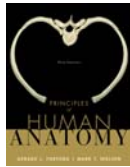


Chapter 15

The Cardiovascular System: Blood Vessels



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Introduction

- The vessels form an extensive system of tubular roadways that carry blood away from the heart toward the tissues, small permeable vessels at the tissue level exchanges, O_2 and nutrient and waste pickup, are made between the blood and surrounding cells.
- This circular pattern of flow to and from the heart constitutes the vascular (blood vessel) component of the cardiovascular system.
- This system of tubular is so extensive that, if all of the individual vessels were placed end- to-end, they would conservatively extend about 75,000 miles, about three times around the earth.

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Anatomy of Blood Vessels

- The five main types of blood vessels are arteries, arterioles, capillaries, venules, and veins.
- **Arteries** carry blood away from the heart to other organs.
- Small arteries called **arterioles**, enter a tissue, and they branch into a myriad of tiny vessels called **capillaries**.
- The thin walls of capillaries allow exchange of substances between the blood and body tissues.
- Capillaries within a tissue reunite to form small veins called **venules**.
- These in turn merge to form progressively larger blood vessels called veins.
- **Veins** are the blood vessels that convey blood from the tissues back to the heart.

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Comparative Structure of a Blood Vessel (Fig. 15.1)

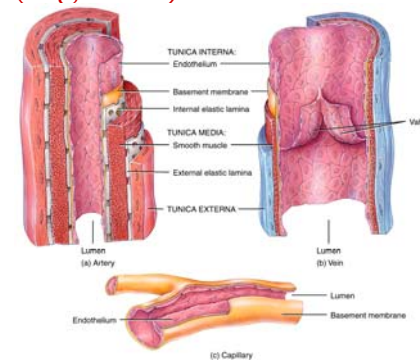


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Tunica Interna (Intima)

- The **tunica interna (intima)**: forms the inner lining of a blood vessel and is in direct contact with the blood.
- Compose of simple squamous epithelium, called **endothelium**, which is continuous with the endocardial lining of the heart.
- Provides a physical support base for the epithelial layer. The collagen fibers affords the basal lamina significant tensile strength, and resilience for stretching and recoil.
- The basal lamina anchors the endothelium to the underlying connective tissue while also regulating molecular movement.
- The outermost part of the tunica interna, which forms the boundary between the tunica interna and tunica media, is the **internal elastic lamina**.

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Tunica Media

- The **tunica media** is a muscular and connective tissue layer that displays the greatest variation among the different vessel types.
- In most vessels, it is a relatively thick layer comprised mainly of smooth muscle cells and substantial amounts of elastic fibers.
- The primary role of the smooth muscle cells, which extend circularly around the lumen is to regulate the diameter of the lumen wall.
- The smooth muscle contraction is crucial in the regulation of blood pressure blood flow and limit loss of blood through the injured vessel, and help produce the elastic fibers within the tunica media that allow the vessels to stretch and recoil under the applied pressure of the blood.

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Tunica Externa

- The outer covering of a blood vessel, the **tunica externa** consists of elastic and collagenous fibers.
- It ranges from a thin connective tissue wrapping to the thickest layer of the blood vessel.
- Separating the tunica externa from the tunica media is a less prominent network of elastic fibers, the **external elastic lamina**.
- **The tunica externa** contains numerous nerves and, especially in larger vessels, tiny blood vessels that supply the tissue of the vessel wall.
- These small vessels that supply blood to the tissues of the vessel are called **vasa vasorum, or vessels to the vessels**.
- They are easily seen on large vessels such as the aorta

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Arteries

- Have high **compliance**, meaning their walls stretch easily or expand without tearing in response to a small increase in pressure.
- An increase in sympathetic stimulation typically stimulates the smooth muscle to contract, squeezing the vessel wall and narrowing the lumen.
- A decrease in the diameter of the lumen of a blood vessel is called **vasoconstriction**.
- In contrast, when **sympathetic stimulation** decreases, or in the presence of nitric oxide, H⁺, and lactic acid, smooth muscle fibers relax. Resulting increase in lumen diameter is called **vasodilation**.

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Elastic Arteries

- The largest arteries in the body are called **Elastic arteries**
- They have the largest diameter among arteries.
- Have well defined internal and external elastic laminae, with a thick tunica media dominated by elastic fibers, the **elastic lamellae**.
- **The elastic lamellae** give the wall a yellowish tint.
- Elastic arteries include the aorta and the pulmonary trunk, and the brachiocephalic, subclavian, common carotid, and common iliac arteries.
- They propel blood onward while the ventricles are relaxing.
- The elastic fibers momentarily store mechanical energy, functioning as a **pressure reservoir**.
- **The elastic fibers recoil and convert** stored (potential) energy in the vessel into kinetic energy of the blood.

