

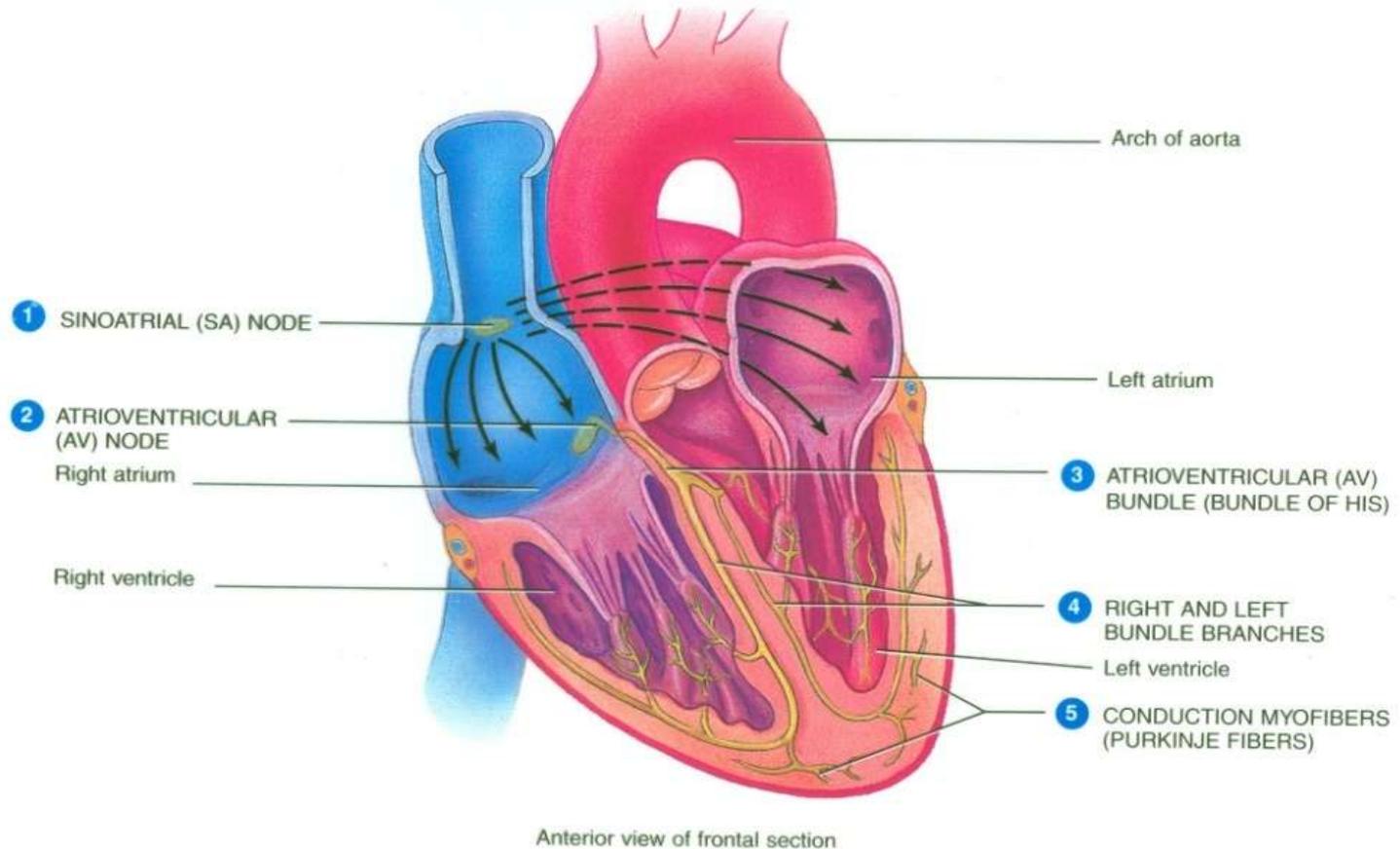
Conduction System of the Heart

Faisal I. Mohammed, MD, PhD

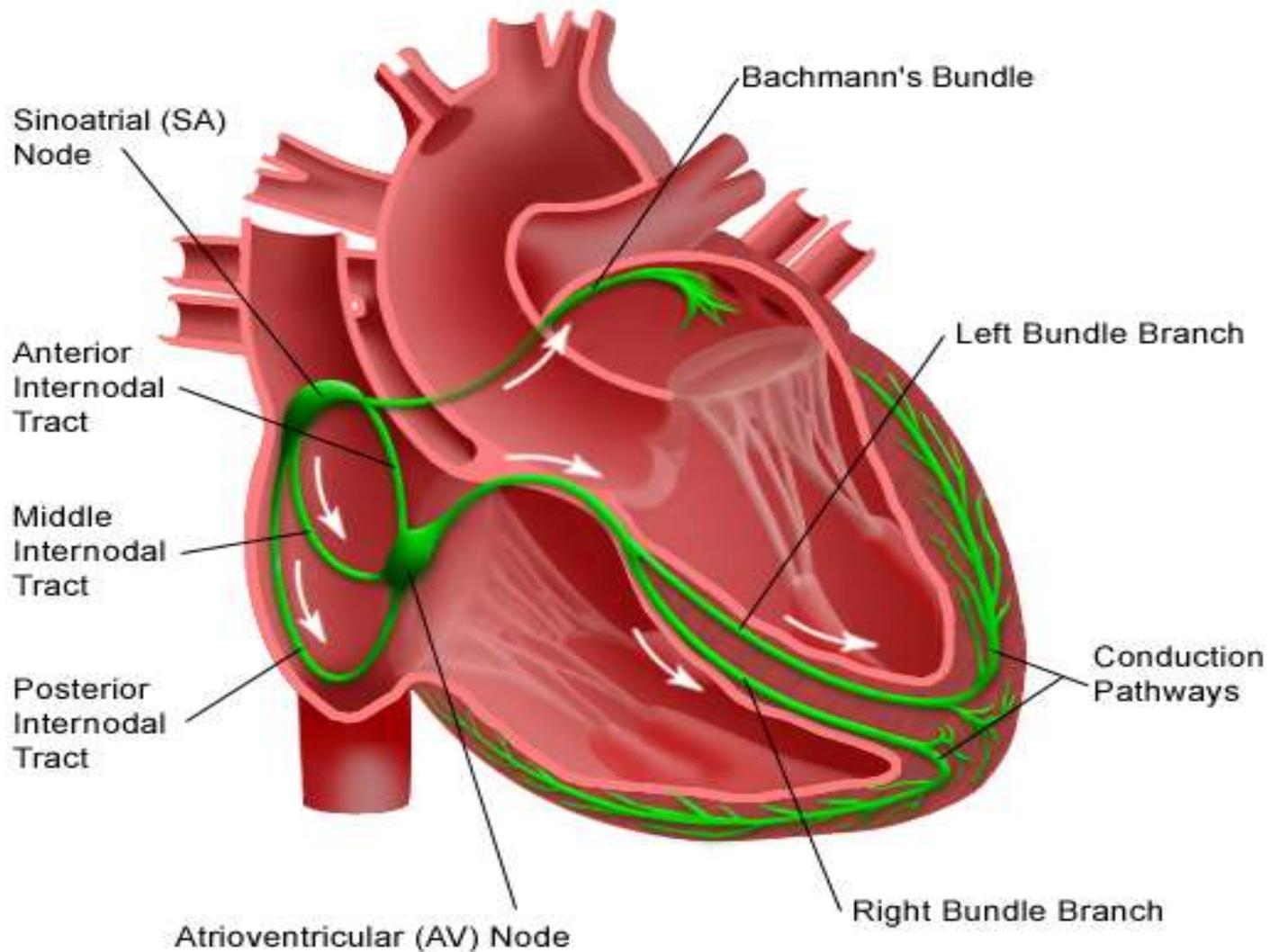
Objectives

- List the parts that comprise the conduction system
- Explain the mechanism of slow response action potential (pacemaker potential)
- Point out the regulation of the conduction system potential by Autonomic Nerves

