Physics of Medical Devices

Fifth lecture

Electrocardiograph II

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Fourth Stage

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Physiology of the Heart

- Normal blood flow through the heart begins at the right atrium, which receives systemic venous blood from the superior and inferior vena cava.
- Blood passes from the right atrium, across the tricuspid valve, to the right ventricle. It is then pumped across the pulmonary valve into the pulmonary arteries.
- Outside the heart, the left and right pulmonary arteries distribute blood to the lungs for gas exchange in the pulmonary capillaries.
- Oxygenated blood returns to the left atrium through the left and right pulmonary veins.
- After passing across the mitral valve, blood enters the left ventricle, where it is pumped across the aortic valve, through the aorta, into the coronary arteries and the peripheral circulation.

Mechanics of Heart Function

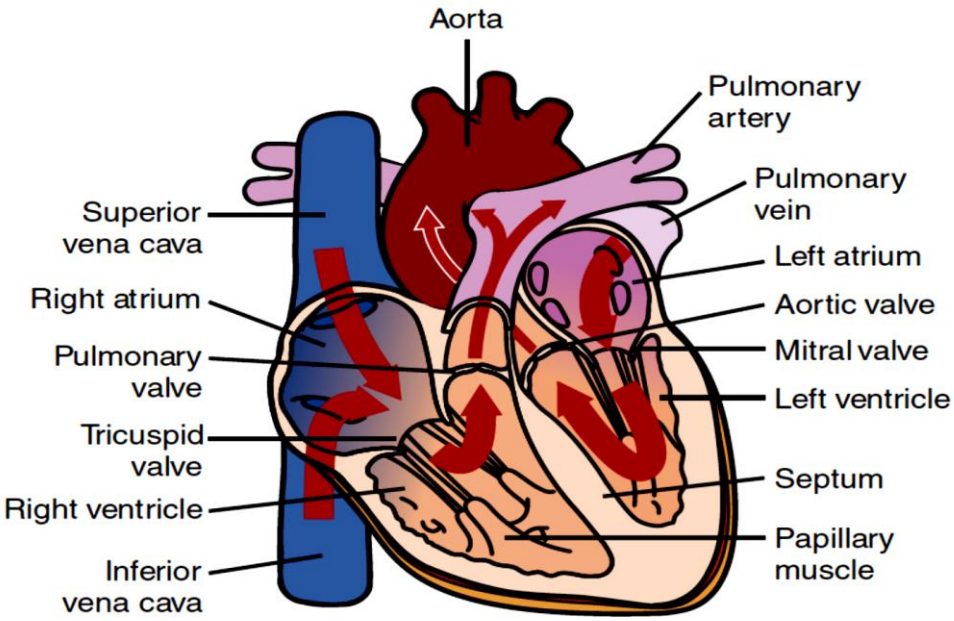
Process	Action
Cardiac cycle	Sequence of events in 1 heartbeat. Blood is pumped through the entire cardiovascular system.
Systole	Contraction phase—usually refers to ventricular contraction.
Diastole	Relaxation phase—the atria and ventricles are filling. Lasts longer than systole.
Stroke volume (SV)	Amount of blood ejected from either ventricle in a single contraction. Starling's Law of the Heart states that the degree of cardiac muscle stretch can increase the force of ejected blood. More blood filling the ventricles increases SV.
Cardiac output (CO)	Amount of blood pumped through the cardiovascular system per min. CO = SV x Heart rate (HR)

Properties of Cardiac Cells

Property	Ability
Automaticity	Generates electrical impulse independently, without involving the nervous system.
Excitability	Responds to electrical stimulation.
Conductivity	Passes or propagates electrical impulses from cell to cell.
Contractility	Shortens in response to electrical stimulation.

