



Cardiovascular Physiology

Cardiac Electrical Activity

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At end of this lecture you should be able to:

- ✓ Discuss the cardiac conductive system & its function
- ✓ Describe the action potential of the cardiac ms & its components
- ✓ Define the refractory period & the 'Excitation-Contraction Coupling'
- ✓ Discuss the control of excitation & conduction of the heart

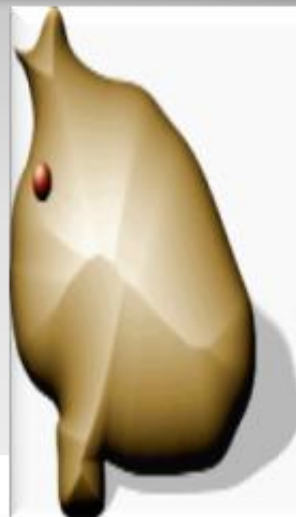
Introduction

- ❑ **Heart's ability to beat is intrinsic:**
 - without nerve impulses
- ❑ **Intrinsic conducting system (Nodal System) of the heart:**
 - network of specialized non-contractile myocardial tissue

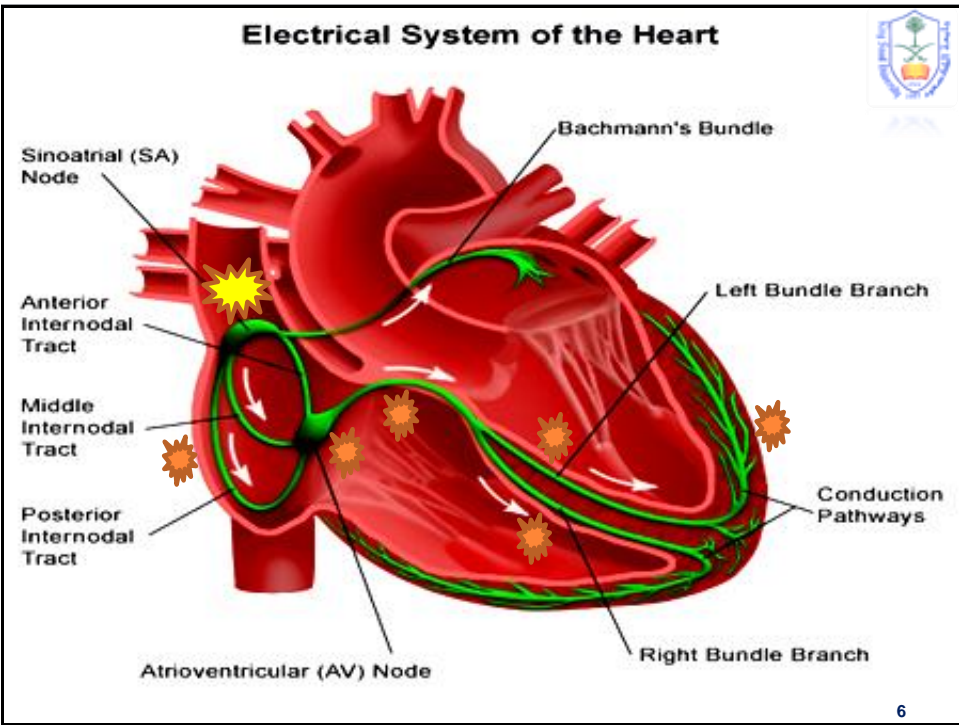
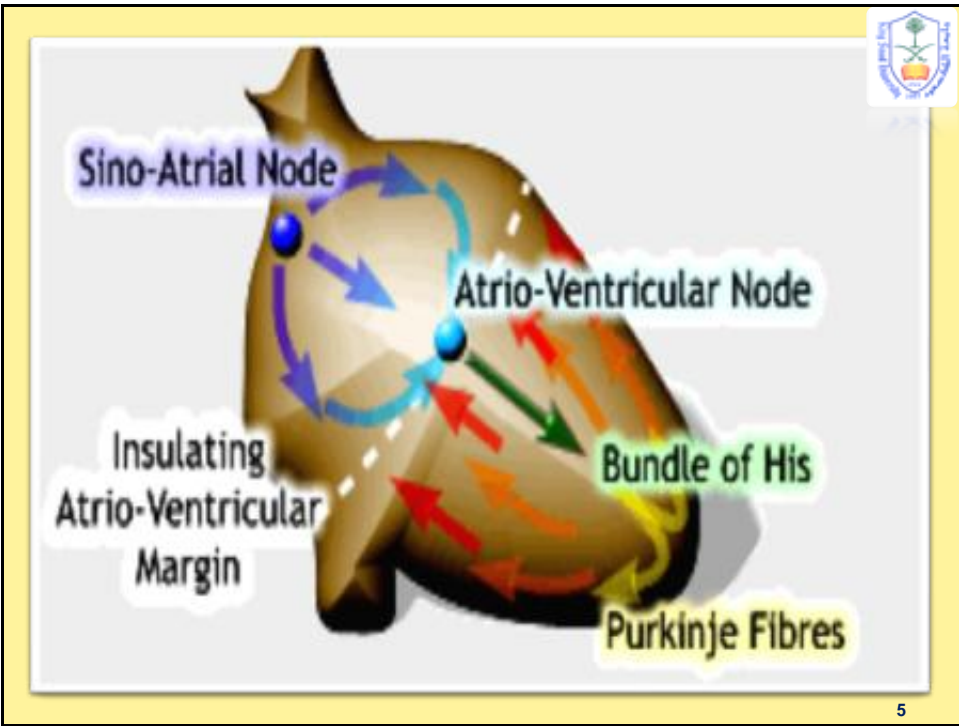
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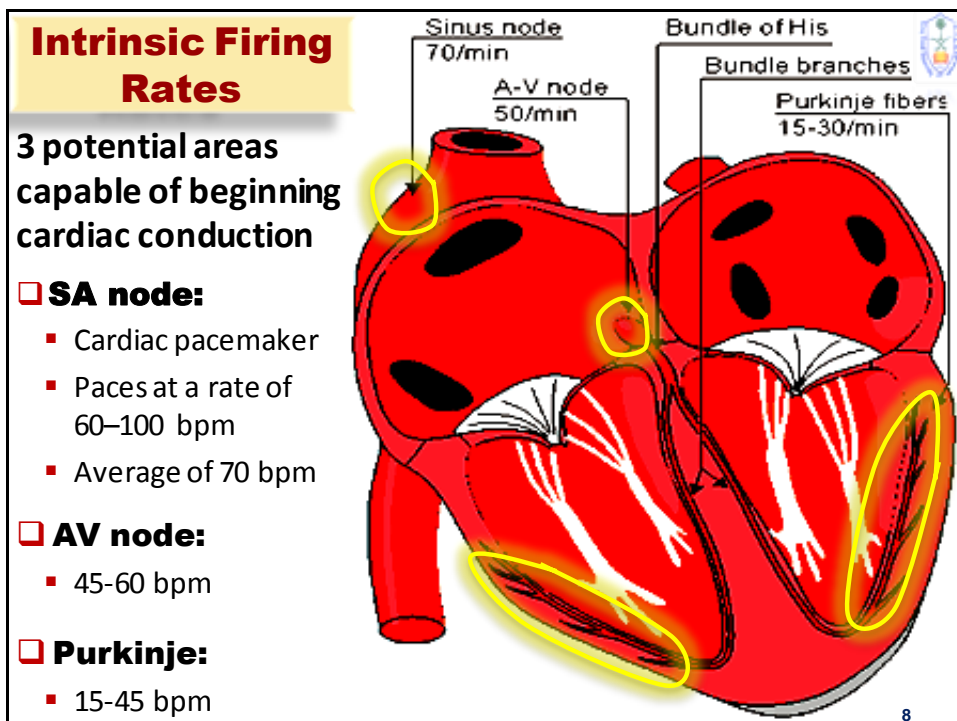
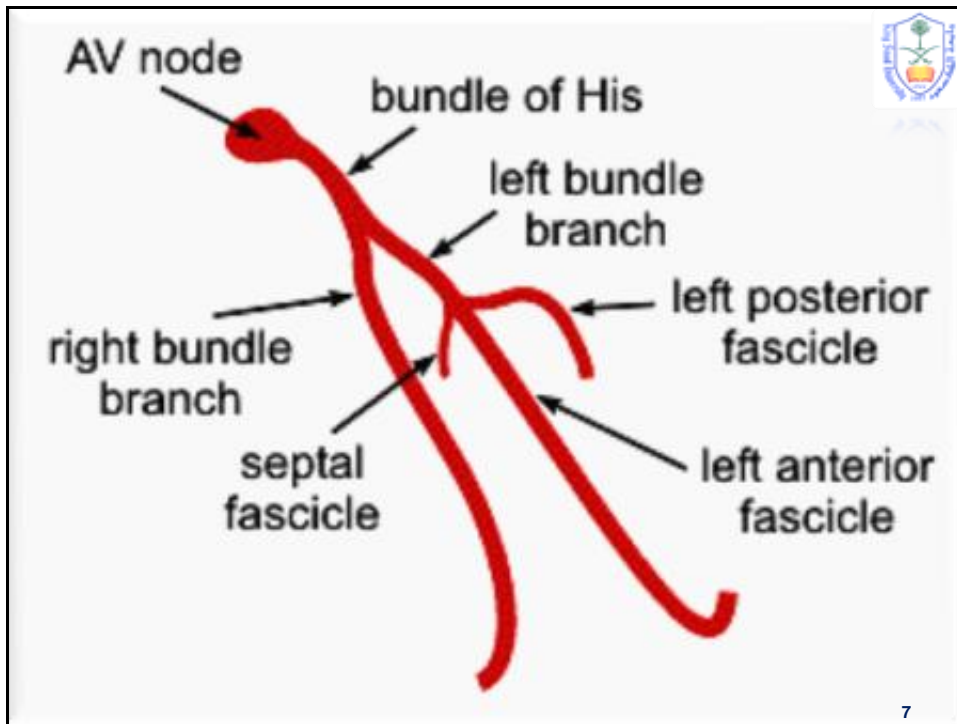
Cardiac Conduction System

