

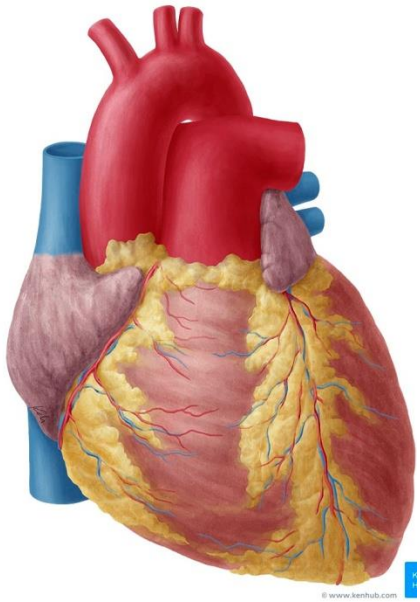
B.Sc. Semester-IV

ZOO CC409- unit 4

PHYSIOLOGY OF HEART:

STRUCTURE AND WORKING OF CONDUCTING MYOCARDIAL FIBERS.

ORIGIN AND CONDUCTION OF CARDIAC IMPULSES.



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Learning Objectives

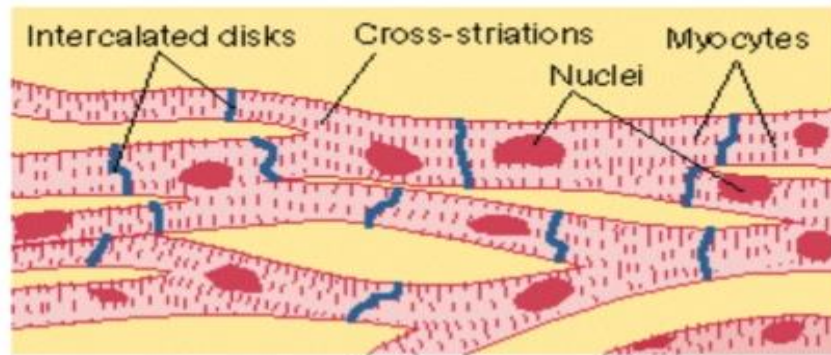
The students will learn to-

- List the properties of cardiac muscles
- List the sequence the pathway of the electrical excitation of the heart
- Describe the functional significance of A-V nodal delay
- List the effects of sympathetic and parasympathetic nervous activity on the conduction of the cardiac impulse

Cardiac Muscle

- Cardiac muscle fibers are arranged in a latticework
- Cardiac muscle are **straited** and has typtical myofibrils that contain ***actin*** and ***myosin filament***.
- These filaments lie side by side and slide along one another during contraction.

