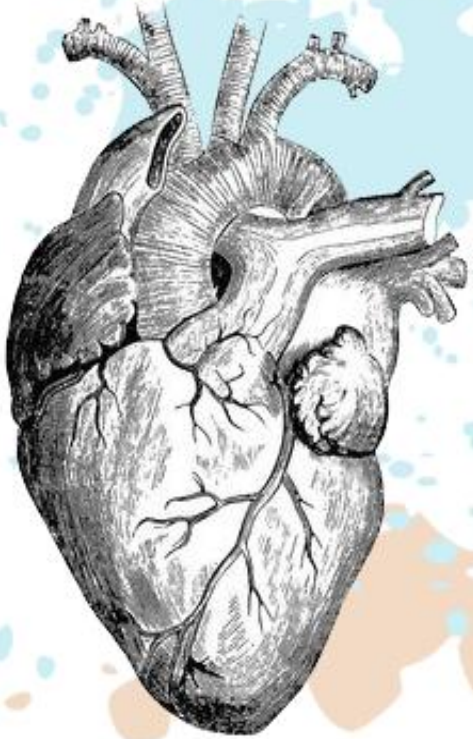


Very important

Extra information

Terms

Physiology

OF THE CARDIOVASCULAR SYSTEM

* Guyton corners, anything that is colored with grey is EXTRA explanation

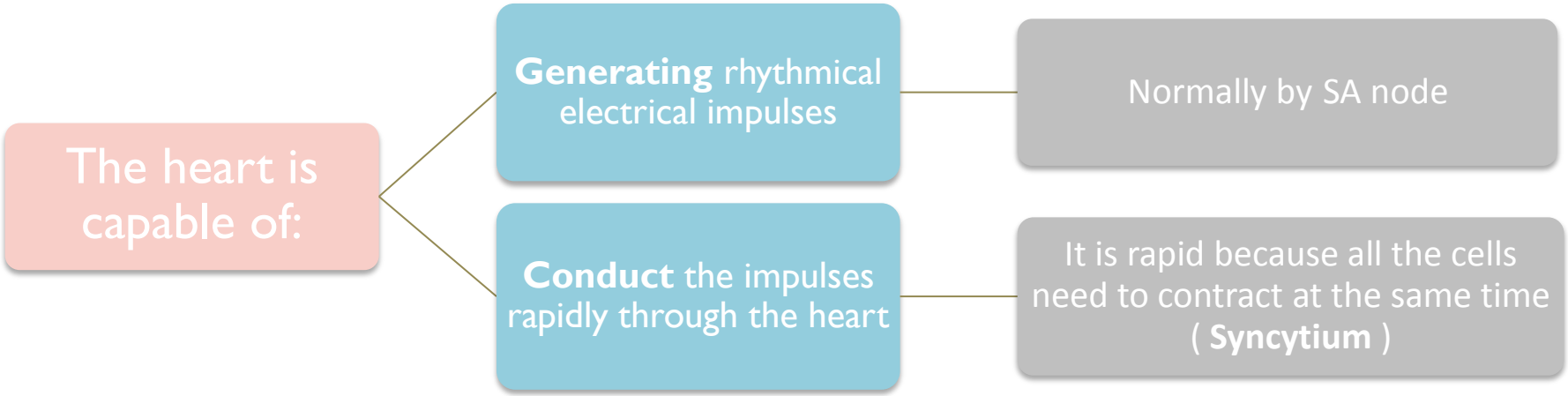
Cardiac electrical activity

Objectives :

- Discuss the cardiac conductive system and its function.
- Describe the action potential of the cardiac muscle and its components.
- Define the refractory period and the excitation-contraction coupling
- Discuss the control of excitation and conduction of the heart.

Contact us : Physiology435@gmail.com

Automaticity of the heart



The atria contract about one sixth of a second ahead of ventricular contraction.

But why does this happen?

To **allow filling** of the ventricles before they pump the blood into the circulation.

- **Guyton corner :**

  Another special importance of the system is that it allows all portions of the ventricles to contract simultaneously, which is essential for the most effective pressure generation in the ventricular chambers.

Specialized Excitatory and Conductive System of the Heart

The heart consist of **2 kinds** of muscle cells:
- **contractile cells**: the working cells of the heart.
- **conducting cells**: constitute the tissue of SAN, the atrial internodal tract, AVN, the bundle of His, and the purkinje system.

