# GROUP 11- PROPERTIES OF CARDIAC MUSCLE.

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# Introduction

- The heart is composed of three major types of cardiac muscles: atrial muscle, ventricular muscle and specialized excitatory and conductive muscle fibres.
- The atrial and ventricular types of muscle contract in the much same way as skeletal muscle except that the duration of contraction is much longer.

- The specialized excitatory and conductive fibres of the heart, however, contract only feebly because they contain few contractile fibrils; instead they exhibit either automatic, rhythmical electrical discharge in form of action potential through the heart, providing an excitatory system that controls the rhythmical beating of the heart.

# PROPERTIES OF CARDIAC MUSCLE

- The properties of cardiac muscle include:

a. Automaticity
b. Excitability
c. Rhythmicity
d. Conductivity
e. Contractility

# EXCITABILITY

- This is the ability of a living tissue to give response to a stimulus. In all living tissues, initial response to stimulus is electrical activity inform of action potential followed by mechanical activity in form of contraction and secretion.
- The duration of action potential in a cardiac muscle is about 0.25-0.35 seconds.

# PHASES OF ACTION POTENTIAL.

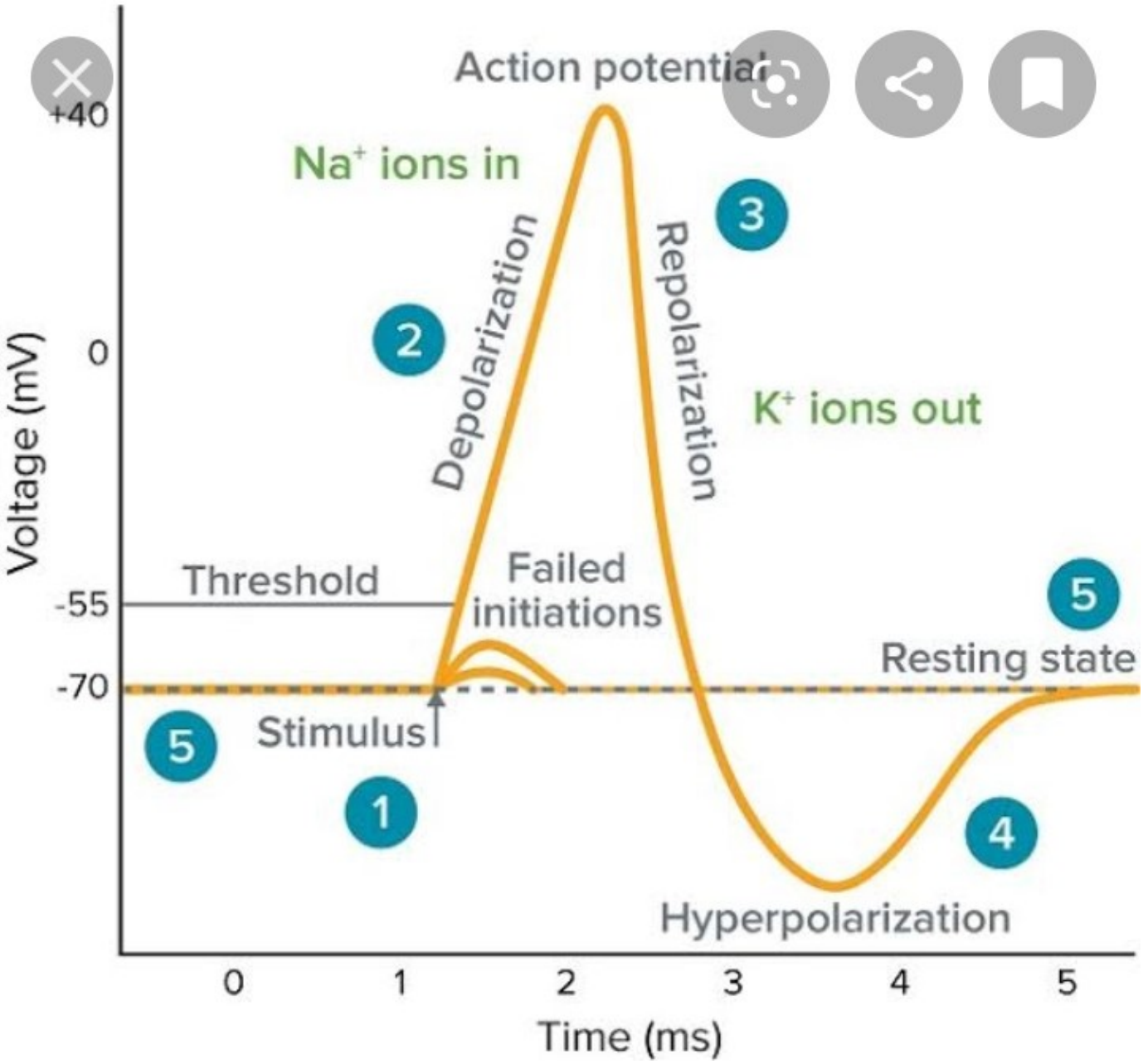
a. Initial depolarization
b. Initial repolarization
c. Plateau/ Final depolarization
d. Final repolarization

- *Initial depolarization* : It is very rapid and lasts for about 2m/sec. It has an amplitude of about +20mv. It occurs as a result of the rapid opening of fast sodium channels and the rapid influx of sodium ions.
- *Initial repolarization* : It occurs immediately after initial depolarization. The end of this phase is represented by a notch. It is due to opening of potassium channels and efflux of small quantity of potassium ions from the muscle fibre.