Cardiac muscle



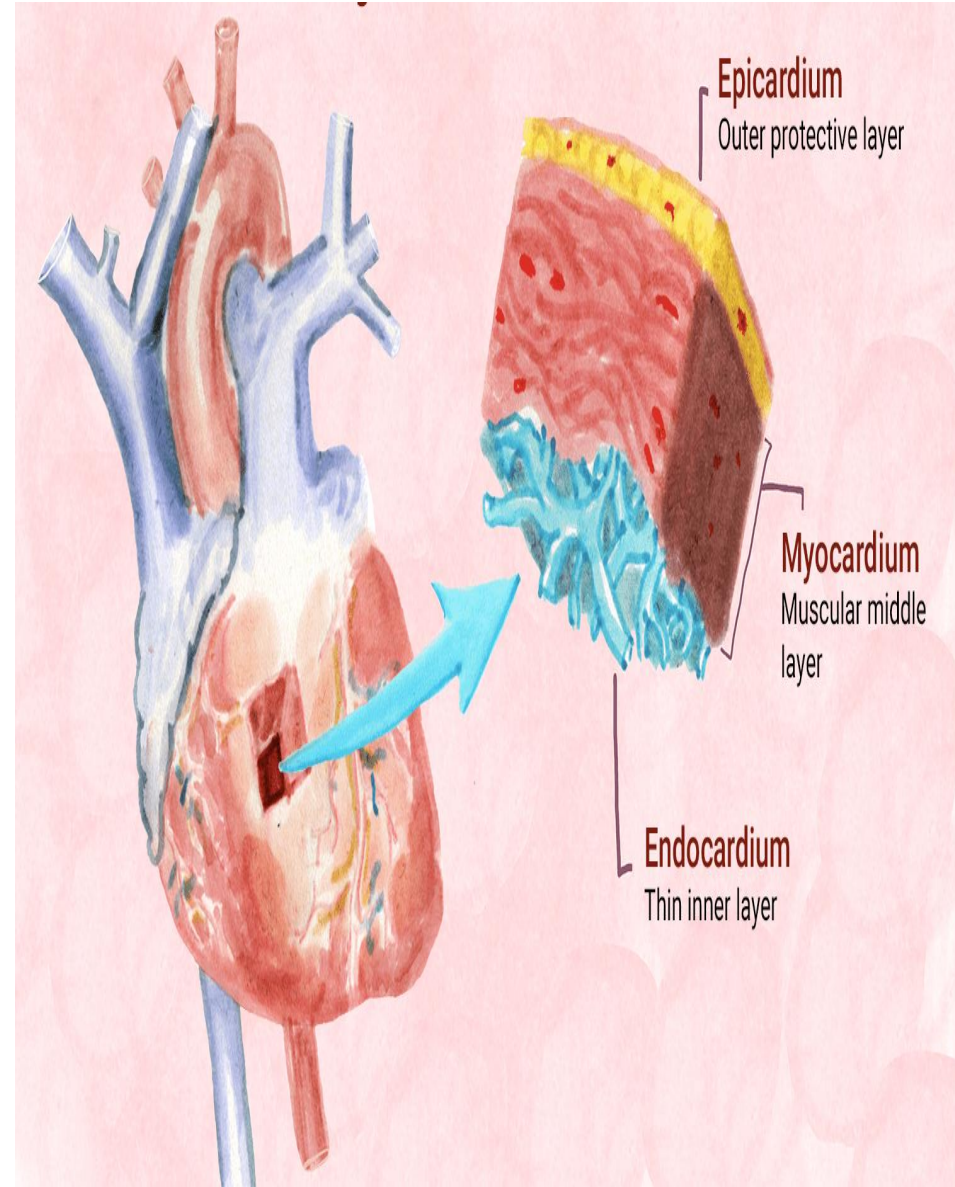
- Contractile proteins
- Contraction achieved through release of calcium
- Rich in mitochondria-aerobic dependent
- Fibres connect to each other through intercalated discs

Myocardial Thickness

- The myocardium has variable levels of thickness with the heart with a thicker myocardium are able to pump blood with more pressure and force compared to chambers of the heart with a thinner myocardium, The myocardium is thinnest within the atria, as the atria fill largely through passive blood flow.

The thickness of the myocardium may change in some individuals as a compensatory adaption to disease.

- The thickness of the myocardium may thicken and become stiff, or it may become thinner and flabby.



Functions of the Myocardium

- Providing a scaffolding for the heart chambers
- Assisting in contraction and relaxation of the cardiac walls so that blood can pass between the chambers
- Conducting electro-stimulation through its own tissues and into the conduction system of heart

Physiological characteristics of Cardiac Muscle

Cardiac muscle is excitable

- Like other living cells they are excitable. They respond to a stimulus
- The cardiac muscle fibres are of three types
 - Contractile
 - Nodal tissues are in the sino-atrial (SA) node and atrioventricular (AV)node.
 - Conducting tissues

- **Autorhythmicity**
- **Cardiac muscle is contractile**
- **Cardiac muscle conducts electrical impulses**
- **It is a syncytium**
- **The action potential in cardiac muscle is prolonged and has a long refractory period**
- **It requires calcium in the extracellular fluid to contract**

Cardiac Electrical Activity

Automaticity of the Heart:

The heart is capable of

- Generating rhythmical electrical impulses
- Conduct the impulses rapidly through the heart
- The atria contract about one sixth of a second ahead of ventricular contraction