- ❑ **Generates & conducts impulses throughout the heart**
- ❑ **Flow of electrical current stimulates myocardial contractions, producing effective pumping of blood & optimize CO**
- ❑ **Ensures the heart beats as a coordinated unit**



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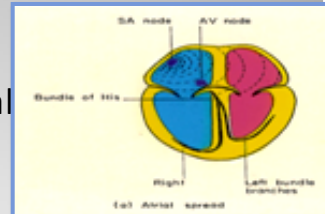


The direction of the impulse:

□ The impulse is conducted:

1st ⇒ Atrial spread

- from **SA- node** → internodal pathways → **ventricles**



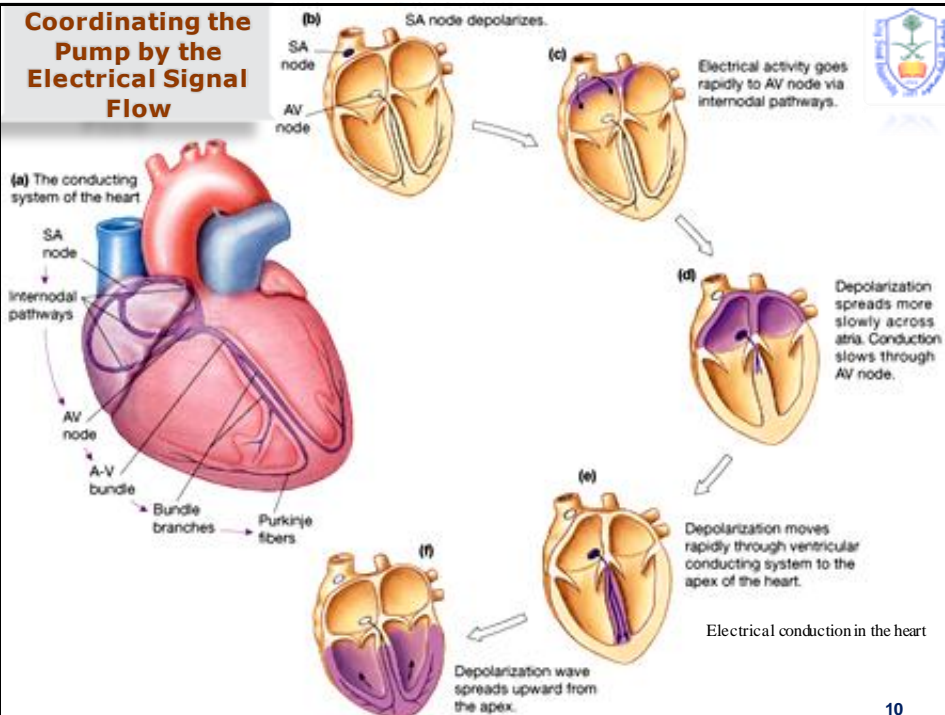
2nd ⇒ Ventricular spread

- from **apex** of the heart → **base**, via Purkinje fibers → endocardium

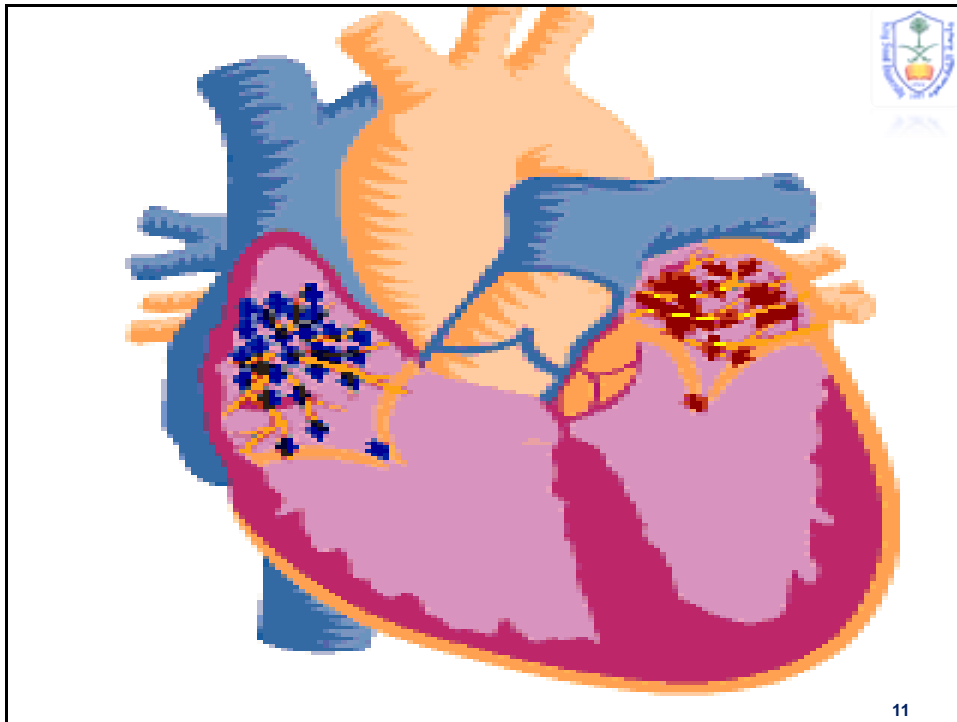


