

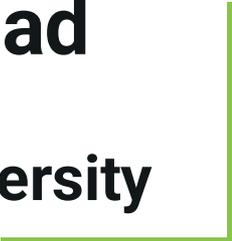


# Heart Rate Regulation

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**11/11/2025**

# Heart Rate

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Heart rate represents: the number of heart beats per minute .

Normal adult resting HR ranges from 60 to 100 bpm .

HR contributes to cardiac output **.RH \* VS = (OC)**

Which is the product of HR and stroke volume, ensuring adequate tissue perfusion.

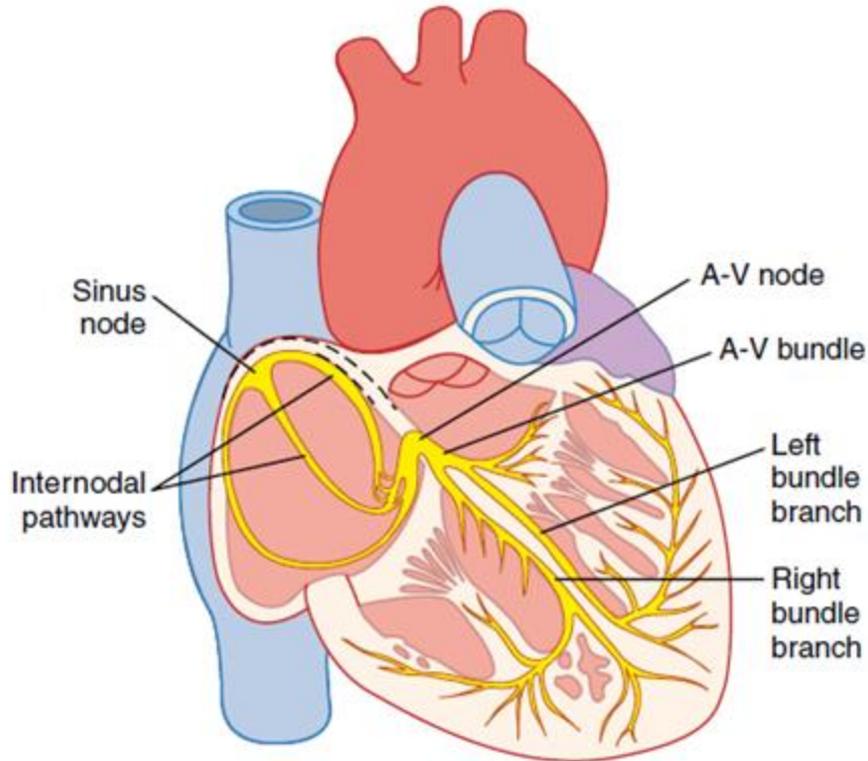
# Determinants of HR include:

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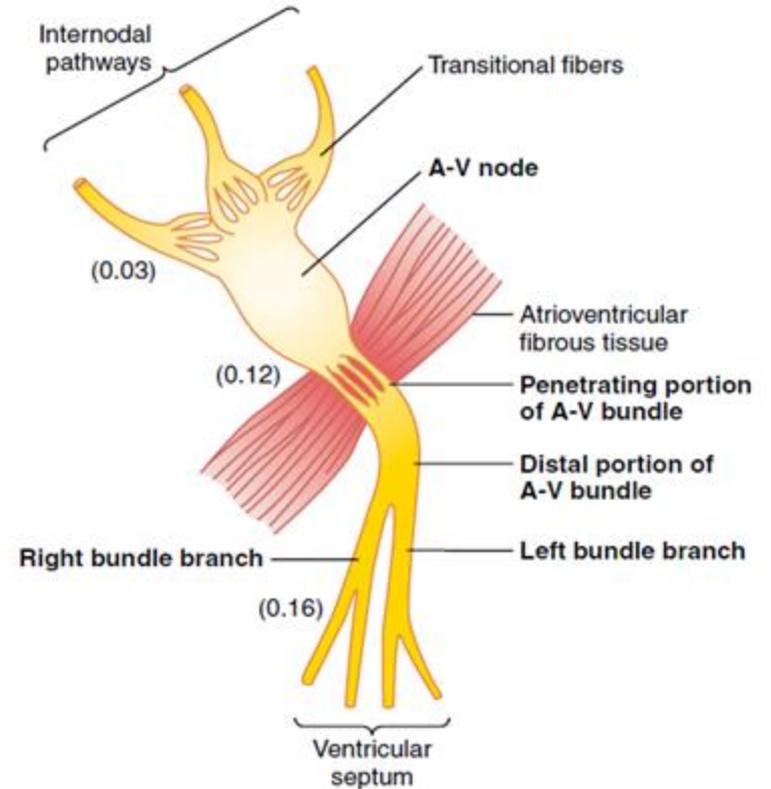
-1 **Intrinsic regulation** edon AS eht yb detaidem si :s automaticity and pacemaker ionic currents that generate spontaneous depolarizations. ( basal rhythm)

-2 **Extrinsic modulation** dna metsys suovren cimonotua eht yb ylniam .  
.senomroh gnitalucric

