Gross Anatomy of Blood Vessels

✓ Identify the body's major arteries and veins, and name the body region supplied by each.

Major Arteries of the Systemic Circulation

The **aorta** is the largest artery of the body, and it is a truly splendid vessel. In adults, the aorta is about the size of a garden hose (with an internal diameter about equal to the diameter of your thumb) where it issues from the left ventricle of the heart. It decreases only slightly in diameter as it runs to its terminus. Different parts of the aorta are named for either their location or their shape. The aorta springs upward from the left ventricle of the heart as the **ascending aorta,** arches to the left as the **aortic arch,** and then plunges downward through the thorax, following the spine **(thoracic aorta)** finally to pass through the diaphragm into the abdominopelvic cavity, where it becomes the **abdominal aorta** (Figure 11.13).

The major branches of the aorta and the organs they serve are listed next in sequence from the heart. Figure 11.13 shows the course of the aorta and its major branches. As you locate the arteries on the figure, be aware of ways to make your learning easier. In many cases the name of the artery tells you the body region or organs served (renal artery, brachial artery, and coronary artery) or the bone followed (femoral artery and ulnar artery).

Arterial Branches of the Ascending Aorta

- The only branches of the ascending aorta are the **right (R.)** and **left (L.) coronary arteries,** which serve the heart.

Arterial Branches of the Aortic Arch

- The **brachiocephalic** (bra″ke-o-se-fal′ik) **trunk** (the first branch off the aortic arch) splits into the **R. common carotid** (kah-ro′tid) **artery** and **R. subclavian** (sub-kla′ve-an) **artery.** (See same-named vessels on left side of body for organs served.)
- The **L. common carotid artery** is the second branch off the aortic arch. It divides, forming the **L. internal carotid,** which serves the brain, and the **L. external carotid,** which serves the skin and muscles of the head and neck.
- The third branch of the aortic arch, the **L. subclavian artery,** gives off an important branch—the **vertebral artery,** which serves part of the brain. In the axilla, the subclavian artery becomes the **axillary artery** and then continues into the arm as the **brachial artery,** which supplies the arm. At the elbow, the brachial artery splits to form the **radial** and **ulnar arteries,** which serve the forearm.

Arterial Branches of the Thoracic Aorta

- The *intercostal arteries* (ten pairs) supply the muscles of the thorax wall. Other branches of the thoracic aorta supply the lungs (*bronchial arteries*), the esophagus (*esophageal arteries*), and the diaphragm (*phrenic arteries*). These arteries are not illustrated in Figure 11.13.

Arterial Branches of the Abdominal Aorta

- The **celiac trunk** is the first branch of the abdominal aorta. It is a single vessel that has three branches: the L. gastric artery, which supplies the stomach; the splenic artery, which supplies the spleen; and the common hepatic artery, which supplies the liver.
- The unpaired **superior mesenteric** (mes″enter′ik) **artery** supplies most of the small intestine and the first half of the large intestine, or colon.
- The **renal** (R. and L.) **arteries** serve the kidneys.
- The **gonadal** (R. and L.) **arteries** supply the gonads. They are called the *ovarian arteries* in females (serving the ovaries) and the *testicular arteries* in males (serving the testes).
- The *lumbar arteries* (not illustrated in Figure 11.13) are several pairs of arteries serving the heavy muscles of the abdomen and trunk walls.
- The **inferior mesenteric artery** is a small, unpaired artery supplying the second half of the large intestine.
- The **common iliac** (R. and L.) **arteries** are the final branches of the abdominal aorta. Each divides into an **internal iliac artery,** which supplies the pelvic organs (bladder, rectum, and so on), and an **external iliac artery,** which enters the thigh, where it becomes the **femoral artery.** The femoral artery and its branch, the **deep artery of the thigh,** serve the thigh. At the knee, the femoral artery becomes the **popliteal artery,** which then splits into the **anterior** and **posterior tibial arteries,** which supply the leg and foot. The anterior tibial artery terminates in the **dorsalis pedis artery,** which via the **arcuate artery** supplies the dorsum of the foot. (The dorsalis pedis is often