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Coordinating the Pump by the Electrical Signal Flow



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To Revise:

☐ Intrinsic conducting system (Nodal System) of the heart:

- Network of tissue

☐ Heart's ability to beat is intrinsic:

nerve impulses

Characteristics of Cardiac Conduction Cells

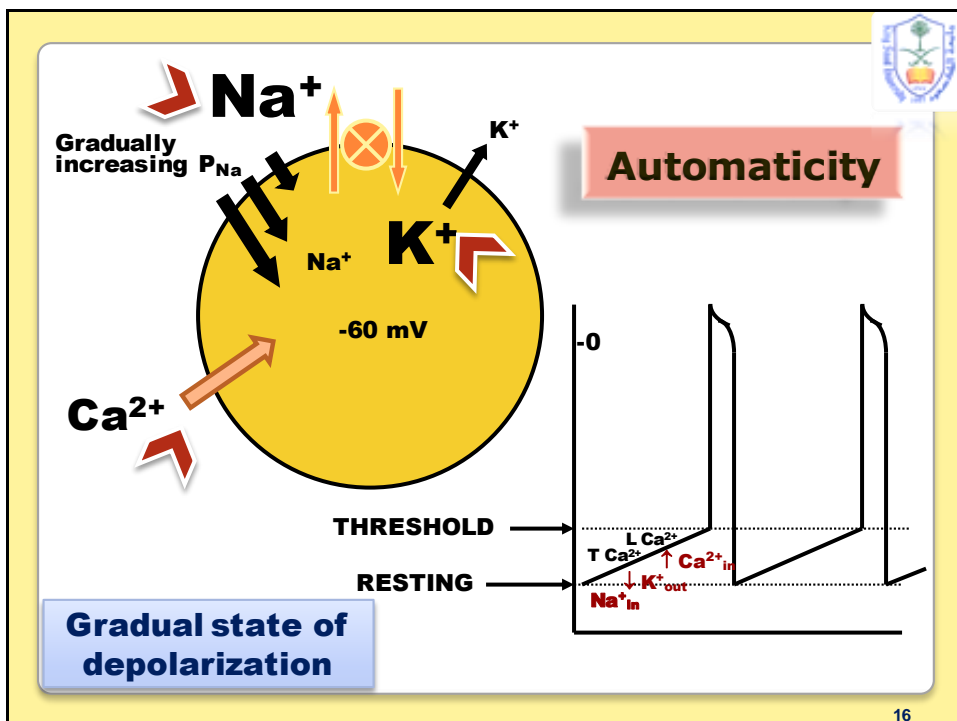
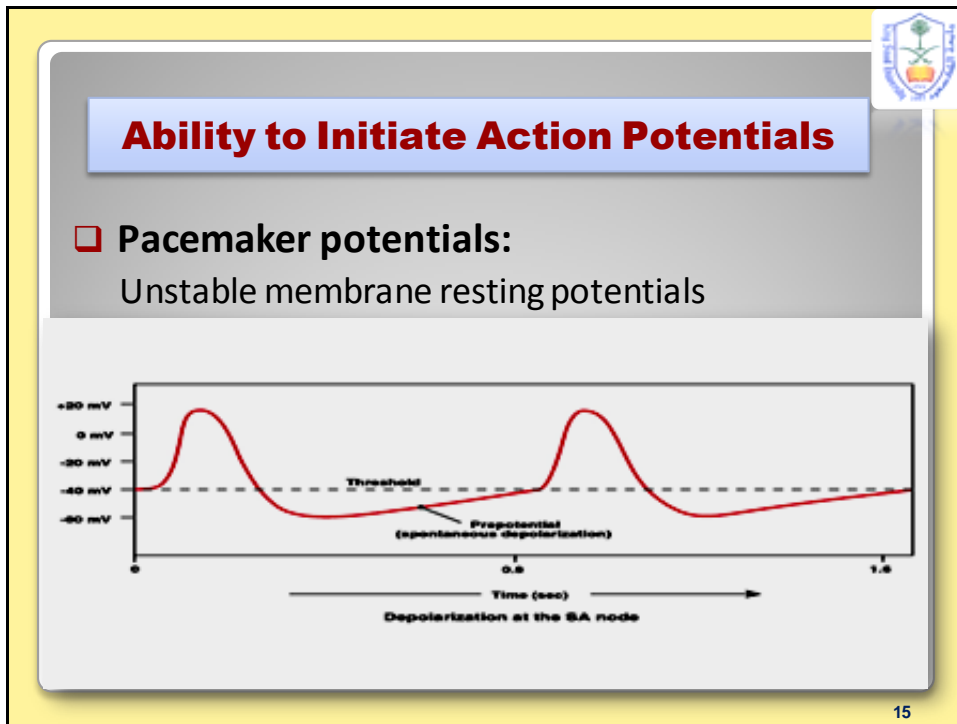
- ❑ **Automaticity:**
Ability to initiate an electrical impulse
- ❑ **Excitability:**
Ability to respond to electrical impulse, by generating an action potential followed by a mechanical contraction
- ❑ **Conductivity:**
Ability to transmit an electrical impulse

