Conduction System of the Heart

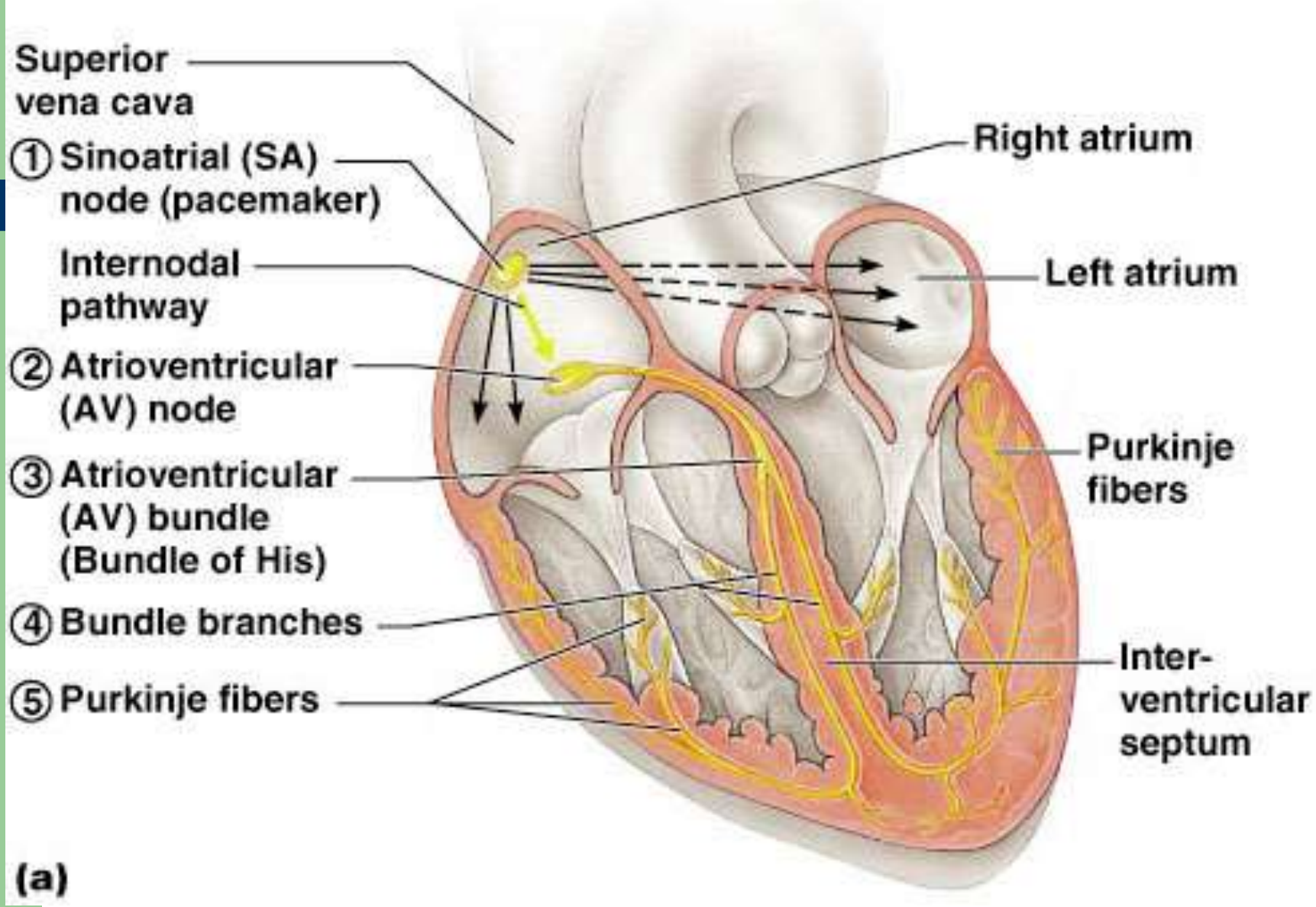
Faisal I. Mohammed, MD, PhD

Yanal A. Shafagoj 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

Conducting System of Heart



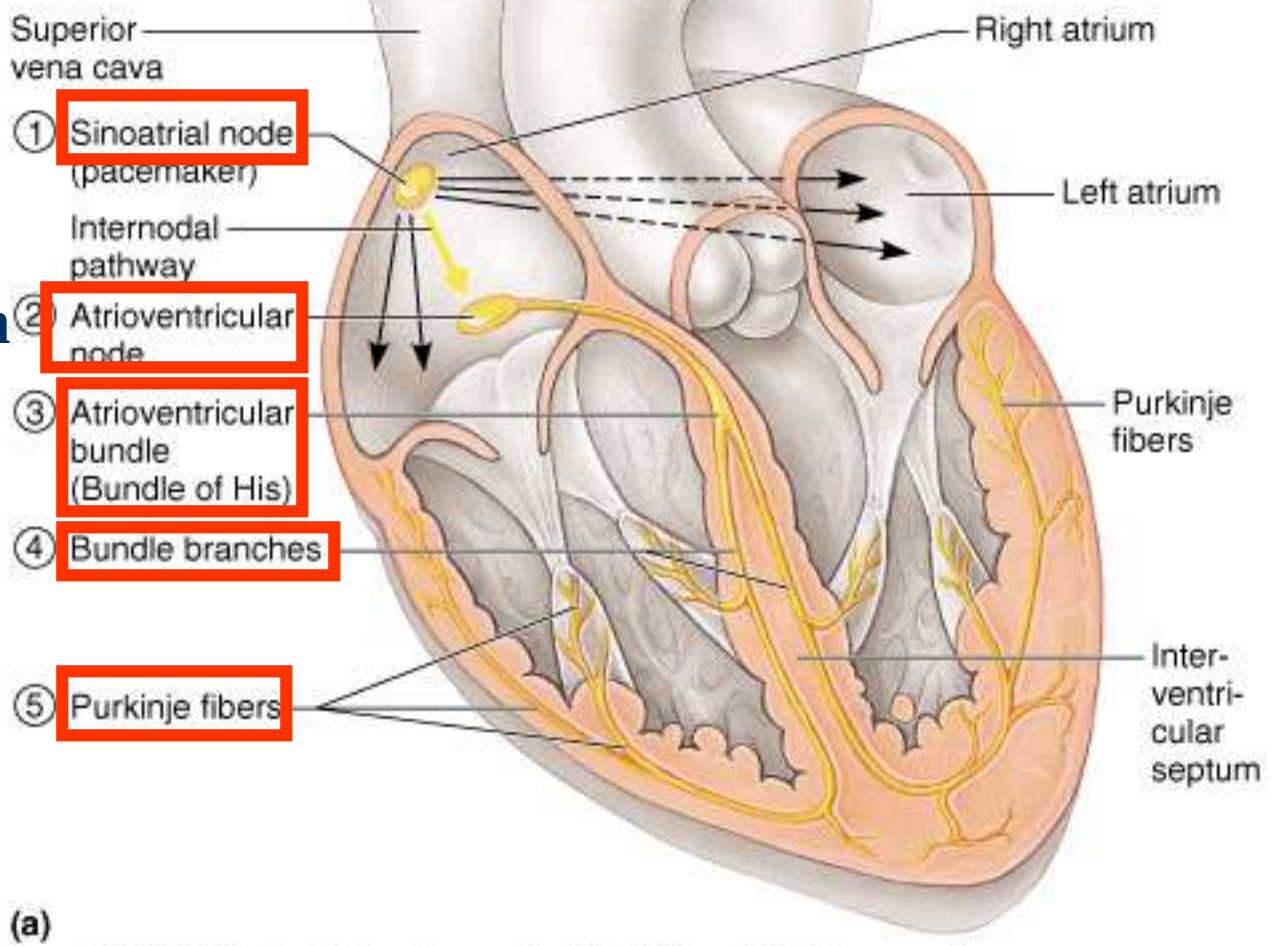
Intrinsic Cardiac Conduction System

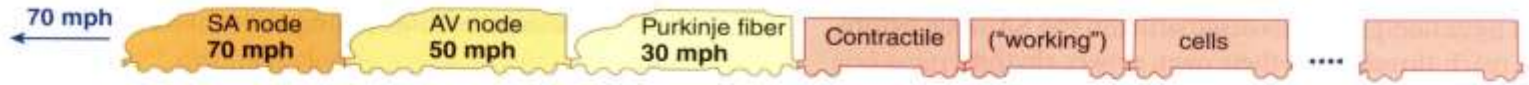
Approximately 1% of cardiac muscle cells are autorhythmic rather than contractile

70-80/min