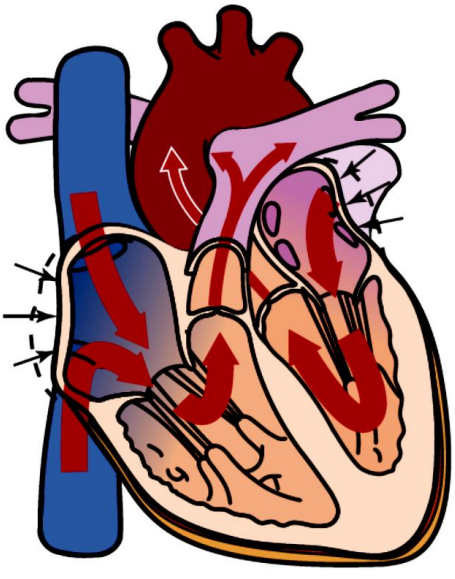
Systolic and Diastolic Phases in the Heart

Diastole: the phase of the heartbeat when the heart muscle relaxes and allows the chambers to fill with blood.

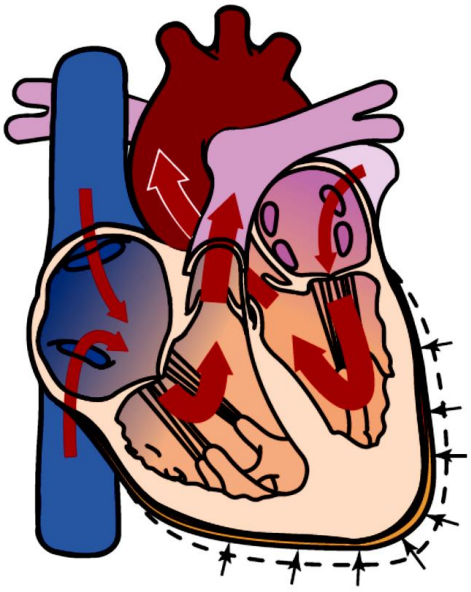


Diastole

Systolic: phase relating to the phase of the heartbeat when the heart muscle contracts and pumps blood from the chambers into the arteries.



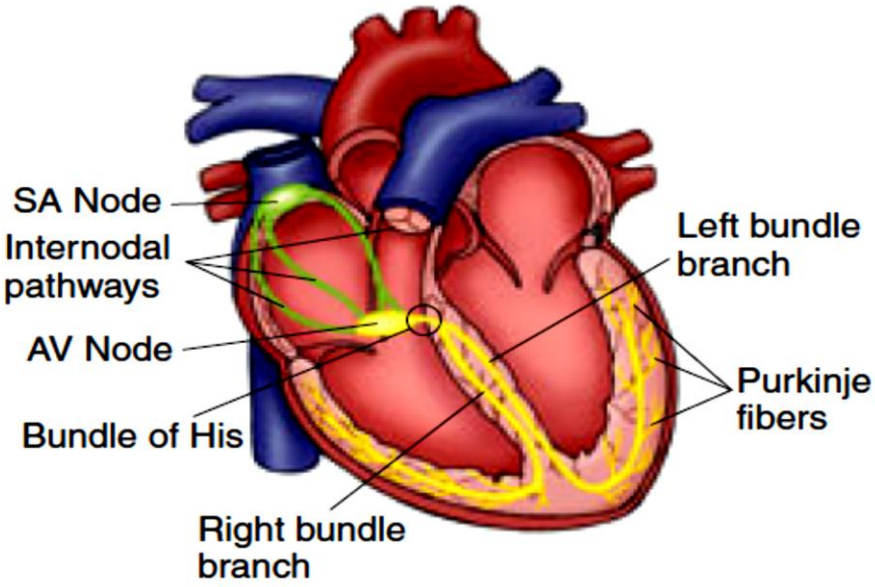
Atrial systolic phase



Ventricular systolic phase

Electrical Conduction System of the Heart

Electrophysiology	
Structure	**Function and Location**
Sinoatrial (SA or sinus) node	Dominant pacemaker of the heart, located in upper portion of right atrium. Intrinsic rate 60—100 bpm.
Internodal pathways	Direct electrical impulses between the SA and AV nodes and spread them across the atrial muscle.
Atrioventricular (AV) node	Part of the AV junctional tissue, which includes some surrounding tissue plus the connected bundle of His. The AV node slows conduction, creating a slight delay before electrical impulses are carried to the ventricles. The intrinsic rate is 40–60 bpm.
Bundle of His	At the top of the interventricular septum, this bundle of fibers extends directly from the AV node and transmits impulses to the bundle branches.
Left bundle branch	Conducts electrical impulses to the left ventricle.
Right bundle branch	Conducts electrical impulses to the right ventricle.
Purkinje system	The bundle branches terminate with this network of fibers, which spread electrical impulses rapidly throughout the ventricular walls. The intrinsic rate is 20–40 bpm.