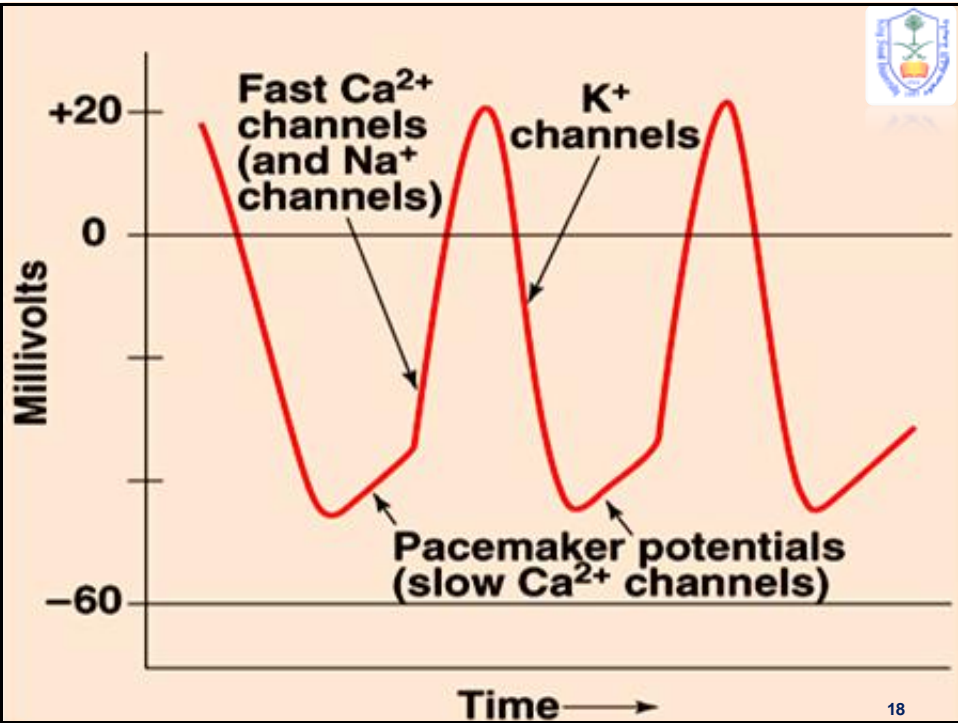
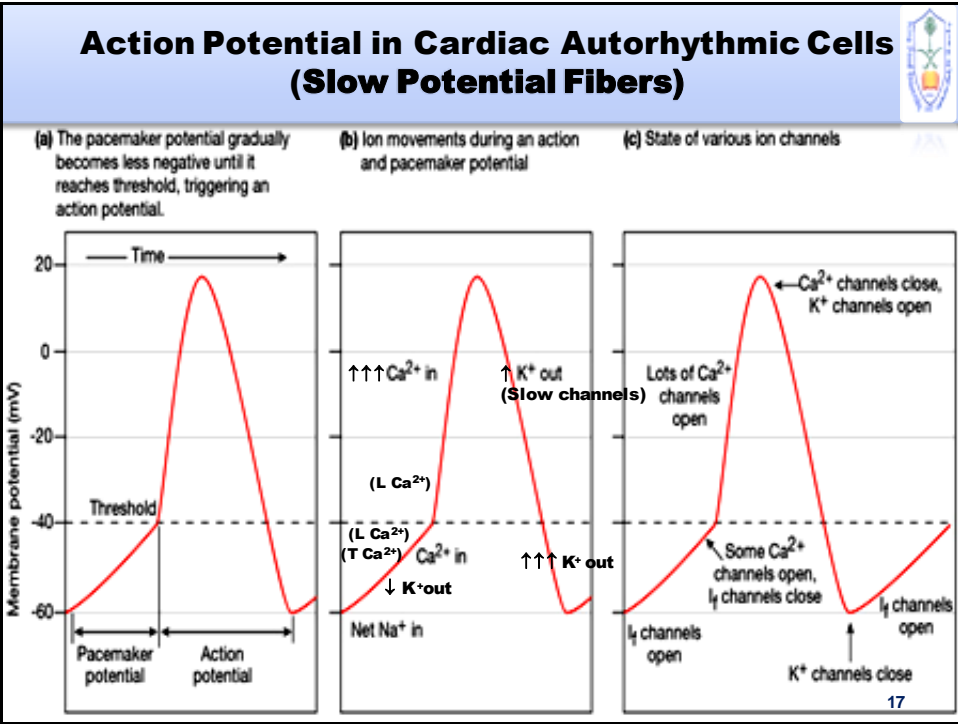
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I: Automaticity (Rhythmicity): Initiates Action Potentials