Structures of the conduction system

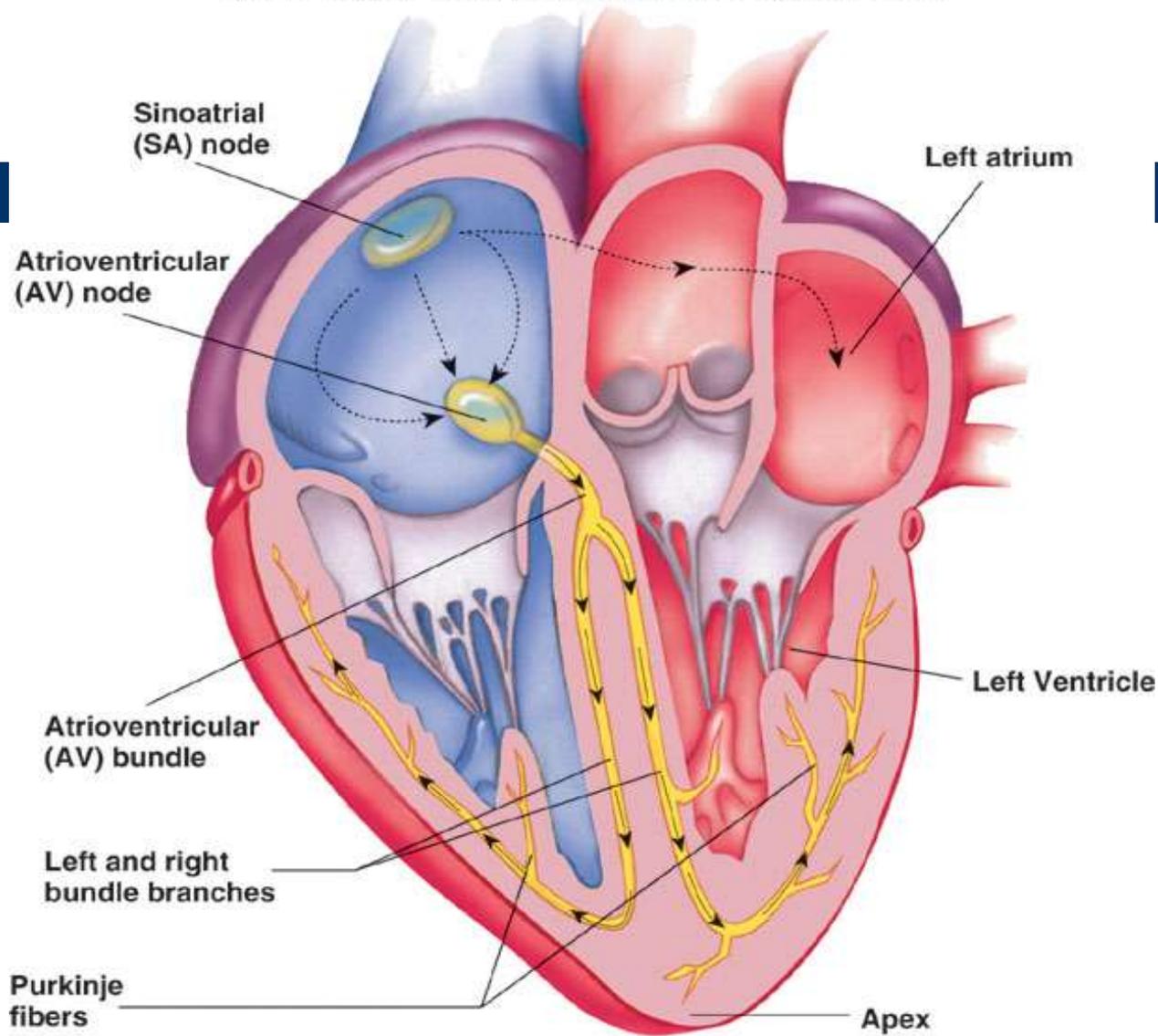


Electrical System of the Heart



Conducting System of Heart

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Superior
vena cava

① Sinoatrial (SA)
node (pacemaker)

Internodal
pathway

② Atrioventricular
(AV) node

③ Atrioventricular
(AV) bundle
(Bundle of His)