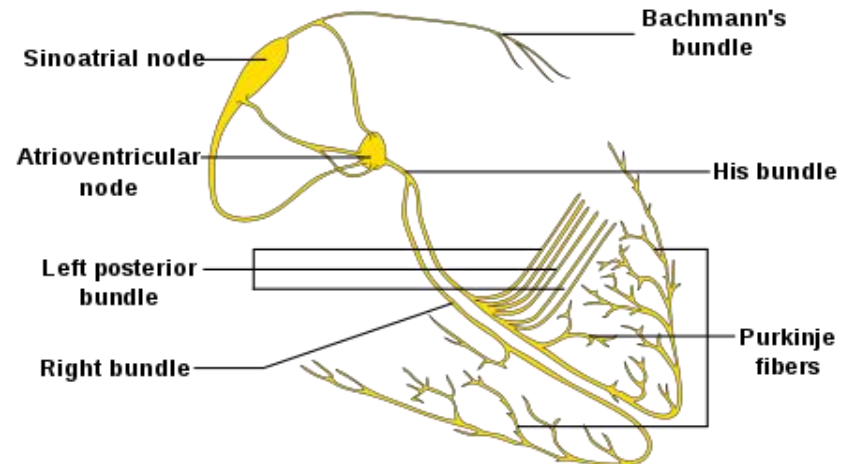
This done in order-

to allow filling of the ventricles before they pump the blood into the circulation

Specialized Excitatory and Conductive system of the Heart

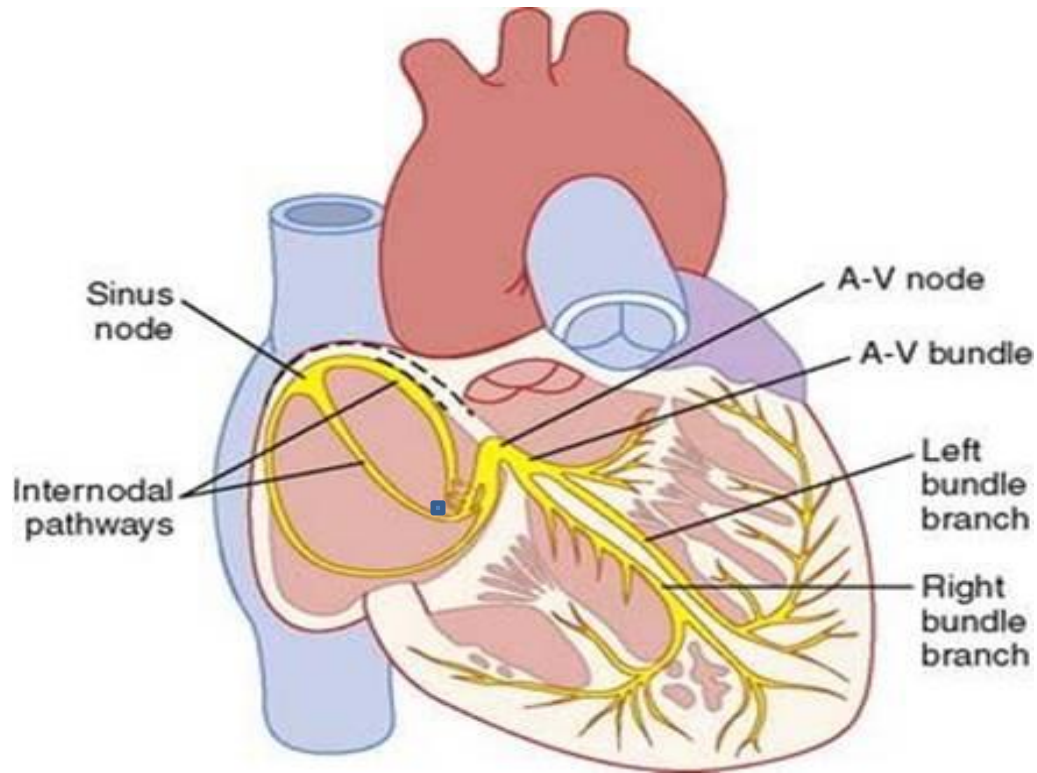
The pathway that controls cardiac contractions are