- ❑ **Ability of cardiac ms to contract in a regular constant manner w/out nerve supply:**
 - Myogenic in origin (i.e. not neurogenic)
 - Initiated by 'pacemaker' of the heart, the SA-node

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The pacemaker of the heart:

the Sinoatrial (SA) node





- ❑ Contains P- cells, which ? actual pacemaker cells
- ❑ Has fastest rhythm (rate of discharge) of all parts of the heart, 90 impulses/min
- ❑ Its fibers have an unstable RMP:
 - spontaneous (w/out stimulation) depolarization, up to firing level

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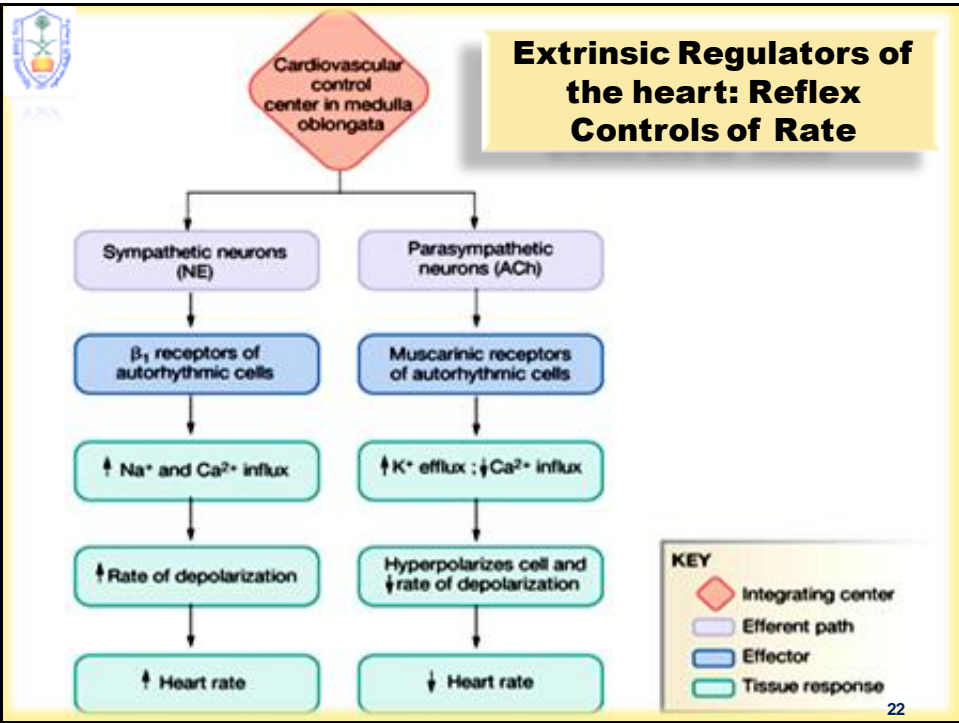
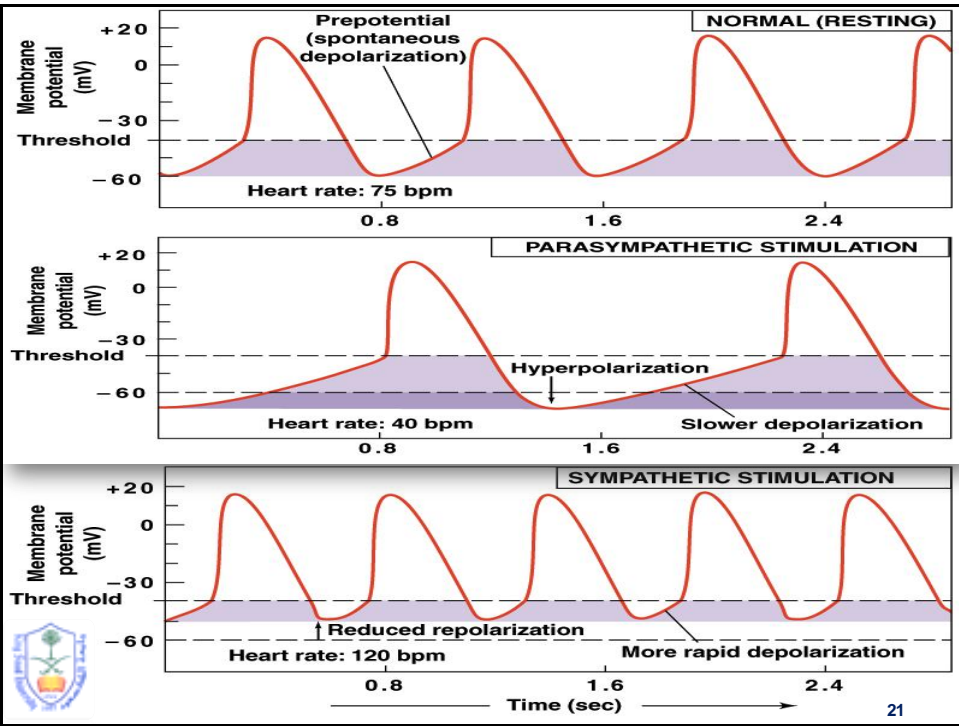


Factors Affecting Myocardial Rhythmicity:

(Chronotropic Effectors)

-  **1. Cardiac innervation: (ANS)**
-  **2. Effect of ions concentration in ECF**
-  **3. Physical factors: (e.g. warming; cooling; exercise)**
-  **4. Chemical factors: (drugs)**

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To Revise:

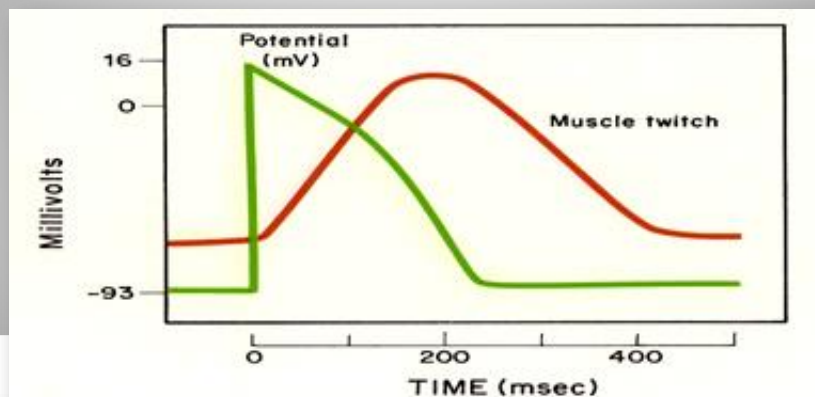
- ❑ What is the Pacemaker of the heart?