④ Bundle branches

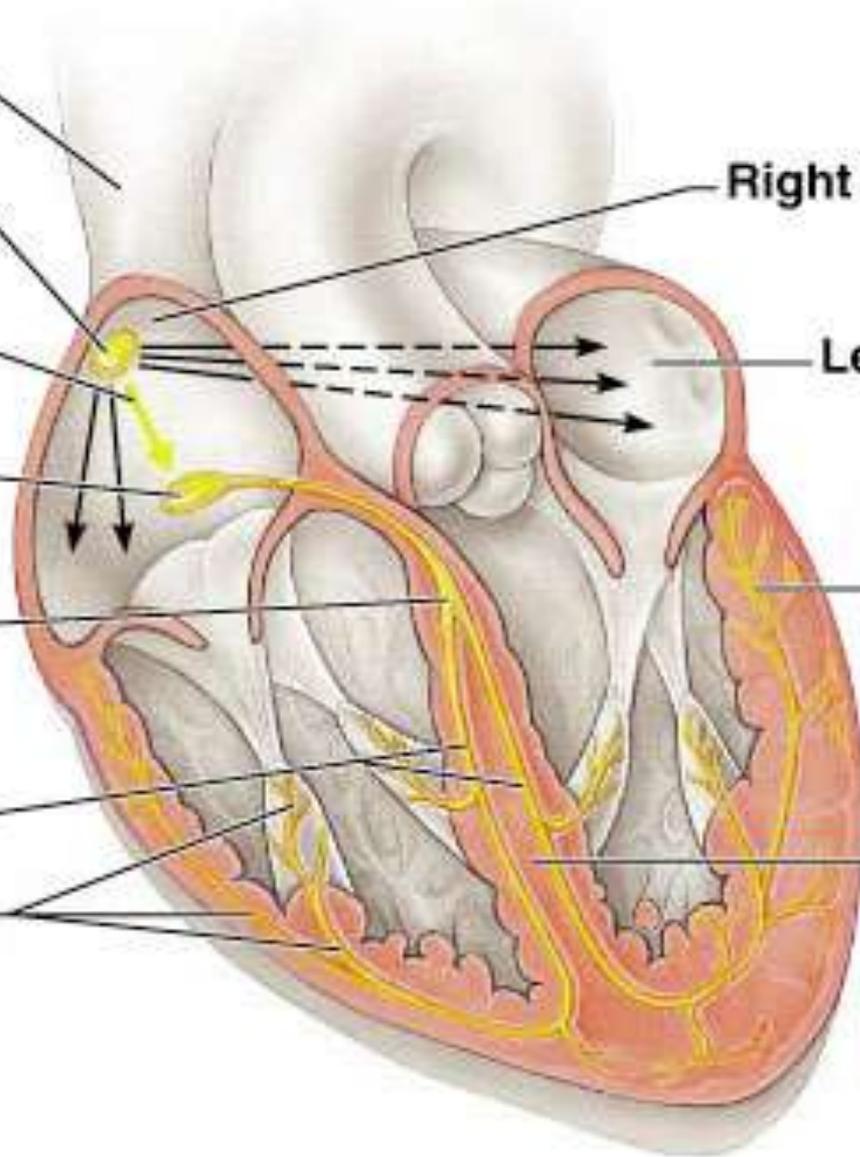
⑤ Purkinje fibers

Right atrium

Left atrium

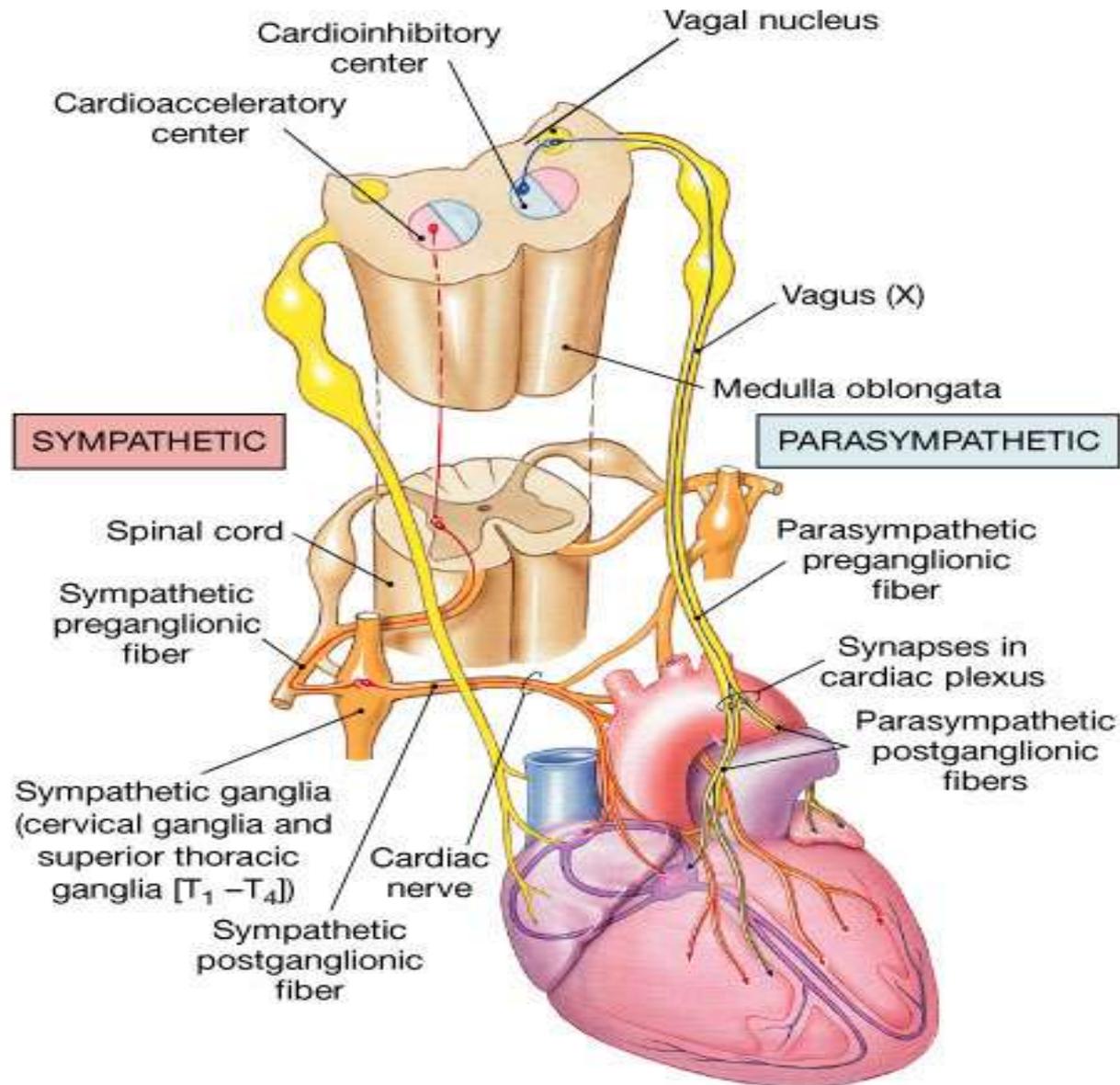
Purkinje
fibers

Inter-
ventricular
septum



(a)

Autonomic Innervation of the Heart



Intrinsic Cardiac Conduction System

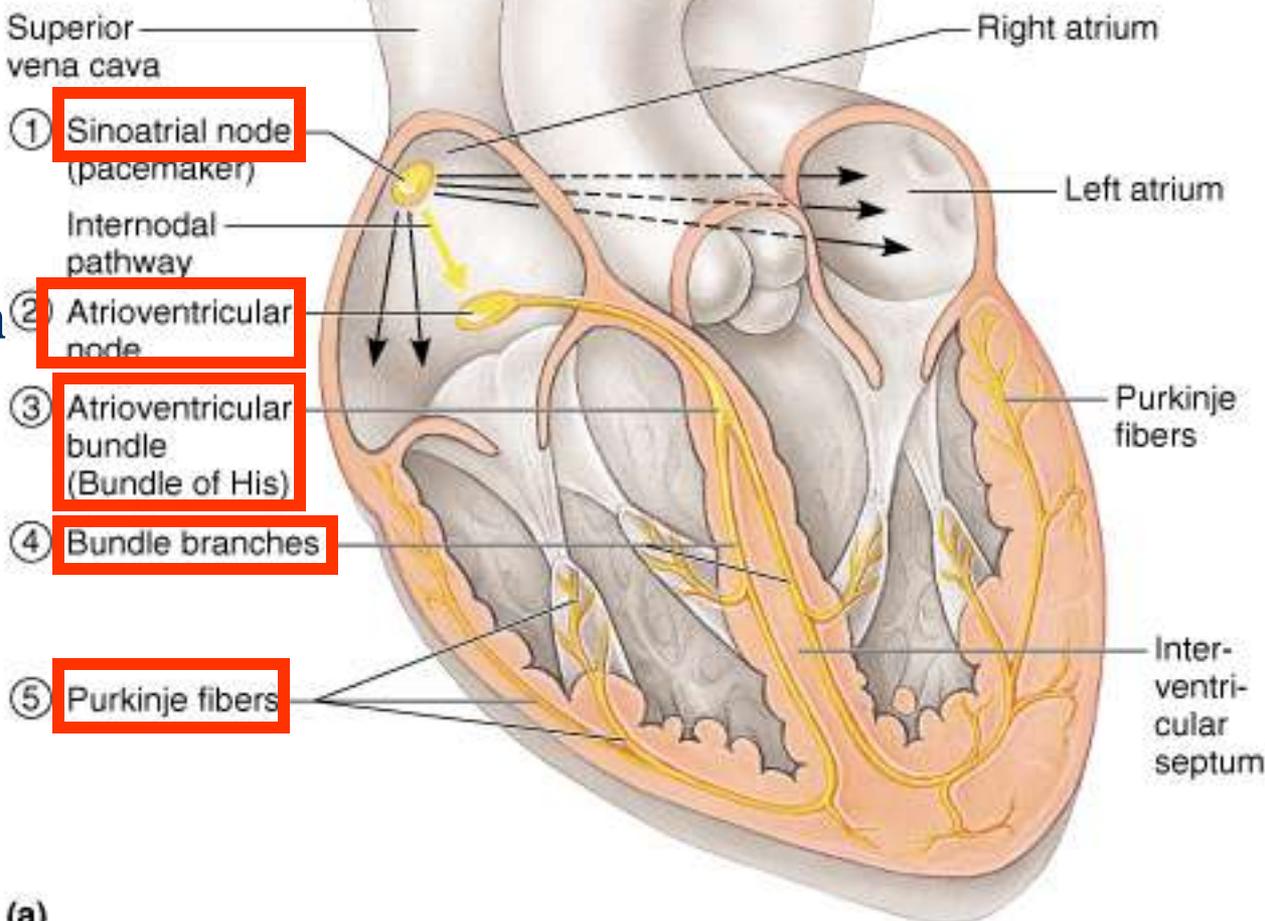
Approximately 1% of cardiac muscle cells are autorhythmic rather than contractile