Simultaneously, the fast sodium channels close and slow sodium channels open, resulting in slow influx of sodium ions.

- *Plateau/ Final depolarization* : This is due to the slow opening of calcium channels. These channels are opened for a longer period and cause influx of large number of calcium ions. Because of the entry of calcium and sodium ions into the muscle fibre , positivity is maintained inside the muscle fibre.

- *Final repolarization* : It is a slow process and lasts for about 50-80msec. It occurs as a result of efflux of potassium ions. The number of potassium ion moving out of the muscle fibre exceeds the number of calcium ion moving inside. It causes negativity inside.
- Due to this negativity, there is activation of sodium-potassium pump in order to restore the resting membrane potential. Three molecules of sodium ion moves out and two molecules of potassium ion moves into the muscle fibre.


Action potential
+40
0
-55
-70
Voltage (mV)
Na+ ions in
Depolarization
Repolarization
K+ ions out
Threshold
Failed initiations
Resting state
Stimulus
Hyperpolarization
1
2
3
4
5
5
0
1
2
3
4
5
Time (ms)

# RHYTHMICITY

- This is the ability of a tissue to produce its own impulses regularly. The mammalian heart has a specialized structure from which production of impulse is maximum. It is referred to as the *pacemaker.*
- The pacemaker is composed of p-cells. The pacemaker of the heart is the sinoatrial node-SA node.

- The SA node is a strip of modified cardiac muscle found in the superior part of the lateral wall of the right atrium, just below the superior vena cava.
- Other parts of the heart such as the atrium, ventricle, atrioventricular node can generate impulses, still SA node is considered the pacemaker because the rate of production and generation of impulse is much greater (about 70-80 per minute.

# CONDUCTIVITY

- The human heart has a specialized conductive system through which electrical impulses from the sinoatrial node (SA node) are transmitted to other parts of the heart.
- The conductive system of the heart is formed by the modified cardiac muscle fibers. These fibers are the specialized cells, which conduct the impulses rapidly from the SA node.

# Components of the Conductive System in Human Heart

I. Atrioventricular node (AV node)
II. Bundle of His
III. Right and left bundle branches
IV. Purkinje fibers

- **SA node** is situated in the right atrium, just below the opening of the superior vena cava.
- It is connected to the **AV node** in the right posterior portion of the intra-atrial septum via the *inter-nodal fibers* .
- There are three types of inter-nodal fibers;

1. Anterior inter-nodal fibers of Bachman
2. Middle inter-nodal fibers of Wenckebach
3. Posterior inter-nodal fibers of Thorel

- All these fibers from SA node converge on AV node and lock together with fibers of AV node. From AV node, the **bundle of His** arises. It divides into the **left and right bundle branches** which harbor **Purkinje fibers** that spread all over the ventricular myocardium.

# Velocity of Impulse at Different Parts of the Conductive

| Part of conducting system | Velocity (m/s) |
|---|---|
| Atrial muscle | 0.3 |
| Inter-nodal fibers | 1.0 |
| AV node | 0.05 |
| Bundle of His | 1.2 - 2.0 |
| Purkinje fibers | 4.0 |
| Left and right bundle branches | 2.0 |

# CONTRACTILITY

- This is the ability of a cardiac muscle to shorten in length (contraction) after receiving stimulus.
- Various factors affect the contractile properties of cardiac muscles. They are:

## All-or-None Law

According to this law, when a stimulus is applied, whatever may be the strength, the whole cardiac muscle either gives maximum response or gives no response at all.

## Staircase Phenomenon

When the base of the ventricle is stimulated at a short interval of 2 seconds, without changing the strength, the force of contraction increases gradually for the first few contractions and then it remains the same. This gradual increase in contraction is known as *staircase phenomenon.*

## Refractory Period

This is the period in which the muscle does not show any response to stimulus.

# AUTOMATICITY

- This is the ability of the heart to spontaneously depolarize and generate an action.
- This is the unique and most important property of cardiac muscles.
- In a normal healthy heart, only cells in the SA node, AV node and His-Purkinje conduction system have the property of automaticity i.e. the ability to spontaneously depolarize when left unstimulated; the transmembrane potential in these cells is never stable (never