Human Circulatory System - V

Course on Human Physiology: Body Fluids & Circulation

Dr Amit Gupta • Lesson 12 • Sept 25, 2021

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▲ 5 • Asked by Dmbailzeri...

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▲ 2 • Asked by Iqbal

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▲ 8 • Asked by Dmbailzeri...

Sir yee kaha h

(1) **Sinuatrial node (SA node).** It is known as the "pacemaker" of the heart. Located in the wall of Rt. Atrium it generates impulses at the rate of about 72 per minute. and initiates heart beat.

(2) **Internodal pathway.** it is the network of neuromuscular pathway that connects the SA node to the AV node.

(3) **Atrioventricular node (AV Node).** It is smaller than SA node and is situated in the atria near AV septum. It capable of generating impulse at rate of about 40/mt.

(4) **Bundle of His (AV Bundle) .** it is the connection between the atrial and ventricular musculature. It begins at the AV node and then divides into left and right branches as it descends down towards ventricles.

The left branches of the AV bundle descends on their respective side of the interventricular septum and is distributed to the ventricles after dividing into Purkinje fibres.

(5) **The Purkinje fibres.** These are distributed through the endocardium of the ventricles and propogate the impulse in the entire ventricle musculature.

Why SA node is called the pacemaker of the heart ?

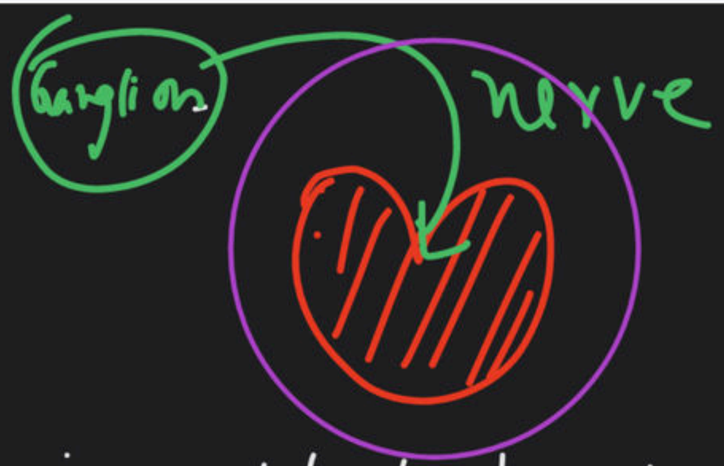
Although impulse is produced by the entire neuromuscular pathway, the frequency of impulse generation is maximum is case of SA node in comparison to other parts of pathway. Hence it guides the rhythm of heart beat and is called the pacemaker of the heart. The AV node on the other hand just conducts the impulse forwards.

WORKING OF HEART

Heart Beat

Rhythmic contraction and expansion of heart is called heart beat. Actually, contraction and expansion occur separately in atrial and ventricle. however, ventricular movements are quite prominent and forceful. Therefore, heart beat is synonym with **ventricular** or **apex beat.** The rate of heart beat in an adult male is on the averge 72 per minute. It is higher in women, children and infants and lower in aged persons. it increases temporarily with activity and disease. In animals heart beat is connected with size. In mammals, smaller animals have higher heart beat is only 28/min in elephant. In frog heart beat is 64/mt. It is maximum among mammals in shrew (800/mt) and minimum in Bluewhale (25 per min).

Heart beat is entirely controlled by nervous supply in arthopods and some annelids. It is called **neurogenic heart beat** and the heart is called **neurogenic heart.** In molluscs and vertebrate heart beat originates from a special muscular tissue. Such a heart beat is called **myogenic heart beat** and this is called **myogenic heart.** Human heart is myogenic.



Invertebrate Heart
(neurogenic)

Decentralisation of Power

Vertebrate Heart
(Myogenic)

Differences between Neurogenic and Myogenic Hearts

	Neurogenic Heart	Myogenic Heart
1.	Impulse of heart beat comes from outside heart.	The impulse of heart develops within the heart.
2.	Impulse is generated by nervous system.	Impulse is generated by a special muscular tissue.
3.	Nerve fibres are spread over the heart to bring about contracton and expansion.	There are special conducting muscles fibres for spreading the impulse.
4.	Heart will stop beating if removed from the body.	It will continue to beat for some time, if detached heart is supplied with proper nourishment and favourable conditions.