The action potential spreads throughout the myocardium in the following sequence:

1. The sinoatrial (SA node)
2. The internodal pathway
3. The atrioventricular (AV node)
4. The atrioventricular bundle (Bundle of His)
5. Purkinje fibers

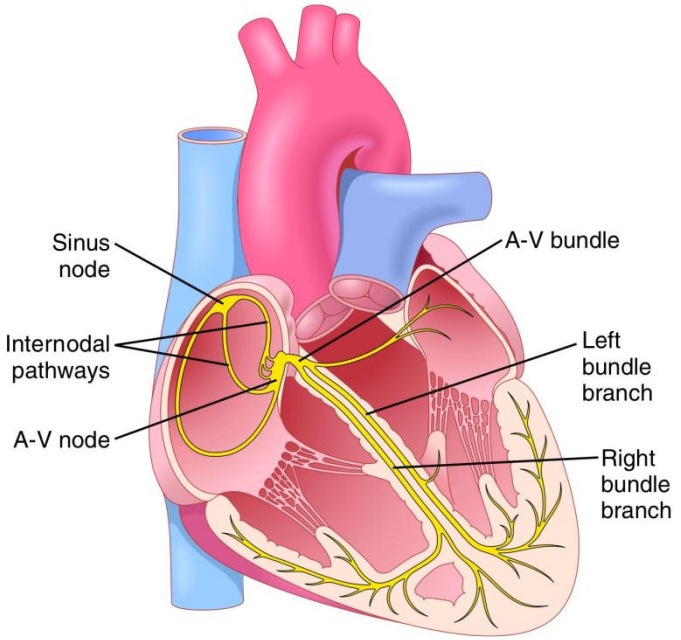
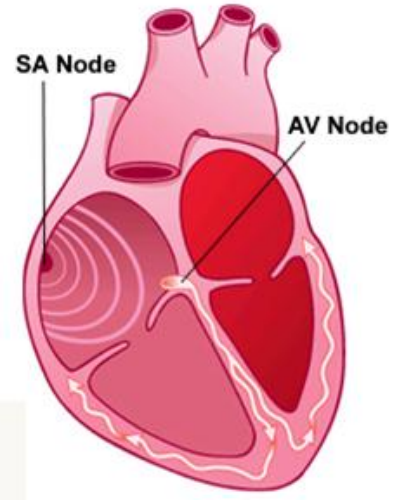


Figure 10-1. Sinus node and the Purkinje system of the heart, showing also the atrioventricular *(A-V)* node, atrial internodal pathways, and ventricular bundle branches.

All of these conducting cells can generate action potentials spontaneously, but this capacity is suppressed in healthy people except for SAN.

Conduction of Impulses

Sinoatrial node (S-A node) : "المسؤولة عن تنظيم ضربات القلب"



- Located in the superior lateral wall of the right atrium near the opening of the superior vena cava.
- It is the Pacemaker of the heart **WHY ?**
  - Its rate of rhythmic discharge is greater than any other part in the heart
  - Highest Frequency

    [Frequency] is : the number of heartbeats per minute.
  - Is capable of originating **Action Potential.**

- sometimes when there is an ischemia in the blood supply to the atria → there will be fibrosis → and this will affect the function of S-A node making it not functioning properly
- The impulses spread from the S-A node to the A-V node through the internodal pathway → which is found in the right atrium.

Video

Conduction of Impulses

- **Guyton corner :**

- The sinus nodal fibers connect directly with the atrial muscle fibers so that any action potential that begins in the sinus node spreads immediately into the atrial muscle wall.

- Some cardiac fibers have the capability of **self-excitation**, a process that can cause automatic rhythmical discharge and contraction.

- This capability is especially true of the fibers of the heart's specialized conducting system, including the fibers of the sinus node

The sinus node fibers, when not stimulated from some outside source, discharge at an intrinsic rhythmical rate of 70 to 80 times per minute, which is faster than the natural self-excitatory discharge rate of either the A-V node or the Purkinje fibers. that is why the sinus node controls the heart's rhythmicity rather than the A-V node or the Purkinje fibers.

- Each time the sinus node discharges, its impulse is conducted into both the A-V node and the Purkinje fibers, also discharging their excitable membranes. However, the sinus node discharges again before either the A-V node or the Purkinje fibers can reach their own thresholds for self-excitation. Therefore, the new impulse from the sinus node discharges both the A-V node and the Purkinje fibers before self-excitation can occur in either of these sites.