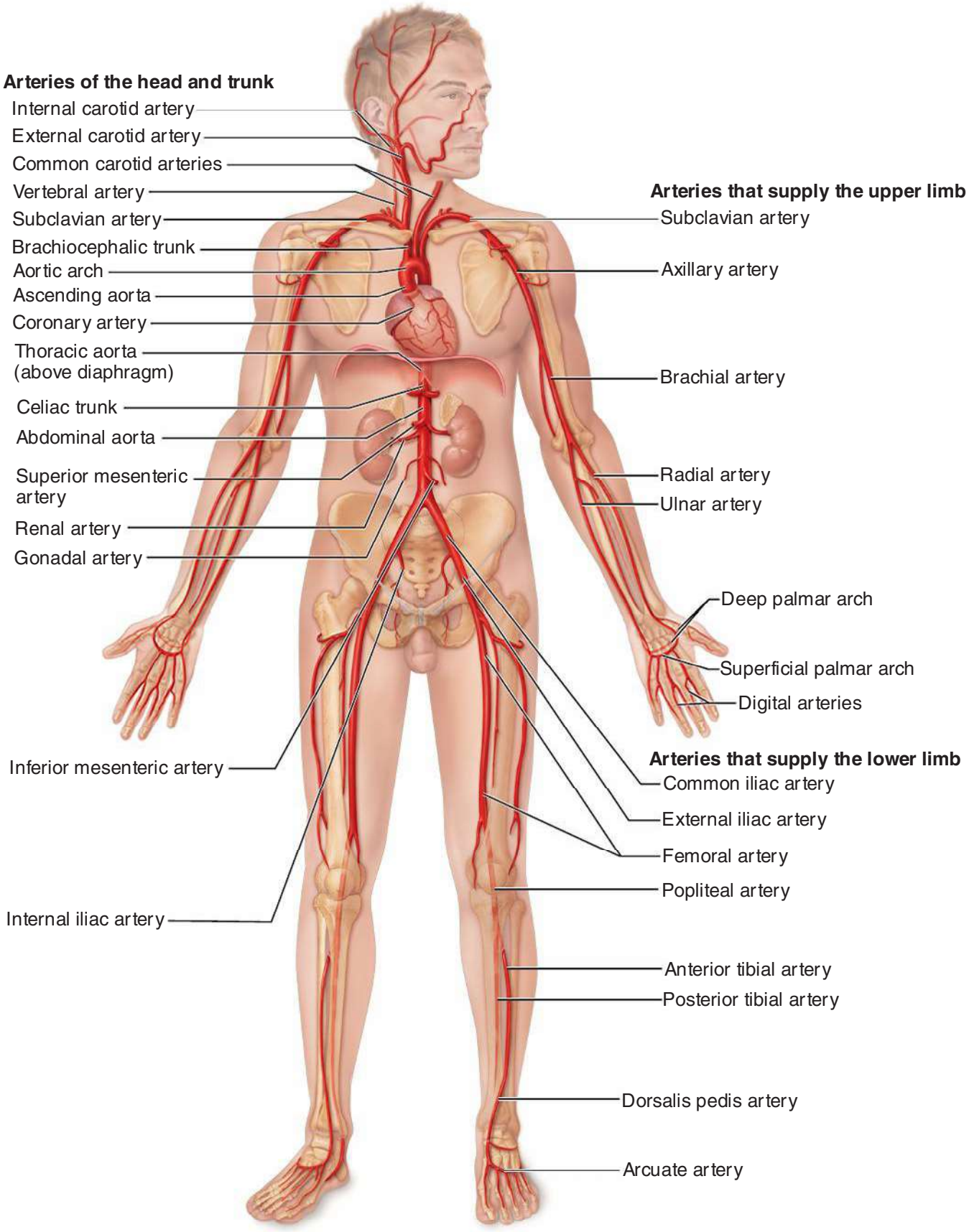


Figure 11.13 **Major arteries of the systemic circulation, anterior view.**

palpated in patients with circulatory problems of the legs to determine whether the distal part of the leg has adequate circulation.)

Major Veins of the Systemic Circulation

Although arteries are generally located in deep, well-protected body areas, many veins are more superficial, and some are easily seen and palpated on the body surface. Most deep veins follow the course of the major arteries, and with a few exceptions, the naming of these veins is identical to that of their companion arteries. Major systemic arteries branch off the aorta, whereas the veins converge on the venae cavae, which enter the right atrium of the heart. Veins draining the head and arms empty into the **superior vena cava,** and those draining the lower body empty into the **inferior vena cava.** These veins are described next and shown in **Figure 11.14**. As before, locate the veins on the figure as you read their descriptions.

Veins Draining into the Superior Vena Cava Veins draining into the superior vena cava are listed in a distal-to-proximal direction; that is, in the same direction the blood flows into the superior vena cava.

- The **radial** and **ulnar veins** are deep veins draining the forearm. They unite to form the deep **brachial vein,** which drains the arm and empties into the **axillary vein** in the axillary region.
- The **cephalic** (se-fal′ik) **vein** provides for the superficial drainage of the lateral aspect of the arm and empties into the axillary vein.
- The **basilic** (bah-sil′ik) **vein** is a superficial vein that drains the medial aspect of the arm and empties into the brachial vein proximally. The basilic and cephalic veins are joined at the anterior aspect of the elbow by the **median cubital vein.** (The median cubital vein is often chosen as the site for blood removal for the purpose of blood testing.)
- The **subclavian vein** receives venous blood from the arm through the axillary vein and from the skin and muscles of the head through the **external jugular vein.**
- The **vertebral vein** drains the posterior part of the head.
- The **internal jugular vein** drains the dural sinuses of the brain.
- The **brachiocephalic** (R. and L.) **veins** are large veins that receive venous drainage from the subclavian, vertebral, and internal jugular veins on their respective sides. The brachiocephalic veins join to form the superior vena cava, which enters the heart.
- The *azygos* (az′ĭ-gos) *vein* is a single vein that drains the thorax and enters the superior vena cava just before it joins the heart. (This vein is not illustrated in Figure 11.14.)