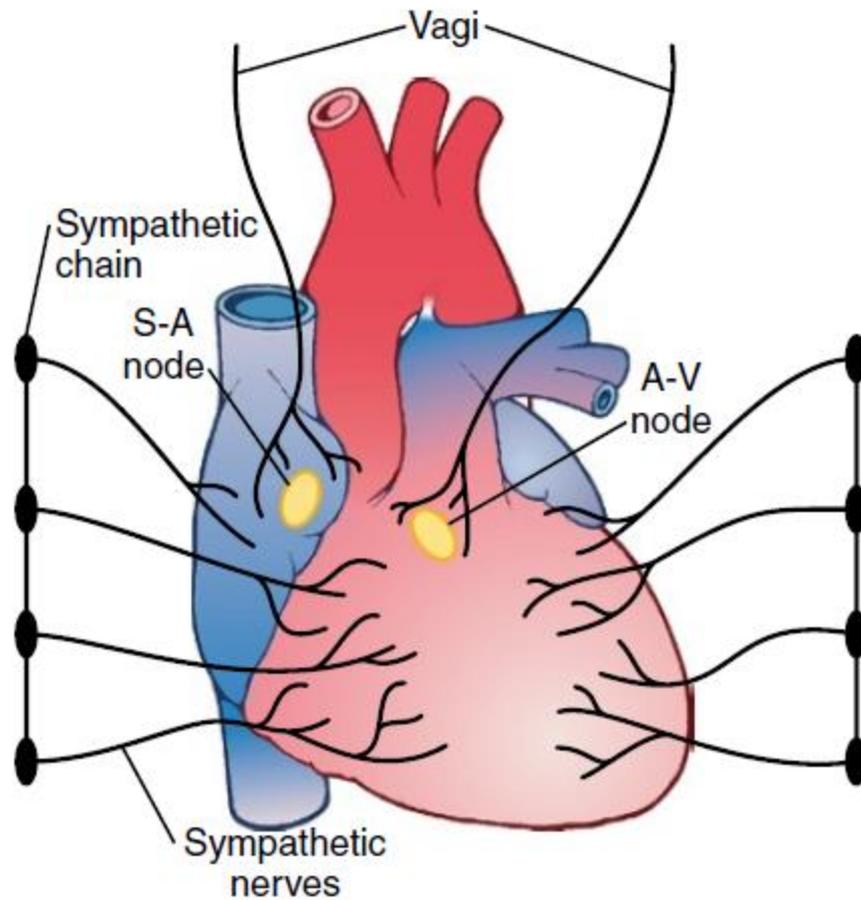
# Cardiac Conduction System



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



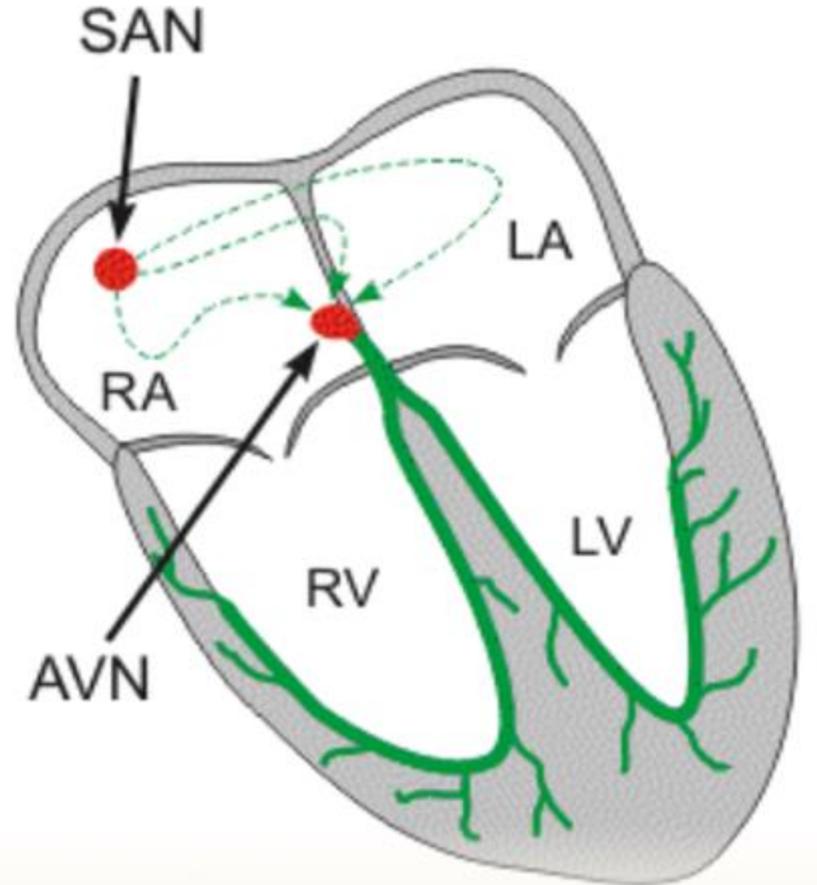
**Figure 10-3** Organization of the A-V node. The numbers represent the interval of time from the origin of the impulse in the sinus node. The values have been extrapolated to human beings.



**Figure 9-12** Cardiac *sympathetic* and *parasympathetic* nerves.  
(The vagus nerves to the heart are parasympathetic nerves.)

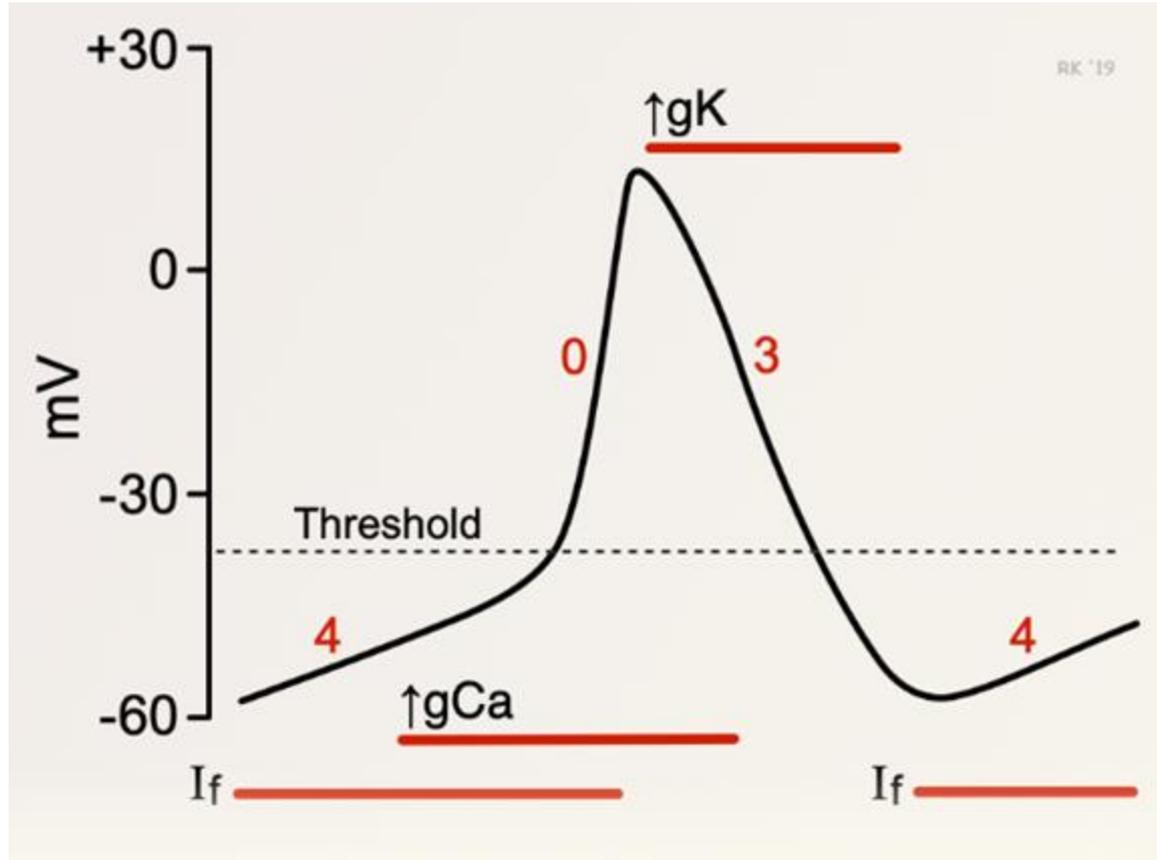
# SA node

The rhythm of the heart is normally determined by a pacemaker called the **(AS) lairtaonis** eht ni detacol **edon** eht fo llaw roiretsop eht raen muirta thgir .avac anev roirepus