75/min

40-60/min

30/min

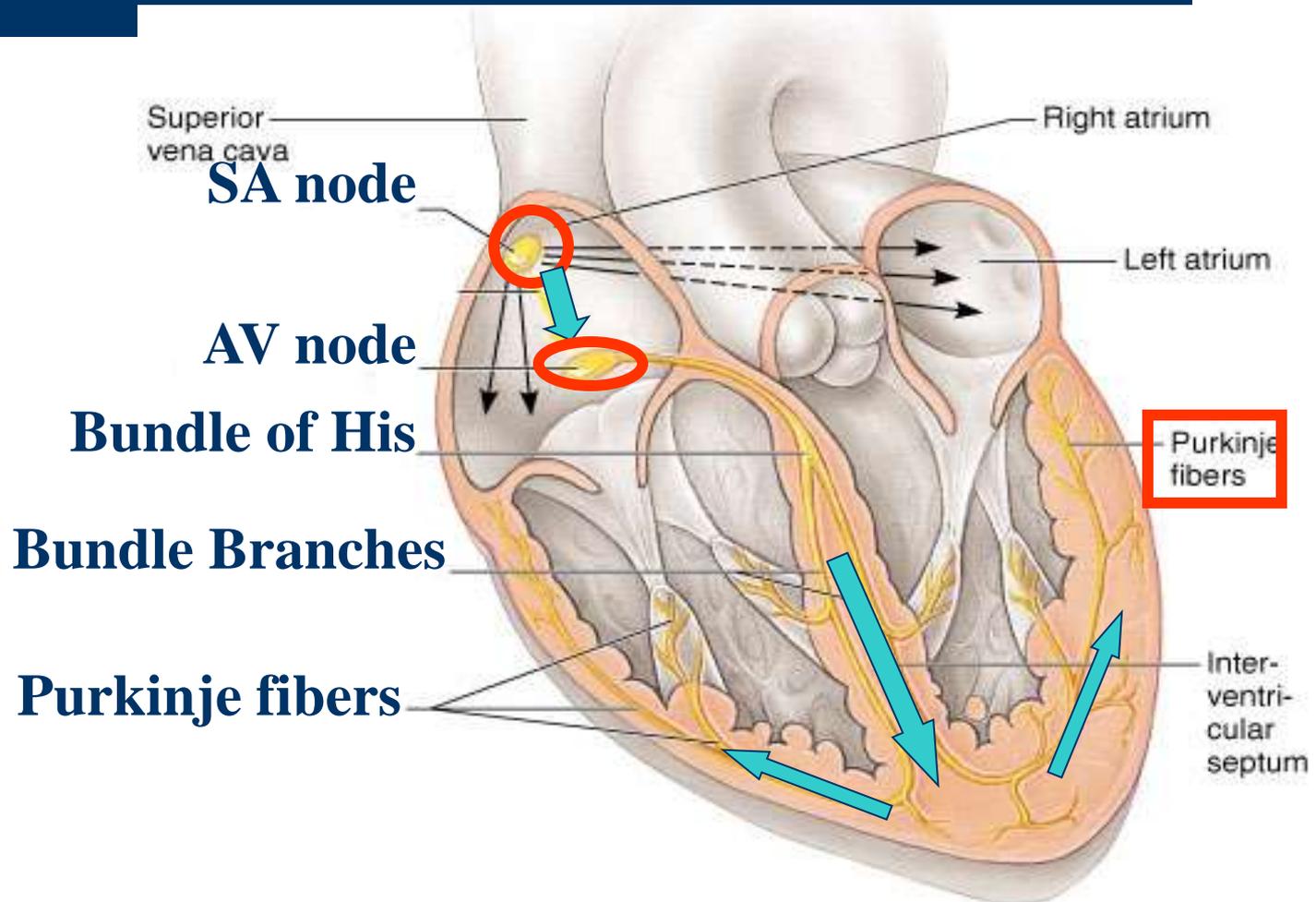


(a)

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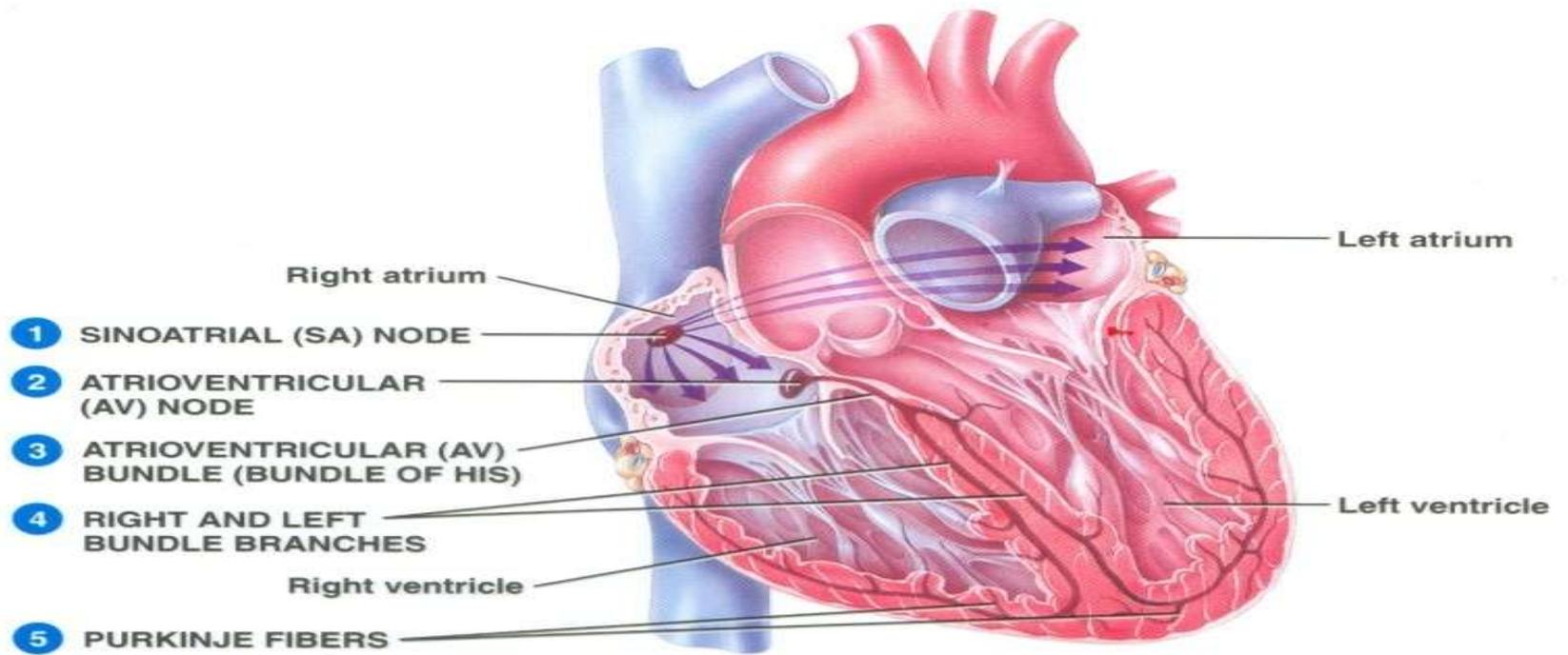
Intrinsic Conduction System

Function: initiate & distribute impulses so heart depolarizes & contracts in orderly manner from atria to ventricles.