- The Sinoatrial (SA) node
- The Atrioventricular (AV) node
- The Bundle of His (the atrioventricular bundle)
- The left and Right Bundle branches
- The Purkinje fibers



Electrical conduction which maintains the rhythmical contraction of the heart

The conduction of impulses



Sinus node and the Purkinje system of the heart showing also the A-V node, atrial internodal pathways, and ventricular bundle branches

Conduction of impulse

Sinus(Sinoatrial node) S-A node

- Located in the superior lateral wall of the right atrium near the opening of the superior vena cava
- Primary Pacemaker of the heart

Cardiac impulse originated at the S.A node is transmitted over both the atria like concentric waves thus P wave is produced in E.C.G.

- Once an impulse is initiated does not flow backward
- The rate of rhythmic discharge is greater than any other part in the heart at highest frequency.
- Controls the rate of beat of the entire heart
- Is capable of **originating action potential**

Sinoatrial node (S-A node)

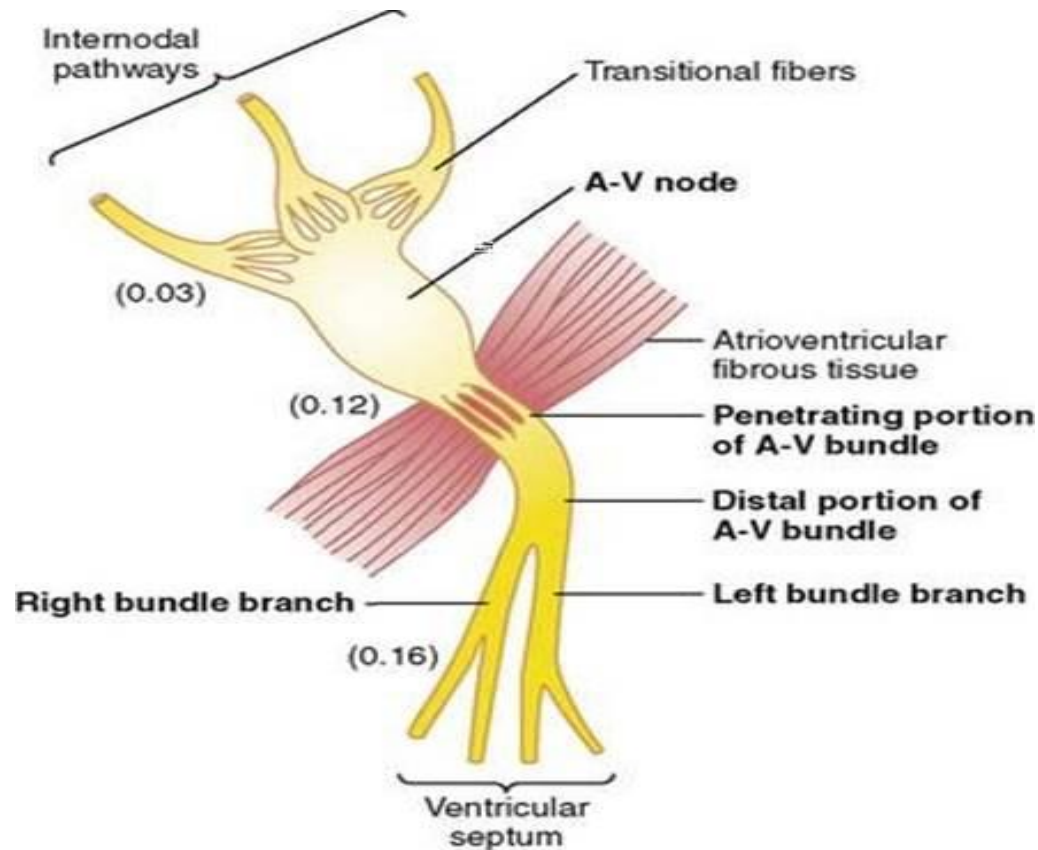
Action potential in the SA node

- Resting potential is less negative -55mV instead of -85mV
- The fast sodium channels are inactivated
- Only the slow sodium channels can be activated
- The atrial nodal action potential is slower to develop than ventricular muscle
- The return of the potential to its negative state occurs slowly

Conduction of Impulses

Atrioventricular node(A-V) node

- Located on the wall of the posterior wall of the right atrium
- Delay in the conduction of impulses(0.1 sec)
- Allows time for the atria to empty the blood into the ventricles before ventricular contraction
- The nodal tissues itself has no pacemaker cells, the tissue surrounding it contains pacemaker cells.