Each heart beat has two components, **systole** and **diastole.** Systole represents contraction while diastole represents expansion or distension of heart chambers.

heart beats are listened with the help of an instrument called stethoscope (invented by Laennec).

Heat Loss = Heat Gain

in warm Blooded Animals (Aves / Mammals)

Heart Rate $\propto$ 1/ Body Size

BMR $\propto$ 1/ Body Size

(Eg BMR of Rat > Elephant)

Heart Rate $\propto$ BMR (Basal metabolic Rate)

(Rate of Physiochemical Reaction / Body mass)

Why Smaller mammals have Higher BMR ?

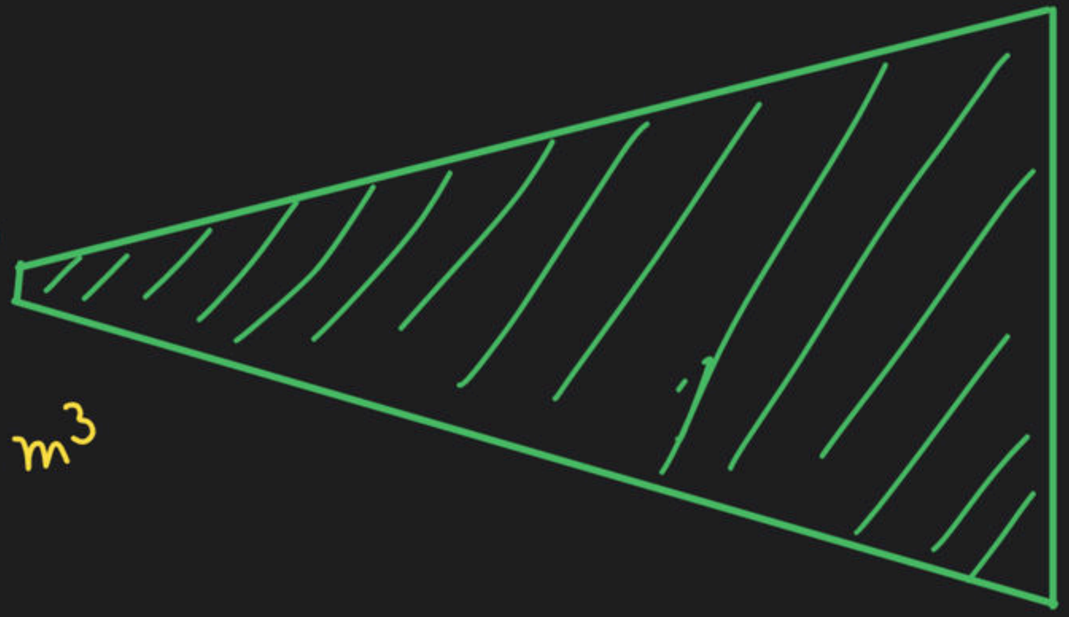
Heat Loss $\propto$ Body Surface Area

Body Surface Area

$0.1\ m^2$

$100\ m^2$.

Rat (A) ——— (B) Elephant



Body Volume

$0.1\ m^3$

$500\ m^3$

$$\text{Ratio of} = \frac{\text{Body surface Area}}{\text{Body volume.}}$$

Rat > Elephant

Relative Heat Loss Rat > Elephant

Rickshawala

(A)

5000/- pm

Motor cycle
(50,000/-)

Businessman.

