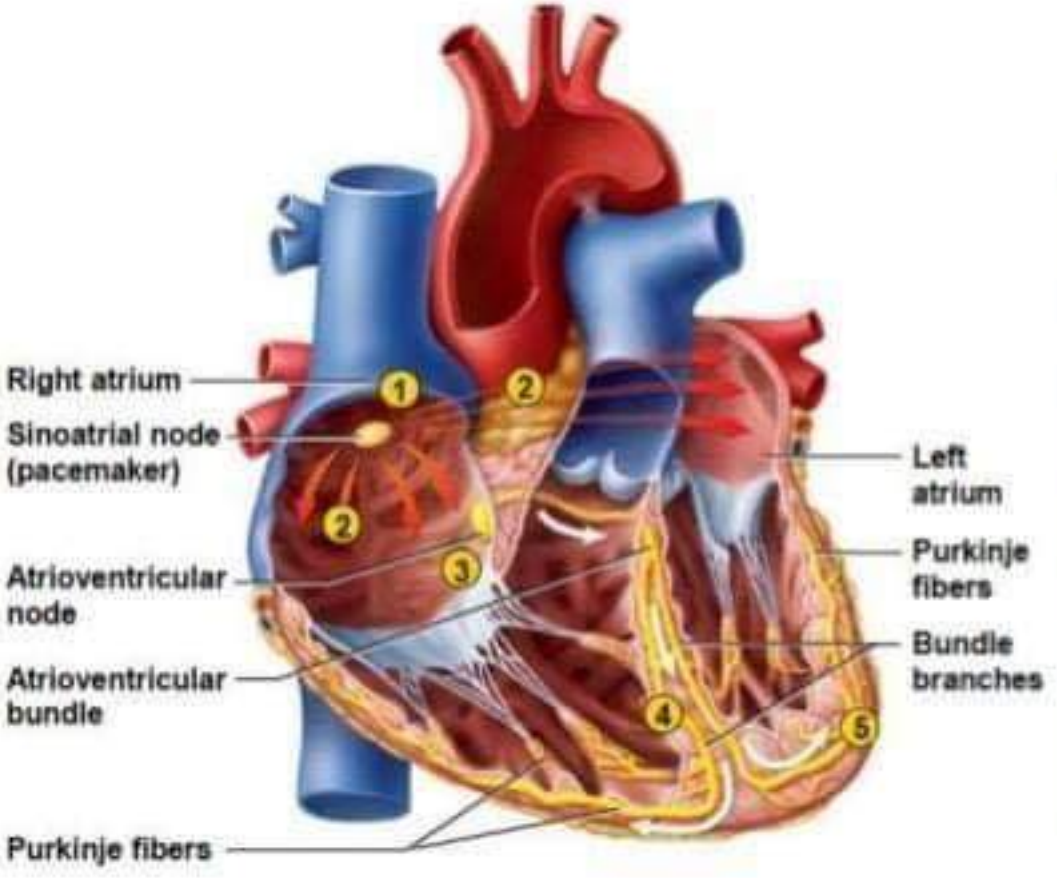
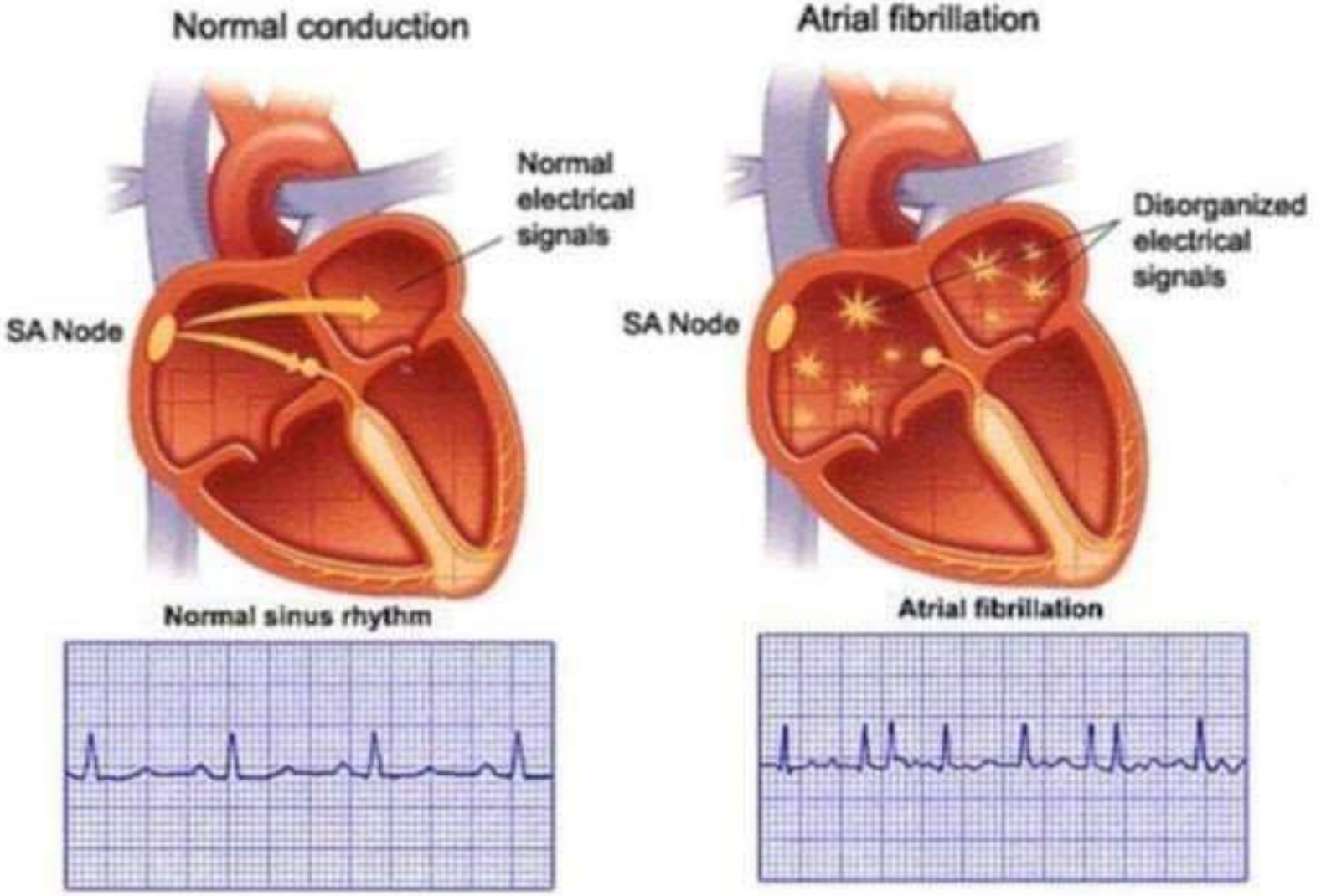
Cardiac Electrophysiology