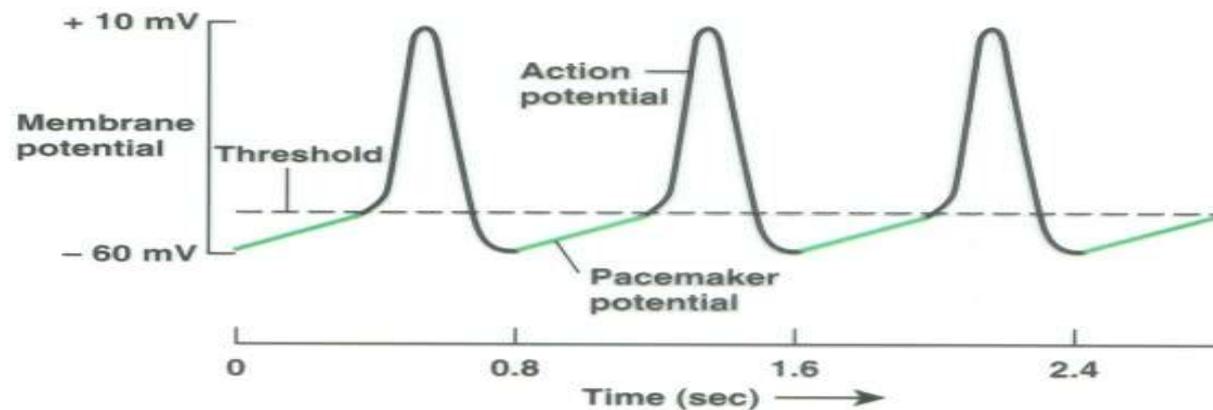


Sinus Node

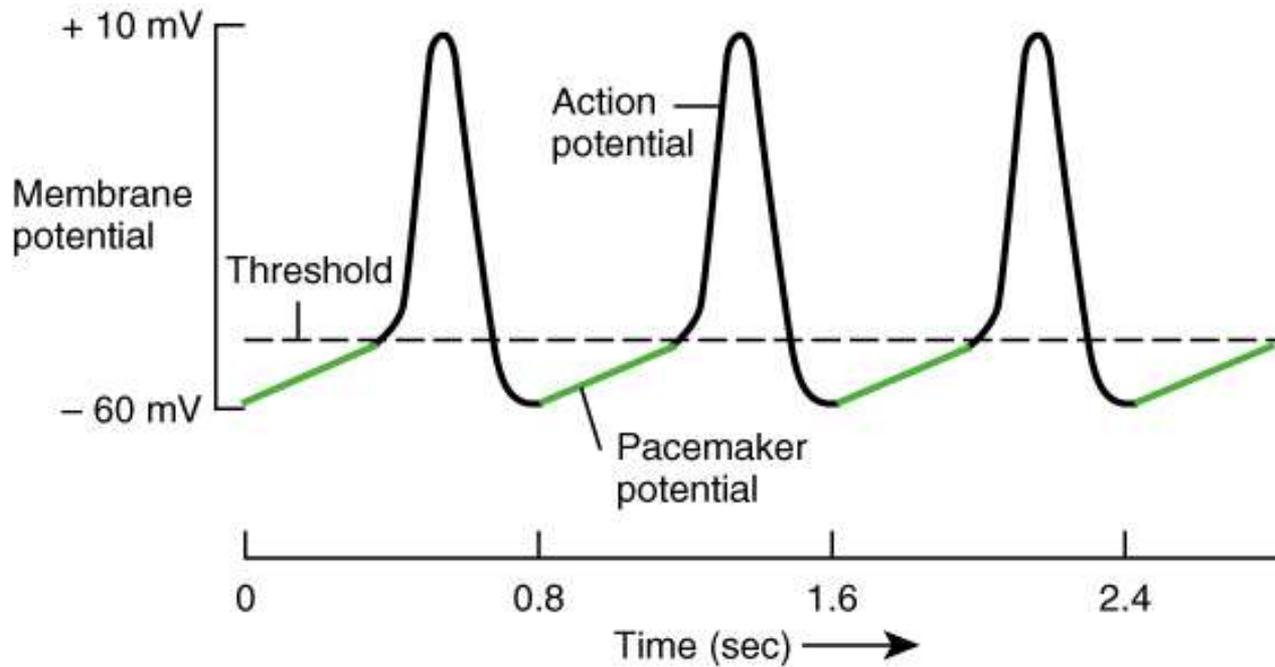
- Specialized cardiac muscle connected to atrial muscle.
- Acts as pacemaker because membrane leaks Na^+ and membrane potential is -55 to -60mV
- When membrane potential reaches -40 mV, slow Ca^{++} channels open causing action potential.
- After 100-150 msec Ca^{++} channels close and K^+ channels open more thus returning membrane potential to -55mV .



(a) Anterior view of frontal section



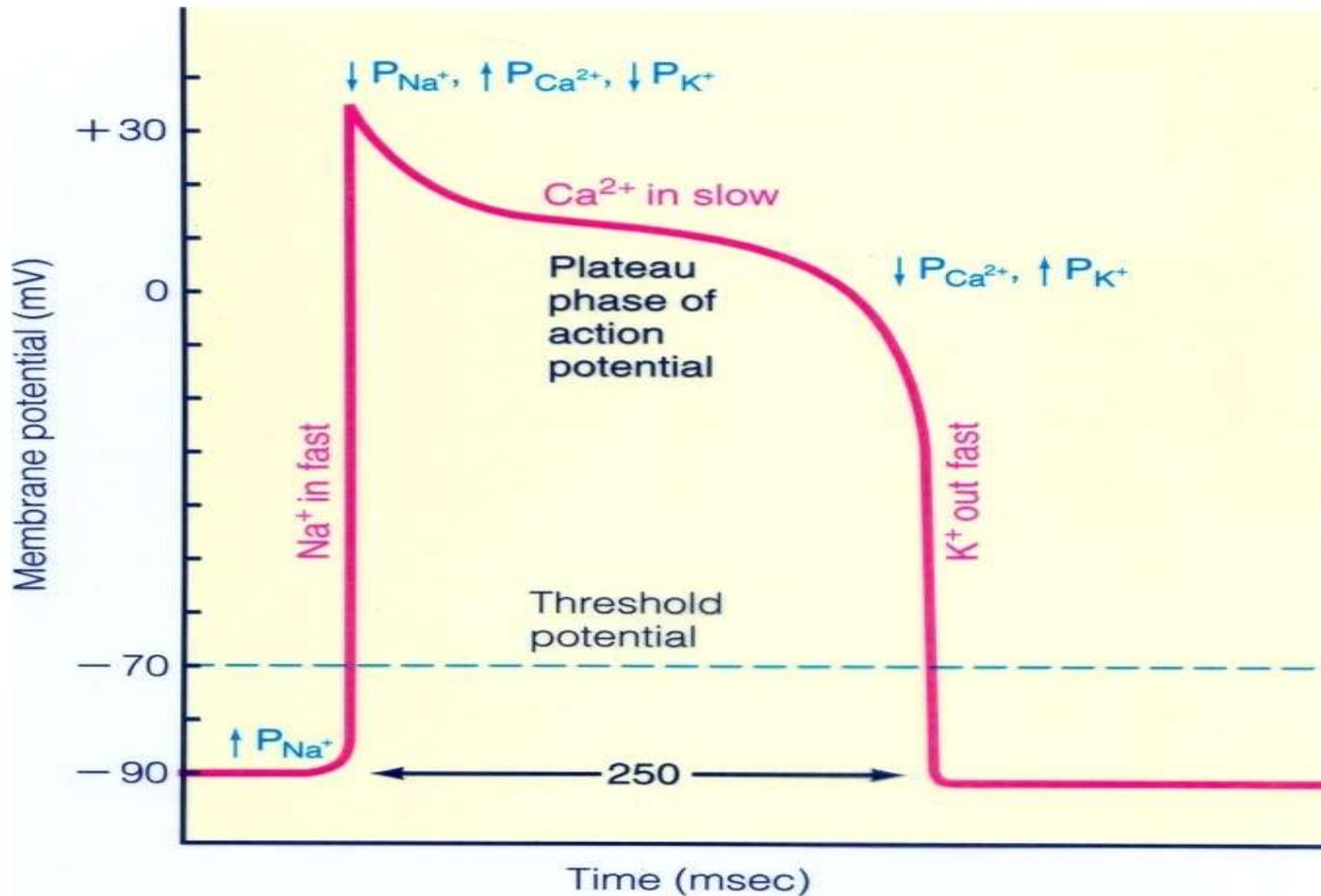
(b) Pacemaker potentials and action potentials in autorhythmic fibers of SA node