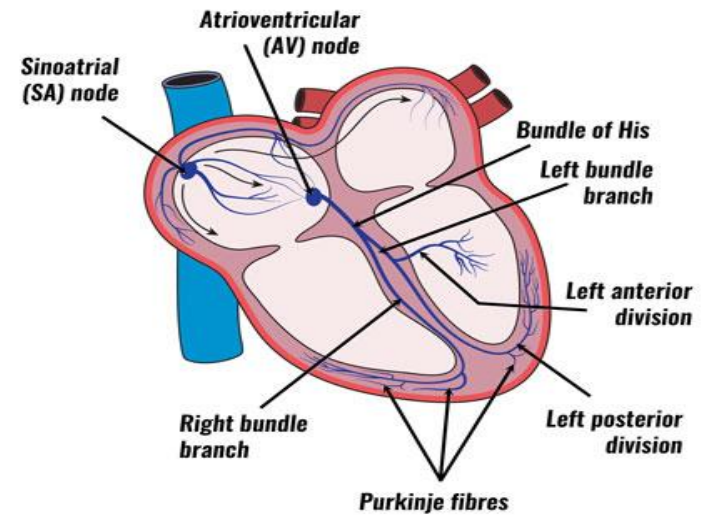


Organization of the A-V node. The numbers represent the interval of time from the origin of the impulse in the sinus node. The valves have been extrapolated to human beings

Conduction of Impulses

The Purkinje System

- Purkinje fibers are very large fibers
- They penetrate atrioventricular fibrous tissue
- Conduct impulses rapidly through the muscle to assist in depolarization and contraction
- Transmit action potentials at a very high velocity (0.1-4.0m/sec)
- Very high permeability of gap junctions
- Extends from the bundle branches into the endocardium and deep into myocardial tissues