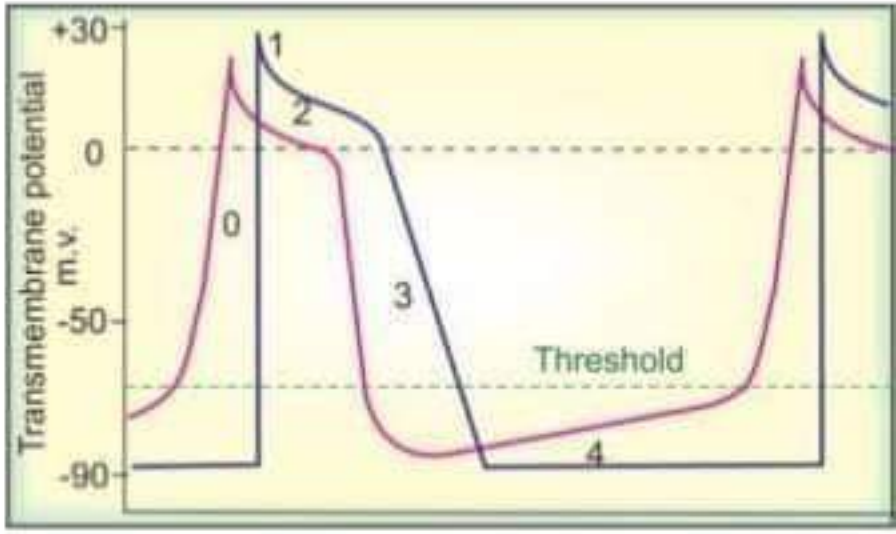
1. SA node fires.
2. Excitation spreads through atrial myocardium.
3. AV node fires.
4. Excitation spreads down AV bundle.
5. Purkinje fibers distribute excitation through ventricular myocardium.