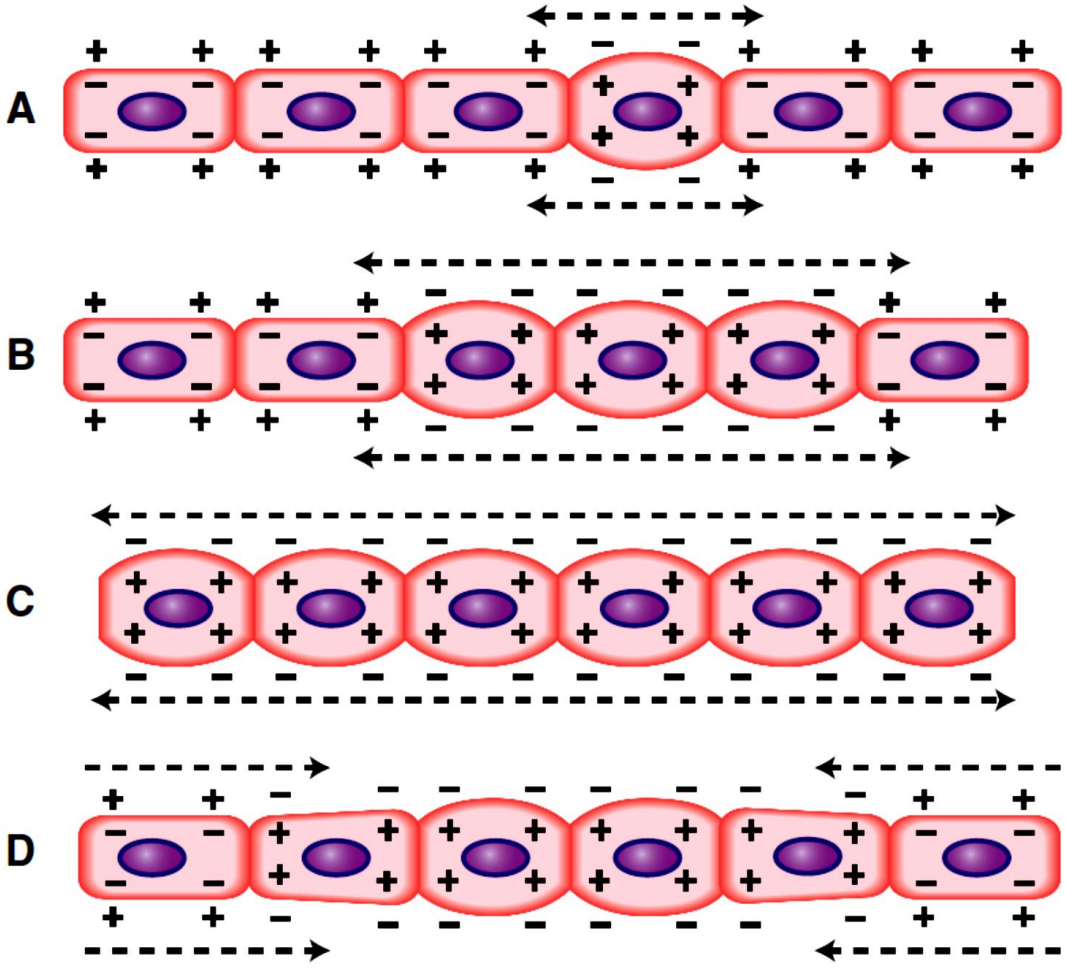
Conduction system of the heart

The Depolarization Process

The electrical charge of a cell is altered by a shift of electrolytes on either side of the cell membrane. This change stimulates muscle fiber to contract.

The Repolarization Process

Chemical pumps re-establish an internal negative charge as the cells return to their resting state.