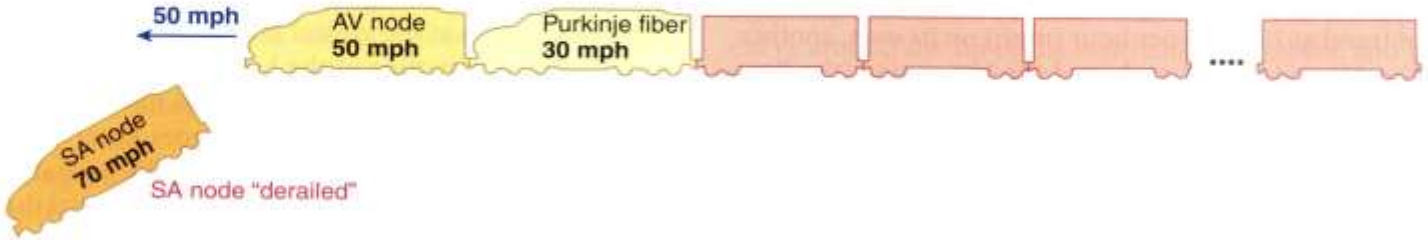
40-60/min

15-40/min

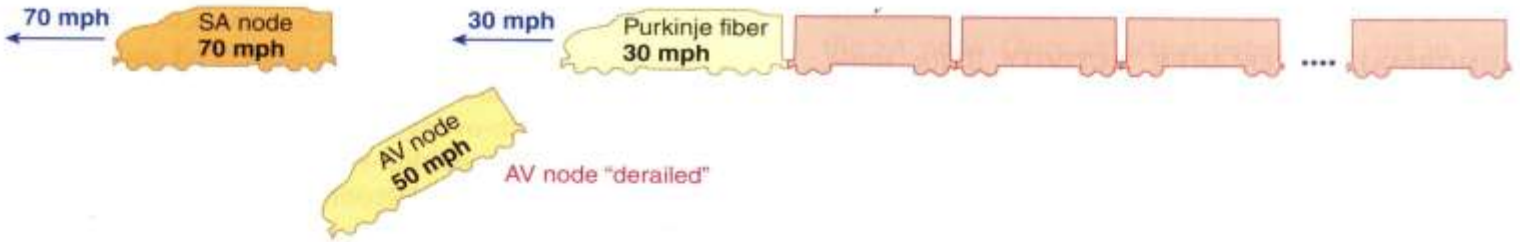




(a) Normal pacemaker activity: Whole train will go **70 mph** (heart rate set by SA node, the fastest autorhythmic tissue).



(b) Takeover of pacemaker activity by AV node when the SA node is nonfunctional: Train will go **50 mph** (the next fastest autorhythmic tissue, the AV node, will set the heart rate).

