SNS COLLEGE OF ALLIED HEALTH SCIENCE

Affiliated to The Tamil Nadu Dr MGR Medical University, Chennai

DEPARTMENT OF CARDIAC TECHNOLOGY

COURSE NAME : Applied Physiology

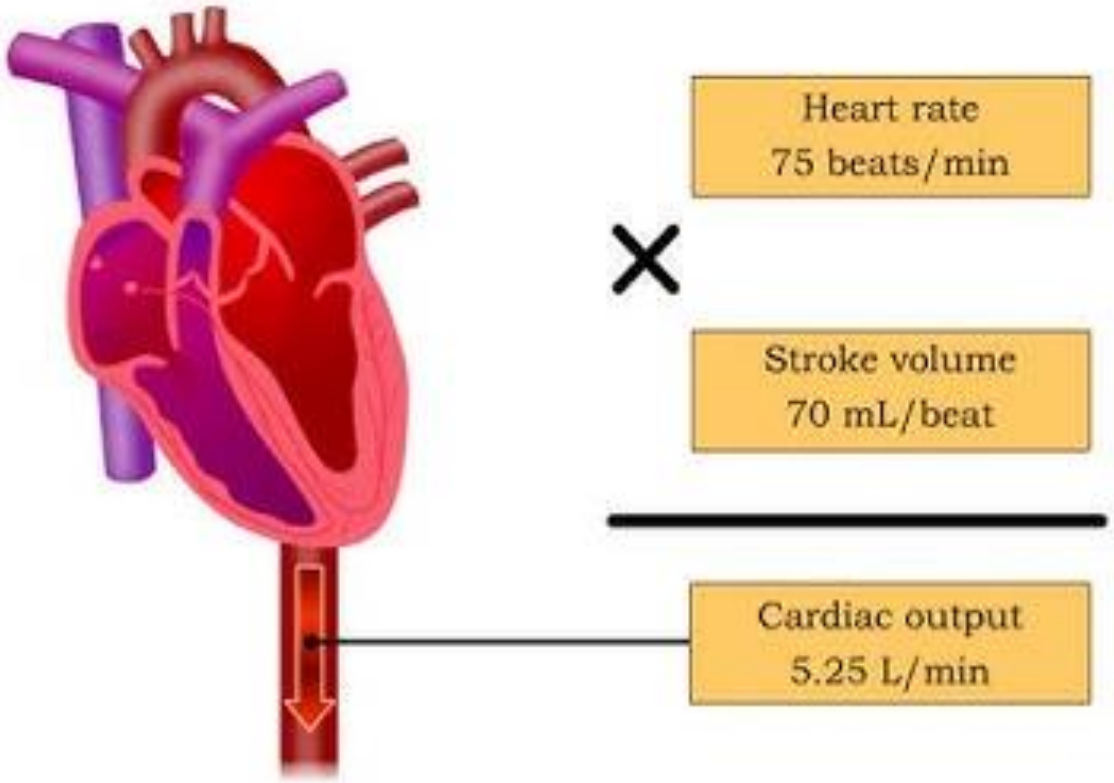
UNIT : Cardiac Cycle and Electrical Activity of Heart