Veins Draining into the Inferior Vena Cava The inferior vena cava, which is much longer than the superior vena cava, returns blood to the heart from all body regions below the diaphragm. As before, we will trace the venous drainage in a distal-to-proximal direction.

- The **anterior** and **posterior tibial veins** and the **fibular vein** drain the leg (calf and foot). (The fibular vein is not shown in Figure 11.14.) The posterior tibial vein becomes the **popliteal vein** at the knee and then the **femoral vein** in the thigh. The femoral vein becomes the **external iliac vein** as it enters the pelvis.
- The **great saphenous** (sah-fe′nus) **veins** are the longest veins in the body. They receive the superficial drainage of the leg. They begin at the **dorsal venous arch** in the foot and travel up the medial aspect of the leg to empty into the femoral vein in the thigh.
- Each **common iliac** (R. and L.) **vein** is formed by the union of the **external iliac vein** and the **internal iliac vein** (which drains the pelvis) on its own side. The common iliac veins join to form the inferior vena cava, which then ascends superiorly in the abdominal cavity.
- The **R. gonadal vein** drains the right ovary in females and the right testicle in males. (The **L. gonadal vein** empties into the left renal vein superiorly.) (The gonadal veins are not illustrated in Figure 11.14.)
- The **renal** (R. and L.) **veins** drain the kidneys.
- The **hepatic portal vein** is a single vein that drains the digestive tract organs and carries this blood through the liver before it enters the systemic circulation. (We discuss the hepatic portal circulation in the next section.)
- The **hepatic** (R. and L.) **veins** drain the liver.

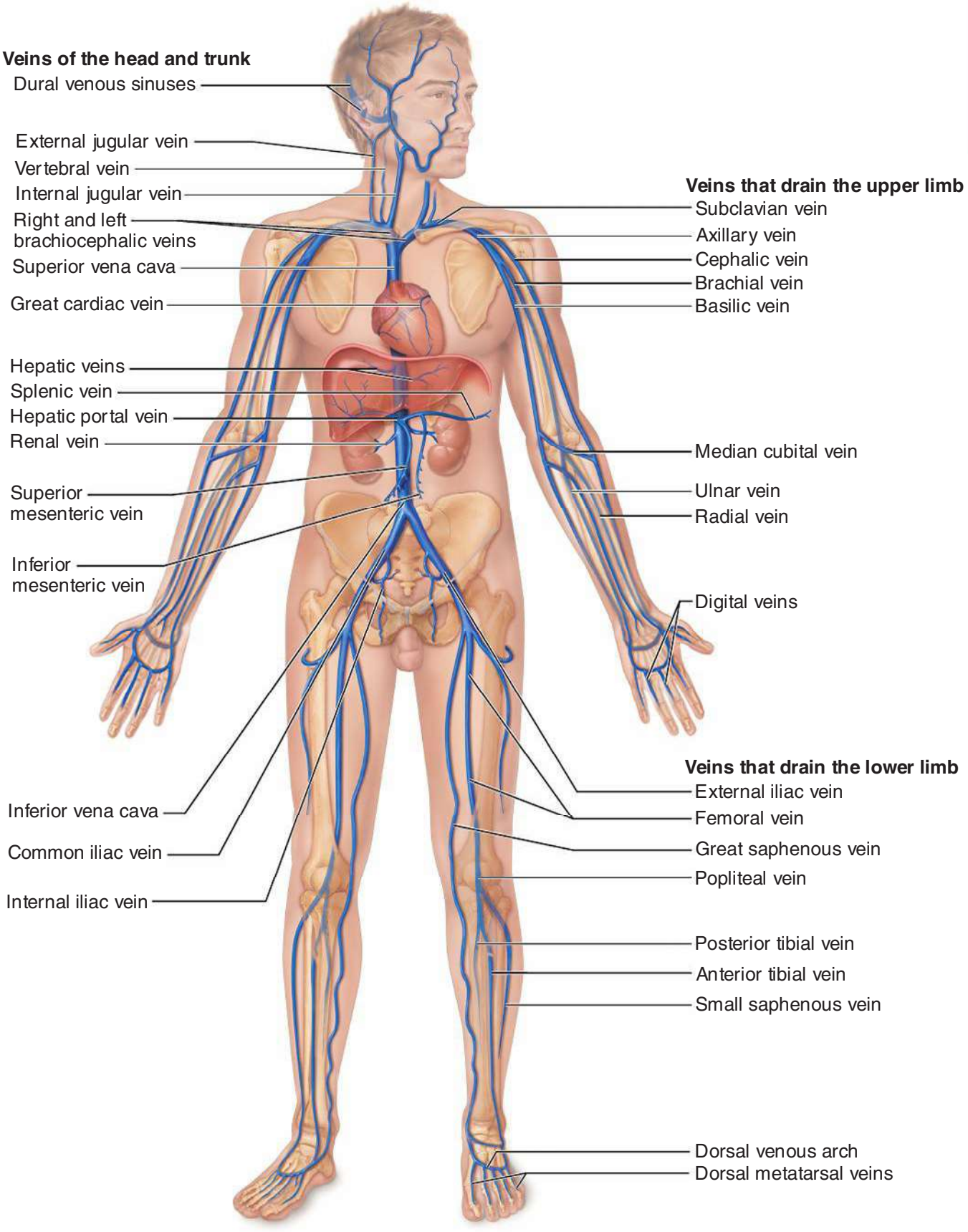


Figure 11.14 Major veins of the systemic circulation, anterior view. The vessels of the pulmonary circulation are not illustrated, accounting for the incomplete appearance of the circulation from the heart.