Cardiac Electrophysiology



Cardiac Electrophysiology

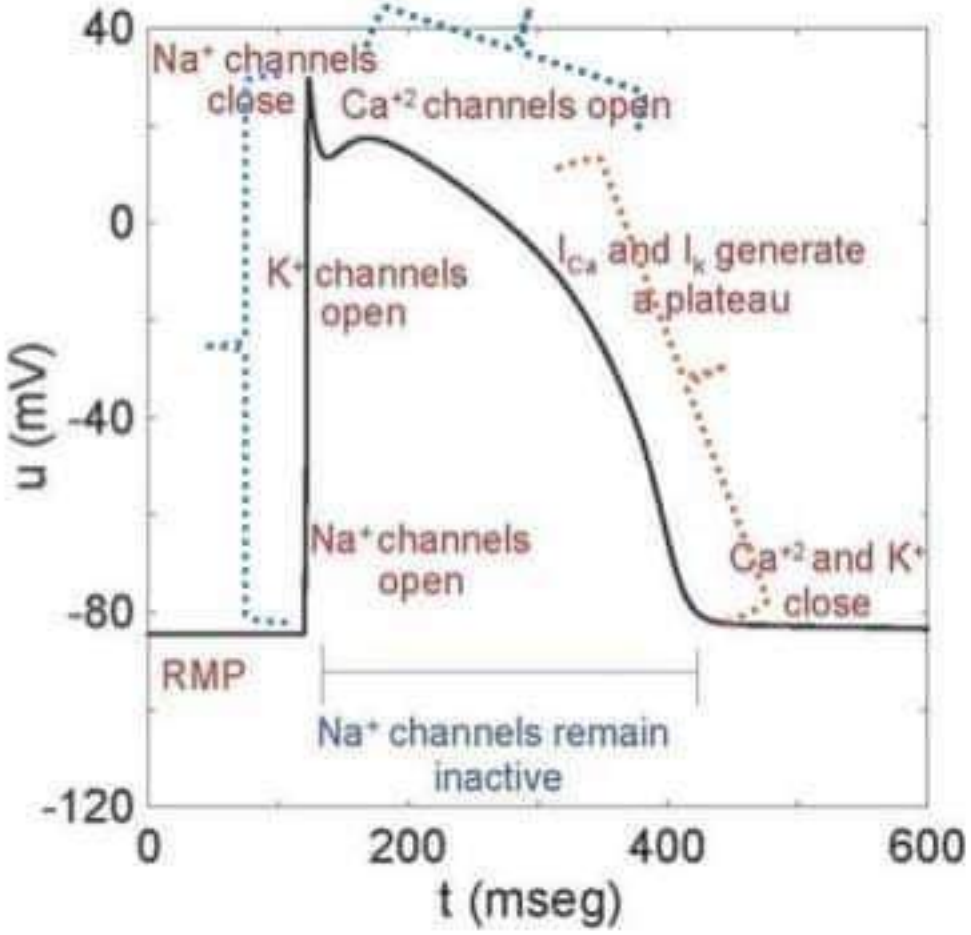
- Impulse generation
  - **Nonautomatic fibres:** Ordinary working myocardial fibers and cannot generate impulse of their own.
  - **Automatic fibres:** SA node, AV node, His-Purkinje system.