TOPIC : Autonomic Regulation of Heart Rate

FACULTY NAME: Kavipriya S

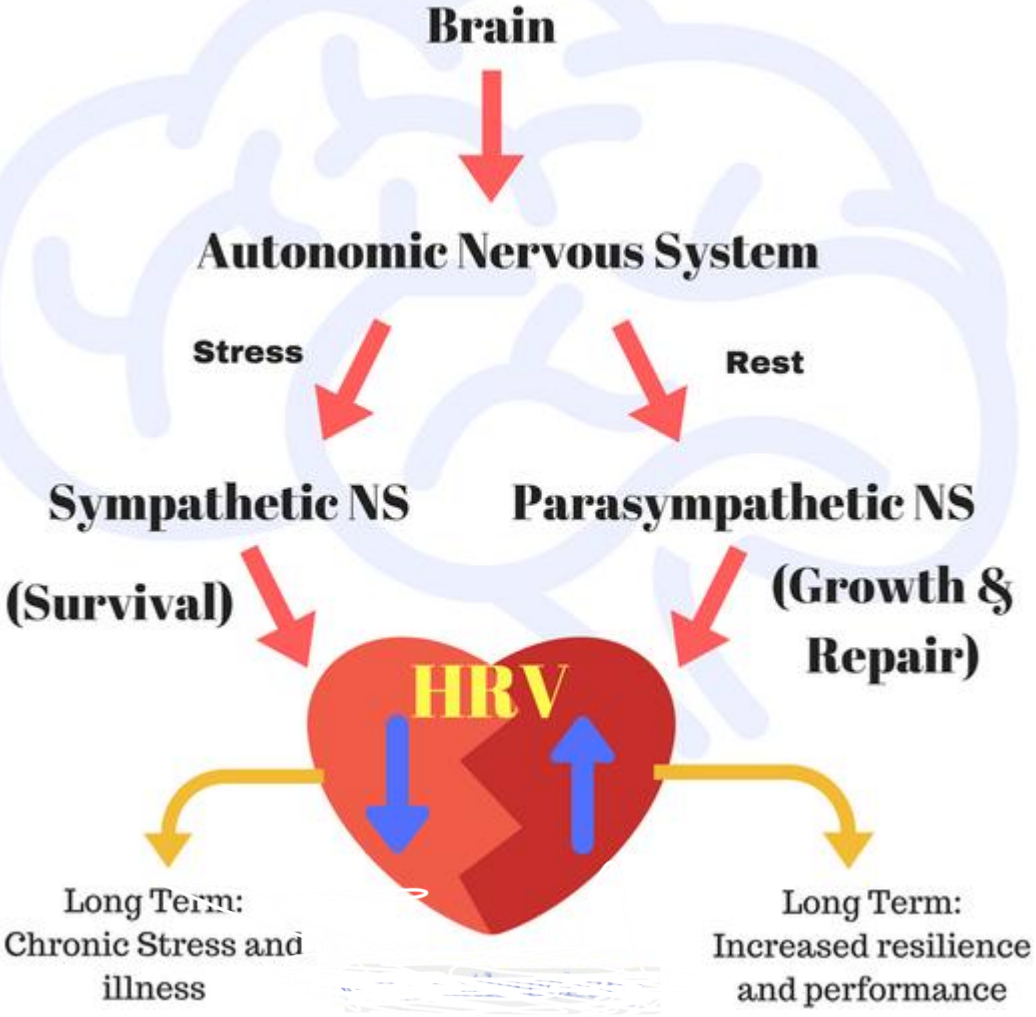
❤️ EMPATHIZE — Why Heart Rate Regulation Matters

- Heart rate (HR) determines **cardiac output (CO = HR × Stroke Volume)**.
- The body must **adjust HR** according to oxygen demand:
- ↑ During exercise, fever, stress.
- ↓ During sleep, rest, meditation.



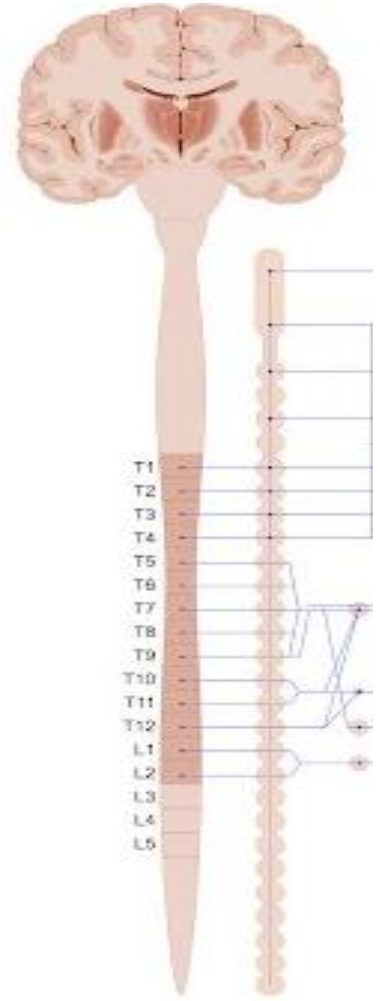
Regulation occurs through the **Autonomic Nervous System (ANS):**

- **Sympathetic system** → accelerates HR.
- **Parasympathetic system (vagal)** → slows HR.