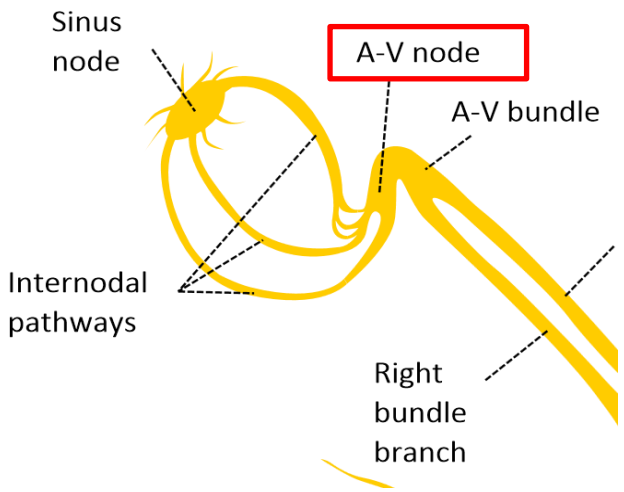
- Thus, **the sinus node controls the beat of the heart** because its rate of rhythmical discharge is faster than that of any other part of the heart. Therefore, the sinus node is almost always the **pacemaker** of the normal heart.

Conduction of Impulses

- **Atrioventricular (A-V) node :**

- located in the posterior wall of the right atrium (immediately behind the tricuspid valve)

- Delay in the conduction of impulses (0.1 sec)



Why is this Delay ?

Allows time for the atria to empty the blood into the ventricles **before** ventricular contraction begin.

- **Guyton corner :**

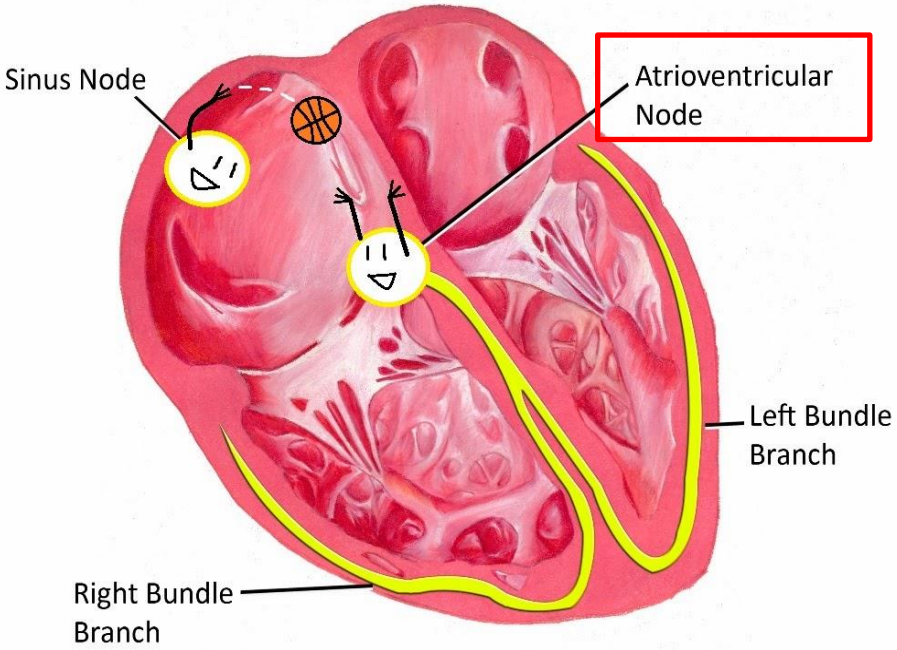
Atrioventricular node and delay of impulses conduction from the atria to the ventricles:

The atrial conductive system is organized so that the cardiac impulse does not travel from the atria to into the ventricles too rapidly ; this delay allow time for the atria to empty the blood into the ventricular before ventricular contraction begins. It is primarily the A-V node and its adjacent conductive fibers that delay this transmission into the ventricles.

Conduction of Impulses

Note :

- The impulses spread from the right atrium to the ventricle through the A-V
- A-V node ' وظيفتها التعطيل ' we said that atria contract before ventricles why ? Because of A-V node.



- **Guyton corner :**

Causes of the slow conduction :

The slow conduction in the transitional , nodal , and penetrating A-V bundle fibers is caused mainly by diminished number of gab junction between successive cells in the conducting pathway , so there is a great resistant to conducting of excitatory ions from one conducting fibers to the next. Therefore, it is easy to see why each succeeding cell is slow to be excited.

PHYSIOLOGY TEAM 435

Conduction of Impulses

The Purkinje System :

- Purkinje fibers are very large fibers.
- Has a very large diameter .
- Transmit action potentials at a very high velocity **(0.1- 4** m/sec **)** :

Why? High permeability of gap junctions → ions are transmitted easily from one cell to the next → enhance the velocity of transmission.

* Remember that : The purkinje fiber has the highest speed of conduction , while the S-A node has the highest frequency.

