atrium and left ventricle. The *tricuspid* valve separates the right atrium and right ventricle. The *pulmonic* valve separates the right ventricle and pulmonary artery. The *aortic* valve separates the left ventricle and aorta.

Conduction System

The heart contains special cells that can carry electrical impulses much more rapidly than ordinary muscle fibers. This special conduction system consists of the sinoatrial (SA) node, the atrioventricular node, bundle of His, right and left bundle branches, and Purkinje fibers. The SA node, the normal pacemaker of the heart, generates a burst of electrical energy approximately 60 to 100 times each minute under normal circumstances. The electrical current flows over the heart in an orderly way to produce contraction of both atria, then both ventricles.

A unique characteristic of the heart is that any cell in any chamber can generate its own electrical impulse to contract. For example, the ventricles can beat independently, but at a rate of less than 40 beats per minute. This provides a backup mechanism should the SA node fail to fire, with an inherent rate that does not compete with SA node firing. In addition, the heart does not require nervous stimulation to contract. However, the autonomic nervous system does influence heart rate. Sympathetic nerves increase heart rate (through the release of epinephrine and norepinephrine); parasympathetic nerves (by way of the vagus nerve) decrease heart rate.

Blood Supply

The heart receives its blood supply from the coronary arteries. Coronary arteries branch off the aorta at the aortic valve and fill during *diastole,* the resting or filling phase of the cardiac cycle. Coronary arteries branch into smaller arteries that supply specific parts of the myocardium, without an overlapping supply from other arterial branches. However, artery-to-artery anastomoses occur between many adjacent vessels. These anastomotic arteries may not supply sufficient blood to the heart if a major artery is suddenly occluded, but they may dilate to considerable size when disease (usually coronary atherosclerosis) develops slowly. The resultant *collateral circulation* may provide a sufficient blood supply for myocardial function, at least during rest.

BLOOD VESSELS

There are three types of blood vessels, arteries, veins, and capillaries. Arteries and veins are similar in that they have three layers. The *intima,* the inner lining, is composed of a layer of endothelial cells next to the blood (to provide a smooth surface for blood circulation) and an elastic layer that joins the media. The *media* is the middle layer of muscle and elastic tissue. The *adventitia* is the outer layer of connective tissue.

Blood vessel walls are composed of two types of cells, *smooth muscle cells* and *endothelial cells.* Vascular smooth muscle functions to maintain blood pressure and blood flow. It contracts and relaxes in response to numerous stimuli, including local and circulating mediators. Contractile properties also vary among blood vessels, with some being more responsive to stimuli than others. Overall, regulation of tone in vascular smooth muscle depends on the intracellular concentration of calcium ions. Increased intracellular calcium leads to increased vascular tone. There are several mechanisms by which calcium ions can enter the cell.

Endothelial cells, once thought to be passive conduits for blood flow, are now known to perform two extremely important functions in maintaining homeostatic processes. One function is structural, in which the cells act as a permeability barrier and regulate passage of molecules and cells across the blood vessel wall. The second function is metabolic, in which the cells secrete opposing mediators that maintain a balance between bleeding and clotting of blood (including activation and inhibition of platelet functions and fibrinolysis), constriction and dilation of blood vessels, and promotion and inhibition of vascular cell growth and inflammation. Selected mediators are listed in Table 50–1; some are discussed in more detail in later chapters.

TABLE 50–1 Endothelial Mediators That Regulate Cardiovascular Function

Promoting Factors	Inhibiting Factors
Vasomotor Tone	
Vasodilators	**Vasoconstrictors**
Endothelial-derived hyperpolarizing factor (EDHF)	Angiotensin II
Nitric oxide (also called endothelial-derived relaxing factor, or EDRF)	Endothelin
Prostacyclin (prostaglandin I_2)	Endothelium-derived constricting factor
	Platelet-derived growth factor
	Thromboxane A_2
Blood Coagulation	
Procoagulants	**Anticoagulants**
Tissue factor	Heparin sulfate
Von Willebrand factor	Thrombomodulin
Platelet activators	**Platelet inhibitors**
Platelet-activating factor	Nitric oxide
Von Willebrand factor	Prostacyclin
Profibrinolytic factors	**Antifibrinolytic factor**
Tissue plasminogen activator (t-PA)	Plasminogen activator inhibitor-1
Urokinase-type plasminogen activator	
Cell Growth	
Angiotensin II	Heparin
Endothelin	Nitric oxide
Platelet-derived growth factor	Prostacyclin
Inflammation	
Proinflammatory factors	**Anti-inflammatory factors**
Cellular and intercellular adhesion molecules	Nitric oxide
Monocyte chemotactic protein-1	
Interleukin-8	