Transmembrane potential of automatic (red) and nonautomatic (purple) myocardial fibres recorded through intracellular electrodes

Cardiac Electrophysiology

- Impulse generation



Rapid depolarization due to opening of voltage-dated fast Na+ channels

Plateau (maintained depolarization) due to opening of voltage-gated slow Ca+ channels and closing of some K+ channels

Repolarization due to opening of voltage-dated K+ channels and closing of Ca+ channels

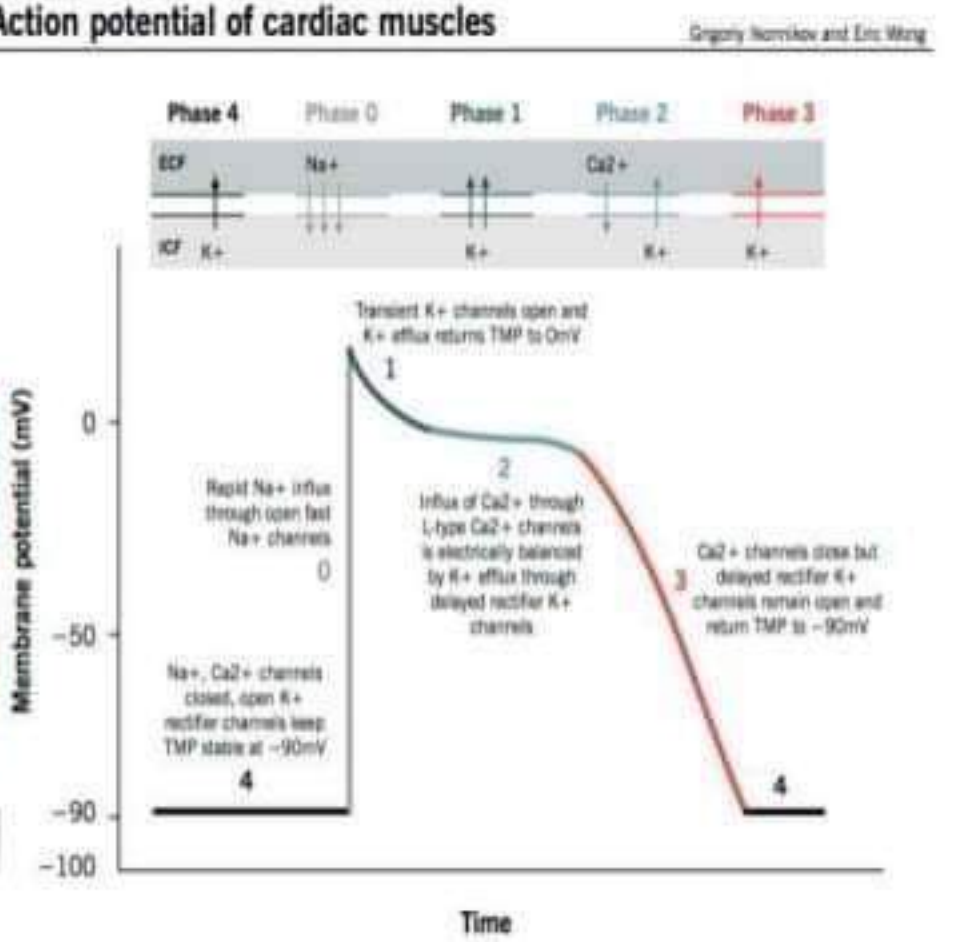
Phase 0: Depolarization
Rapid Na+ entry

Phase 1: Early depolarization
Ca++ slow entry

Phase 2: *Plateau*
continuous repolarization
Slow entry of sodium and calcium

Phase 3: Repolarization
Potassium outflow

Phase 4: Pacemaker potential



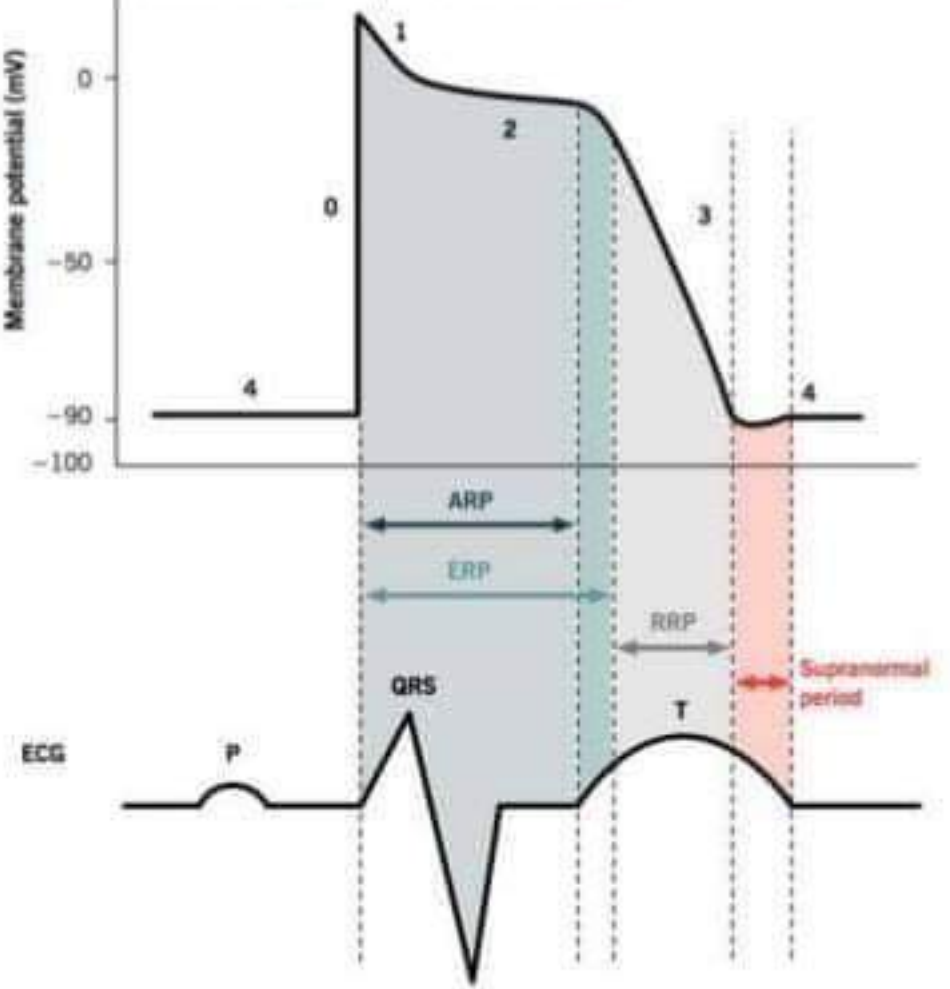
Phase 1 – 3: Refractory period

Ref: Pharmacol Ther. 2005;107(1):59-79.

Refractory periods in cardiac cycle

Grigoriy Ikonnikov and Eric Wong

The refractory periods in cardiac muscles allow complete emptying of the ventricles prior to the next contraction. Refractoriness of each phase of the action potential is governed by the number of sodium channels ready to activate. The **absolute refractory period (ARP)** does not allow for any depolarizations. The **effective refractory period (ERP)** may allow for non-propagated depolarization. The **relative refractory period (RRP)** allows a stronger than normal stimulus to cause a full depolarization. The **supranormal period** is a hyperexcitable period where even a weak stimulus can cause an action potential. See text for details.



Ref: Ikonnikov G, Yelle D. Physiology of cardiac conduction and contractility. Available in http://www.pathophys.org/physiology-of-cardiac-conduction-and-contractility/ [Last accessed on 28/08/2017]