- ❑ Explain Why its considered the pacemaker of the heart?

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II: Excitability (Irritability):

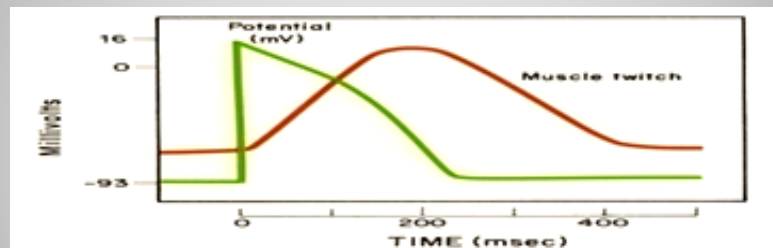
- = Ability to respond to electrical impulse by generating an action potential followed by a mechanical contraction



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Relation between action potential & mechanical response

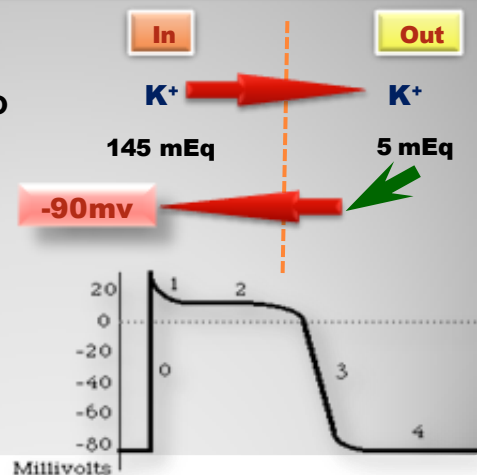
- ❑ **Cardiac ms begins to contract few msec after AP begins:**
 - Mechanical response consists of contraction (systole) & relaxation (diastole)



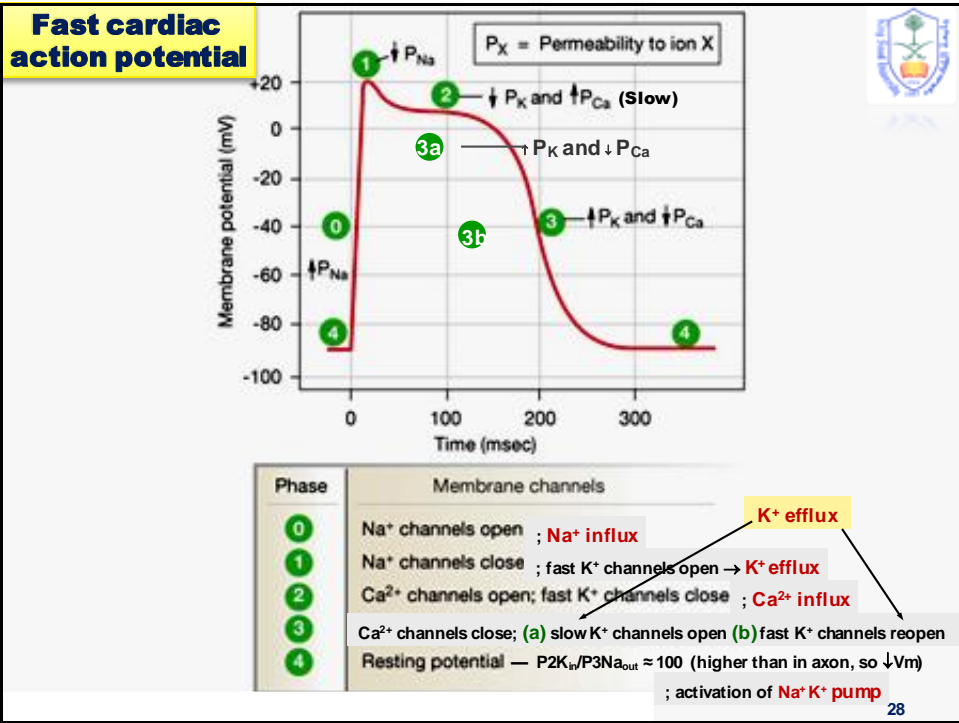
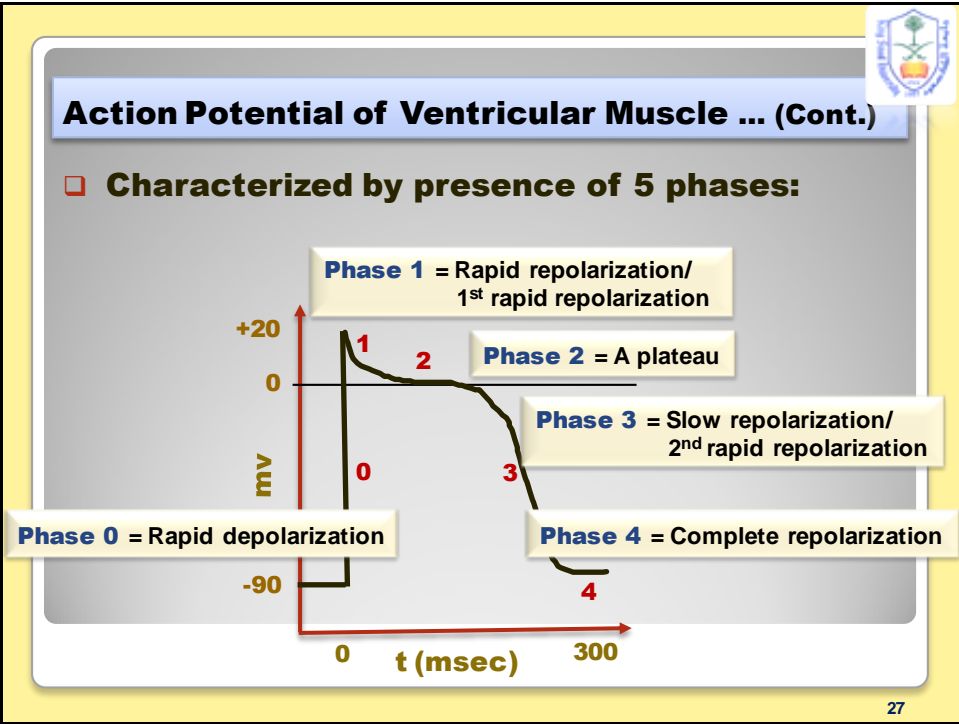
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Action Potential of Ventricular Muscle (Fast Potential Fibers)