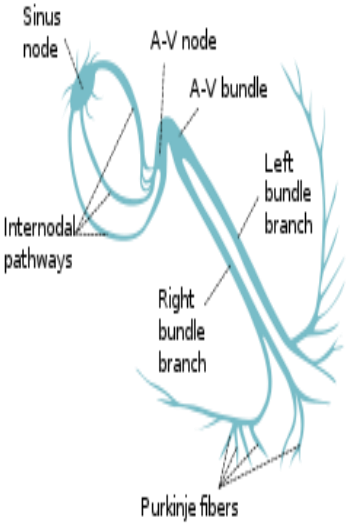
- Ventricular muscle contract at almost the **SAME** time.

- **Guyton corner :** they are very large fibers, even larger than the normal ventricular muscle fibers, and they transmit action potentials at a velocity of 1.5 to 4.0 m/sec, a velocity about six times that in the usual ventricular muscle.

Conduction of Impulses

The Purkinje System :

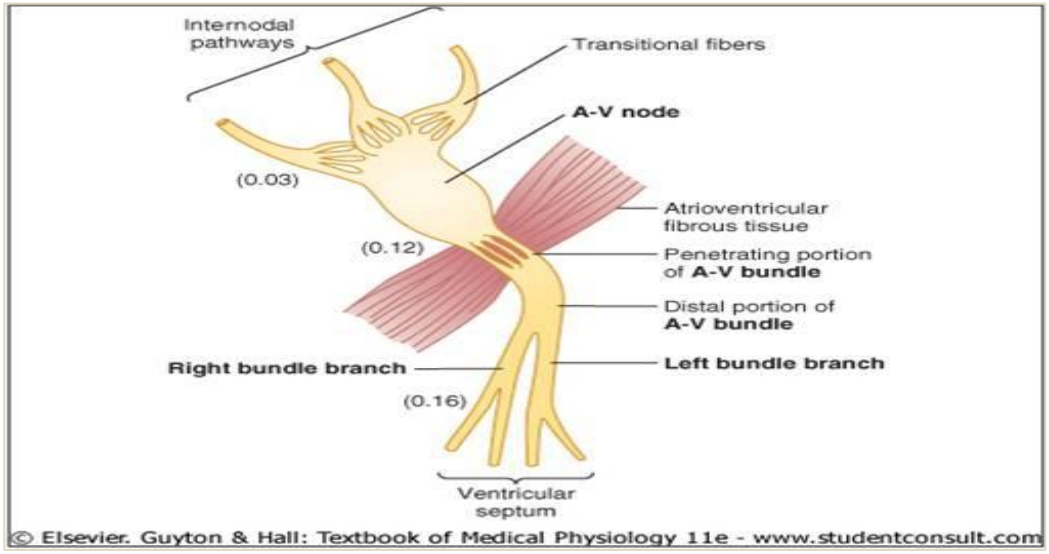
1. Penetrate Atrio-ventricular fibrous tissue.
2. divides into right and left bundle branches.
3. each branch spread toward the **apex** of the heart
4. divide into small branches.
5. penetrate and become continuous with cardiac muscle fibers.



The purkinje fibers keep dividing into smaller and smaller branches to reach every single area in the heart.

Conduction of Impulses

The Purkinje System :



- **Guyton corner :**

the rapid transmission of action potentials by purkinje fibers is believed to be caused by a very high level of permeability of gap junction at the intercalated discs between the successive cells that make up the purkinje fibers. Therefore, ions are transmitted easily from one cell to the next, thus enhancing the velocity of transmission. The purkinje fibers also have very few myofibrils, which means that they contract little or not at all during the course of impulse transmission.

Control of excitation and conduction in the heart

- Electrical impulses usually arise in the :
  Sino-Atrial (SA) node.

- The sinus node (SA) is the pacemaker of the heart.
  "As we mentioned before"

What's a pacemaker?

A pacemaker the part of an organ or of the body that controls any rhythmic physiological activity. Commonly being the sinus node in the human heart, and the resultant rhythm is a sinus rhythm.

Why?

Because its rate of rhythmical discharge is **FASTER** than that of any other part of the heart.

Click here for a GIF showing the heart's electrical activity

- **Guyton corner :**

Some cardiac fibers have the capability of self-excitation, a process that can cause automatic rhythmical discharge and contraction. This capability is especially true in the fibers of the Sino- Atrial (SA) node. For this reason, the sinus node ordinarily controls the rate of beat and is thus, the heart's natural pacemaker.