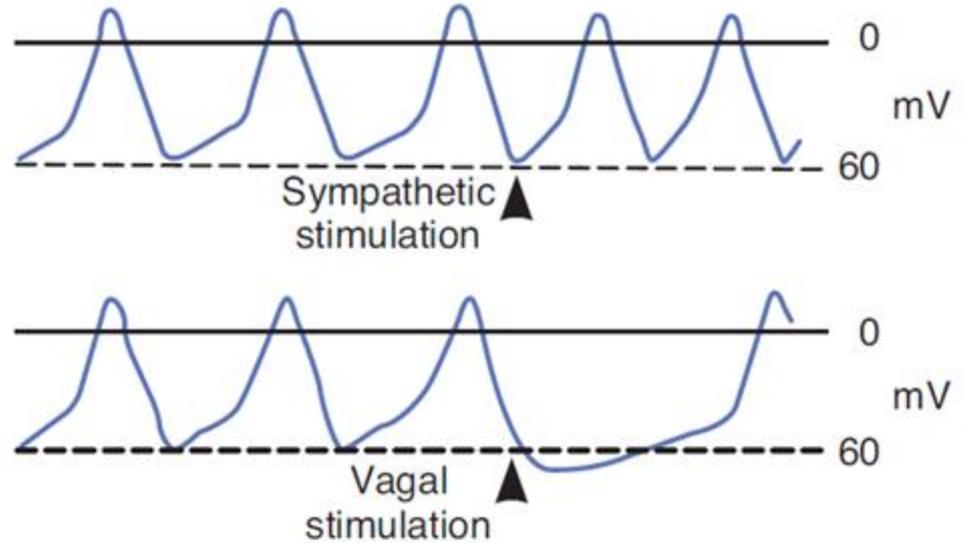
# SA node

The SA node comprises specialized cells that undergo spontaneous generation of action potentials at **110-100** action potentials ("beats") per minute.



# SA node

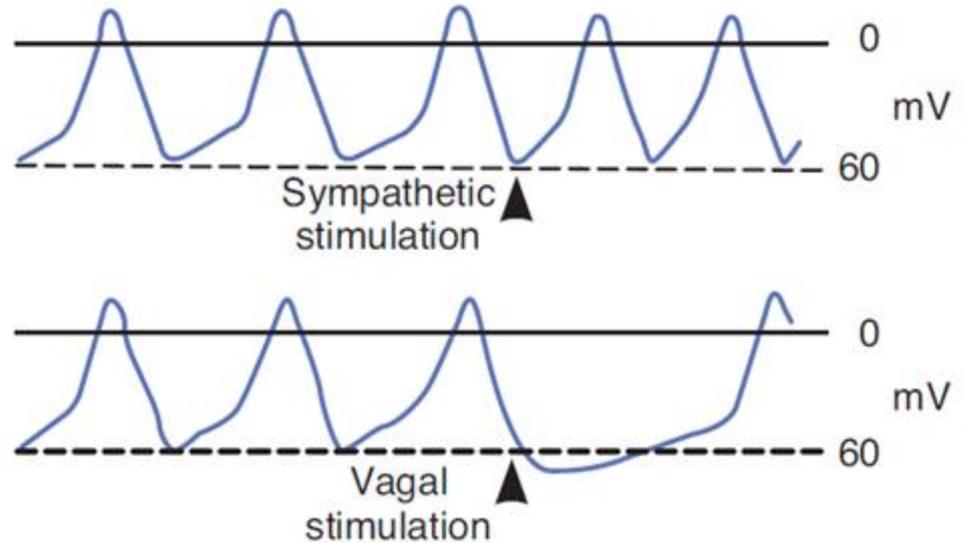
This intrinsic rhythm is strongly influenced by autonomic nerves, with the **vagus nerve** and sympathetic nervous system. The vagus nerve (parasympathetic) slows the heart rate by decreasing the slope of the prepotential and increasing the threshold for firing. Sympathetic stimulation increases the heart rate by increasing the slope of the prepotential and decreasing the threshold for firing.



**FIGURE 30-3** Effect of sympathetic (noradrenergic) and vagal (cholinergic) and sympathetic (noradrenergic) stimulation on the membrane potential of the SA node. Note the reduced slope of the prepotential after vagal stimulation and the increased spontaneous discharge after sympathetic stimulation.

# SA node

This "vagal tone" brings the resting heart rate down to 70-60 beats/minute .  
The normal range for sinus rhythm is 100-60 beats/minute .  
Sinus rates below this range are termed **sinus bradycardia**.  
sinus rates above this range are termed **sinus tachycardia** .



**FIGURE 30-3** Effect of sympathetic (noradrenergic) and vagal (cholinergic) and sympathetic (noradrenergic) stimulation on the membrane potential of the SA node. Note the reduced slope of the prepotential after vagal stimulation and the increased spontaneous discharge after sympathetic stimulation.

# Regulation of Pacemaker Activity

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The rate of SA nodal firing can be altered by:

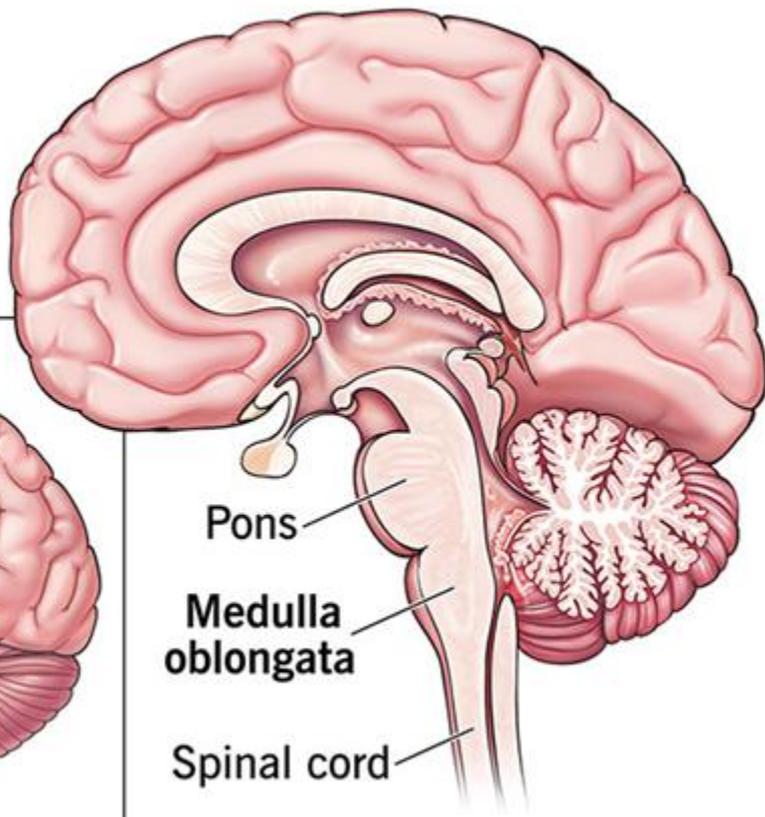
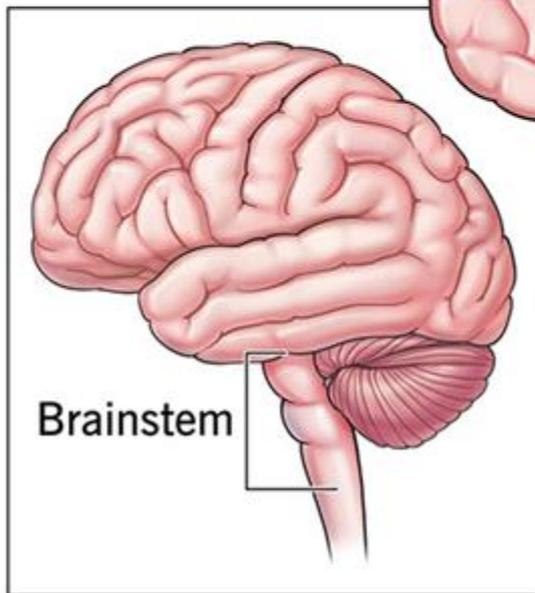
-1 Changes in autonomic nerve activity (sympathetic and vagal).

