisms that are maintaining her blood pressure in the face of blood loss.
49. During a lethal heart attack, a blood clot lodges in the first part of the circumflex branch of the left coronary artery, blocking blood flow through this vessel. What parts of the heart will become ischemic and die?
50. Mr. Grimaldi was previously diagnosed as having a posterior pituitary tumor that causes hypersecretion of ADH. He comes to the clinic regularly to have his blood pressure checked. Would you expect his blood pressure to be chronically elevated or depressed? Why?
51. Grandma tells Suzy not to swim for 30 minutes after eating. Explain why taking a vigorous swim immediately after lunch is more likely to cause indigestion than cramping of your muscles.
52. The guards at the royal palace in London stand at attention while on duty. On a very hot day, it is not unusual for one (or more) to become lightheaded and faint. Explain this phenomenon.



Critical Thinking and Clinical Application Questions