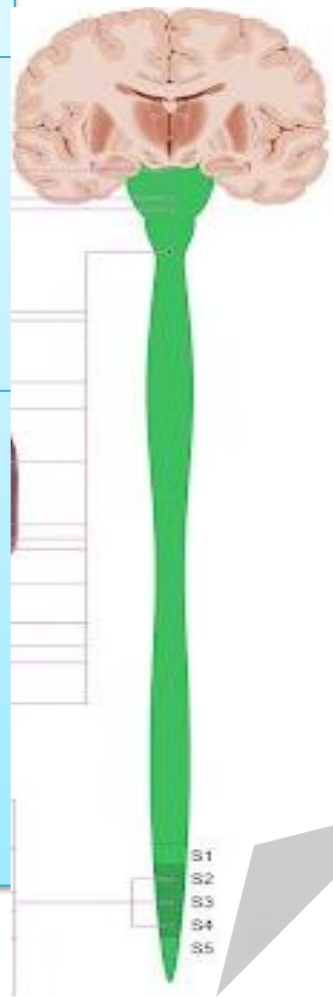
💡 2. DEFINE — Identifying the Core Concept

Sympathetic



Component	Origin	Nerves	Neurotransmitter	Receptors	Effect
Sympathetic	Medulla → T1–T5 spinal cord	Cardiac nerves	Norepinephrine (NE)	β_1 receptors	↑ HR (positive chronotropy)
Parasympathetic	Medulla (Dorsal vagal & nucleus ambiguus)	Vagus nerve (CN X)	Acetylcholine (ACh)	Muscarinic M_2 receptors	↓ HR (negative chronotropy)

Parasympathetic



IDEATE — Mechanism of Autonomic Control

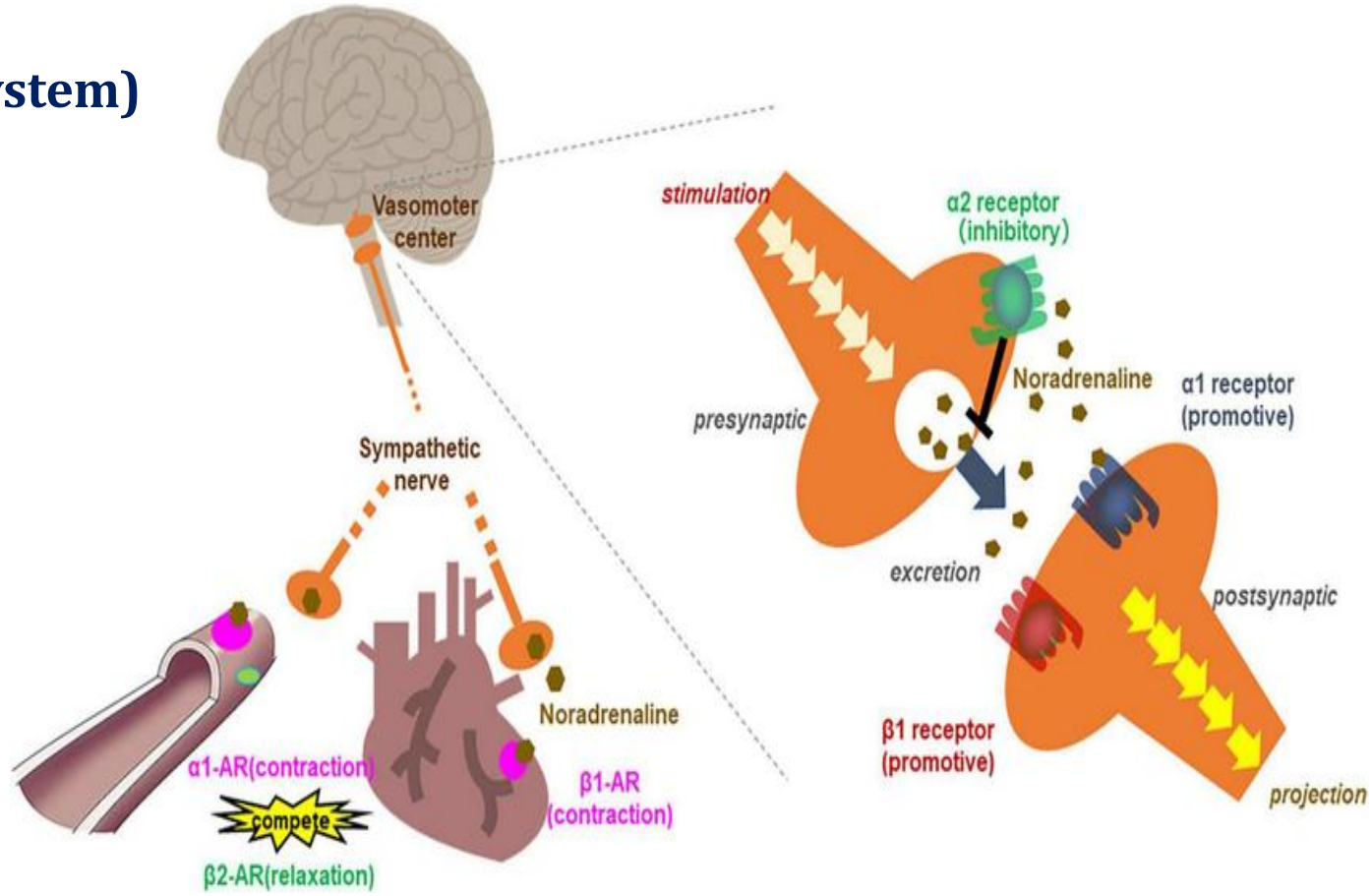
A. Sympathetic Control (Cardioacceleratory System)