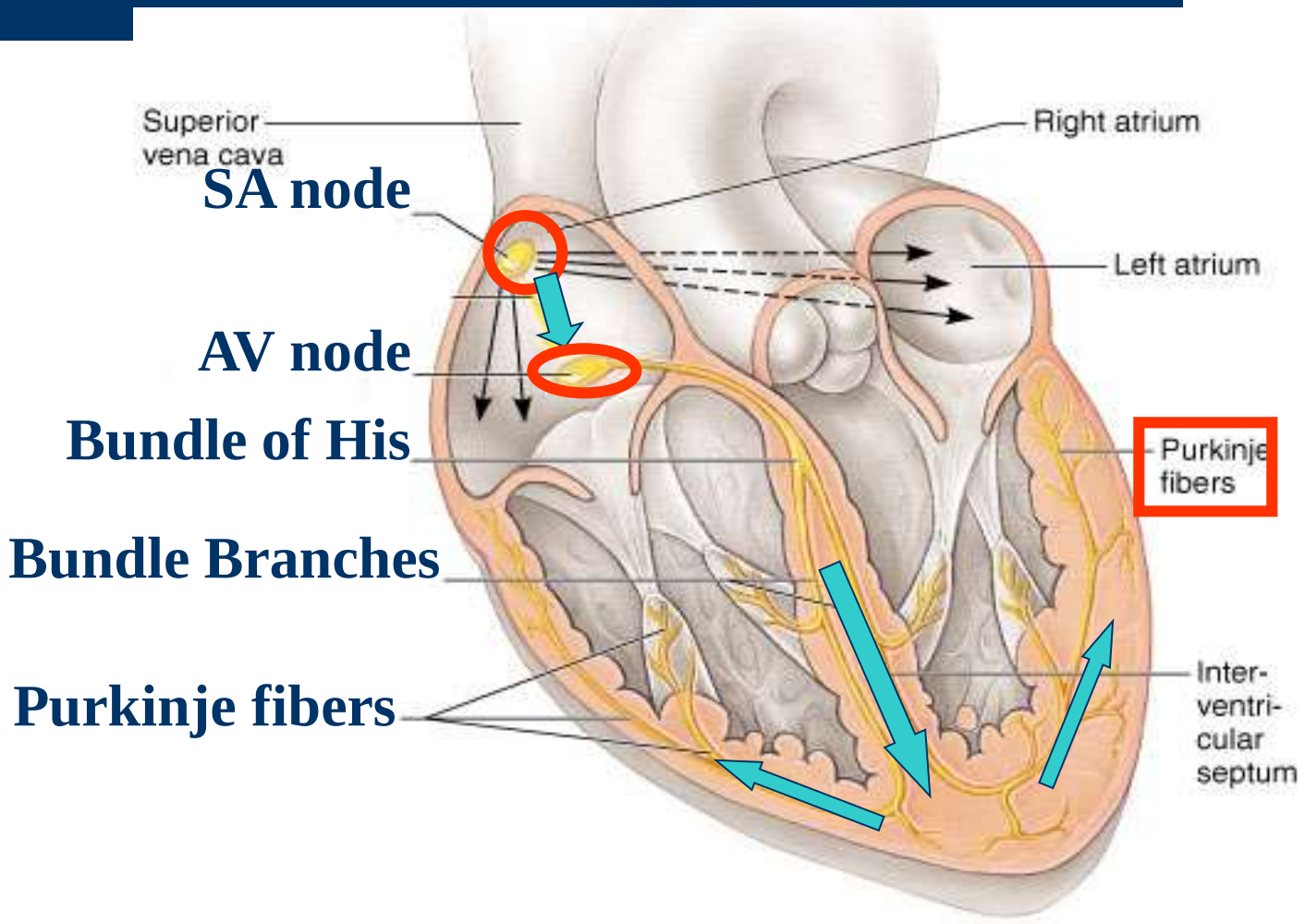


(c) Takeover of ventricular rate by the slower ventricular autorhythmic tissue in complete heart block: First part of train will go **70 mph**; last part will go **30 mph** (atria will be driven by SA node; ventricles will assume own, much slower rhythm).

(d) Takeover of pacemaker activity by an ectopic focus: Train will be driven by ectopic focus, which is now going faster than the SA node (the whole heart will be driven more rapidly by an abnormal pacemaker).