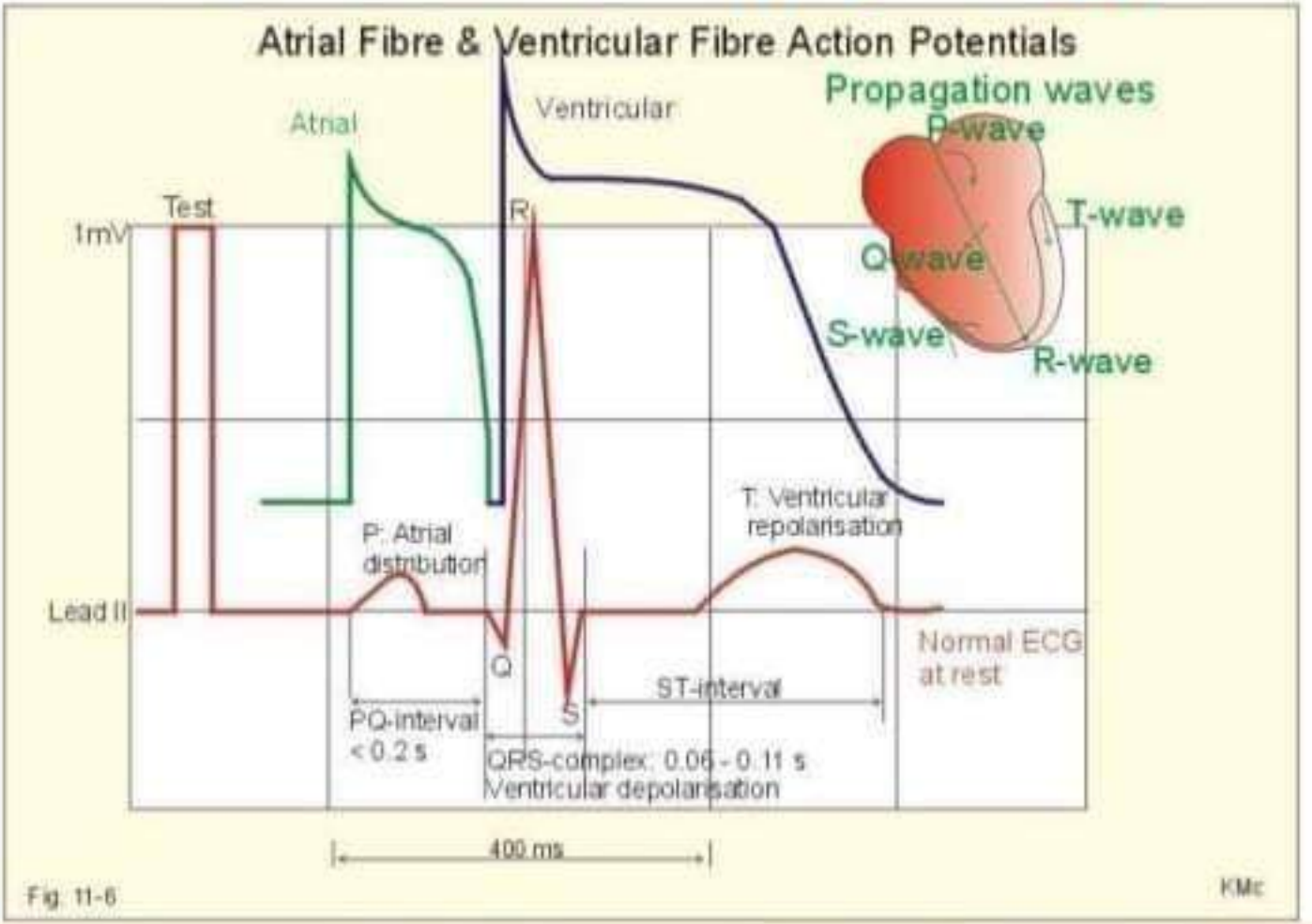
Cardiac Electrophysiology

- **Conduction:**
  - The Na+ channels get progressively inactivated as the resting membrane potential (RMP) drops over the –80 to –60 mV range.
  - Consequently, less negative the RMP at which activation occurs, fewer are the Na+ channels available for activation-slope of '0' phase depolarization, AP amplitude and conduction velocity are reduced.