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Muscular Arteries

- Medium-sized arteries are called **muscular arteries** they contains more smooth muscle and fewer elastic fibers.
- Capable of greater vasoconstriction and vasodilation to adjust the rate of blood flow.
- Have a well-defined internal elastic lamina, but a thin external elastic lamina.
- Because of the reduced amount of elastic tissue in the walls, these vessels do not have the ability to recoil and help propel the blood like the elastic arteries.
- The thick, muscular tunica media is primarily responsible for the functions of the muscular arteries.
- The ability of the muscle to contract and maintain a state of partial contraction is referred to as **vascular tone**.

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Anastomoses

- Most tissues of the body receive blood from more than one artery.
- The union of the branches of two or more arteries supplying the same body region is called an **anastomosis**.
- The alternate route of blood flow to a body part through an anastomosis is known as **collateral circulation**.
- **Anastomoses** may also occur between veins and between arterioles and venules.
- Arteries that do not anastomose are known as **end arteries**.
- **Obstruction** of an end artery interrupts the blood supply to a whole segment of an organ, producing necrosis (death) of that segment.
- Alternate blood routes may also be provided by nonanastomosing vessels that supply the same region of the body.

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Arterioles

- **Arterioles** are microscopic vessels that regulate the flow of blood into the capillary networks of the body's tissues.
- The approximately 400 million arterioles have diameters that range in size from 30 μ m to 15 μ m.
- The tunica media consists of one to two layers of smooth muscle cells having a circular orientation in the vessel wall.
- The terminal end of the arteriole, the region called the **Metarteriole**.
- At the metarteriole–capillary junction, **precapillary sphincter**, monitors the blood flow into the capillary;
- Arterioles play a key role in regulating blood flow from arteries into capillaries by regulating resistance, they are known as **resistance vessels**.

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Arterioles, Capillaries, and Venules (Fig. 15.2)

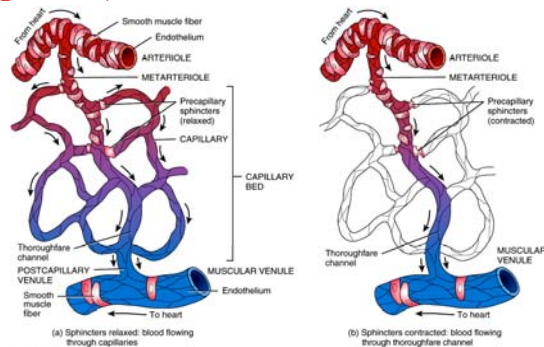


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Capillaries

- **Capillaries**, the smallest of blood vessels, have diameters of 5–10 mm.
- Blood cells have a diameter of 8 mm,
- Capillaries form an extensive network, approximately 20 billion in number, of short, branched, interconnecting vessels that course among the individual cells of the body.
- The flow of blood from a metarteriole through capillaries and into a **postcapillary venule**.
- The primary function of capillaries is the exchange of substances between the blood and interstitial fluid.
- Capillaries are found near almost every cell in the body, but their number varies with the metabolic activity of the tissue they serve.

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The body contains 3 different types of capillaries:

1. **Continuous capillaries:** in which the plasma membranes of endothelial cells form a **continuous tube** that is interrupted only by intercellular clefts, gaps between neighboring endothelial cells. Found in the brain, skeletal and smooth muscle, connective tissues, and the lungs.
2. **Fenestrated capillaries:** The plasma membranes of the endothelial cells in these capillaries have many **fenestrations, small pores** ranging from 70 to 100 nm in diameter. Found in the kidneys, villi of the small intestine, choroid plexuses of the ventricles in the brain, ciliary processes of the eyes, and endocrine glands.
3. **Sinusoids: wider and more winding than** other capillaries. Their endothelial cells may have unusually large fenestrations. In addition to having an incomplete or absent basement membrane, sinusoids have very large intercellular clefts that allow proteins and in some cases even blood cells to pass from a tissue into the bloodstream.

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Types of Capillaries (Fig. 15.3)

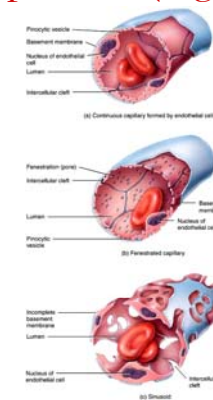


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Venules

- **Venules** and veins have thin walls that do not readily maintain their shape.
- Venules drain the capillary blood and begin the return flow of blood back toward the heart .
- Venules that initially receive blood from capillaries are called **postcapillary venules**.
- They are the smallest venules, measuring 10 mm to 50 mm in diameter and have loosely organized intercellular junctions and thus are very porous.
- Function as significant sites of exchange of nutrients and wastes and white blood cell emigration.
- The postcapillary venules continue to enlarge, they acquire one or two layers of circularly arranged smooth muscle cells.
- These **muscular venules (50 mm to 200 mm) have thicker walls** and exchanges with the interstitial fluid can no longer occur.