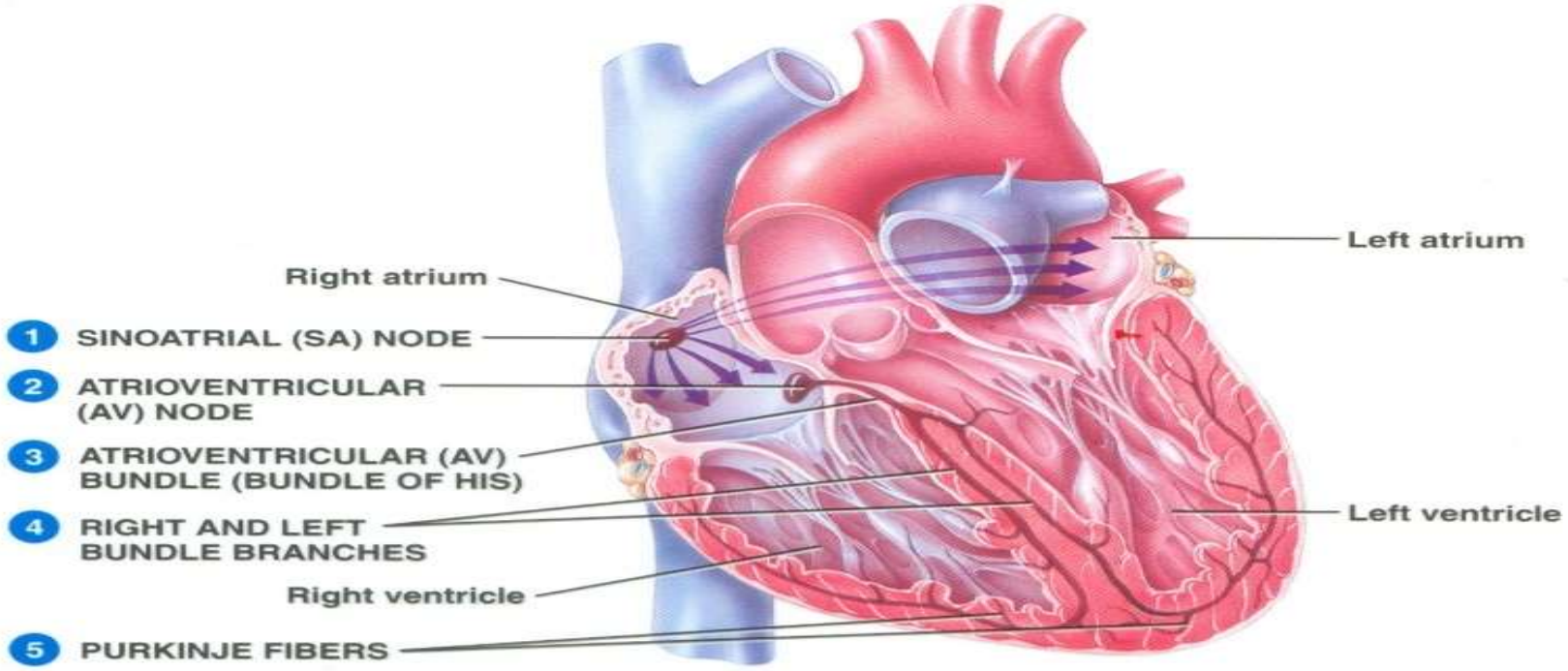
Intrinsic Conduction System

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

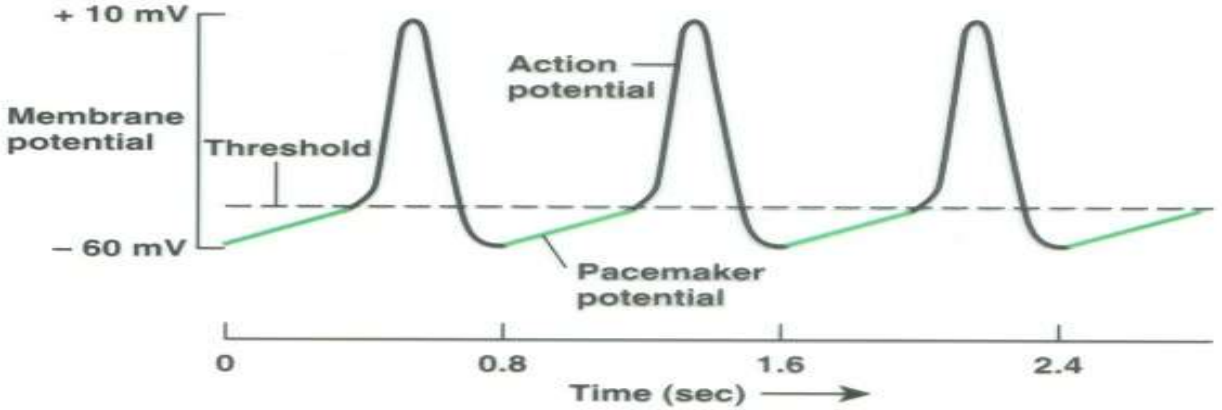


Sinus Node

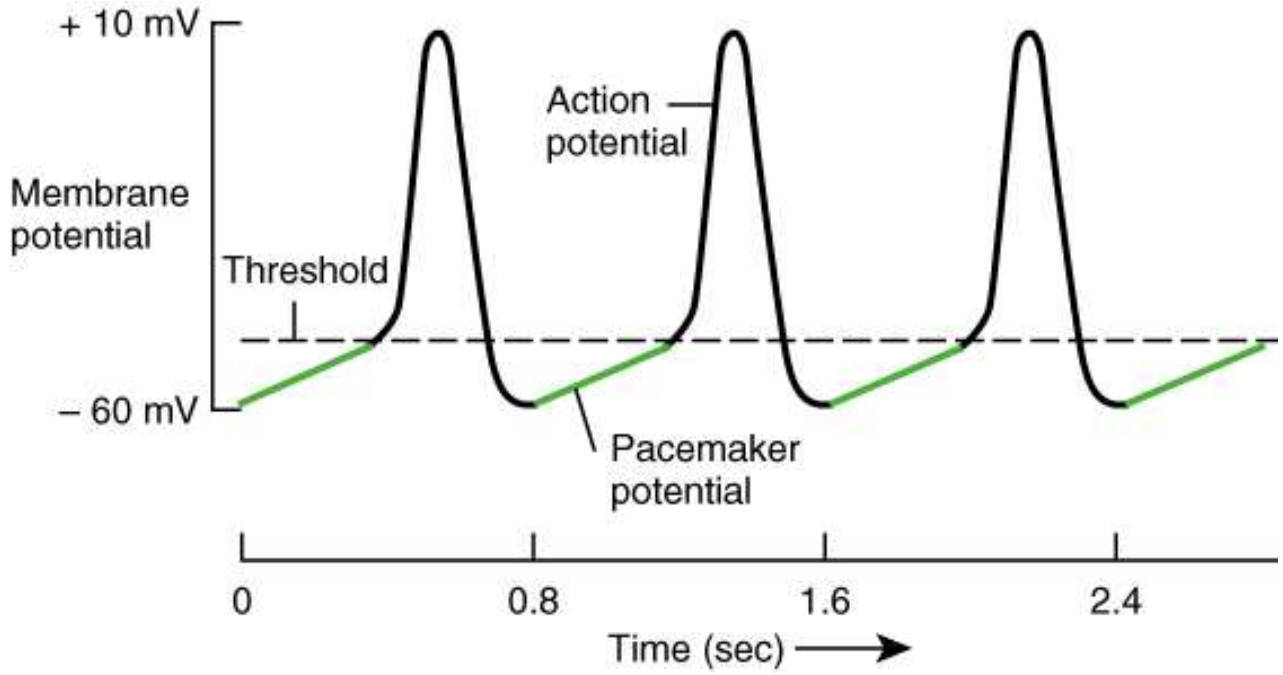
- Specialized cardiac muscle connected to atrial muscle.
- Acts as pacemaker because membrane leaks Na^{+} and membrane potential is -55 to -60mV
- When membrane potential reaches -40 mV, slow Ca^{++} channels open causing action potential.
- After 100-150 msec Ca^{++} channels close and K^{+}channels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