Cardiac Electrophysiology

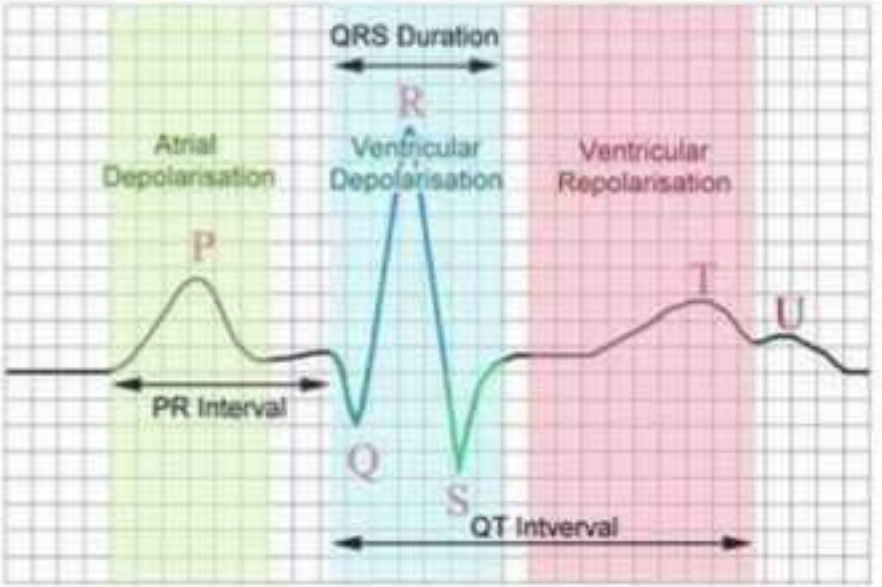
- **Excitability:**
  - Hyperpolarization decreases excitability while small reductions in resting membrane potential increase excitability by respectively increasing and decreasing the gap between it and the threshold potential.
- **Refractory period**
  - The effective refractory period (ERP) which is the minimum interval between two propagating Action Potentials.
  - **Most antiarrhythmic drugs increase ERP/Action Potential duration ratio.**

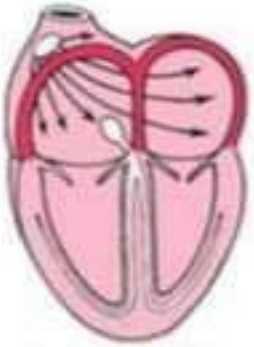
Cardiac Electrophysiology



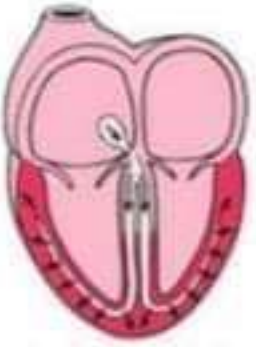
Paulev-Zubieta. New human physiology - Zubieta University. 2nd Edition.
Available in http://www.zuniv.net/physiology/book/chapter11.html [Last accessed on 28-08-2017