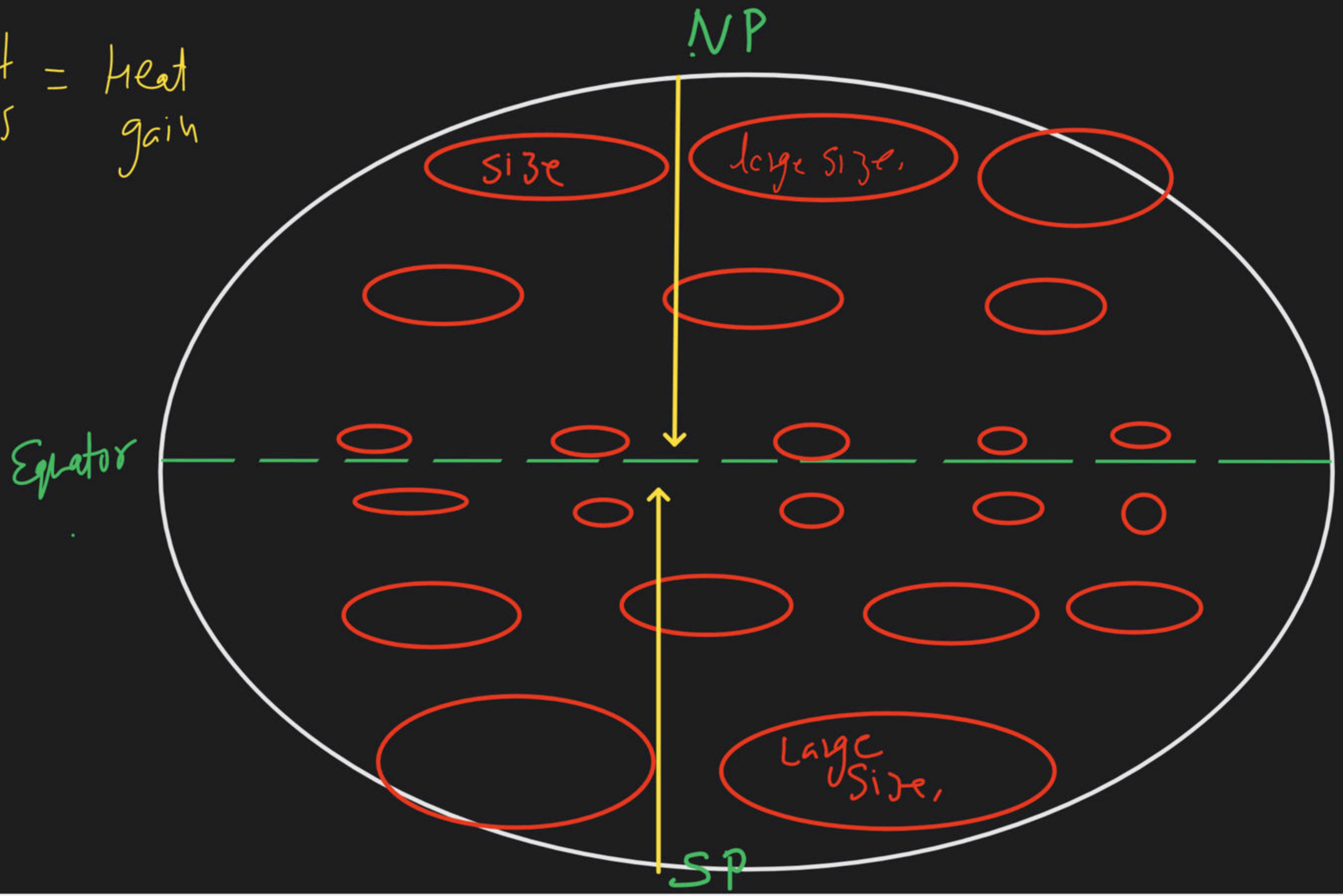
(B)