Autonomic regulation of cardiovascular function is controlled by the central nervous system.

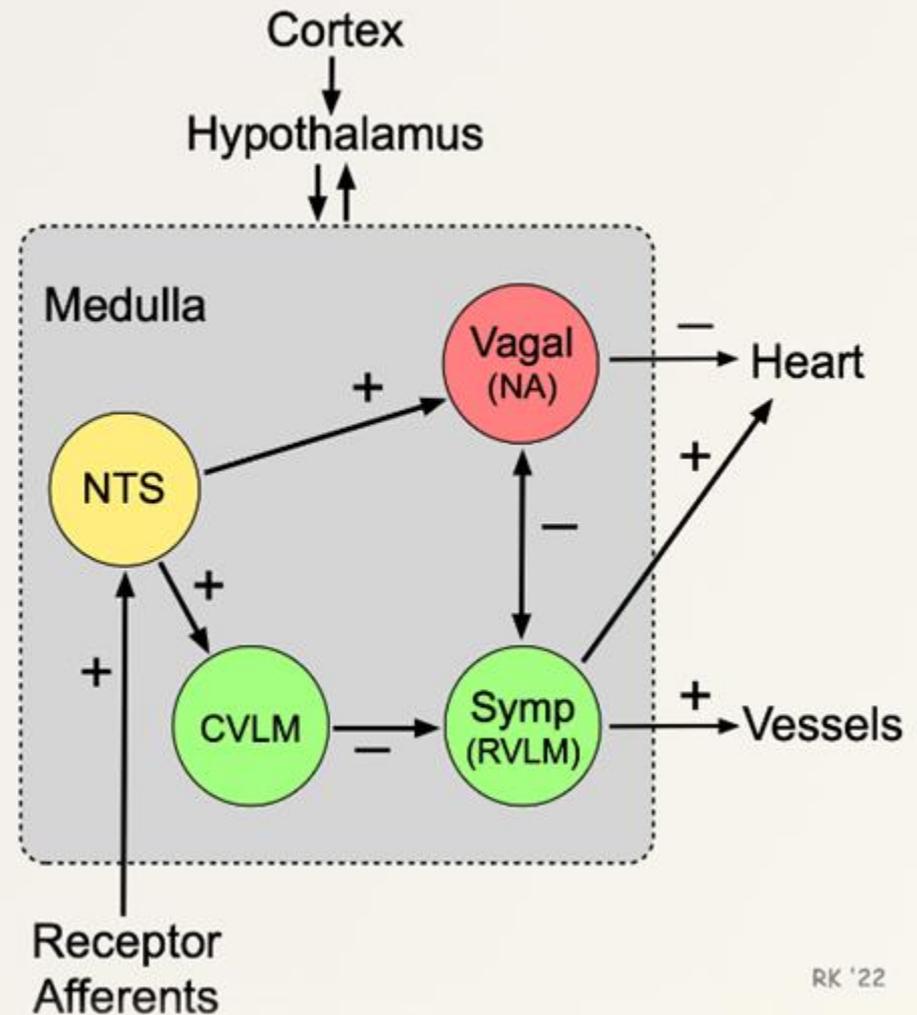
The major site in the brain for regulating autonomic nerve outflow to the heart and blood vessels is **the medulla**, lanips eht evoba metsniarb eht ni detacol .erusserp lairetra fo noitaluger kcabdeef mret-trohs rof tnatropmi si dna ,droc

# Medulla oblongata

Side view (outside)



Side view (inside)



# PARASYMPATHETIC INNERVATION

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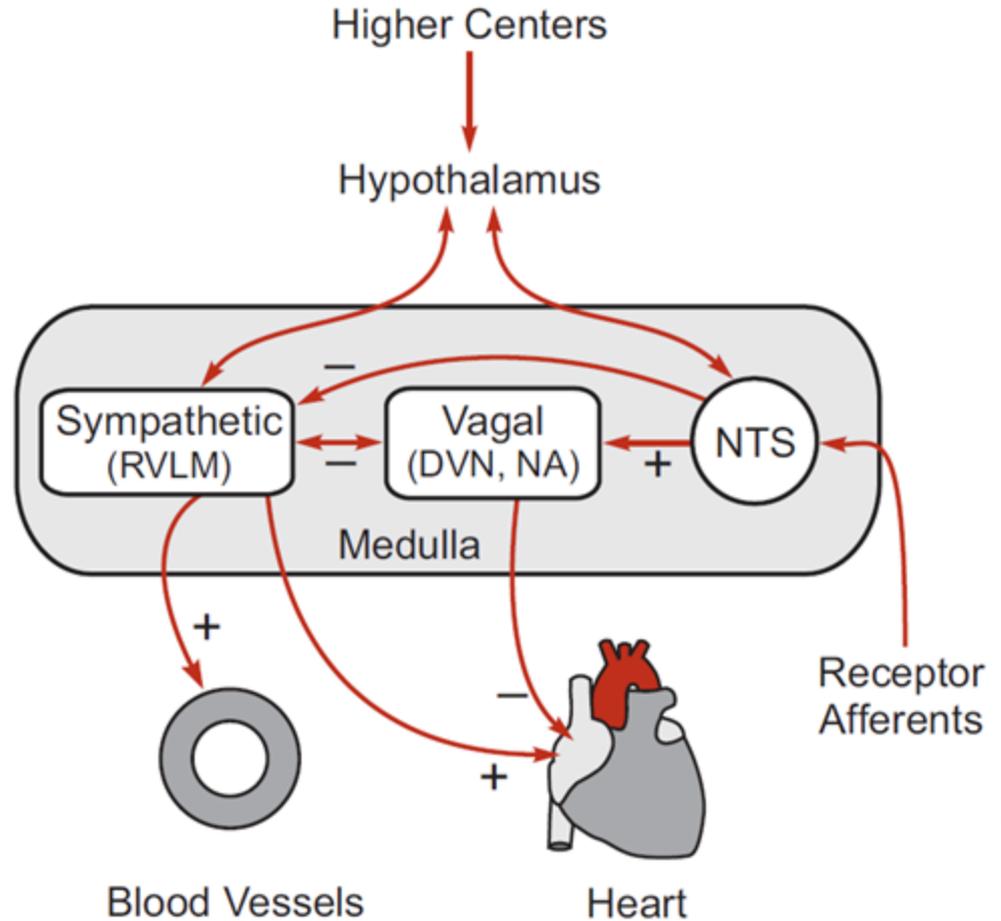
The parasympathetic vagal fibers innervating the heart originate from cell bodies located within the medulla of the brainstem.