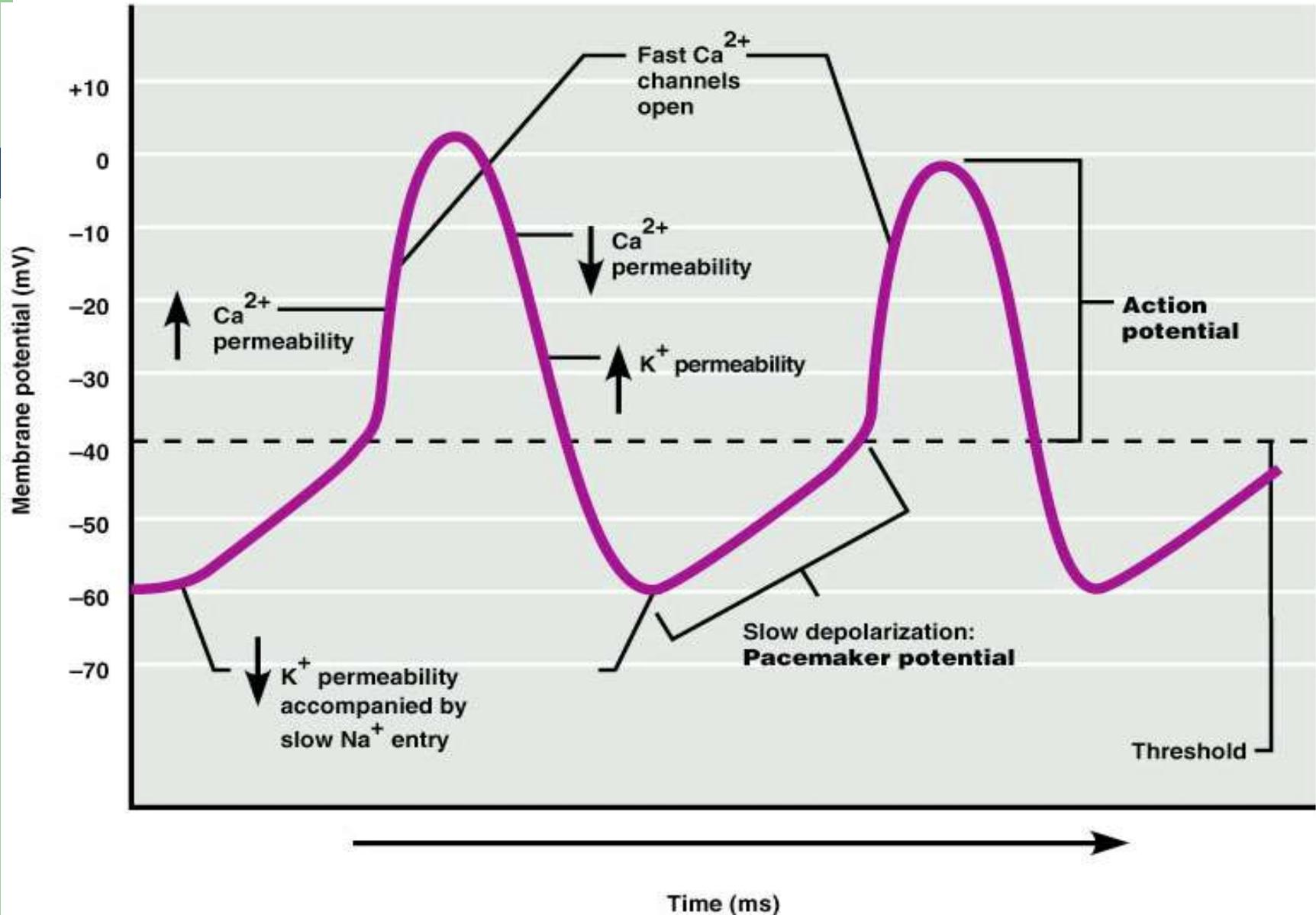
(b) Pacemaker potentials and action potentials in autorhythmic fibers of SA node

20.10b

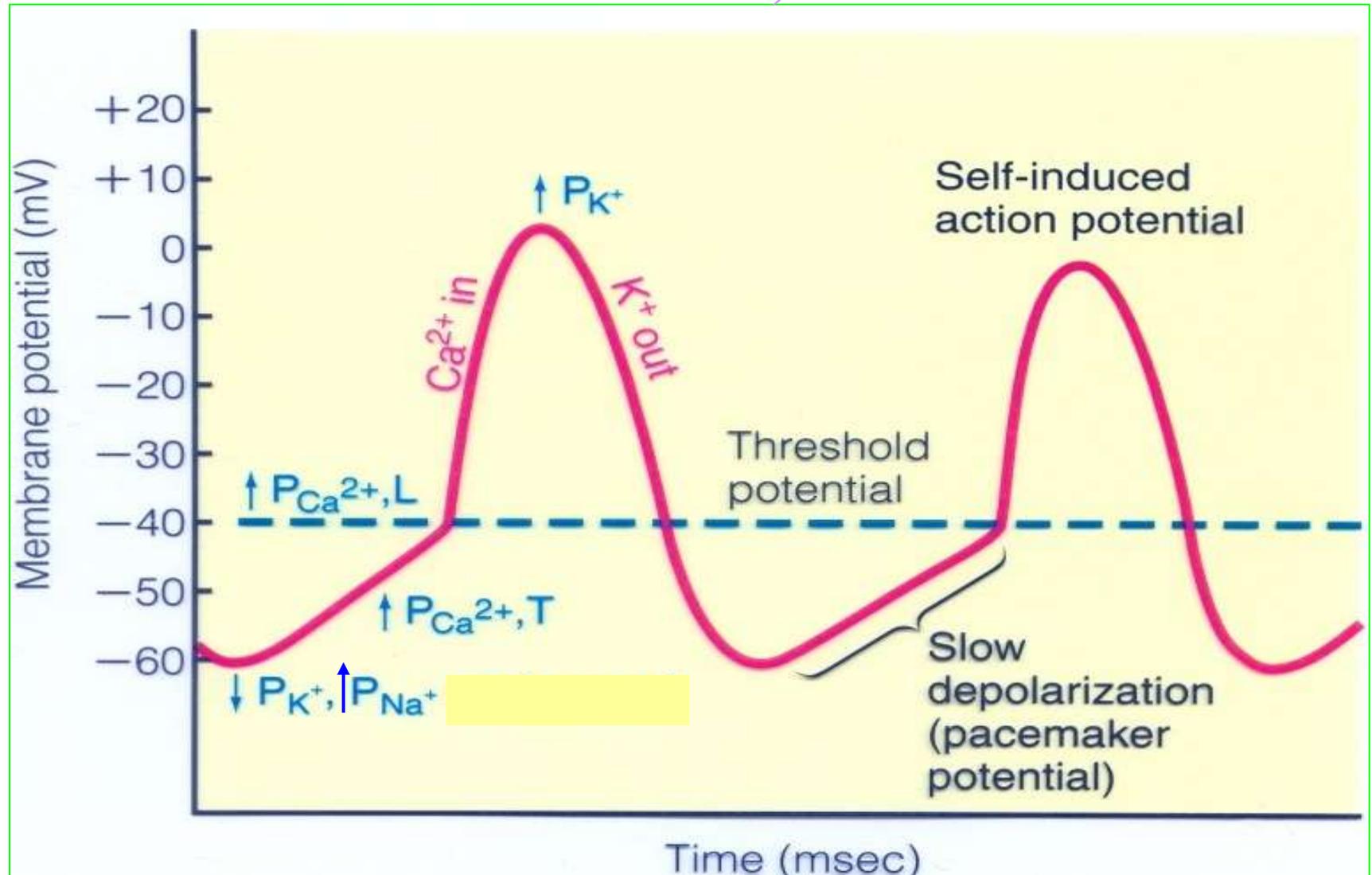
Fast Response Action Potential of Contractile Cardiac Muscle Cell



Pacemaker and Action Potentials of the Heart



Slow Response Action Potential (Pacemaker Potential)