(a) Anterior view of frontal section



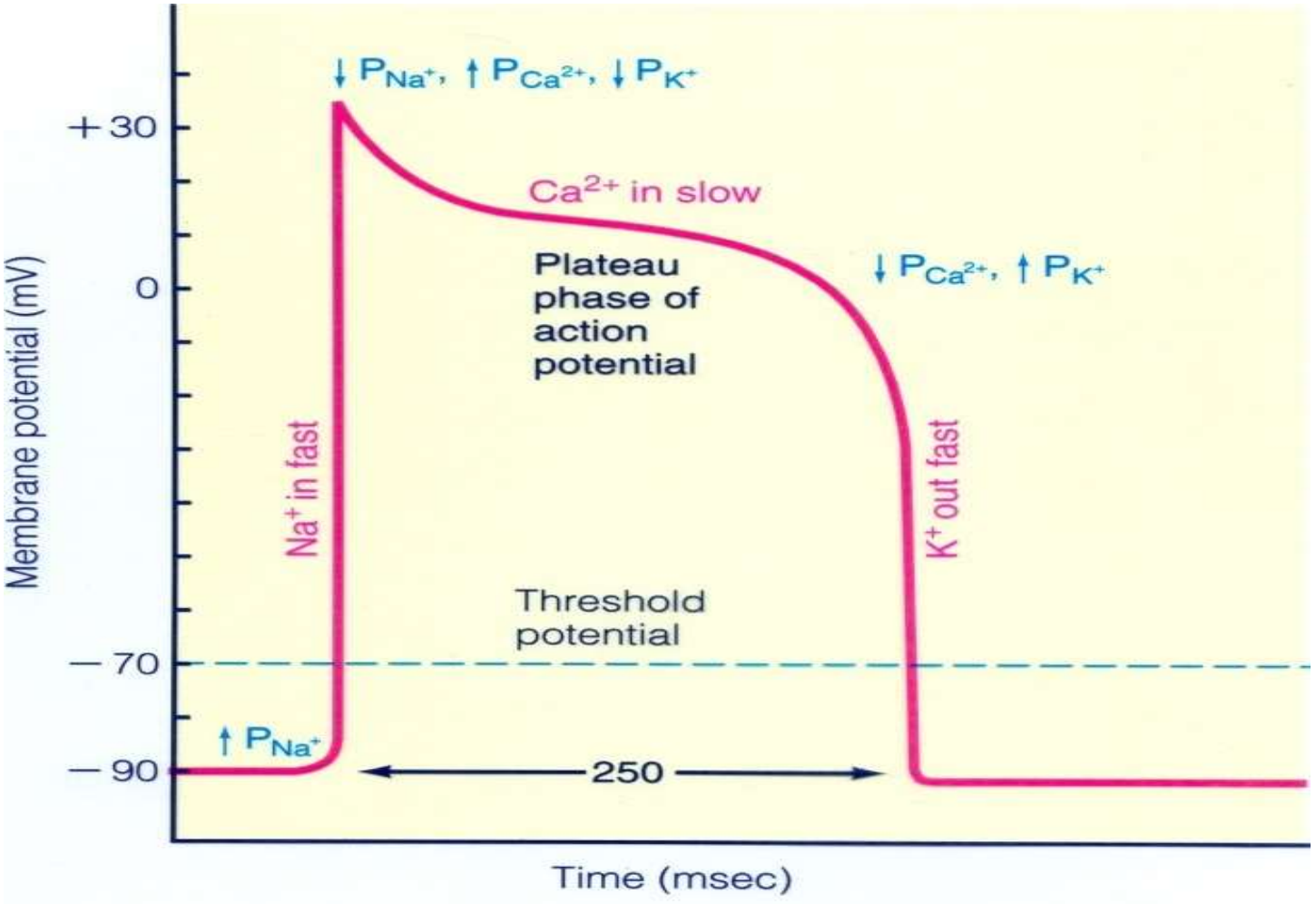
(b) Pacemaker potentials and action potentials in autorhythmic fibers of SA node



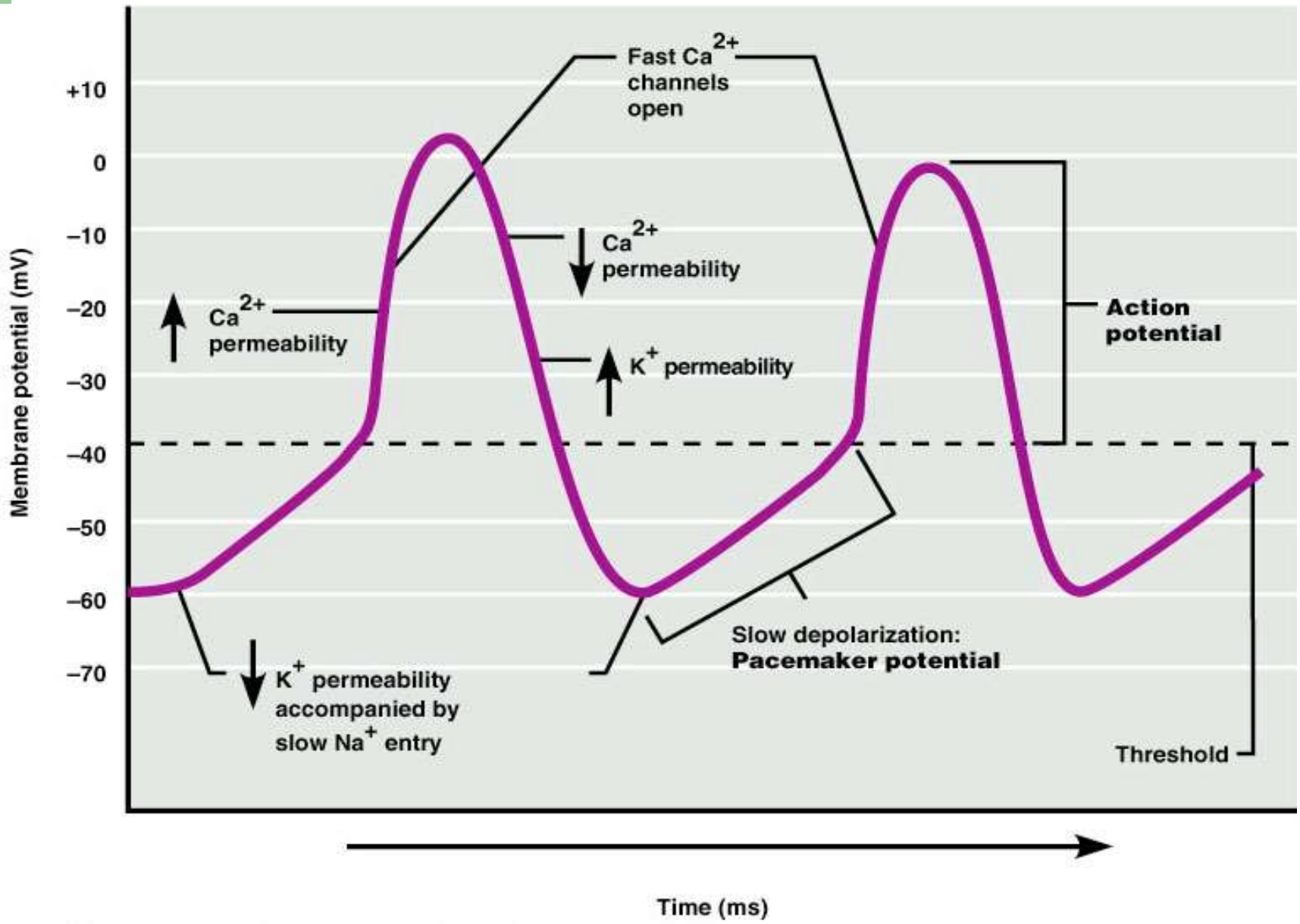
(b) Pacemaker potentials and action potentials in autorhythmic fibers of SA node