These cell bodies are found in collections of neurons called the **dorsal vagal nucleus (DVN)** and **nucleus ambiguus (NA)**.



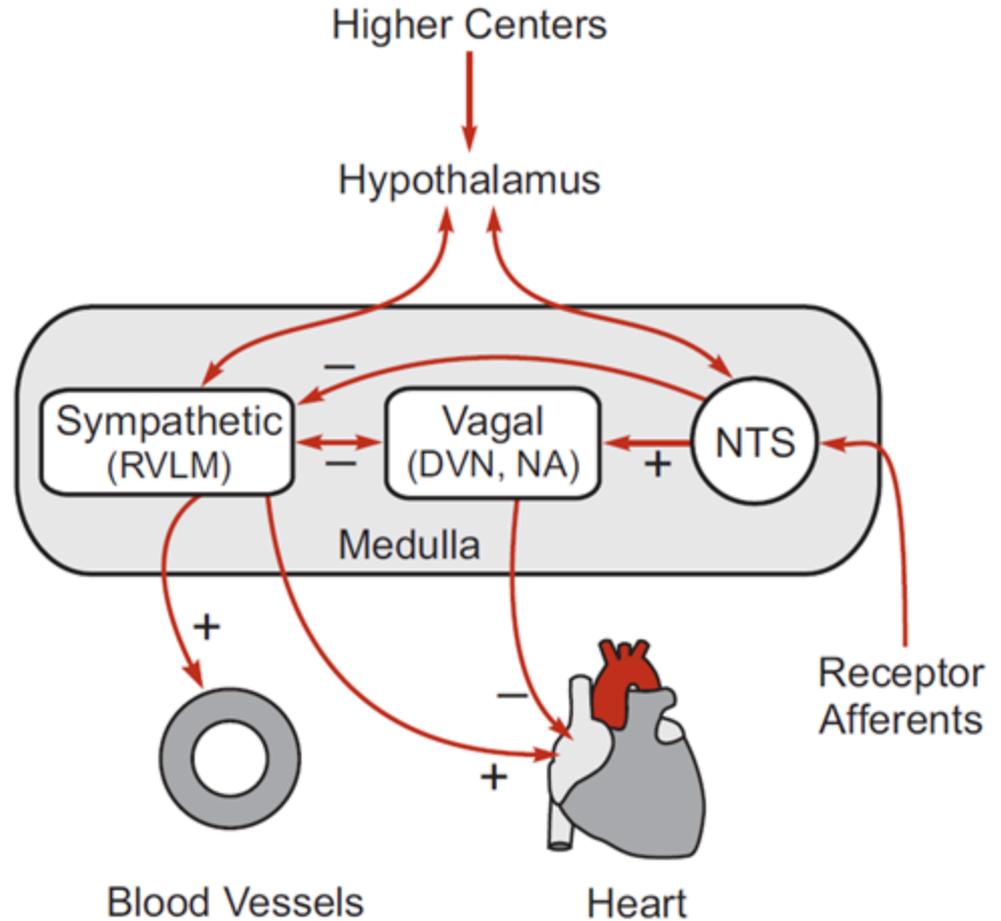
Increased activity of these nuclei :

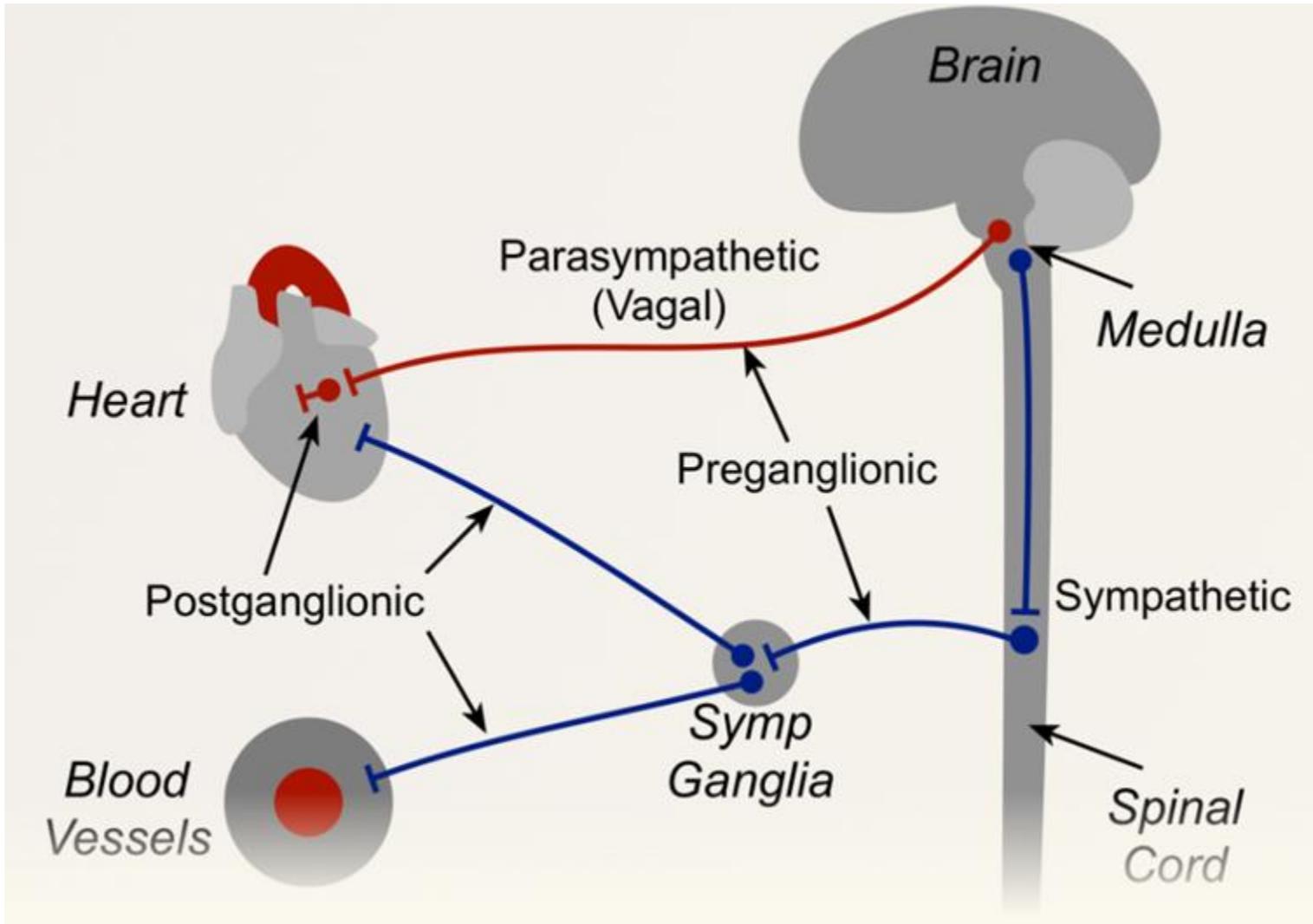
- 1 Reduces SA nodal firing (negative chronotropy).
- 2 Slows AV nodal conduction (negative dromotropy).