Focus on CAREERS

Certified Surgical Technologist (CST)

Surgical technologists use their knowledge of anatomy to assist surgeons in the operating room.

Ask Nathan Williams what it takes to be a good surgical technologist, and he will list several key qualities. "Attention to detail is crucial," he says. "You have to be methodical, orderly, and cool. There is a lot of stress in the operating room, and surgeons are under tremendous pressure. You have to remain calm and do your job well, so the surgeons can do theirs."

Surgical technologists (sometimes called surgical technicians) are allied health professionals who work under the supervision of a surgeon. They make sure that the operating room environment is safe, the equipment functions properly, and procedures are conducted safely. Surgical technologists combine their knowledge of anatomy, surgical procedures, and surgical tools and technologies to facilitate a physician's performance in the operating room.

Says Williams, "My primary job is to maintain the sterility of the operating room environment. I start the day by setting up a sterile field—that is, I carefully open sealed surgical instruments and lay them out in an orderly fashion to prepare for each procedure. I try to anticipate everything the surgeon will need during that operation. Everything remains sterile until the end of the procedure, when I assist the patient onto a stretcher. After that, I sort out instruments for decontamination and remove my surgical gown and gloves. If this sterile environment is compromised, it can have devastating effects because the patient is contaminated. The most common result is a staph infection—an infection by *Staphylococcus* bacteria that can be life-threatening."

Careers

Another big part of Williams's job is anticipating the surgeon's next move. "I'm the surgeon's extra eyes and ears, and I have to be alert and stay a step ahead at all times. This is where my training in anatomy is crucial, because I have to be aware of which body tissues surgeons will encounter next. For instance, when they work in areas where there are lots of blood vessels, I always keep a clamp handy to stop bleeding. As another example, there are many types of forceps, some with smooth edges and some with teeth. During the initial incision, surgeons need forceps with teeth because they handle skin most effectively. But after surgeons pierce through the skin and enter the body, I have to be sure to hand them only the smooth type, because forceps with teeth could puncture internal organs."

Surgical technologists must complete an accredited training program, usually 9 to 12 months long, and including at least 900 classroom and clinical hours. Then they must pass a national exam to be certified for a six-year period.

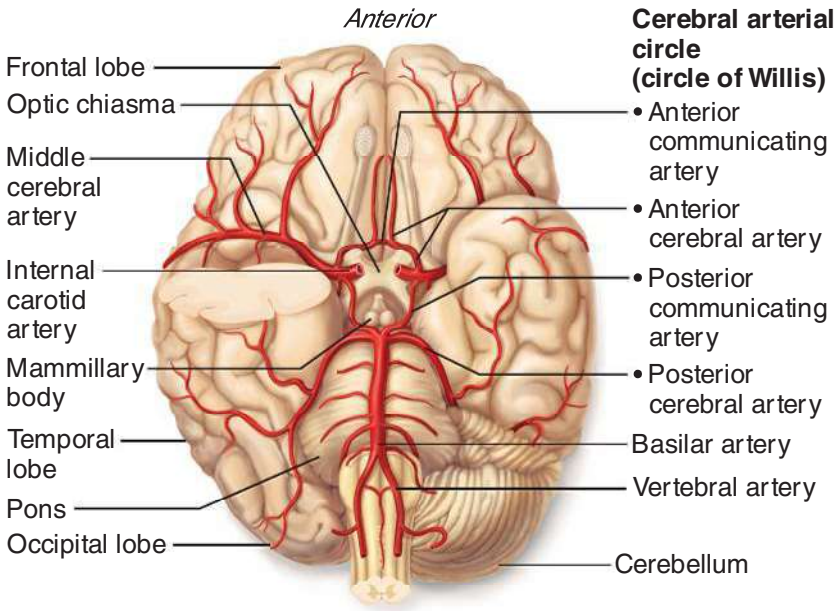
I'm the surgeon's extra eyes and ears . . . This is where my training in anatomy is crucial.

They can renew certification by earning continuing education credits or by retesting. Accreditation procedures vary from state to state.

