TOPIC: ELECTRICAL CONDUCTION SYSTEM OF THE HEART

Introduction to the Intrinsic Cardiac Conduction System

- **Intrinsic Cardiac Conduction System**: _____ and conducts action potentials through the heart.
  - "Intrinsic" – does not require _____ system to function; contained entirely within the _____.
  - Results in heartbeats that are _____ & _____.
- *Recall*: cardiac muscle cells are connected by gap junctions; allows _____ to be passed from cell to cell.

Coordinated: cells must contract _____.

- **Gap junctions**: allow action potentials to _____.
- **Conducting fibers**: specialized cardiac cells with _____ myofibrils; insulated from contractile cells.

Regular: heart must contract at right _____.

- **Nodes**: _____ action potentials.
- **Pacemaker cells**: specialized cardiac cells that _____ at regular intervals.

PRACTICE

Which feature of cardiac tissue allows for the rapid spread of action potentials through the heart?

a) Nodes.

b) Myelin sheaths.

c) Pacemaker cells.

d) Gap junctions.

PRACTICE

Which statement best describes intrinsic conduction of the heart?

a) Cells within the heart can initiate and transmit action potentials without nervous system input.

b) Cells in the heart can beat continually without fatigue.

c) Cells in the heart follow a specific rhythm that is set by the brain stem.

d) Cells in the heart pass action potentials between cells using gap junctions instead of neurotransmitters.

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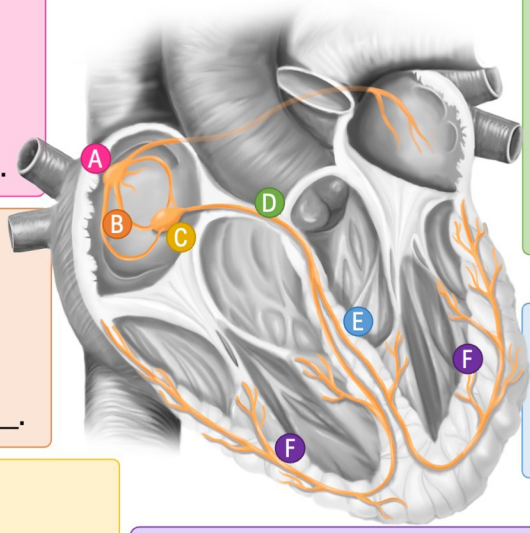
Anatomy of the Intrinsic Cardiac Conduction System:

◆ *Recall:* Intrinsic conduction system consists of specialized myocytes that initiate and _____ electrical signal.

A. Sinoatrial (SA) Node:
- Superior _____ atrial wall, below vena cava.
- Contains _____ cells.

B. Internodal Pathways/ Atrial Conducting Fibers:
- Connect SA and ____ nodes.
- Distribute AP through _____.

C. Atrioventricular (AV) Node:
- Inferior right _____ wall.
- Initiates _____ contraction.
- Contains _____ pacemaker cells.



D. Atrioventricular (AV) Bundle (Bundle of His):
- Superior portion of _____.
- Conducting fibers.
- _____ pacemaker cells.

E. Right & Left Bundle Branches:
- Inferior portion of _____.
- Conducting fibers.

F. Subendocardial Conducting Network (Purkinje fibers):
- Smallest _____ fibers.
- Connect to contractile cells.

EXAMPLE

For each structure in the cardiac conduction system, identify in which region of the heart wall it is found by writing the location in the space provided. Then, answer the question below. Note: some structures may span multiple regions.

Heart wall regions:

Right Atrium (RA) Left Atrium (LA) Right Ventricle (RV) Left Ventricle (LV) Septum (S)

Structures of the Cardiac Conduction System

Sinoatrial node:	
Atrioventricular node:	
AV bundle:	

Right bundle branch:	
Left bundle branch:	
Subendocardial conducting network:	

In order to contract, the contractile cells of the heart must be stimulated by an action potential, but the conducting fibers of the heart do not directly connect to all contractile cells. What feature of heart muscle will allow all contractile cells to receive electrical signals?