20.10b

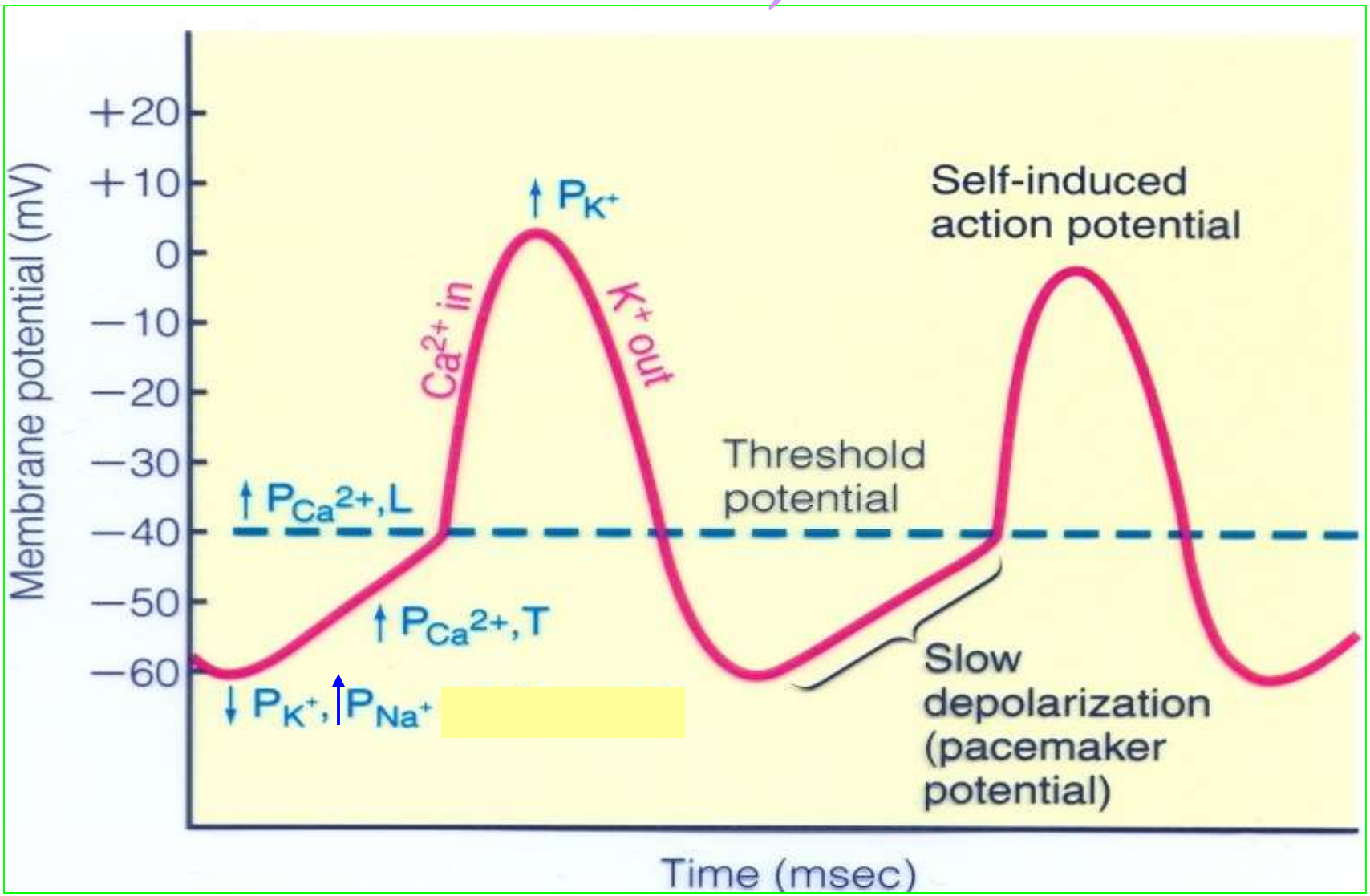
Fast Response Action Potential of Contractile Cardiac Muscle Cell



Pacemaker and Action Potentials of the Heart



Slow Response Action Potential (Pacemaker Potential)



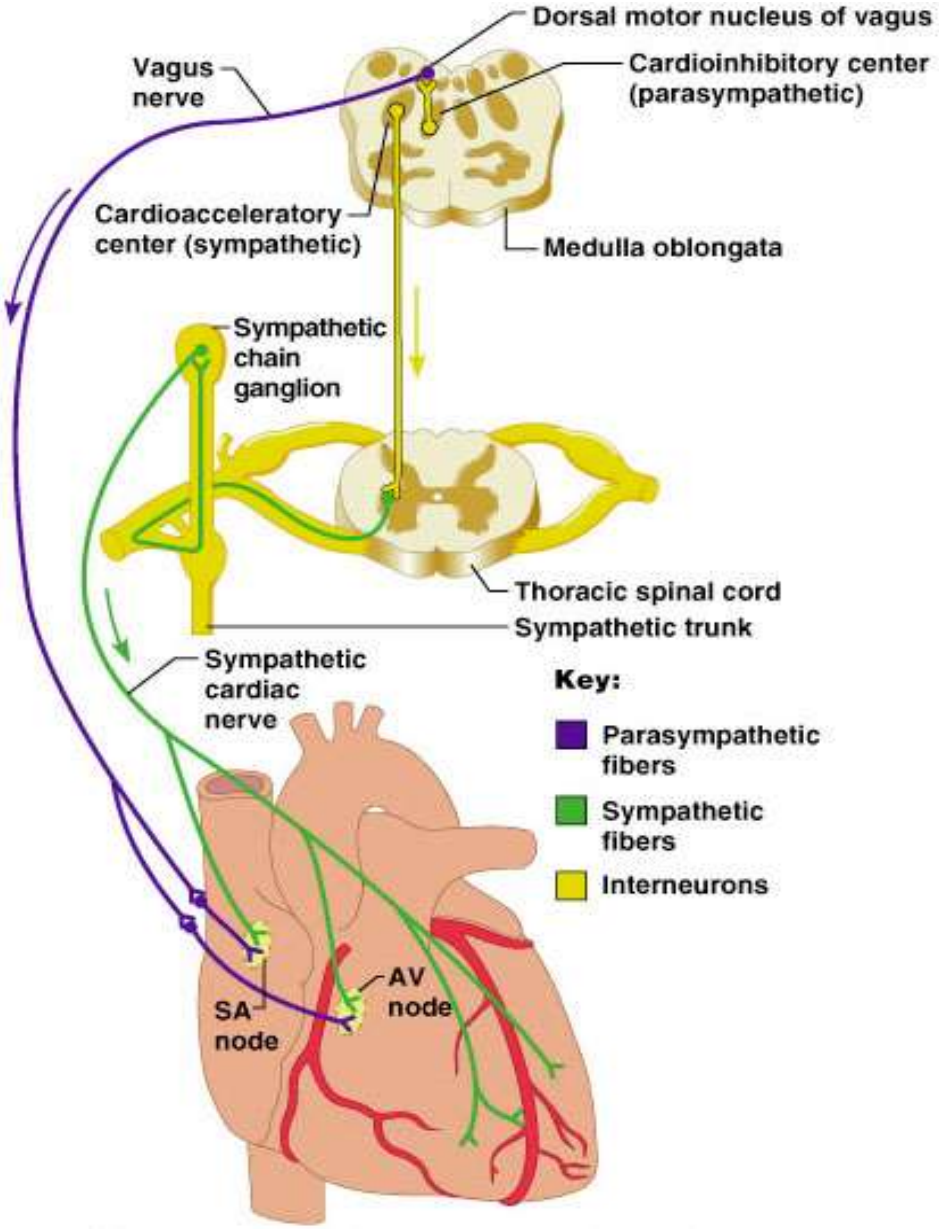
Intrinsic rate and speed of conduction of the components of the system