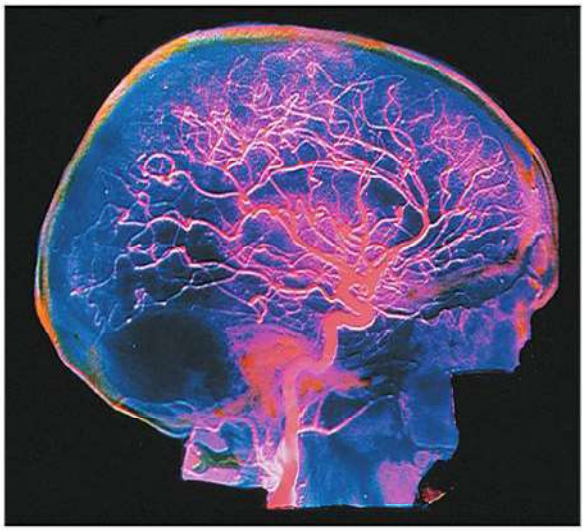
For more information, contact the Association of Surgical Technologists:

6 West Dry Creek Circle, Suite 200
Littleton, CO 80120-8031
Telephone: (303) 694-9130
FAX: (303) 694-9169
http://www.ast.org

For additional information on this career, click the Focus on Careers link at **www.anatomyandphysiology.com.**



(a)



(b)

Figure 11.15 **Arterial supply of the brain.** **(a)** Major arteries of the brain. (Cerebellum is shown only on the left side of the brain.) **(b)** Colorized arteriograph of the brain's arteries.

DID YOU GET IT?

15. In what part of the body are the femoral, popliteal, and arcuate arteries found?

16. In what part of the body are the axillary, cephalic, and basilic veins located?

For answers, see Appendix D.

Special Circulations

✓ Discuss the unique features of the arterial circulation of the brain, fetal circulation, and hepatic portal circulation.

Arterial Supply of the Brain and the Circle of Willis Because a lack of blood for even a few minutes causes the delicate brain cells to die, a continuous blood supply to the brain is crucial. The brain is supplied by two pairs of arteries, the internal carotid arteries and the vertebral arteries (**Figure 11.15**).

The **internal carotid arteries,** branches of the common carotid arteries, run through the neck and enter the skull through the temporal bone. Once inside the cranium, each divides into the

anterior and **middle cerebral arteries,** which supply most of the cerebrum.

The paired **vertebral arteries** pass upward from the subclavian arteries at the base of the neck. Within the skull, the vertebral arteries join to form the single **basilar artery.** This artery serves the brain stem and cerebellum as it travels upward. At the base of the cerebrum, the basilar artery divides to form the **posterior cerebral arteries,** which supply the posterior part of the cerebrum.

The anterior and posterior blood supplies of the brain are united by small *communicating arterial branches.* The result is a complete circle of connecting blood vessels called either the **cerebral arterial circle** or the **circle of Willis,** which surrounds the base of the brain. The cerebral arterial circle protects the brain by providing more than one route for blood to reach brain tissue in case of a clot or impaired blood flow anywhere in the system.

Fetal Circulation Because the lungs and digestive system are not yet functioning in a fetus, all nutrient, excretory, and gas exchanges occur through the placenta. Nutrients and oxygen move from the mother's blood into the fetal blood, and fetal wastes move in the opposite direction. As shown in **Figure 11.16**, the *umbilical cord* contains three blood vessels: one large **umbilical vein** and two smaller **umbilical arteries.** The umbilical vein carries blood rich in nutrients and oxygen to the fetus. The umbilical arteries carry carbon dioxide and debris-laden blood from the fetus to the placenta. As blood flows superiorly toward the heart of the fetus, most of it bypasses the immature liver through the **ductus venosus** (duk′tus ve-no′sus) and enters the inferior vena cava, which carries the blood to the right atrium of the heart.

Because fetal lungs are nonfunctional and collapsed, two shunts see to it that they are almost entirely bypassed. Some of the blood entering the right atrium is shunted directly into the left atrium through the **foramen ovale** (fo-ra′men o-val′e), a flaplike opening in the interatrial septum. Blood that does manage to enter the right ventricle is pumped out the pulmonary trunk, where it meets a second shunt, the **ductus arteriosus** (ar-ter″e-o′sus), a short vessel that connects the aorta and the pulmonary trunk. Because the collapsed lungs are a high-pressure area, blood tends to enter the systemic circulation through the ductus arteriosus. The aorta carries blood to the tissues of the fetal body and ultimately back to the placenta through the umbilical arteries.

At birth, or shortly after, the foramen ovale closes. Its remnant, the **fossa ovalis,** is visible in the right atrium (see Figure 11.3b). The ductus arteriosus collapses and is converted to the fibrous **ligamentum arteriosum** (lig″ah-men′tum arter″e-o′sum) (see Figure 11.3a). As blood stops flowing through the umbilical vessels, they become obliterated, and the circulatory pattern converts to that of an adult.

Hepatic Portal Circulation The veins of the **hepatic portal circulation** drain the digestive organs, spleen, and pancreas and deliver this blood to the liver through the **hepatic portal vein** (**Figure 11.17**). When you have just eaten, the hepatic portal blood contains large amounts of nutrients. Because the liver is a key body organ involved in maintaining the proper glucose, fat, and protein concentrations in the blood, this system "takes a detour" to ensure that the liver processes these substances before they enter the systemic circulation. As blood flows slowly through the liver, some of the nutrients are removed to be stored or processed in various ways for later release to the blood. The liver is drained by the hepatic veins that enter the inferior vena cava. Like the portal circulation that links the hypothalamus of the brain and the anterior pituitary gland (see Chapter 9), the hepatic portal circulation is a unique and unusual circulation. Normally, arteries feed capillary beds, which in turn drain into veins. Here we see *veins* feeding the liver circulation (Figure 11.17).