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Veins

- Veins range in size from 0.5 mm in diameter for small veins to 3 cm in the large caval veins entering the heart.
- Veins have the same essential three layers as arteries: The tunica interna is thinner; the tunica media is much thinner than in arteries, with little smooth muscle and elastic fibers. The tunica externa of a vein is its thickest layer and consists of collagen and elastic fibers.
- Veins lack the external or internal elastic laminae. They are distensible enough to adapt to variations in the volume and pressure of blood passing through them, but are not designed to withstand high pressure.
- The lumen of a vein is larger, and often collapsed when sectioned.
- The pumping action of the heart is a major factor in moving venous blood back to the heart. The contraction of skeletal muscles in the free lower limbs also helps boost venous return to the Heart. The average blood pressure in veins is considerably lower than in arteries.

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Veins

- Many veins, especially those in the free limbs, contain **valves**, thin folds of tunica interna that form flaplike cusps.
- The valve cusps project into the lumen, pointing toward the heart. The low blood pressure in veins allows blood returning to the heart to slow and even back up; the valves aid in venous return by preventing the backflow of blood.
- A **vascular (venous) sinus** is a vein with a thin endothelial wall that has no smooth muscle to alter its diameter. The surrounding dense connective tissue replaces the tunica media and tunica externa in providing support.
- Example of a vascular sinus is the coronary sinus of the heart.
- Veins are more numerous than arteries.

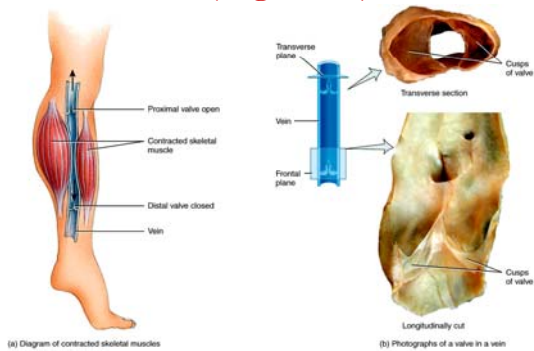
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Blood Distribution

- The largest portion of your blood volume at rest about 64% is in systemic veins and venules.
- Systemic arteries hold about 13% of the blood volume, systemic capillaries hold about 7%, pulmonary blood vessels hold about 9%, and the heart holds about 7%.
- Veins and venules, function as blood reservoirs from which blood can be diverted quickly if the need arises.
- For example, when there is increased muscular activity, the cardiovascular center in the brain stem sends more sympathetic impulses to veins. The result is **venoconstriction**, constriction of veins, which reduces the volume of blood in reservoirs and allows a greater blood volume to flow to skeletal muscles.

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Skeletal Muscle Contractions and Venous Valves (Fig. 15.4)



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Circulatory Routes

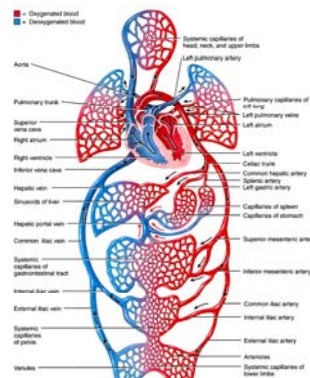
- The **circulatory routes** for blood flow are parallel.
- Each organ receives its own supply of freshly oxygenated blood.

The two basic routes for blood flow:

- **The systemic circulation** includes all the arteries and arterioles that carry oxygenated blood from the left ventricle to systemic capillaries.
- **The pulmonary circulation** carries deoxygenated blood from the right ventricle to the air sacs within the lungs and returns oxygenated blood from the air sacs to the left atrium.

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Circulatory Routes (Fig. 15.5)



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Systemic Circulation

- The systemic circulation carries oxygen and nutrients to body tissues and removes carbon dioxide and other wastes and heat from the tissues. All systemic arteries branch from the aorta.
- Deoxygenated blood returns to the heart through the systemic veins. All the veins of the systemic circulation drain into the **superior vena cava, inferior vena cava, or coronary sinus, which in turn empty into the right atrium.**
- The blood vessels are organized in the exhibits according to regions of the body.
- Blood returns to the heart from the systemic route, it is pumped out of the right ventricle through the **pulmonary circulation** to the lungs.

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