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

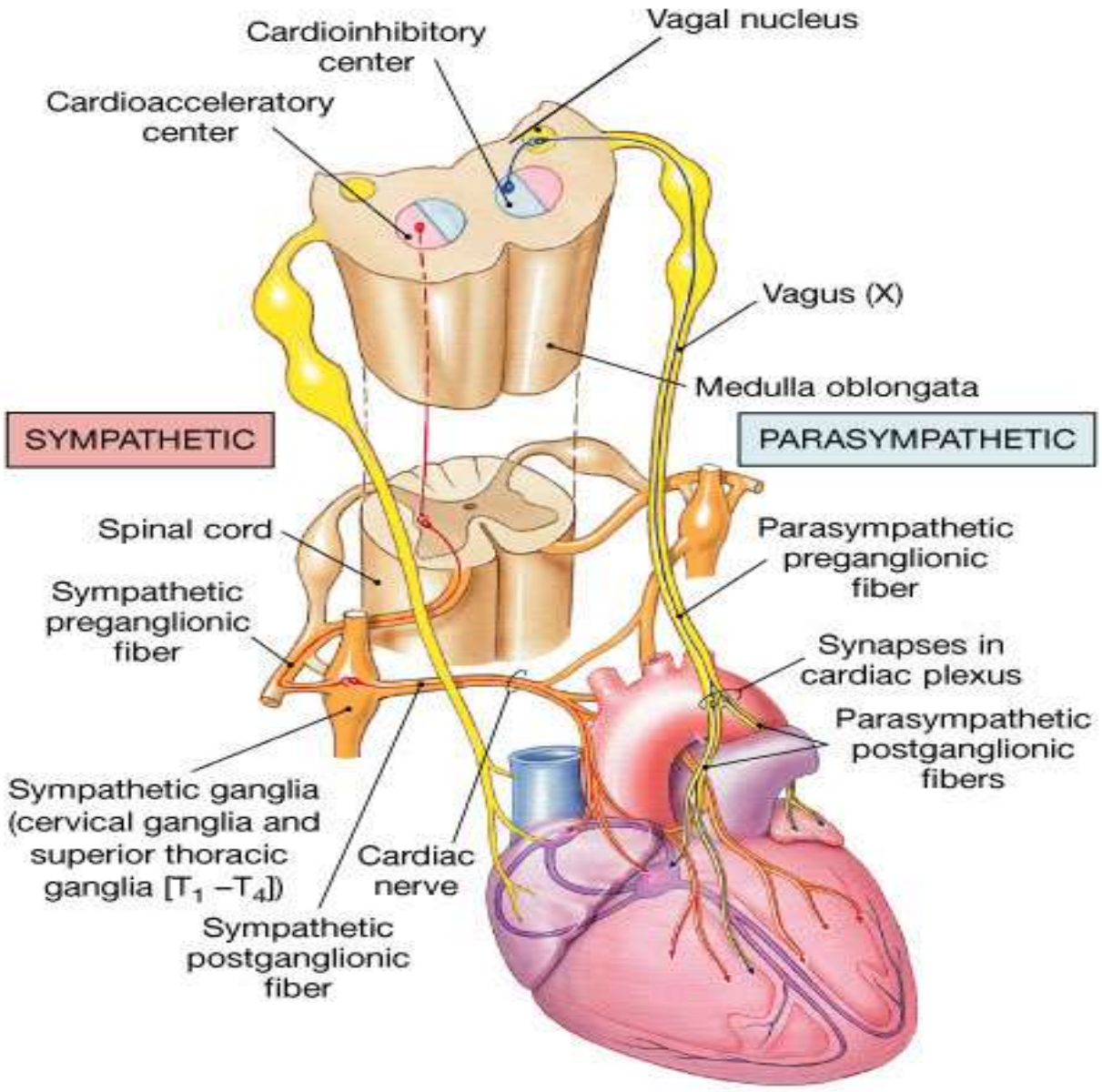
Conduction Speed

- 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***

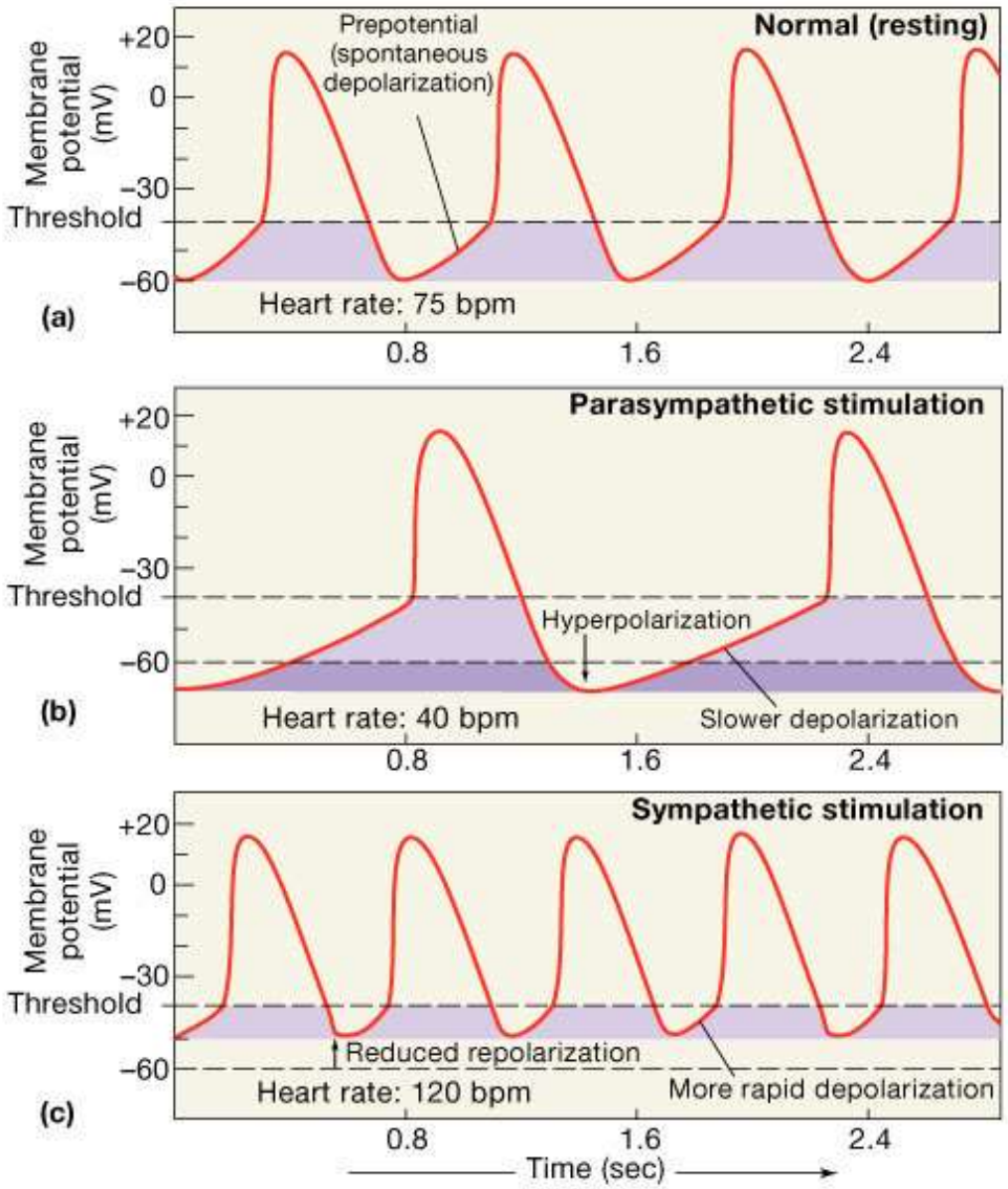
Extrinsic Innervation of the Heart



Autonomic Innervation of the Heart



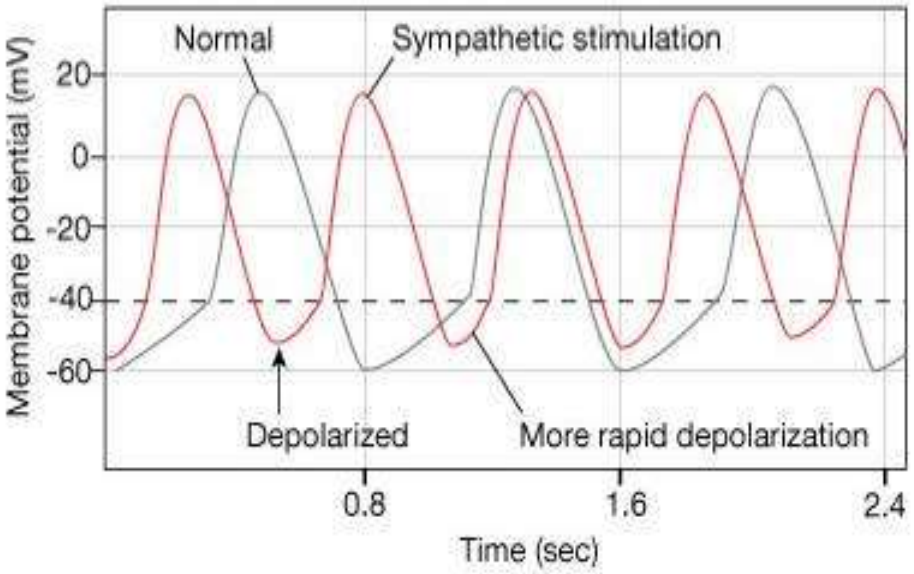