_____

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PRACTICE

The intrinsic conduction system ensures a coordinated and efficient heartbeat. If the sinoatrial (SA) node malfunctions, which part of the heart's conduction system is most likely to take over as the pacemaker?

a) Atrioventricular (AV) node.

b) Bundle of His.

c) Purkinje fibers.

d) Atrial muscle cells.

PRACTICE

Which answer choice below correctly matches the cardiac conduction structure to where it's found in the heart?

a) Atrioventricular node: left ventricle.

b) Purkinje fibers: left atrium.

c) Sinoatrial node: left atrium.

d) Right and left bundle fibers: septum.

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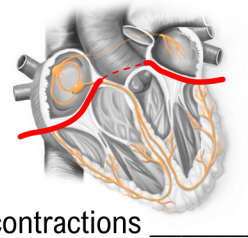
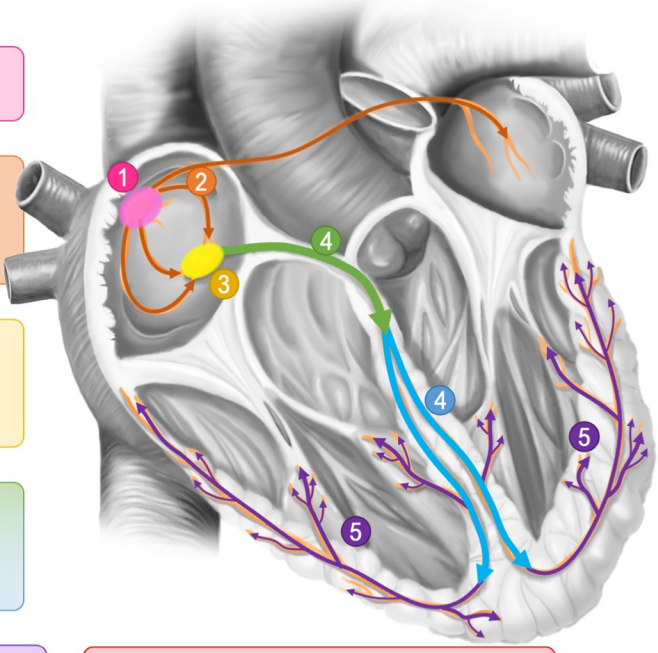
Conduction Pathway and Contraction



- To pump blood properly the conduction system must cause:
  1. Atria to contract ___ and contract _____.
  2. Ventricles to contract ___ and contract _____.
- No gap junctions between cardiomyocytes of atria and ventricles: keeps contractions _____.
  - Must use _____ system to stimulate ventricles.

Steps of Cardiac Conduction

1. Pacemaker cells in ___ **node** initiate action potential.
2. AP spreads across _____ through conducting fibers and contractile cells: **atria contract**.
3. Action potential reaches ____ **node**. After _____ pause, AV node initiates a new AP.
4. AP moves down _____ through **AV Bundle (Bundle of His)** & **L+R Bundle Branches**.
5. AP spreads through **Subendocardial conducting network (Purkinje fibers):** stimulate _____ cells.
6. AP spreads through contractile cells: _____ **contracts.**



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EXAMPLE

The steps of electrical conduction in the heart are listed below in the incorrect order. Fill in the blanks with the letter corresponding to each step to put the pathway in the correct order.

A. Action potential moves down the right and left bundle branches.

B. Purkinje fibers distribute action potential.

C. 100 ms delay.

D. Action potential reaches the AV node.

E. Action potential is passed through the atria.

F. Action potential is passed through contractile cells of the ventricles.

G. Action potential moves down the AV bundle.

Pacemaker cells initiate an action potential. → ___ → ___ → ___ → ___ → ___ → ___ → ___ → **Ventricles contract**

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PRACTICE

The AV node has fewer gap junctions than the SA node, leading to slower conduction. How does this slower conduction help the heart function?

a) Ensures that the ventricles have enough time to fill with blood before they contract.

b) Initiates the electrical impulse in the heart.

c) Conducts the impulse rapidly to the bundle of His.

d) Allows the ventricles to beat at a slower rate than the atria.

