PHYSIOLOGY OF THE CARDIAC MUSCLE

The heart is composed of three major types of cardiac muscle: 1) atrial muscle, 2) ventricular muscle, and 3) specialized excitatory and conductive muscle fibers. The atrial and ventricular types of muscle contract in much the same manner as skeletal muscle fibers. On the other hand the specialized excitatory and conductive fibers contract only feebly because they contain few contractile fibrils; instead they provide an excitatory system for the heart and a transmission system for rapid conduction of impulses throughout the heart.

Cardiac muscle as a "Functional Syncytium." The angulated dark areas crossing the cardiac muscle fibers are called intercalated discs; however, they are actually cell membranes that separate individual cardiac muscle cells from each other. Yet electrical resistance through the intercalated disc is only 1/400 the resistance through the outside membrane of the cardiac muscle fiber. Therefore, ions flow with relative ease along the axes of the cardiac muscle fibers so that action potentials travel from one cardiac muscle cell to another, past the intercalated discs, without significant hindrance. Therefore, cardiac muscle is a functional syncytium, in which the cardiac muscle cells are so tightly bound that when one of these cells becomes excited, the action potential spreads to all of them, spreading from cell to cell and spreading throughout the latticework interconnections.

The heart is composed of two separate functional syncytiums, the atrial syncytium and the ventricular syncytium. These are separated from each other by the fibrous tissue surrounding the valvular rings, but an action potential can be conducted from the atrial syncytium into the ventricular syncytium by way of a specialized conductive system, the A-V bundle.

All-or-Nothing Principle as Applied to the Heart. Because of the syncytial nature of the cardiac muscle, stimulation of any single atrial muscle fiber causes the action potential to travel over the entire ventricular muscle mass. This is called the all-or-nothing principle.

EXCITATION-CONTRACTION COUPLING – ROLE OF CALCIUM IONS

The action potential initiates contraction in the cardiac muscle in almost exactly the same way that it does in skeletal muscle. The action potential causes calcium ions to be released into the muscle fiber sarcoplasm from the cisternae of the sarcoplasmic reticulum and to a less extent from the fluid of the T tubules as well. These calcium ions diffuse rapidly into the myofibrils and there initiate the chemical reactions that promote the sliding of the actin and myosin filaments along each other, which promotes the muscle contraction.

Immediately after the action potential is over, the calcium ions are transported back into the sarcoplasmic reticulum or into the T tubules so that within another few milliseconds the muscle relaxes.