5 Lakh pm

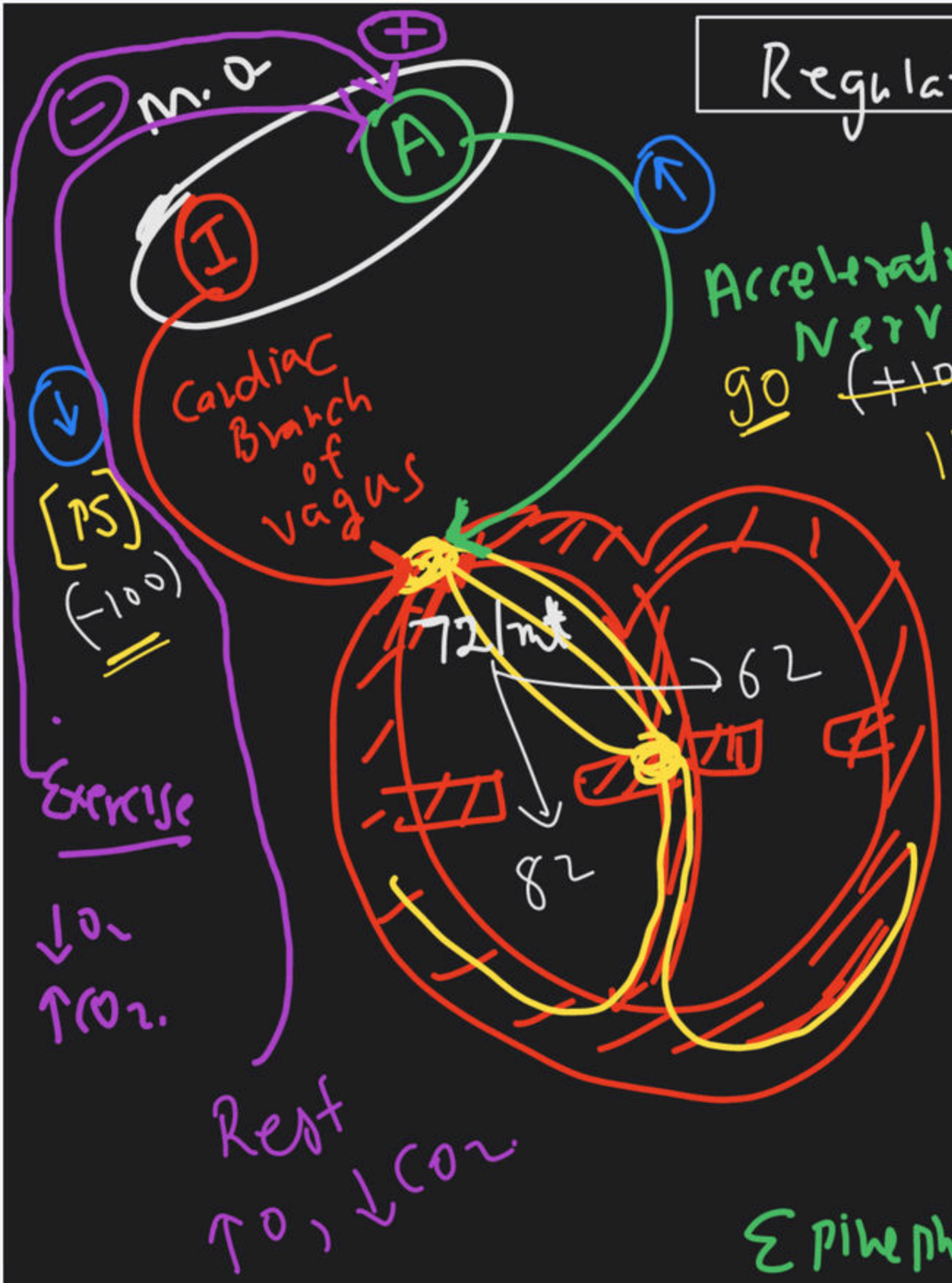
Nano Car
(1 lakh)