It is important to rednu taht **eton**  
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these neurons are tonically  
active, thereby producing what is  
termed **“vagal tone”** on the heart,  
resulting in resting heart rates  
significantly below the intrinsic  
firing rate of the SA nodal  
pacemaker.





# SYMPATHETIC INNERVATION

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The sympathetic adrenergic control of the heart and vasculature originates from neurons found within the medulla, the most important of which are located in the **rostral ventrolateral medulla (RVLM).**

Sympathetic neurons within the RVLM have spontaneous action potential activity, which results in tonic stimulation of the heart and vasculature.

Therefore, **acute sympathetic denervation** results in **cardiac slowing and systemic vasodilation.**

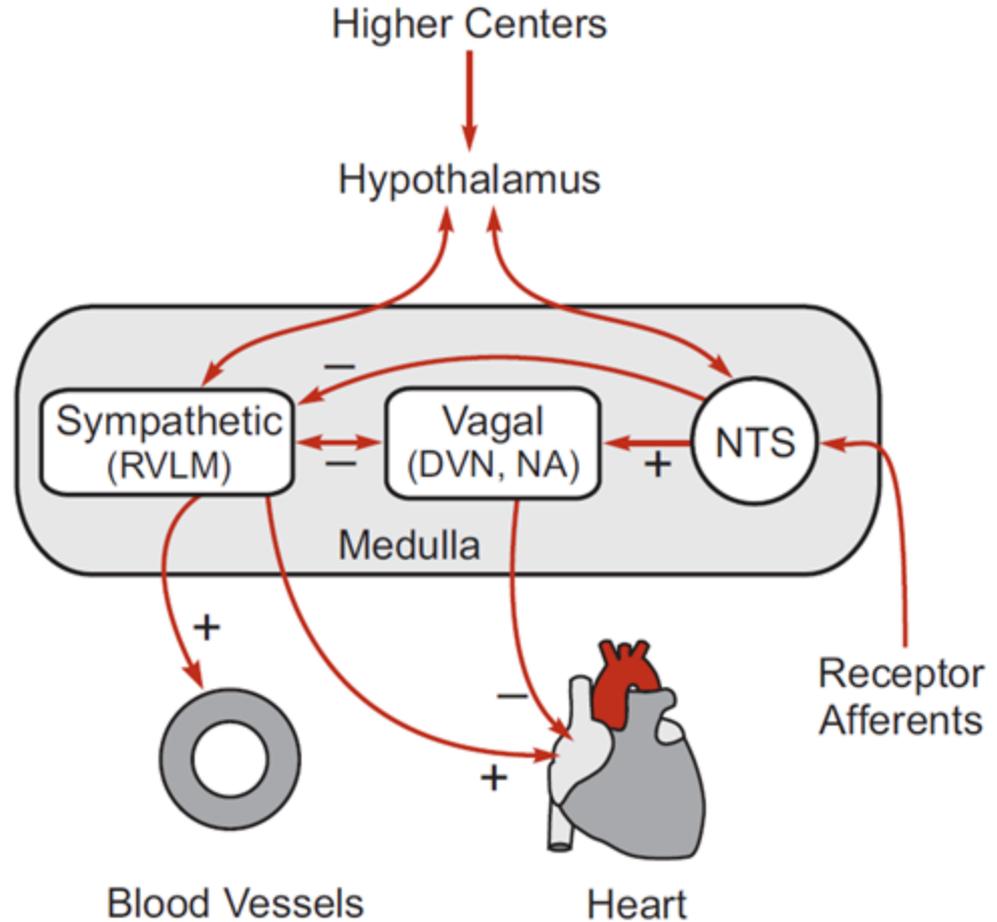
# SYMPATHETIC INNERVATION

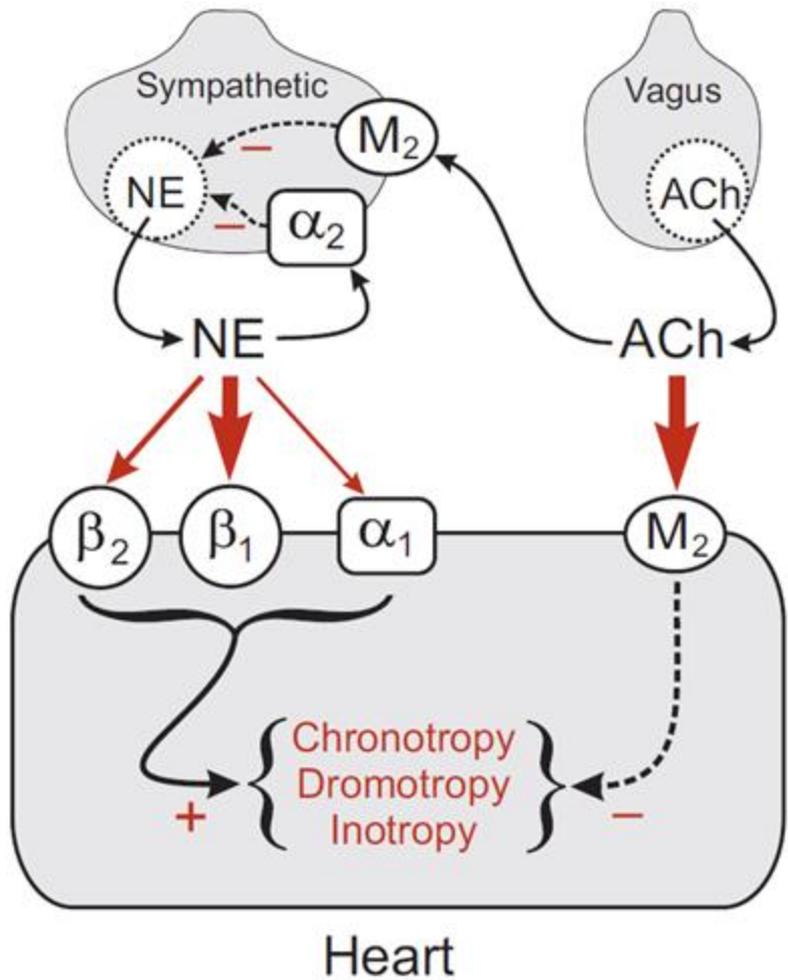
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**Postganglionic sympathetic** AS eht etavrenni traeh eht ot gnilevart srebfi eht sa llew sa ,setycoym caidrac dna ,metsys noitcudnoc eht ,sedon VA dna .erutalucsav yranoroc

Sympathetic activation increases chronotropy, dromotropy, and inotropy. In blood vessels, sympathetic activation directly constricts both resistance and capacitance vessels, thereby increasing systemic vascular resistance (and arterial blood pressure) and decreasing venous capacitance (which increases venous pressure)