The major vessels composing the hepatic portal circulation (**Figure 11.18**) include the inferior and superior mesenteric veins, the splenic vein, and the left gastric vein. The **inferior mesenteric vein,** draining the terminal part of the large intestine, drains into the **splenic vein,** which itself drains the spleen, pancreas, and the left side of the stomach. The splenic vein and **superior mesenteric vein** (which drains the small intestine and the first part of the colon) join to form the hepatic portal vein. The **L. gastric vein,** which drains the right side of the stomach, drains directly into the hepatic portal vein.

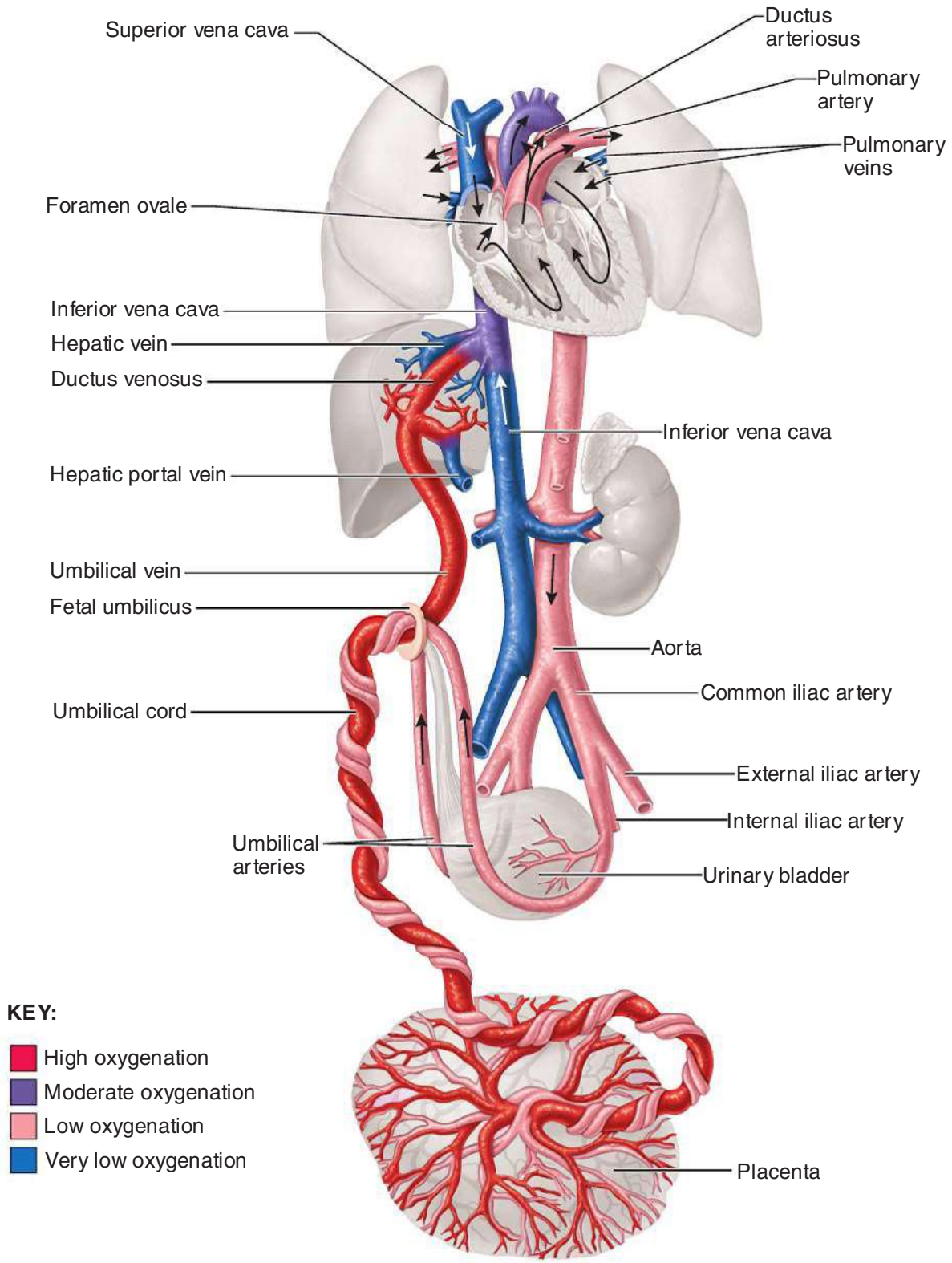


Figure 11.16 **Schematic of the fetal circulation.**

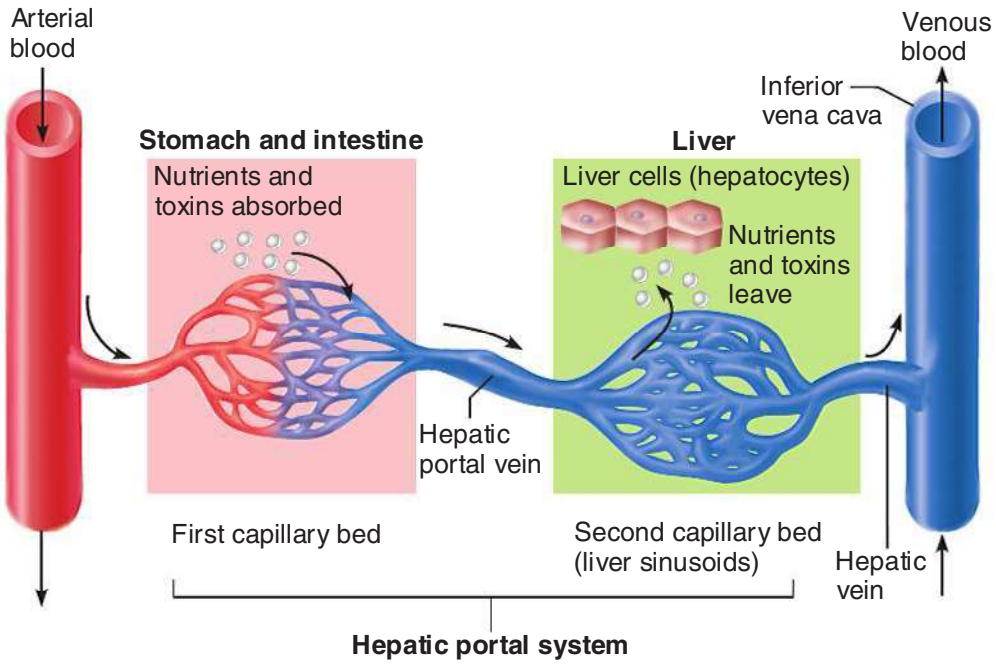


Figure 11.17 **The basic scheme of the hepatic portal system.** Note the presence of two capillary beds within the portal system. Nutrients and toxins picked up from capillaries in the stomach and intestine are transported to the liver for processing. From the liver sinusoids, the blood continues into the hepatic veins and inferior vena cava.