Rat $\frac{\text{single area not so low}}{\text{very low volume}}$

Heat loss = Heat gain



Regulation of Heart Rate



Nervous Control

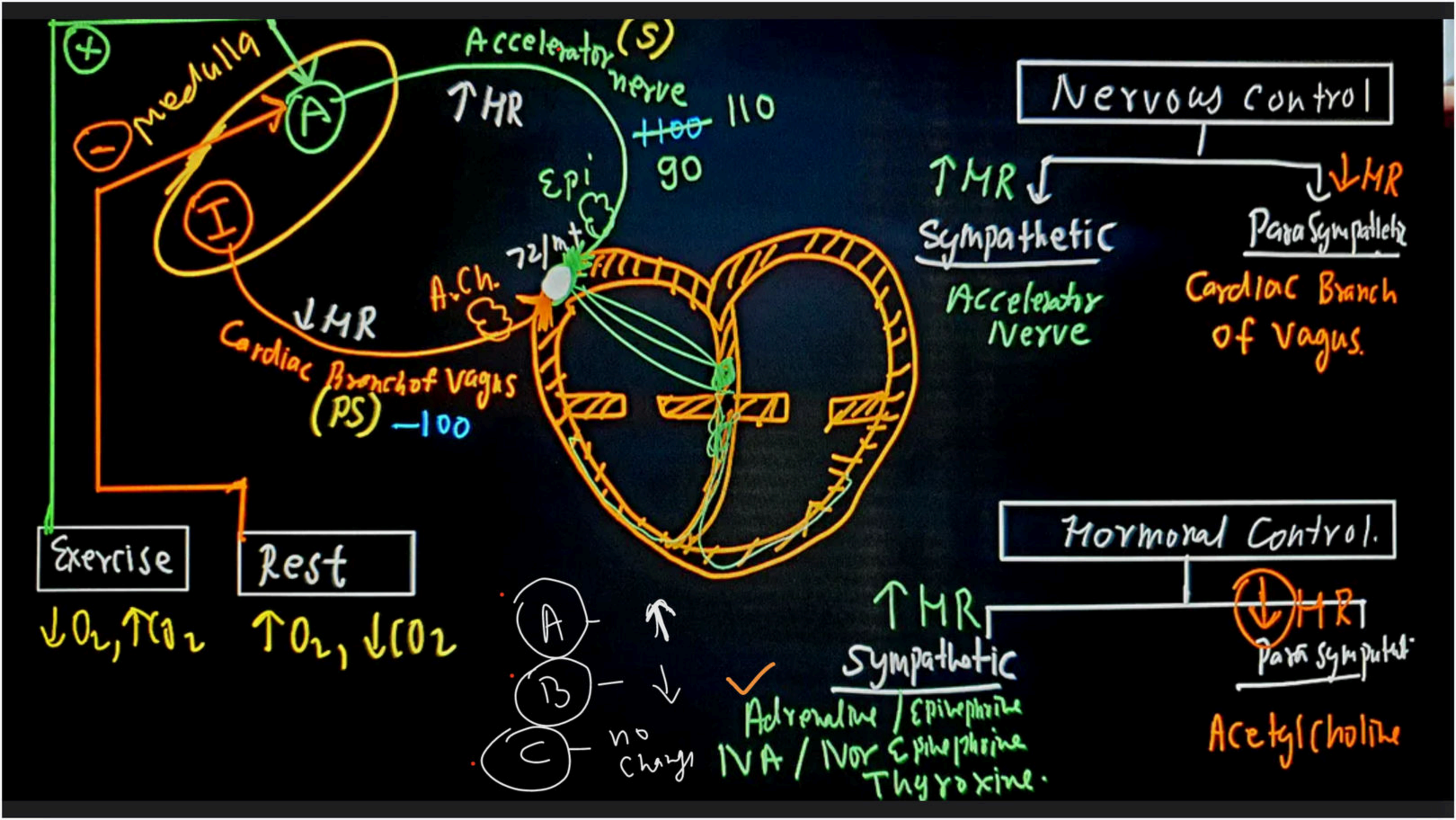
↑ HR — Sympathetic — Sympathetic Nerve

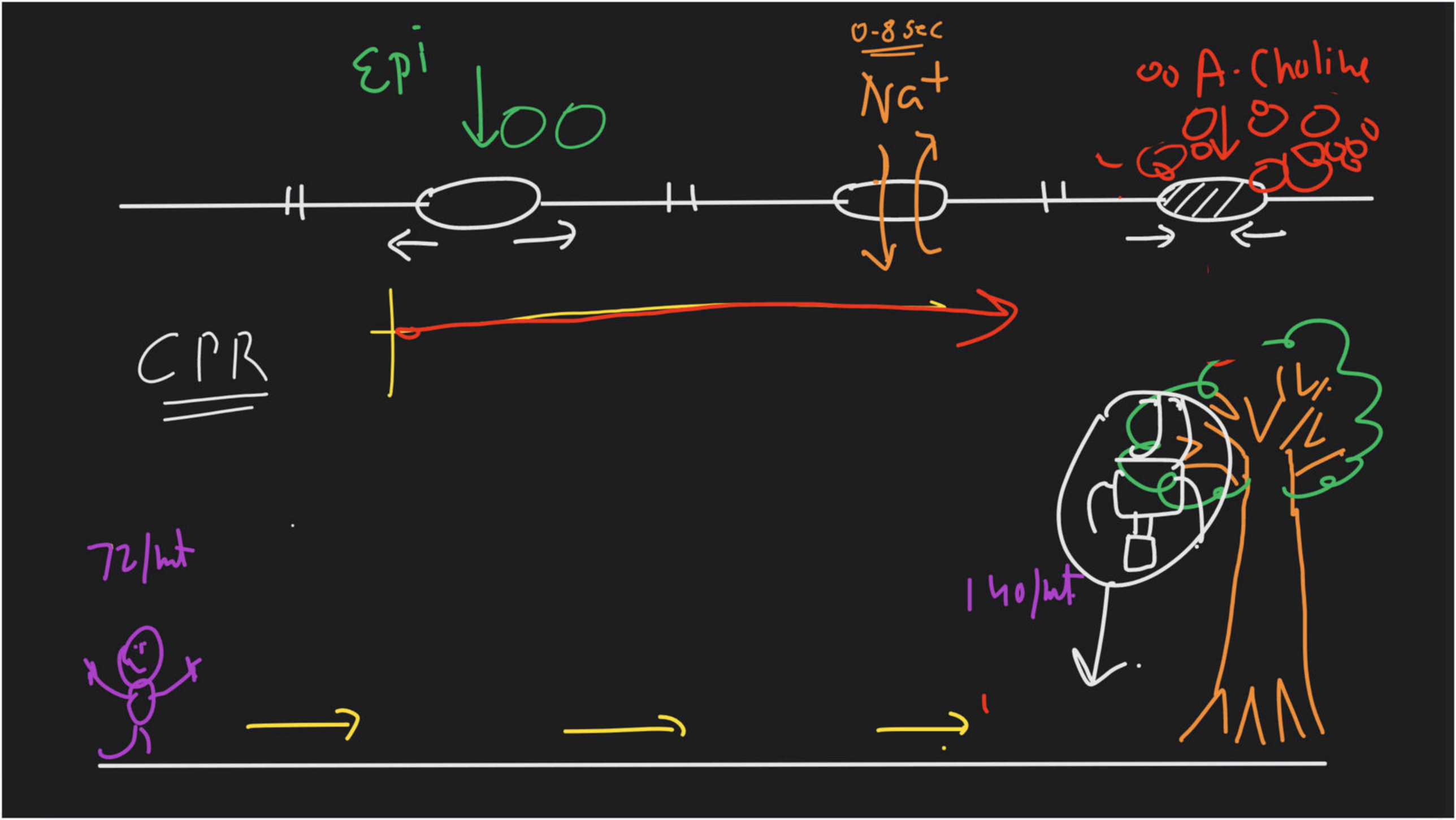
↓ HR — Parasympathetic — Cardiac Branch of Vagus

Hormonal Control

↑ HR — Sympathetic — Epinephrine / Noradrenaline / Thyroxine

↓ HR — Parasympathetic — Acetyl Choline


+
medulla
-
A
I
Accelerator (S) nerve
THR
110
90
Epi
72/mt
A.Ch.
↓HR
Cardiac Branch of Vagus
(PS) -100
Exercise
Rest
↓O2, ↑CO2
↑O2, ↓CO2
A
B
C
no change
Nervous control
↑HR
↓HR
Sympathetic
Accelerator Nerve
Parasympathetic
Cardiac Branch of Vagus.
Hormonal Control.
↑HR
Sympathetic
Adrenaline / Epinephrine
NA / NOR Epinephrine
Thyroxine.
↓HR
Parasympathetic
Acetylcholine


Epi
0-8 sec
Na+
A·Cholin
CPR
72/mt
140/mt

REGULATION OF HEART BEAT

The rate of heart beat is regulated by two mechanism.