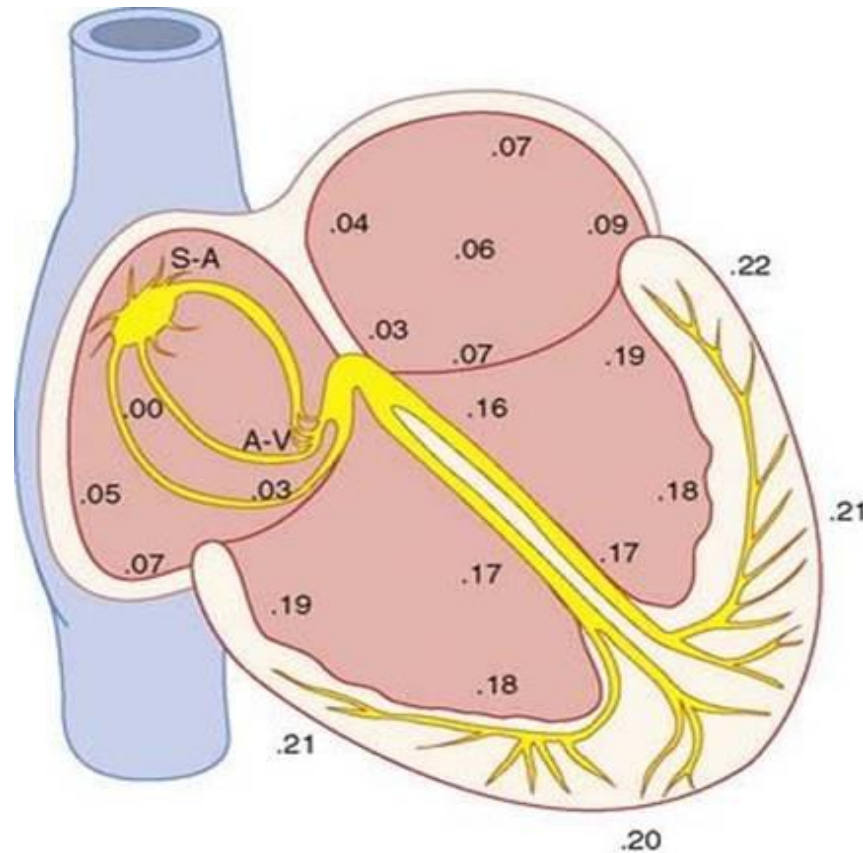


Tissues	Conduction rate (m/s)
SA node	0.05
Atrial muscle	0.3
Atrial pathways	1
AV node	0.05
Bundle of HIS	1
Purkinje system	4
Ventricular muscle	0.3-0.5

Control of Excitation and Conduction in the Heart

- The impulse normally arises in the sinus node
- The sinus node is the **pacemaker** of the heart
- Its rate of rhythmical discharge is faster than that of any other part of the heart
- The sinus node is always the pacemaker of the normal heart