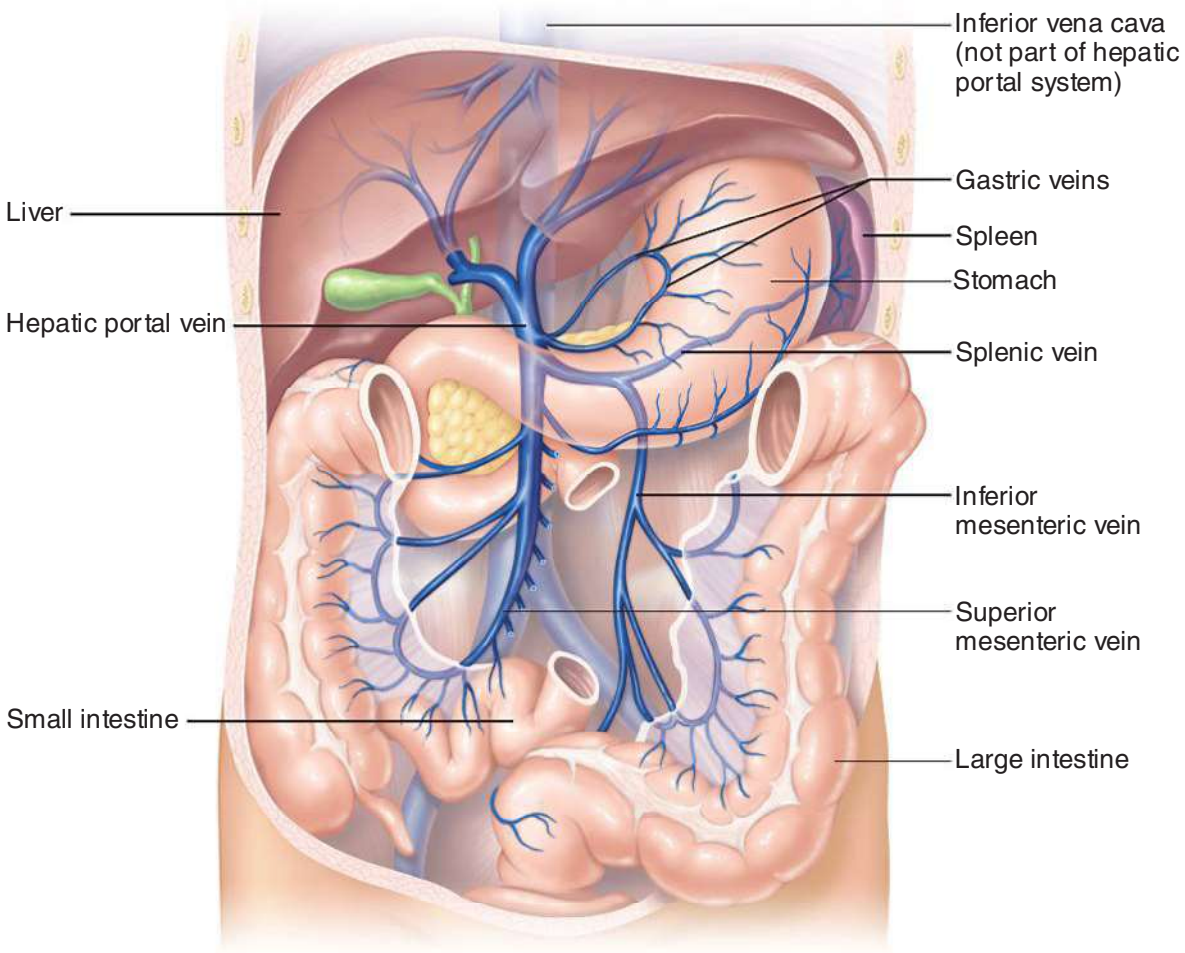


Figure 11.18 **The hepatic portal circulation.**

DID YOU GET IT?

17. Which vessel—the hepatic portal vein, hepatic vein, or hepatic artery—has the highest content of nutrients after a meal?

18. In what two important ways is the pulmonary circulation different from the systemic circulation?

19. What is the ductus venosus, and what is its function?

For answers, see Appendix D.

Physiology of Circulation

✓ Define *pulse,* and name several pulse points.

A fairly good indication of the efficiency of a person's circulatory system can be obtained by taking arterial pulse and blood pressure measurements. These measurements, along with those of respiratory rate and body temperature, are referred to collectively as **vital signs** in clinical settings.

Arterial Pulse

The alternating expansion and recoil of an artery that occurs with each beat of the left ventricle creates a pressure wave—a **pulse**—that travels through the entire arterial system. Normally the pulse rate (pressure surges per minute) equals the heart rate (beats per minute). The pulse averages 70 to 76 beats per minute in a normal resting person. It is influenced by activity, postural changes, and emotions.

You can feel a pulse in any artery lying close to the body surface by compressing the artery against firm tissue; this provides an easy way of counting heart rate. Because it is so accessible, the point where the radial artery surfaces at the wrist (the radial pulse) is routinely used to take a pulse measurement, but there are several other clinically important arterial pulse points (**Figure 11.19**). Because these same points are compressed to stop blood flow into distal tissues during hemorrhage, they are also called **pressure points.