Abnormal pacemakers

	Ectopic pacemaker	Blockage pacemaker
Definition	A pacemaker elsewhere other than the sinus node.	Resulted from blockage of transmission of the cardiac impulse from the sinus node to the other parts of the heart.
Cause	Developing of a rhythmical discharge rate that is more rapid than that of the sinus node at any part or the heart.	-
Examples	• A-V node • Purkinje fibers	A-V blockage
Consequences	Abnormal heart beats	Cardiac impulses fails to pass from atria into the ventricles. ⬇ Atria beats with its normal rate of rhythm of the(S-A)node. ⬇ New pacemaker developed in purkinje fibers with a new rate.

Control of Heart Rhythmicity and Impulse Conduction by the Cardiac Nerves

The heart is supplied with both sympathetic and parasympathetic nerves.

1- Sympathetic nerves :

Origin : Sympathetic trunk.

Supply : to all parts of the heart with strong supply to the ventricles.

↑ Rate of rhythm of the Sino-atrial node (S-A node).
↑ Transmission of impulses to the Atrio-ventricular node (A-V node).
↑ Force of contraction.
↑ Heart rate.

- **Guyton corner :**

Parasympathetic stimulation has **no effect on the force of contraction** because it does not supply the ventricles .
The sympathetic stimulation has a crucial effect on the contraction because it supply the ventricles .

Control of Heart Rhythmicity and Impulse Conduction by the Cardiac Nerves

2- Parasympathetic nerves (vagi) :

Origin : Vagus nerve.
Supply : mainly to the S-A and A-V nodes.
↓ rate of rhythm of the sinoatrial node (S-A node).
↓ transmission of impulses to the atrioventricular node (A-V node).
↓ heart rate.

- Strong stimulation of the vagi result in :

- Stop completely the rhythmical excitation by the S-A node .
- Block completely transmission of cardiac impulses from the atria to the ventricle through A-V node .
- Some point in the Purkinje fibers develop a rhythm of its own "Ventricular Escape".
- Parasympathetic stimulation has **no** effect on the force of contraction because it does not supply the ventricles .

- **Guyton corner :**

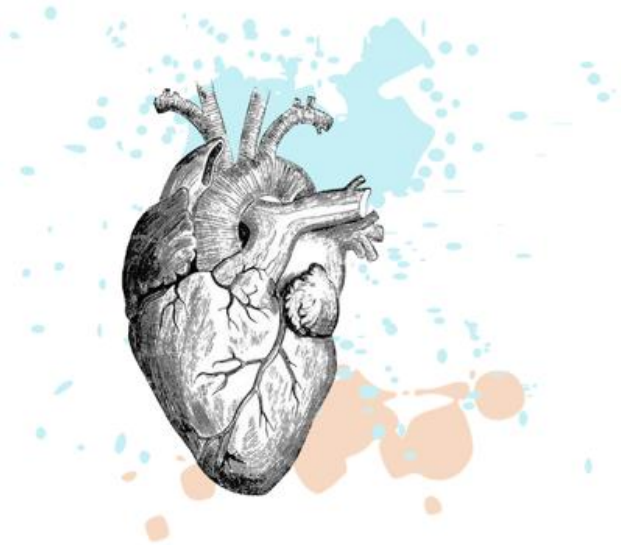
In strong stimulation of vagi the ventricles may stop beating for 5-20 sec, but then some small area in the purkinje fibers develop a rhythm of its own and causes ventricular contraction at 15-20 beats per minute , that's called VENTICULAR ESCAPE.

Heart innervation

Physiology
OF THE CARDIOVASCULAR SYSTEM

Physiology Leaders :

Khawla Alammari
Nojood Alhaidri
Rawaf Alrawaf



Girls team :

- Atheer Alnashwan
- Asrar Batarfi
- Afnan Almalki
- Alhanouf Aljlaoud
- Deema AlFaris
- Elham Alzahrani
- Johara Almalki
- Lojain alsiwat
- Malak Alsharif
- Monirah Alsalouli
- Monera Alayuni
- Nurah Alqahtani
- Nouf Alabdulkarim
- Nora Albusayes
- Nora Alsomali
- Norah Alakeel
- Reem Alageel
- Rawan Aldhuwayhi
- Reham Al-Obaidan
- Samar AlOtaibi
- Shamma Alsaad

Boys team :

- Abdullah Aljaafar
- Omar Alotaibi
- Abdulrahman Albarakah
- Adel Alshehri
- Abdulaziz Alghanaym
- Abdulmajeed Alotaibi
- Khalil Alduraibi
- Hassan Albeladi
- Omar Alshehri
- Saleh Alshawi
- Abdulaziz Alhammad
- Faisal Alabdulatif
- Abdulnasser Alwabel
- Saad Almutairy