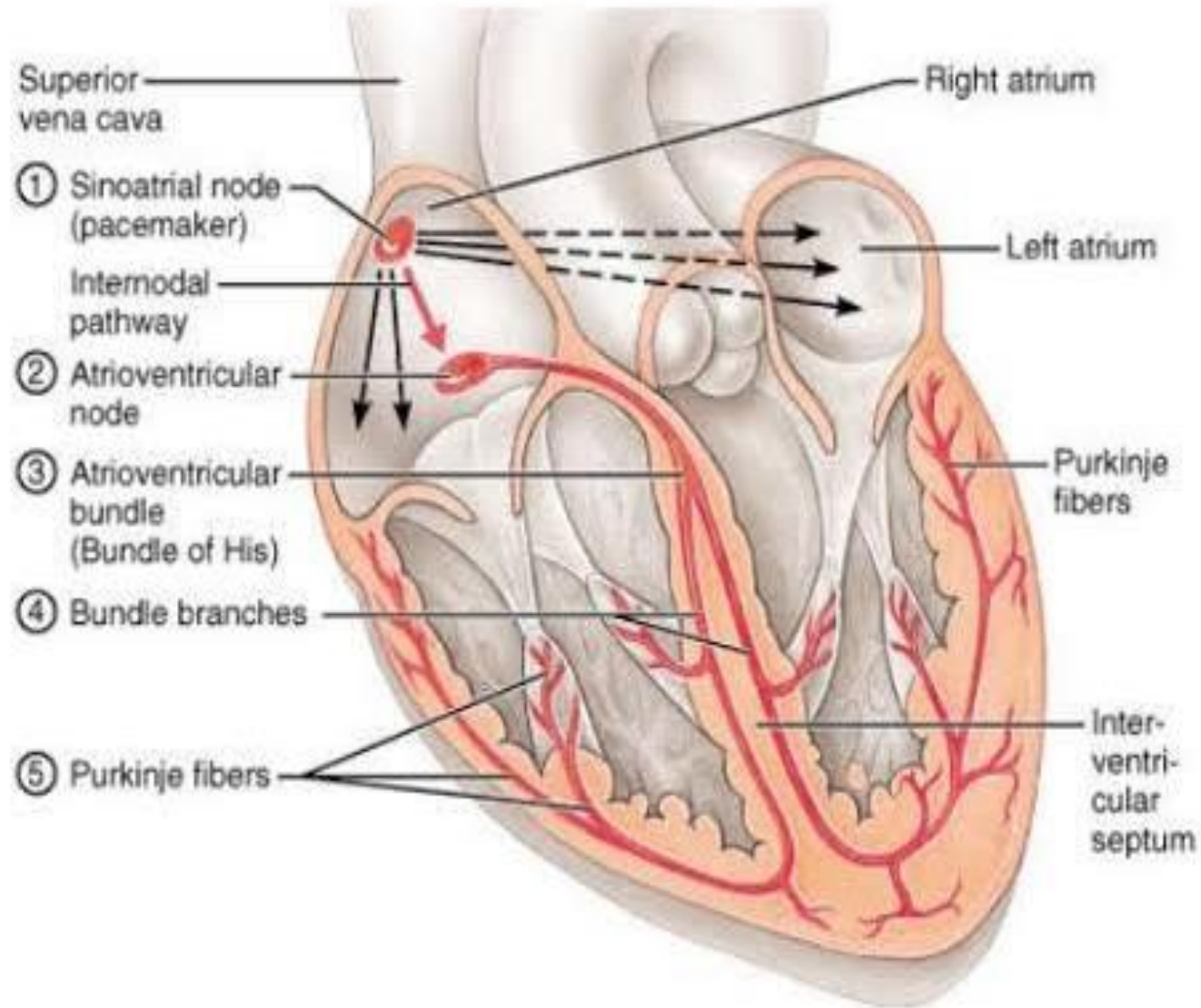
Spread of the cardiac through the heart



Transmission of the cardiac impulse through the heart showing the time of appearance (in fractions of a second after initial appearance at the sinoatrial node) in different parts of the heart

Conducting System

- Network of specialized tissue that stimulates contraction
- Modified cardiac myocytes
- The heart can contract without any innervation



Abnormal pacemakers

- Ectopic pacemaker : a pacemaker other than sinus node
- The cause-Any other part of the heart develops a rhythmical rate that is more rapid than that of the **sinus node**
- Example the AV- node or in Purkinje fibers

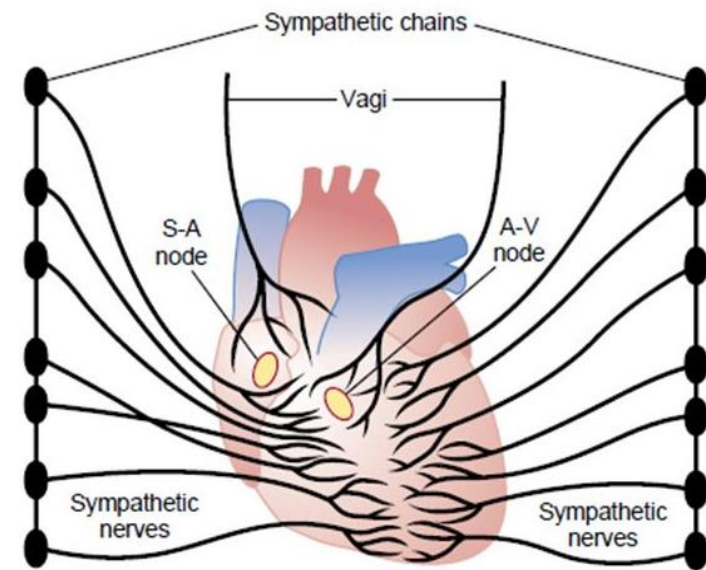
Abnormal pacemakers

- Blockage of transmission of the cardiac impulse from the sinus node to the other parts of the heart

Example: A-V block

- i) Cardiac impulse fails to pass from atria into ventricles
- ii) The atria continues to beat at the normal rate of the rhythm of the SA node
- iii) A new pacemaker develops in the Purkinje fibres with a new rate