Cardiac Electrophysiology

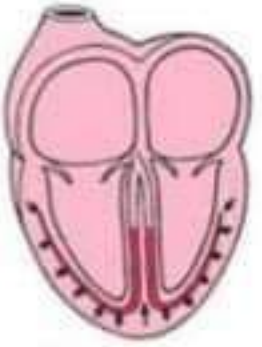




Activation of the atria



Activation of the ventricles



Recovery wave

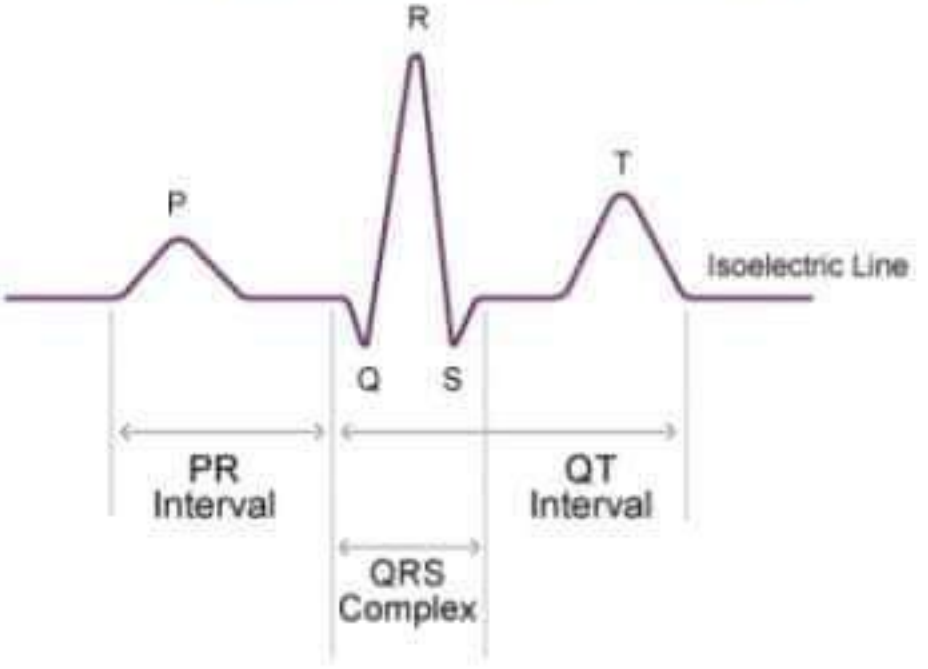
Normal Heartbeat

Fast Heartbeat

Slow Heartbeat

Irregular Heartbeat

Normal Intervals



P-R interval* = 0.12 - 0.20 sec

QRS width = 0.08 - 0.12 sec

Q-T interval 0.35 - 0.43 sec

* The PR interval should really be referred to as the PQ interval; however it is commonly referred as the PR interval

Autonomic influences on cardiac electrophysiology and contractility

Parameter	*Effect of stimulation*	
	Parasympathetic (ACh)	***Sympathetic (Adr)***
Automaticity		
SA node	Bradycardia	Tachycardia
Ectopic ventricular	--	Enhanced
Refractory period		
Atria	Shortened (inhomogeneous)	Shortened
Conducting tissue	Prolonged	Shortened
Conductivity	Decreased	Enhanced
Contractility	Decreased (little effect on ventricle)	Increased

AN EVERYDAY HEALTH INFOGRAM

7 STEPS TO A HEALTHIER HEART

You don't have to make big changes to reduce your heart attack and stroke risk. Here are 7 healthy habits that could save your life:

Live smoke-free. If you smoke, quit.

Monitor your blood pressure. Keep your numbers below 120/80 mm Hg.

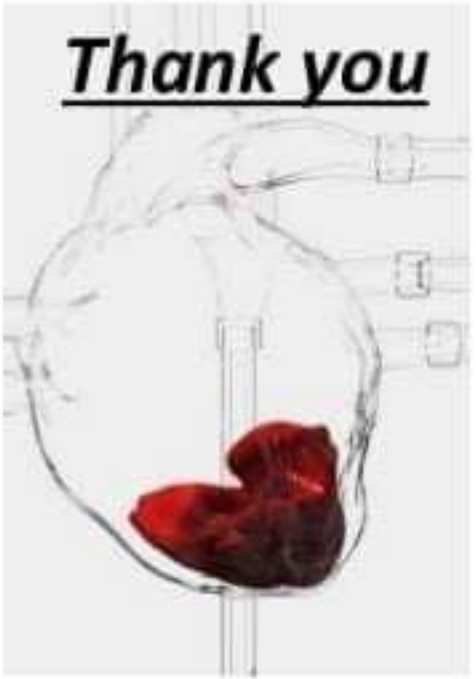
Maintain a healthy weight. Target a body mass index (BMI) of less than 25.

Watch your cholesterol. Strive for a total cholesterol less than 200 mg/dL.

Control your blood sugar. Aim for a fasting blood glucose less than 100 mg/dL.

Get active. Log 150 minutes of moderate intensity activity - like brisk walking - per week (or 75 minutes of vigorous-intensity activity).

Eat a heart-healthy diet. Make vegetables and fruits, whole grains, and fish mealtime staples. Limit sodium, saturated fat, and added sugar.



Source: American Heart Association

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