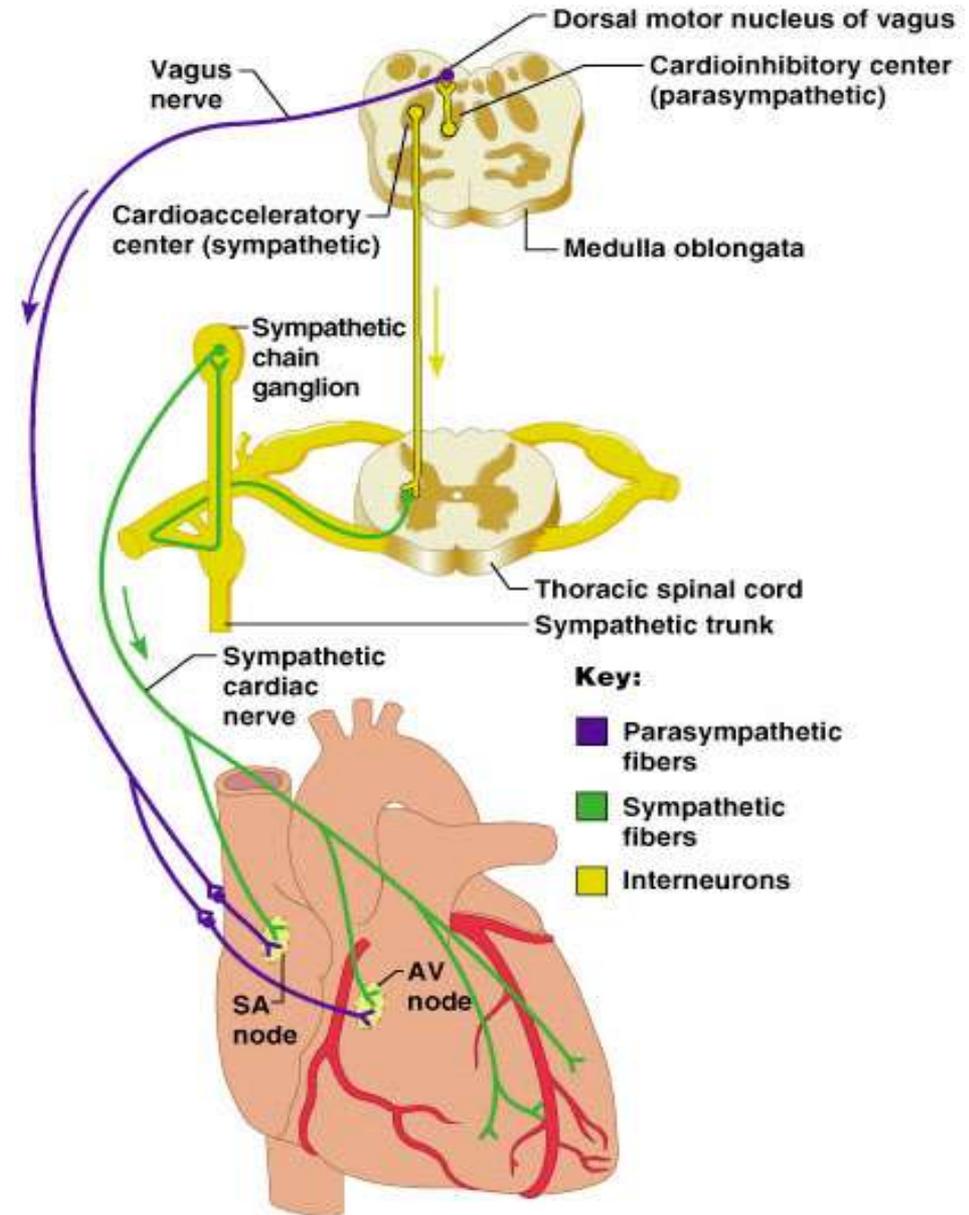
Intrinsic rate and speed of conduction of the components of the system

- SA node 60-80 action potential /min (*Pacemaker*)
- AV node 40-60 action potential /min
- Purkinje 15-40 action potential /min

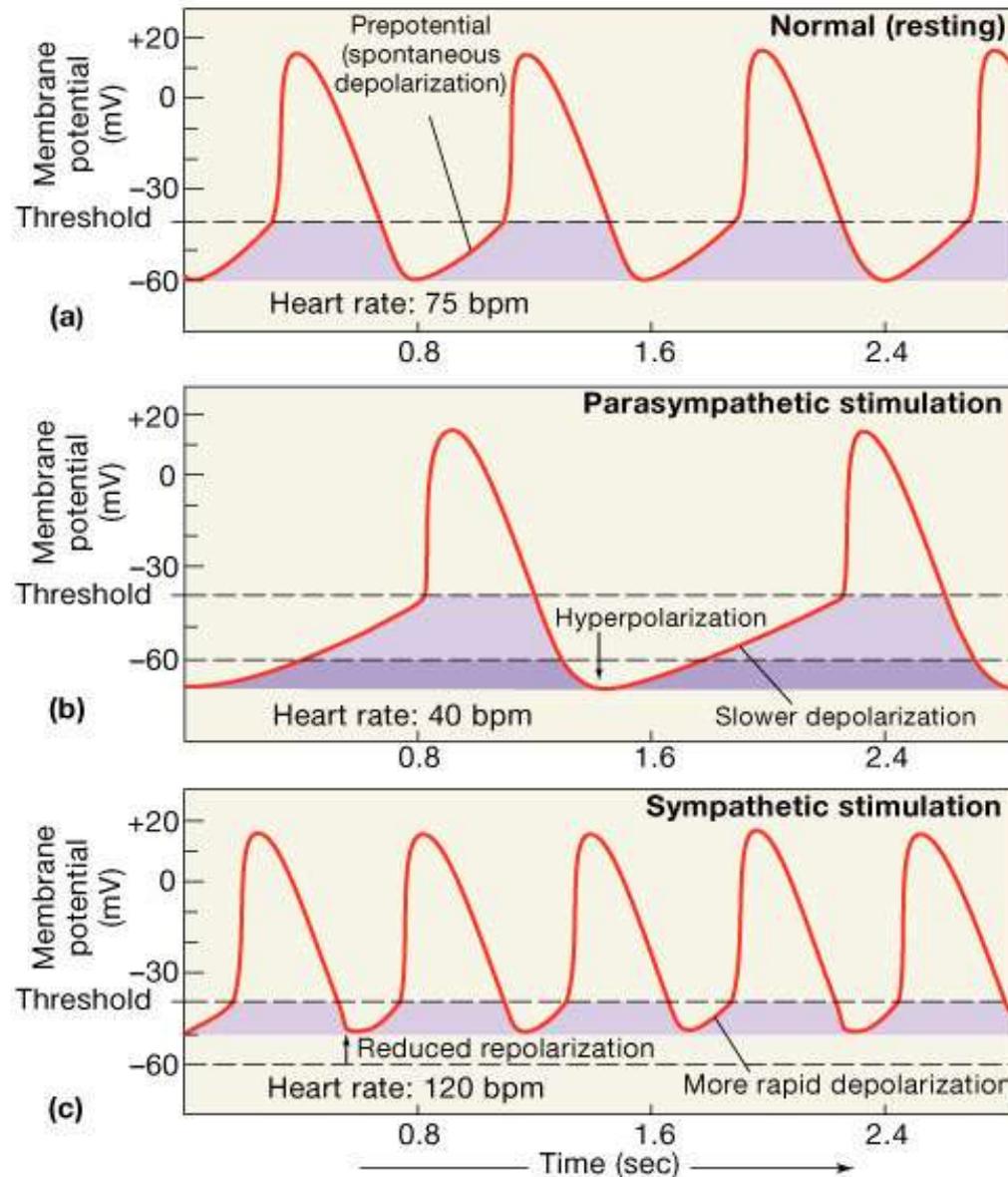
Conduction Speed

- SA node: slow speed of conduction
- Ventricular and Atrial muscle: Moderate speed
- AV node: slowest speed of conduction
- Purkinje fibers: Fastest speed of conduction
- *Ectopic Pacemaker- Abnormal site of pacemaker*