- RMP of ventricular ms ≈ -90 mV (-85 to -95 mV)
- Trans-membranous AP overshoots to $\approx +20$ mV



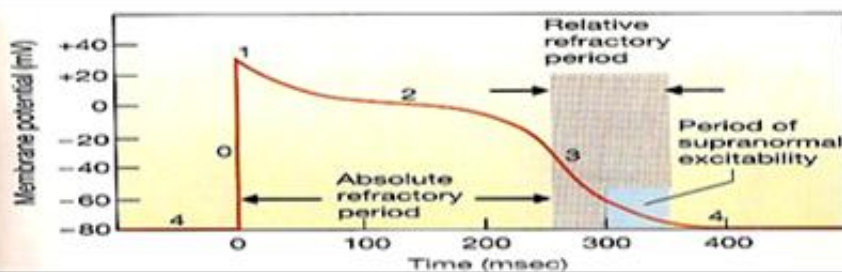
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Excitability changes during the action potential

Passes through 3 periods:

1. Absolute refractory period (ARP)
2. Relative refractory period (RRP)
3. Dangerous period (supranormal period)

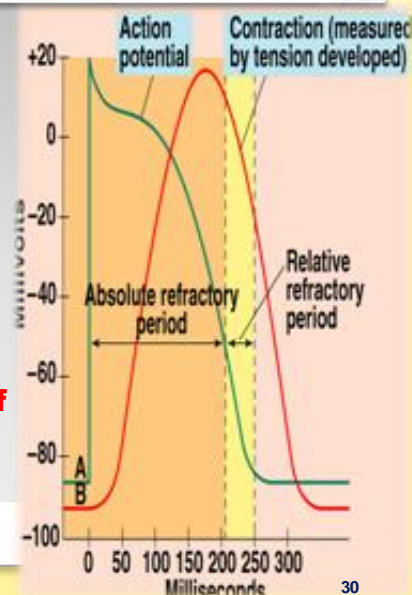


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1. Absolute Refractory Period (ARP):

- **V. long**
- **Excitability is completely lost:**
 - Doesn't respond to 2nd stimulus
- **Occupies whole period of systole:**
 - Heart can't be tetanized

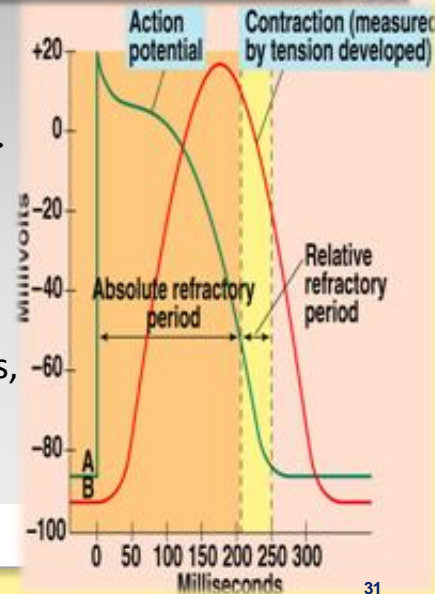
(N.B the longer the duration of AP, the longer the refractory period)



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2. Relative Refractory Period (RRP):

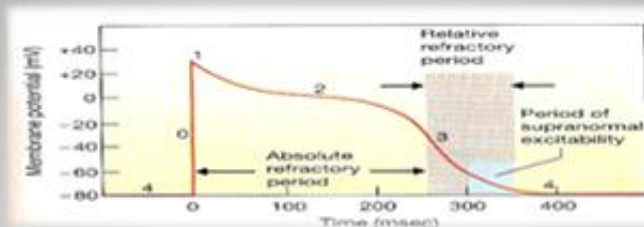
- ❑ **Excitability is partially recovered:**
 - Require stronger stimuli > normal to excite ms
- ❑ **Occupies time of diastole**
- ❑ **Can be affected by:**
 - HR, temp, bacterial toxins, autonomic nervous stimulation & drugs



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3. Dangerous Period (Supranormal):

- ❑ **Just at end of the AP**

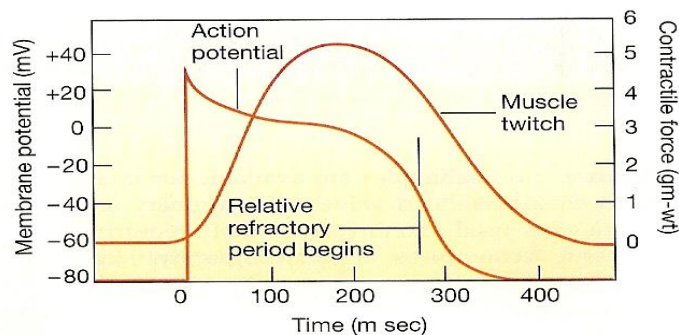


- ❑ **Excitability of cardiac ms is supranormal**
 - Weaker stimuli > normal can excite the ms
- ❑ **? result in ventricular fibrillation**

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Relation between action potential & mechanical response ... (Cont.)