# RECIPROCAL SYMPATHETIC AND VAGAL ACTIVITY

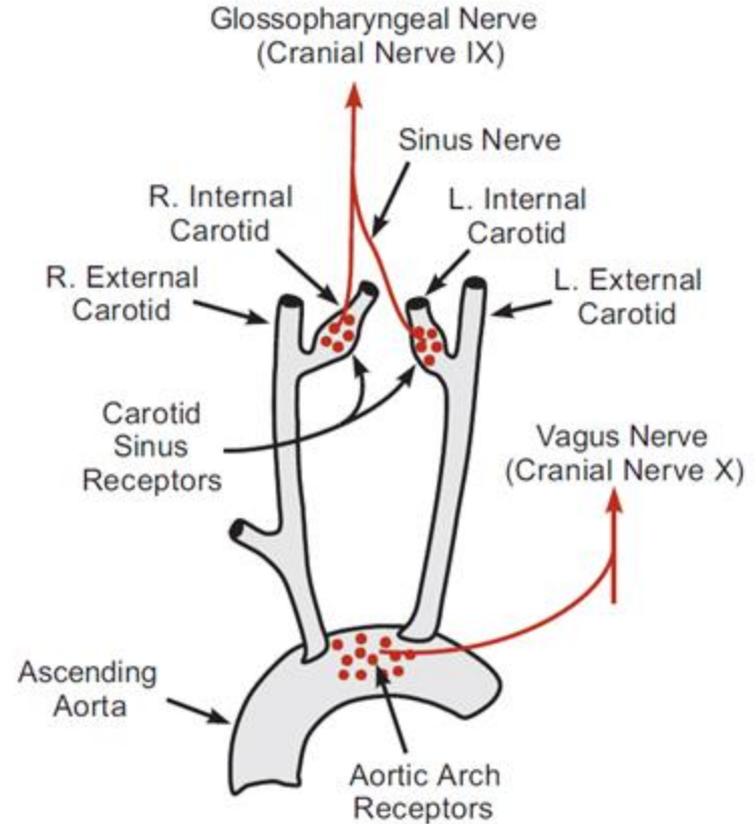




# Baroreceptors

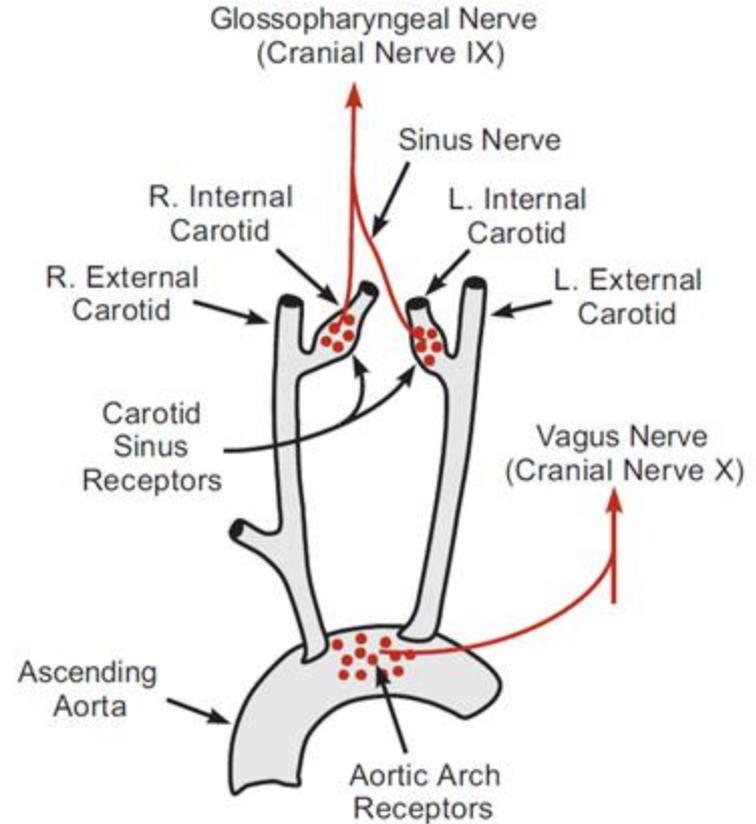
The baroreceptors are stretch receptors in the walls of the heart and blood vessels.

Monitor the arterial circulation.  
Monitor low-pressure part of the circulation (cardiopulmonary receptors).



# Baroreceptors Feedback

The arterial baroreceptors respond to the stretching of the vessel walls produced by increases in arterial blood pressure.

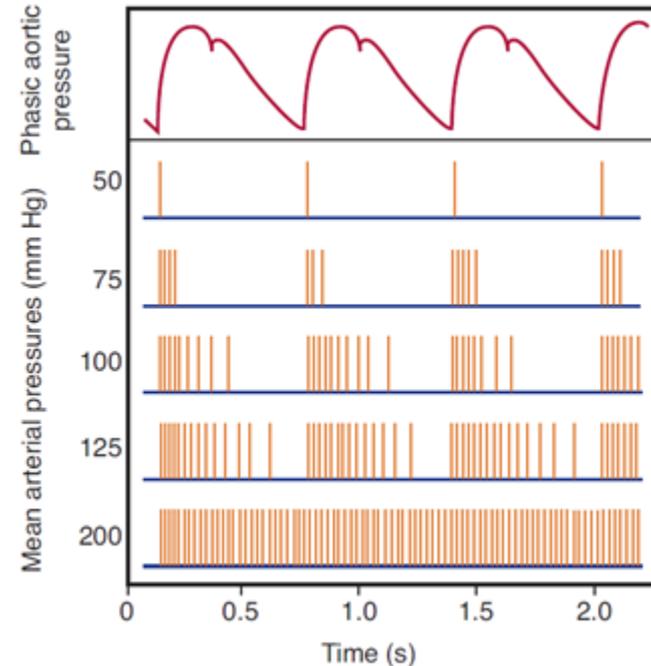


# Baroreceptors Feedback

Arterial blood pressure is regulated through negative feedback systems incorporating pressure sensors (baroreceptors) found in strategic locations within the cardiovascular system :

-1 In the carotid sinus (small dilation of the internal carotid artery just above the bifurcation of the common carotid into external and internal carotid branches) .

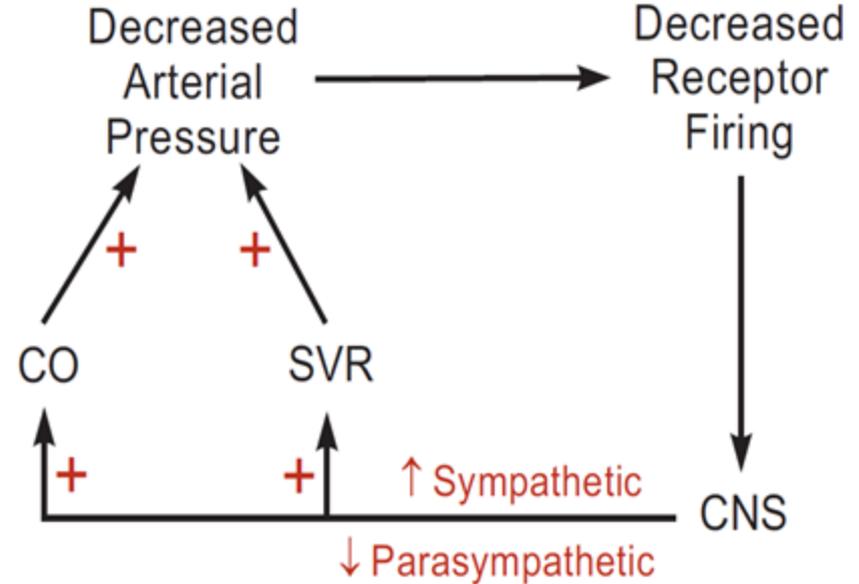
-2 In the aortic arch.