Extrinsic Innervation of the Heart



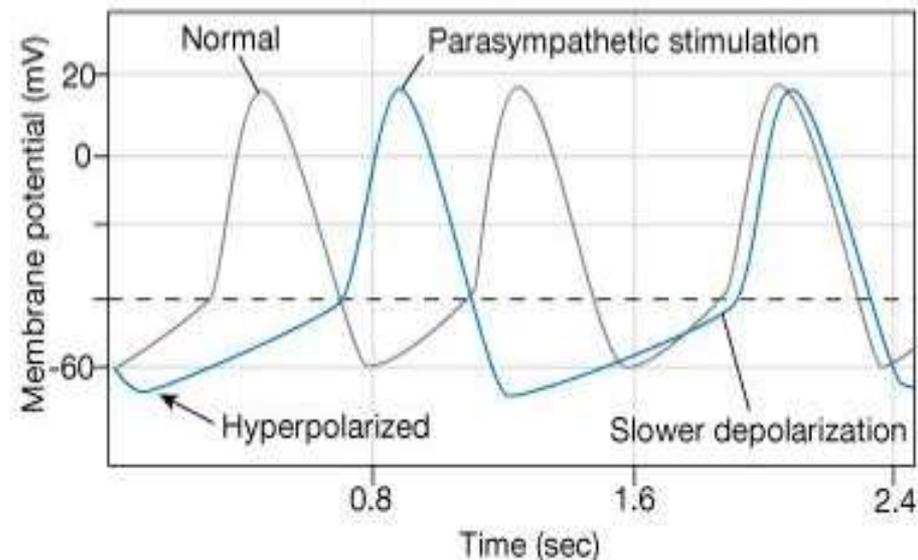
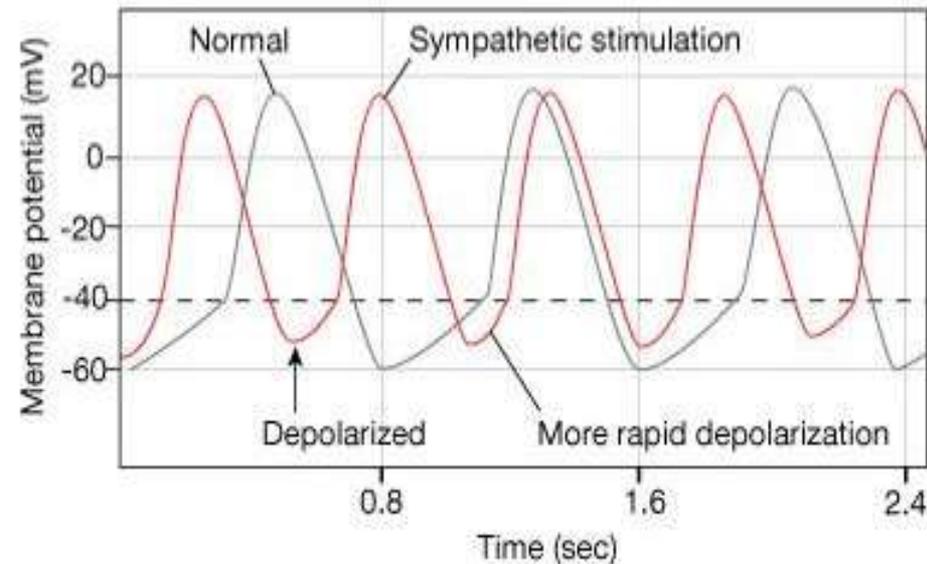
Pacemaker Function



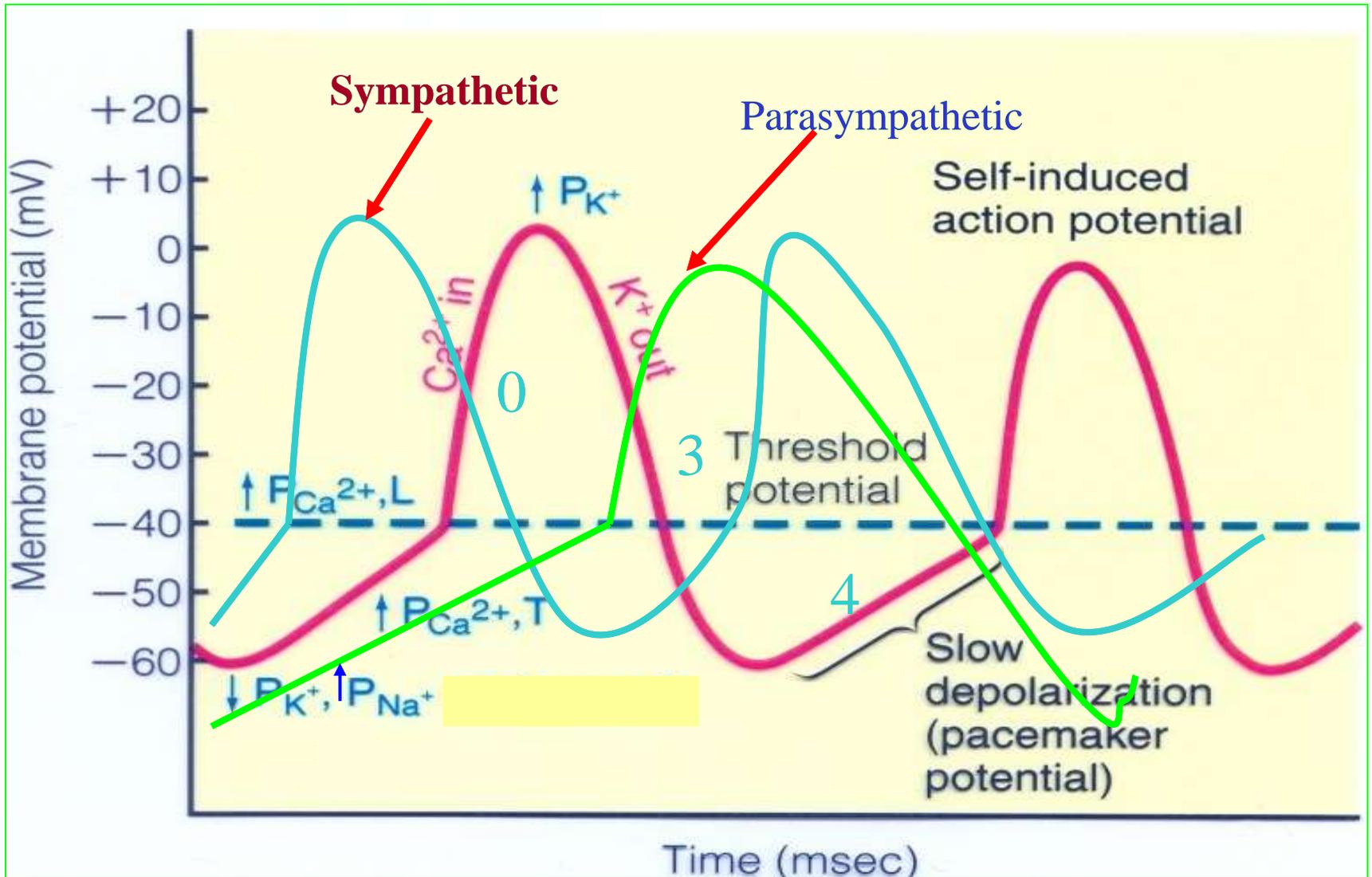
Autonomic neurotransmitters affect ion flow to change rate

- **Sympathetic** – increases heart rate by \uparrow Ca^{+2} & I_f channel (net Na^+) flow
- **Parasympathetic** – decreases rate by \uparrow K^+ efflux & \downarrow Ca^{+2} influx

What part of the graph is not changed by autonomic influences?



Effect of Sympathetic & Parasympathetic Stimulation



Regulation of the heart beat

- Sympathetic from the cardiac plexus supplies all parts of the heart (atria, ventricle and all parts of the conduction system)
- Parasympathetic from Vagus nerves supply mainly the atria, SA and AV nodes, very little supply to ventricles
- Sympathetic: increase the permeability of the cardiac cells to Na^+ and Ca^{++} i.e Positive **Chronotropic** and positive **Inotropic** action
- Parasympathetic: Increase the permeability of the cardiac cells to K^+ and decrease its permeability to Na^+ and Ca^{++}

Sinus Node is Cardiac Pacemaker

- Normal rate of discharge in sinus node is 70-80/min.; A-V node - 40-60/min.; Purkinje fibers - 15-40/min.
- Sinus node is pacemaker because of its faster discharge rate
- Intrinsic rate of subsequent parts is suppressed by “Overdrive suppression”

Ectopic Pacemaker

- This is a portion of the heart with a more rapid discharge than the sinus node.
- Also occurs when transmission from sinus node to A-V node is blocked (A-V block).

Parasympathetic Effects on Heart Rate

- Parasympathetic (vagal) nerves, which release acetylcholine at their endings, innervate S-A node and A-V junctional fibers proximal to A-V node.
- Causes hyperpolarization because of increased K^+ permeability in response to acetylcholine.
- This causes decreased transmission of impulses maybe temporarily stopping heart rate.

Sympathetic Effects on Heart Rate

- Releases norepinephrine at sympathetic ending
- Causes increased sinus node discharge (*Chronotropic effect*)
- Increases rate of conduction of impulse (*Dromotropic effect*)
- Increases force of contraction in atria and ventricles (*Inotropic effect*)

Thank You