PRACTICE

What is the primary function of the pacemaker cells in the SA node in the heart?

a) Slow the action potentials to allow for a 100 ms delay.

b) Regulation of blood pressure in the right atrium.

c) Rhythmic generation of action potentials.

d) Conduction of action potentials throughout the atria.

PRACTICE

Which structure or structures are most directly responsible for allowing contraction of the ventricles to begin at the apex of the heart rather than in the septum closer to the AV node?

a) Purkinje fibers.

b) Sinoatrial and atrioventricular nodes.

c) AV bundle and the left and right bundle branches.

d) Atrial conducting fibers.

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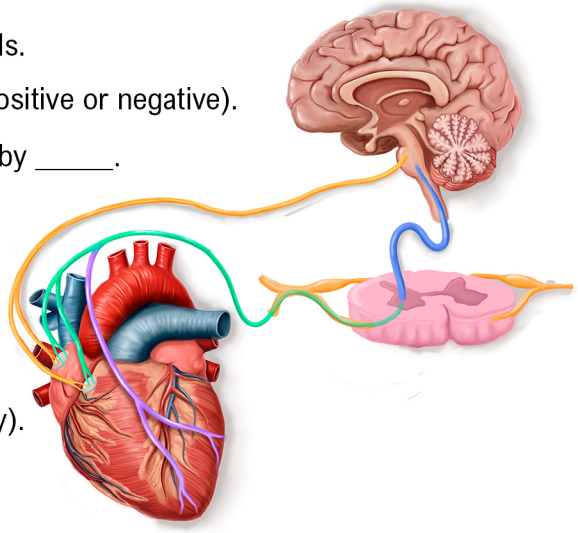
Control of Heart Rate

- ___ major ways that heart rate is controlled:
  1. *Pacemaker cells*: intrinsic _____ initiation of action potentials.
  2. *Chronotropic factors*: extrinsic factors that affect heart _____ (positive or negative).
- **Medulla Oblongata**: responsible for chronotropic control of heart rate by _____.
- Dual innervation of the heart:
  - Sympathetic nervous system: _____ heart rate.
    - Cardio_____ center.
    - Innervates the SA node, AV node, & heart _____.
    - Increases both rate and _____ of heartbeat (contractility).
  - Parasympathetic nervous system: _____ heart rate.
    - Cardio_____ center.
    - Signal travels down the _____ nerve.
    - Innervates the SA & AV nodes.



EXAMPLE

Without any extrinsic factors, the SA node will set a heart rate of about 100 bpm. The typical resting heart rate is around 75 bpm. During exercise, heart rates are often in the range of 120-150 bpm.

Knowing this, what would you expect the effect to be if the nerves of (a) the Sympathetic and (b) the Parasympathetic nervous system were severed? Consider the effect both 1) on resting heart rate and 2) on heart rate during exercise.

Effect of Severing	1) On resting heart rate	2) On heart rate during exercise
a) Sympathetic nerve fibers		
b) Parasympatheic nerve fibers		

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PRACTICE

Which center in the medulla oblongata controls the sympathetic neurons that stimulate the heart?

a) Cardioinhibitory center.
b) Cardiorespiratory center.
c) Vagus center.
d) Cardioacceleratory center.

PRACTICE

Which statement best describes a difference between how the sympathetic and parasympathetic nervous system affects the heart?

a) The sympathetic nervous system affects heart rate, while the parasympathetic nervous system affects contractility.
b) The sympathetic nervous system affects contractility and heart rate, while the parasympathetic only affects heart rate.
c) Both the sympathetic and parasympathetic nervous systems affect contractility, while the parasympathetic also affects heart rate.
d) Heart rate is controlled by the parasympathetic nervous system, while the sympathetic nervous system controls contractility.