- ❑ **Diastole begins at the end of the plateau**
- ❑ **2nd rapid repolarization is completed at about the middle of diastole**



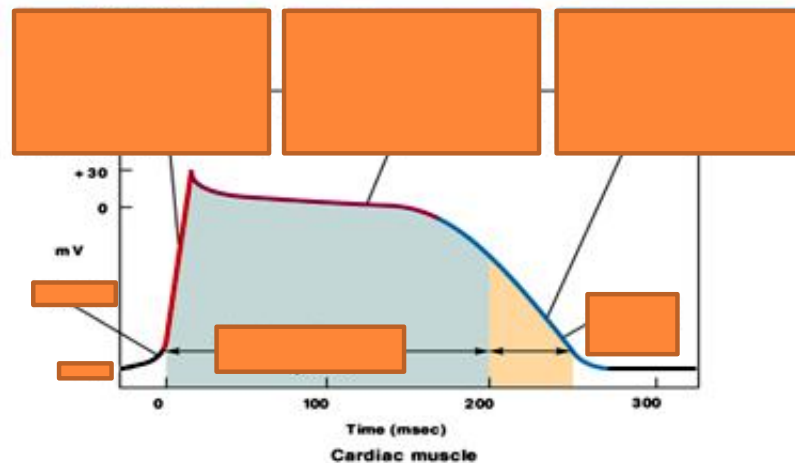
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Factors Affecting Myocardial Excitability:

1. **Cardiac innervation:** (ANS)
2. **Effect of ions concentration in ECF:** (e.g. Ca^{2+} ; K^+)
3. **Physical factors:** (e.g. warming; cooling)
4. **Blood flow**
5. **Chemical factors:** (drugs) (e.g. Digitalis; Ca^{2+} channel blockers)

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To Revise:

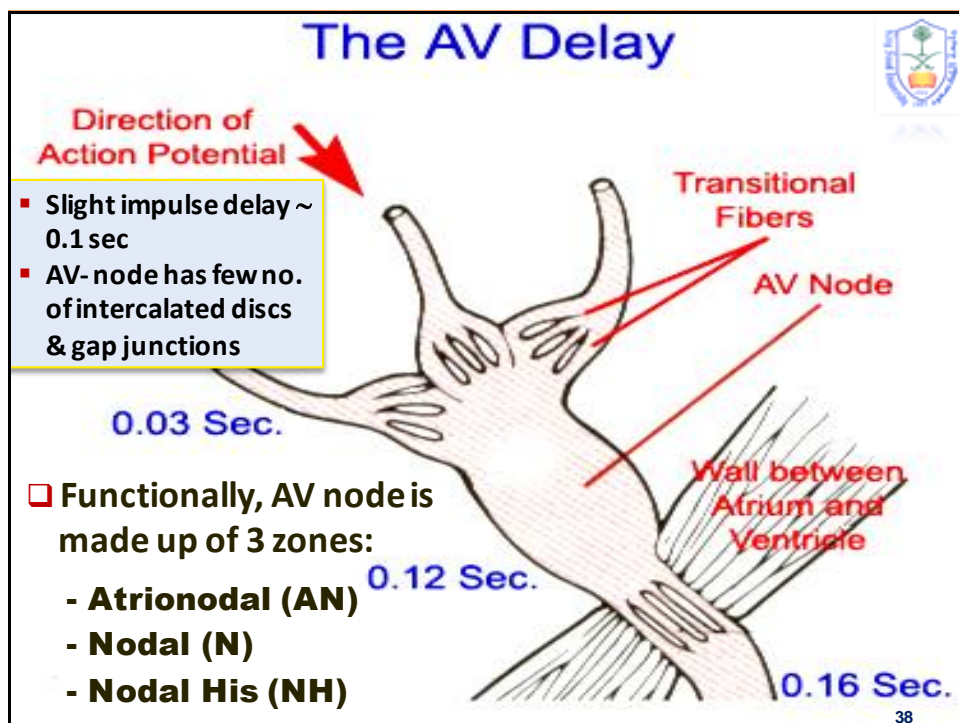
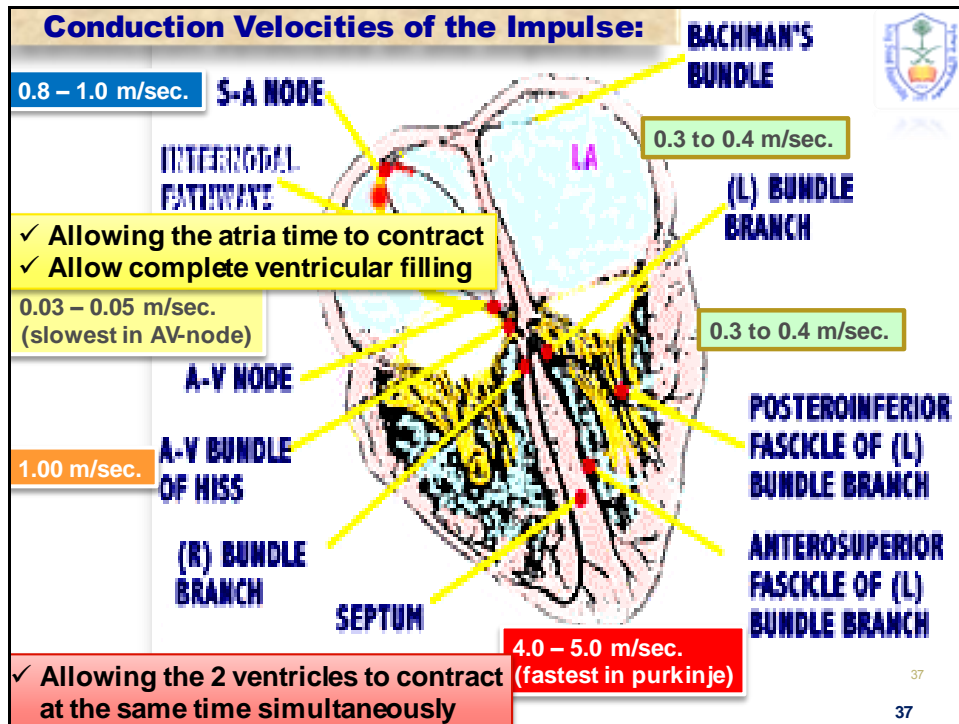



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III: Conductivity:






Ability of cardiac ms fibers to conduct cardiac impulses initiated in SA- node (pacemaker of the heart)

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Factors Affecting Myocardial Conductivity:

-  **1. Cardiac innervation:** (ANS)
-  **2. Effect of ions concentration in ECF:**
(e.g. Ca^{2+} ; K^{+})
-  **3. Physical factors:** (e.g. warming; cooling)
-  **4. Blood flow**
-  **5. Chemical factors:** (drugs)
(e.g. Digitalis)

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