# Baroreceptors Feedback

Baroreceptors are very important in short-term control of arterial pressure.

Orthostatic hypotension.  
Carotid sinus massage.  
Valsalva maneuver.  
Cushing reflex.



■ **FIGURE 6.8** Baroreceptor feedback loop.

# Bainbridge Reflex

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There are stretch receptors located at the venoatrial junctions.

They detect stretch from increased atrial filling (  $\uparrow$ venous return  $\uparrow$   $\rightarrow$ atrial volume).

When venous return increases  $\rightarrow$ atrial stretch increases  $\rightarrow$ these receptors send signals to the medulla via vagal afferent fibers.

The medulla responds by increasing sympathetic output to the SA node.

This causes an increase in heart rate.

# Chemoreceptors

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-1 Peripheral Chemoreceptors

-2 Central Chemoreceptors

# Peripheral Chemoreceptors

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The peripheral chemoreceptors are found in two locations.

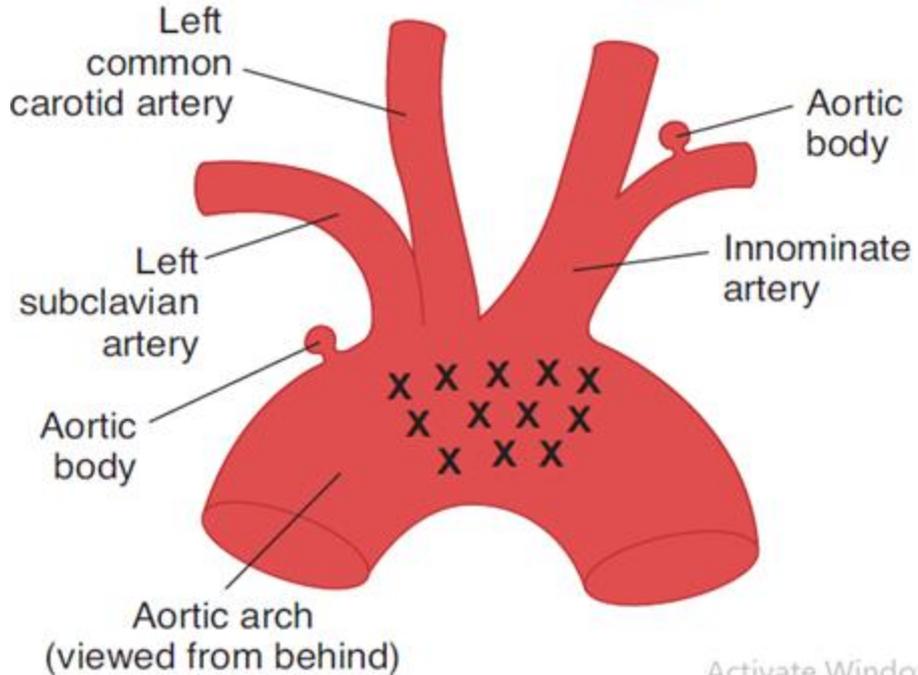
-1 In carotid bodies: at bifurcation of external & internal carotid arteries.

Carotid body afferents → sinus nerve → glossopharyngeal nerve → NTS.

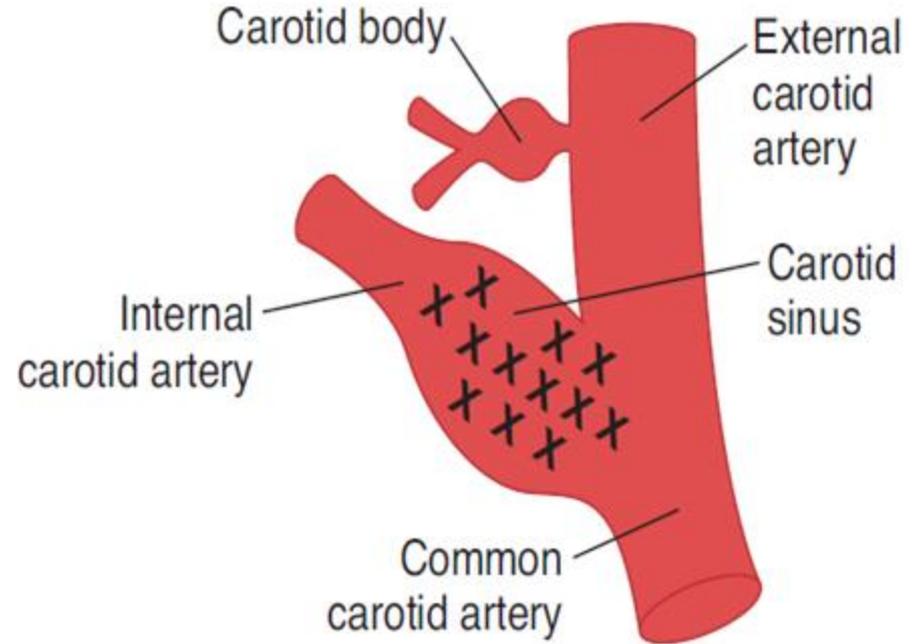
-2 In aortic bodies (aortic arch).

Aortic body afferents → vagus nerve → NTS.

# Peripheral Chemoreceptors



Activate Windo



# Peripheral Chemoreceptors

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Stimulated by:

↓ -1 arterial  $P_{O_2}$  (hypoxemia)

↑ -2 arterial  $P_{CO_2}$  (hypercapnia)

↑ -3  $H^+$  (acidosis)

↓ -4 blood flow to carotid bodies.

# Peripheral Chemoreceptors

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Chemoreceptors exert their main effects on respiration; however, their activation also leads to vasoconstriction .

# Central Chemoreceptors

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Central Chemoreceptors: Located in **medullary areas** + VC gnillortnoc .sret nec yrotaripser

Stimulated mainly by  $\uparrow\text{CO}_2$  and  $\uparrow\text{H}^+$  in CSF ( $\text{H}^+$  formed from  $\text{CO}_2$  via bicarbonate system).

- Not directly stimulated by low  $\text{PO}_2$

# Hormonal control

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- **-1 Circulating catecholamines :**

\*\*The adrenal medulla releases catecholamines (80% epinephrine, 20% norepinephrine).

\*\*Sympathetic nerves innervating blood vessels are another source of circulating catecholamines, principally norepinephrine.

# Hormonal control

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- **-2Thyroid hormones :**

Increase the heart rate by:

\*\*Stimulate SA node.

\*\*Increase the adrenaline sensitivity.

# Hormonal control

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-**3Atropine** : citehtapmysarap gnikcolb yb etar traeh eht setarelecca sihT .ytivitca

-**4Histamine**.RH esaercni oslA .rotalidosav tnetop a si sihT :

-**5Bile salts** :.ytivitca edon AS eht tibihni esehT



Any questions???



**THANK YOU**