** For example, if you seriously cut your hand, you can stop the bleeding somewhat by compressing the brachial artery.

- Palpate each of the pulse points shown in Figure 11.19 by placing the tips of your first two or three fingers of one hand over the artery at the site indicated. Do not use your thumb because it has its own pulse. Compress the artery firmly as you begin and then immediately ease up on your pressure slightly. In each case, notice the regularity and relative strength of the pulse.

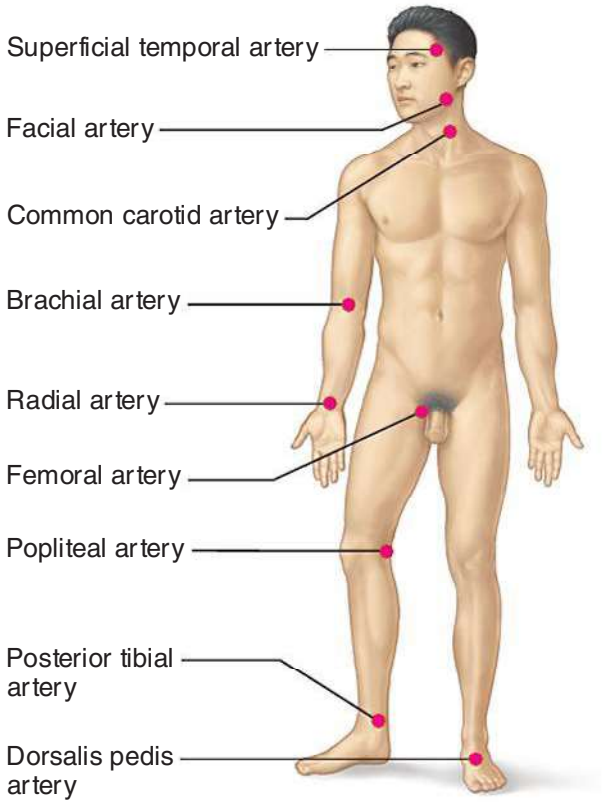


Figure 11.19 Body sites where the pulse is most easily palpated. (The specific arteries indicated are discussed on p. 374.)

DID YOU GET IT?

20. Which artery is palpated at the wrist? At the groin? At the side of the neck?

For the answer, see Appendix D.

Blood Pressure

✓ Define *blood pressure,* and list factors affecting and/or determining blood pressure.

✓ Define *hypertension* and *atherosclerosis,* and describe possible health consequences of these conditions.

Any system equipped with a pump that forces fluid through a network of closed tubes operates under pressure, and the closer the pump, the higher the pressure. **Blood pressure** is the pressure the blood exerts against the inner walls of the blood vessels, and it is the force that keeps blood circulating continuously even between heartbeats.