Conduction of heart rhythmicity and Impulse conduction by Cardiac Nerves



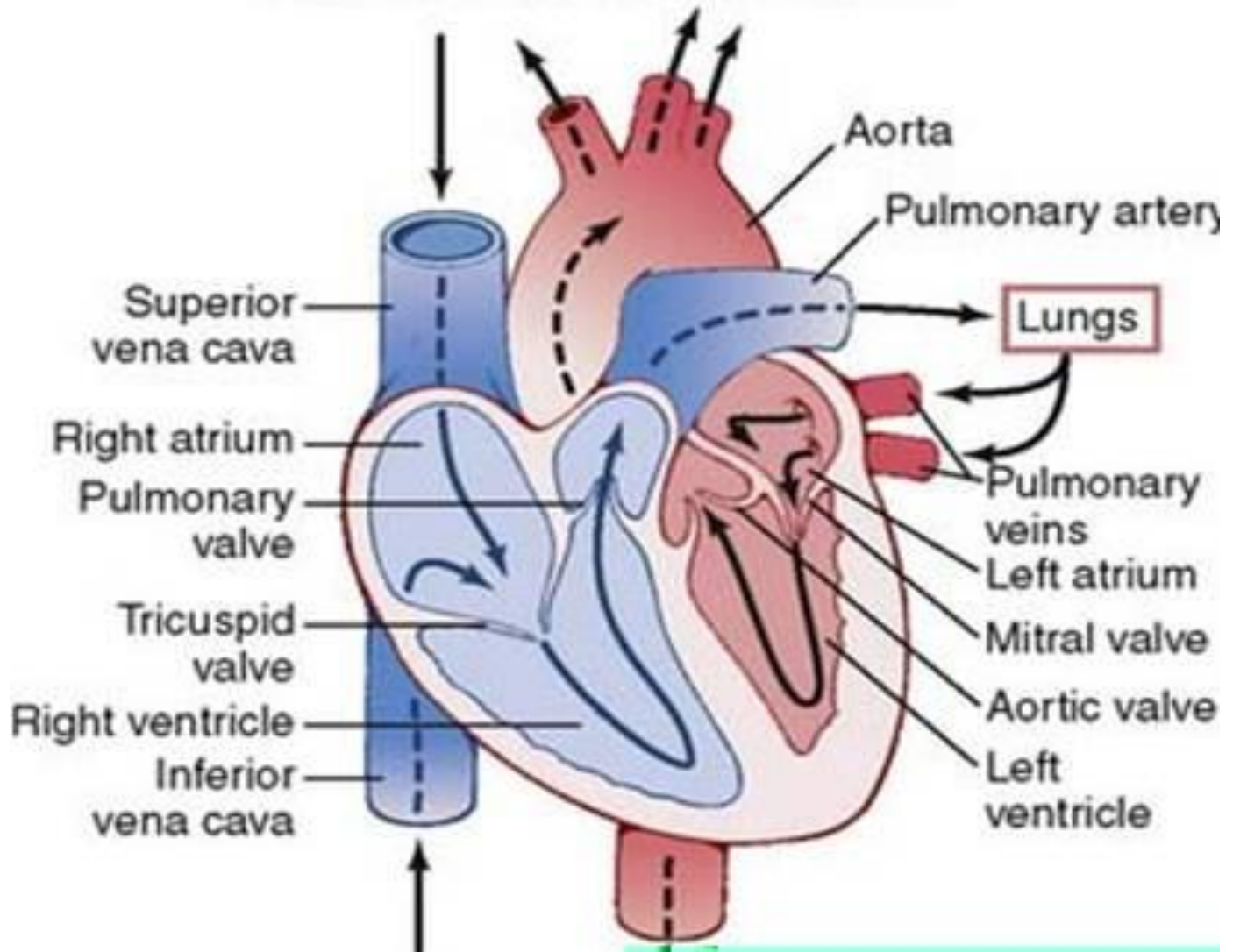
Parasympathetic nerves(vagi)

- Slows the heart
- Mainly to S-A and A-V nodes
- Decreases rate of rhythm of S-A node
- Decreases transmission of impulses to the A-V node
- Strong Stimulation of the vagi

Sympathetic nerves

- Accelerates the heart
- Increases rate of rhythm of the S-A node
- Increases transmission of impulses to the A-V node
- Force of contraction
- Two chemicals are influenced by the sympathetic system-epinephrine and norepinephrine
- All parts of the heart with strong supply to the heart with strong supply to the ventricles

HEAD AND UPPER EXTREMITY



Cardiac *sympathetic* and *parasympathetic* nerves.
(The vagus nerves to the heart are parasympathetic nerves)

References

- Guyton,A.C.& Hall,J.E.(2013).Textbook of Medical physiology.XII Edition, W.B.Saunders Company.
- Chatterjee C.C. (2004) Human Physiology Volume I Medical allied agency
- Youtube videos