- Nervous regulation
- Hormonal regulation

NERVOUS REGULATION

The cardiac centre lies in the upper part of ventral wall of the medulla oblongata.

Cardiac centre is composed of-

- Cardioinhibitory centre (CIC)
- Cardioacceleratory centre (CAC)

Cardioinhibitory centre

(i) It decreases rate of heart beat.

(ii) The cardio-inhibitor is connected with SA node through vagus nerve or parasymphathetic nerve fibre.

(iii) It decreases the rate of heart beat (about 20 to 30 times/minute) as well as strength of heartbeat (by 20 to 30 percent).

Cardioacceleratory centre

(i) It accelerates the rate of heart beat.

(ii) Cardio acceleratory centre is associated with SA node through sympathetic nerve fibre.

(iii) It increase rate of heart beat.

HORMONAL REGULATION

(i) Heart beat is mainly regulated **by adrenaline** (epinephrine) and **non adrenaline** (nor epinephrine). Both hormones are secreted by medulla of adrenal gland.

(ii) **Nor adrenaline** and **adrenaline** both accelerate the rate of heart beat but operate in different conditions. Adrenalin increase the heart beat during emergency conditions, whereas non adrenaline increase the heart beat during normal conditions.

Hormonal control	Adrenaline – ↑ Rate
	Nor adrenaline – ↑ Rate
	Thyroxine – ↑ Rate
	Vagal stimulation releases Acetyl choline – ↓ Rate
Autonomonic Nervous System	Sympathetic – ↑ Rate
	Parasympathetic – ↓ Rate

Tachycardia. It is the condition where heart rate exceeds 90 per minute for an average adult.

Common causes of tachycardia :

(i) **Temperature.** Rate of heart beat increases. Fever causes tachycardia because increased body temperature increases the rate of metabolism of the sinus node, whihc in turn directly increases its excitability and rhythm.

(ii) **Stimulation by sympathetic nerves.** Stimulation of the sympathetic nerves releases the hormone norepinephrine at the sympathetic nerve endings. Therefore this leads to increase in the heart rate.

(iii) **Weak condition of the heart.** Weakening of the myocardium usually increases the heart rate because the weakened heart does not pump blood into the arterial tree to a normal extent, and this causes sympathetic reflexes to increase heart rate.

(iv) **Circulatory Shock/loss of blood.** When a patient looses and passes into a state of shock or semishock, reflex stimulation of heart occurs which increases the frequency of heart beat to compensate for less delivery.

(v) **Exercise.** Physical exhertion cause in increased consumption of oxygen by tissues. In order to meet the increased demand the heart has to work faster.

(vi) **Sinus tachycardia.** Increased frequency of impulse discharges from the SA node will in run increase the heart rate.

increase the heart rate.

Bradycardia. It is the condition where the heart rate falls below 60 per minute in an average adult.

Common causes of bradycardia :

(i) **Temperature.** Fall in body temperature leads to fall in the rate of SA node metabolism, which in turn reduces its Excitability and rhythm.

(ii) **Stimulation by parasympathetic Vagus.** Parasympathetic stimulation of acetylcholine secreted by vagus has an inhibitory effect on the SA node. (opposite phenomenon of sympathetic stimulation occurs here).

(iii) **Stronger condition of the heart.** The athelete's heart is considered stronger than that of a normal person. This allows it to pump greater stroke volume output per heart beat. When the athelete is at rest, this exessive quantity of pumped blood causes a negative feed back response resulting in bradycardia when he is at rest.

(iv) **Rest.** When at rest or sleeping, the oxygen demand of body is lesser this gives a negative feedback resulting in fall in heart rate.

(v) **Sinus bradycardia.** Peduced frequency of impulse discharge from SA node will reduce the heart rate.