Initiation and Conduction of an Impulse During a Heartbeat

The sequence of electrical events that normally triggers the heartbeat occurs as follows (**Figure 13.10**):

① An action potential is initiated in the SA node. From the SA node, impulses travel to the AV node by way of *internodal pathways*—systems of conduction fibers that run through the walls of the atria. As these signals move through the internodal pathways, they also spread through the bulk of the atrial muscle by way of *interatrial pathways.*

② The impulse is conducted to cells of the AV node, which transmit action potentials less rapidly than other cells of the conduction system. As a result, the impulse is momentarily delayed by about 0.1 second (called the **AV nodal delay**) before moving onward.

③ From the AV node, the impulse travels through the atrioventricular bundle, also known as the **bundle of His** (pronounced "hiss"), a compact bundle of muscle fibers located in the interventricular septum. The AV node and bundle of His are the only electrical connection between the atria and the ventricles, which are otherwise separated by the fibrous skeleton.

④ The signal travels only a short distance through the atrioventricular bundle before it splits into left and right **bundle branches,** which conduct impulses to the left and right ventricles, respectively.

⑤ From the bundle branches, impulses travel through an extensive network of branches referred to as **Purkinje fibers,** which spread through the ventricular myocardium from the apex upward toward the valves. From these fibers, impulses travel through the rest of the myocardial cells.

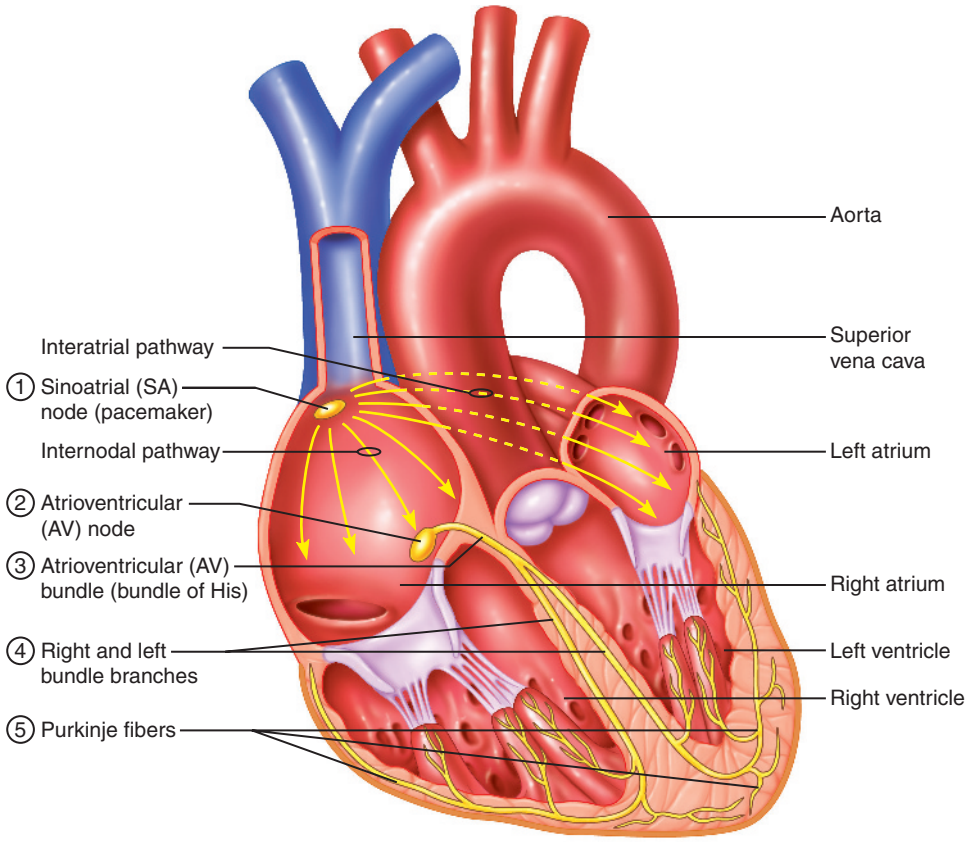

Figure 13.10 The conduction system of the heart.

However, if the SA node fails to fire an action potential or if it slows down dramatically, the AV node *will* initiate action potentials, which travel through the conducting system and trigger ventricular contraction in the normal manner. The AV node can also take over control of the heartbeat if conduction between the nodes becomes blocked or slows down for some reason. In these circumstances, the AV node functions as an emergency backup system that keeps the ventricles beating. If for some reason the AV node is unable to drive ventricular contraction, the heart has yet another backup system: Certain cells in the Purkinje fibers (sometimes referred to as *idioventricular pacemakers*) can take over. However, the firing frequency of these cells is only 30–40 impulses per minute.

Control of the Heartbeat by Pacemakers

Although the SA node and the AV node are both capable of generating spontaneous action potentials, the heartbeat is normally triggered by impulses originating from the SA node. The AV node rarely initiates contractions for two reasons. First, action potentials originating in the SA node travel through the AV node on their way to the ventricles. When this happens, cells in the AV node go into a refractory period, during which they cannot generate their own action potentials. Second, the SA node has a higher frequency of action potentials than the AV node—about 70 impulses per minute for the SA node, as opposed to 50 impulses per minute for the AV node. Thus the AV node rarely has a chance to fire an action potential because the SA node always "beats it to the punch."

Apply Your Knowledge

Sometimes a contraction is initiated outside the normal conduction pathway at a site called an *ectopic focus*. If this site is located in the atrium, it can cause a premature atrial contraction (PAC); current will then spread through gap junctions, followed by a ventricular contraction. If the ectopic focus is located in the ventricle, it can cause a premature ventricular contraction (PVC), with no atrial contraction being involved. This extra beat, called an *extrasystole*, is followed by a skipped beat, leaving a pause between ventricular contractions. Why would the heart skip its next regular beat following an extrasystole?