Pacemaker Function

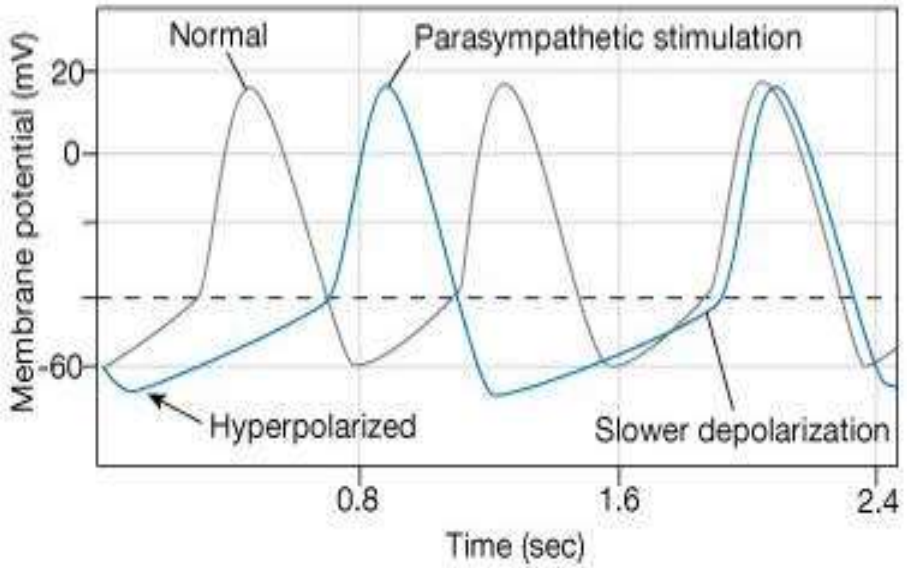


Autonomic neurotransmitters affect ion flow to change rate

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

What part of the graph is <u>not</u> changed by autonomic influences?





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