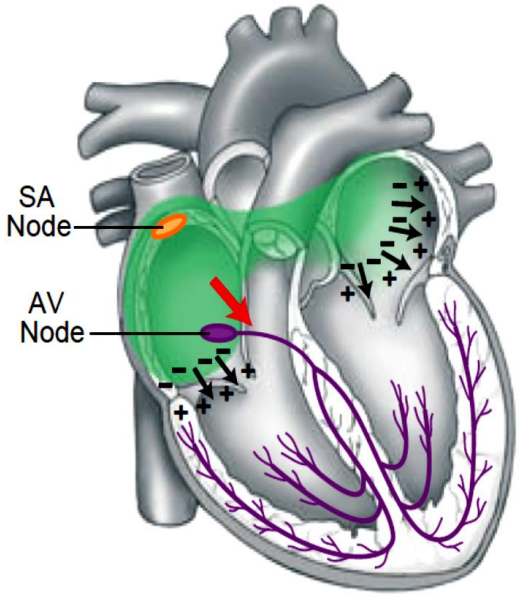
(A) A single cell has depolarized.

(B) A wave propagates from cell to cell.

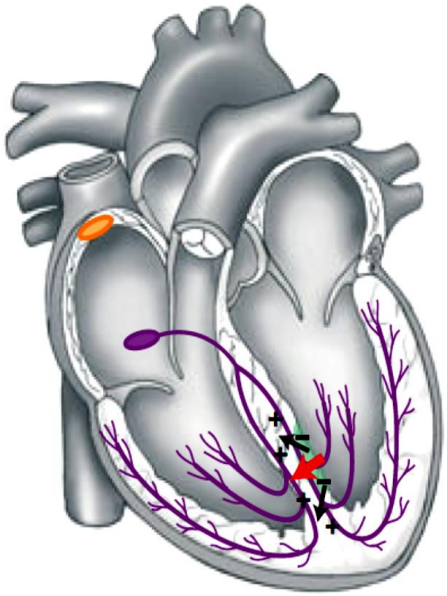
(C)Wave propagation stops when all cells are depolarized.

(D) Repolarization restores each cell's normal polarity.

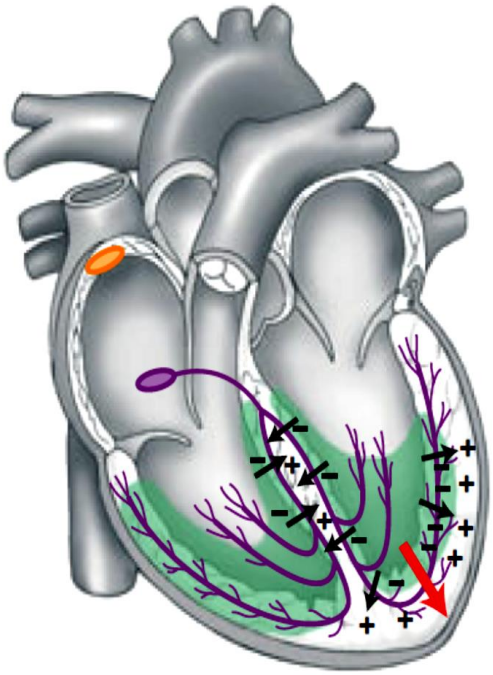
Progression of Depolarization through the Heart



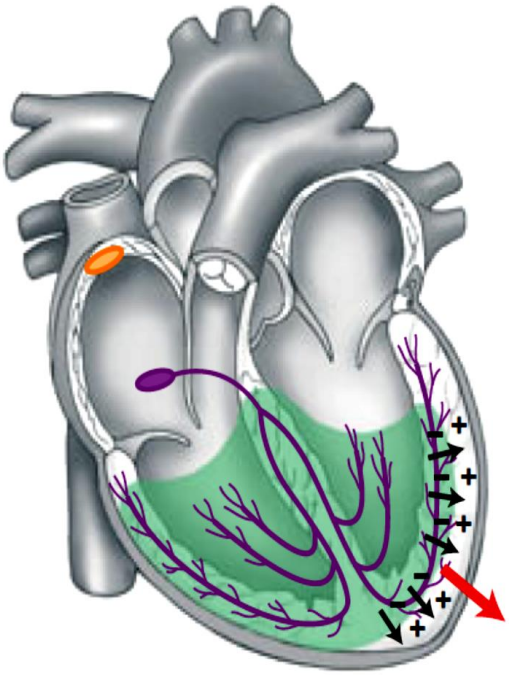
Atrial depolarization



Septal depolarization



Apical depolarization



Left ventricular depolarization