Pathway:

Medulla → T1–T5 spinal segments → Cardiac sympathetic nerves → SA & AV nodes, atrial & ventricular muscle.

Neurotransmitter: Norepinephrine (NE).

Receptor: β_1 adrenergic.



🧠 IDEATE — Concept Formation & Theory

Mechanism:

↑ Na^+ and Ca^{2+} channel opening in SA node.

↑ rate of spontaneous depolarization (Phase 4).

↓ threshold potential → faster impulse generation.

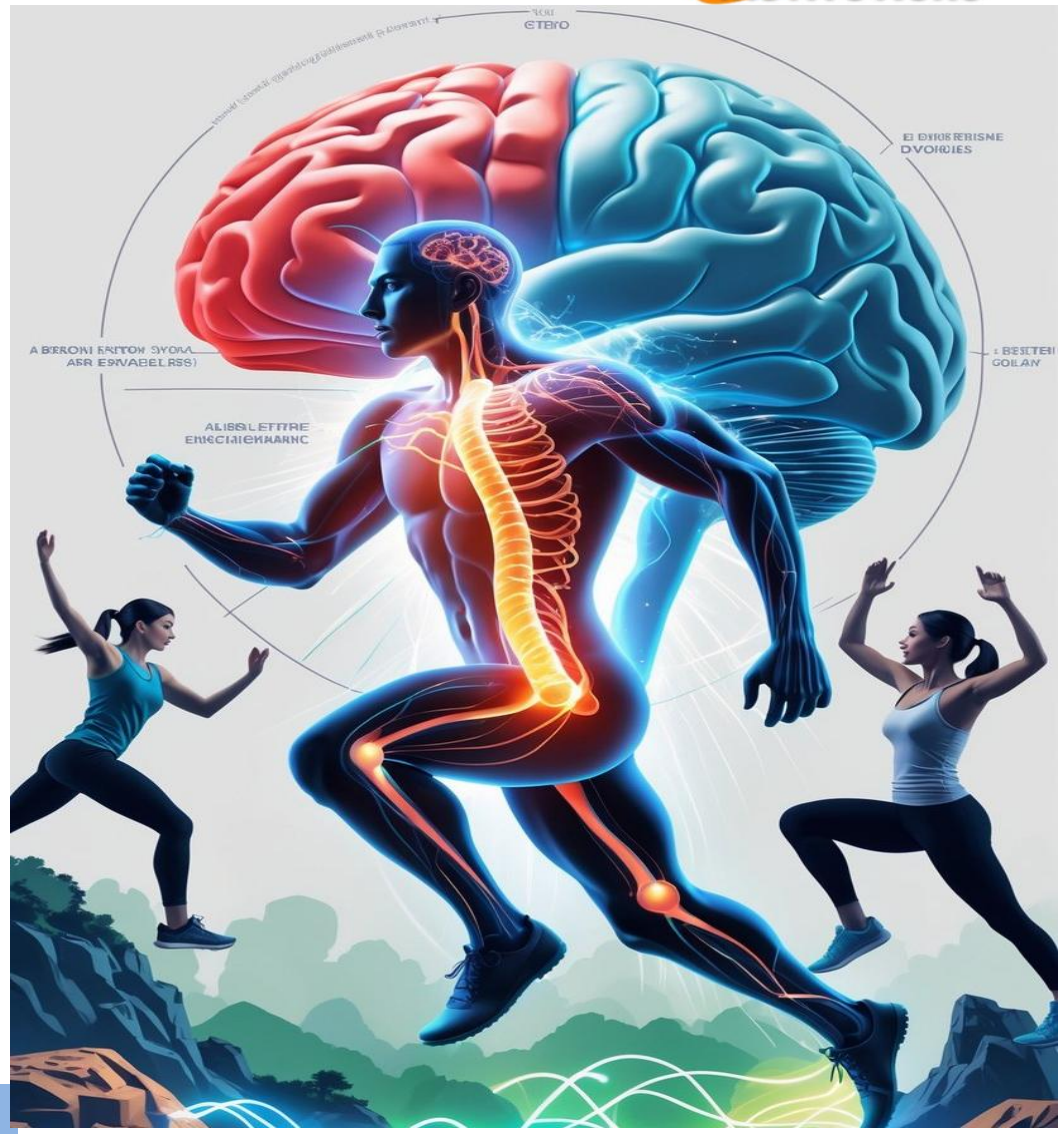
Effect:

↑ SA node firing → ↑ HR.

↓ AV nodal delay → faster conduction.

↑ Contractility (positive inotropy).

Clinical example: Exercise, fear, stress, adrenaline infusion.



🧠 IDEATE — Concept Formation & Theory

B. Parasympathetic Control (Cardioinhibitory System)

Pathway:

Medulla → Vagus nerve → SA & AV nodes.

Neurotransmitter: Acetylcholine (ACh).

Receptor: Muscarinic M_2.

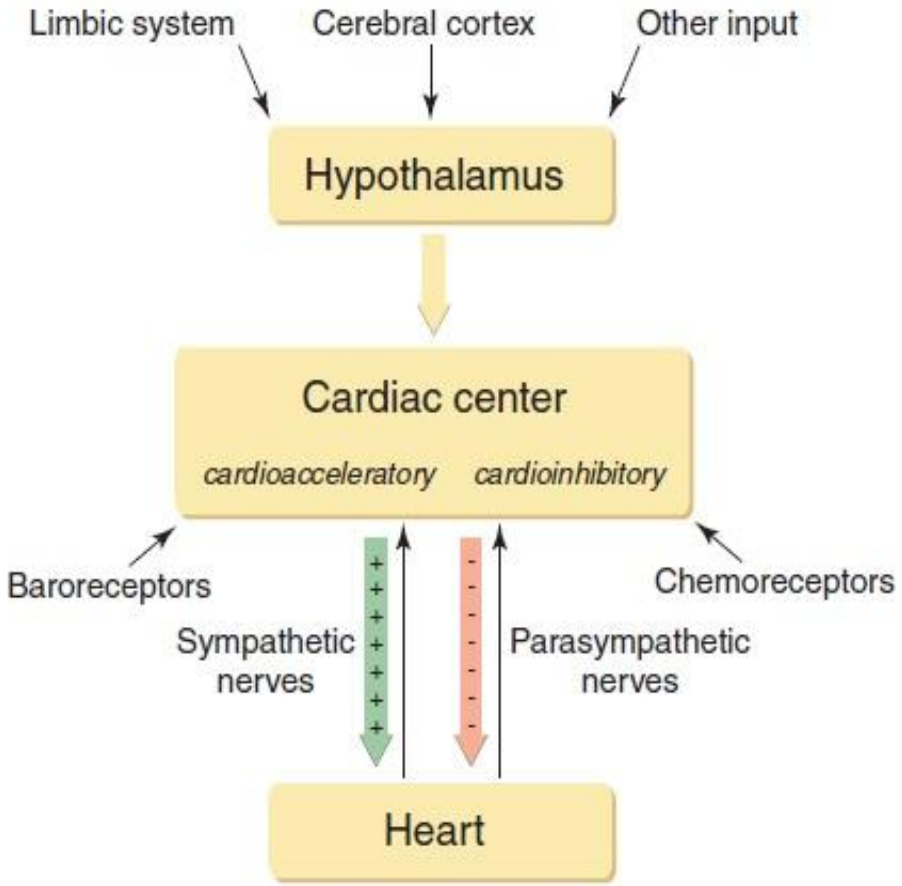


FIGURE 8.13. A Schematic Representation of the Innervation of the Heart, Cardiac Centers, and its Communications

Central Regulation (Higher Control Centers)

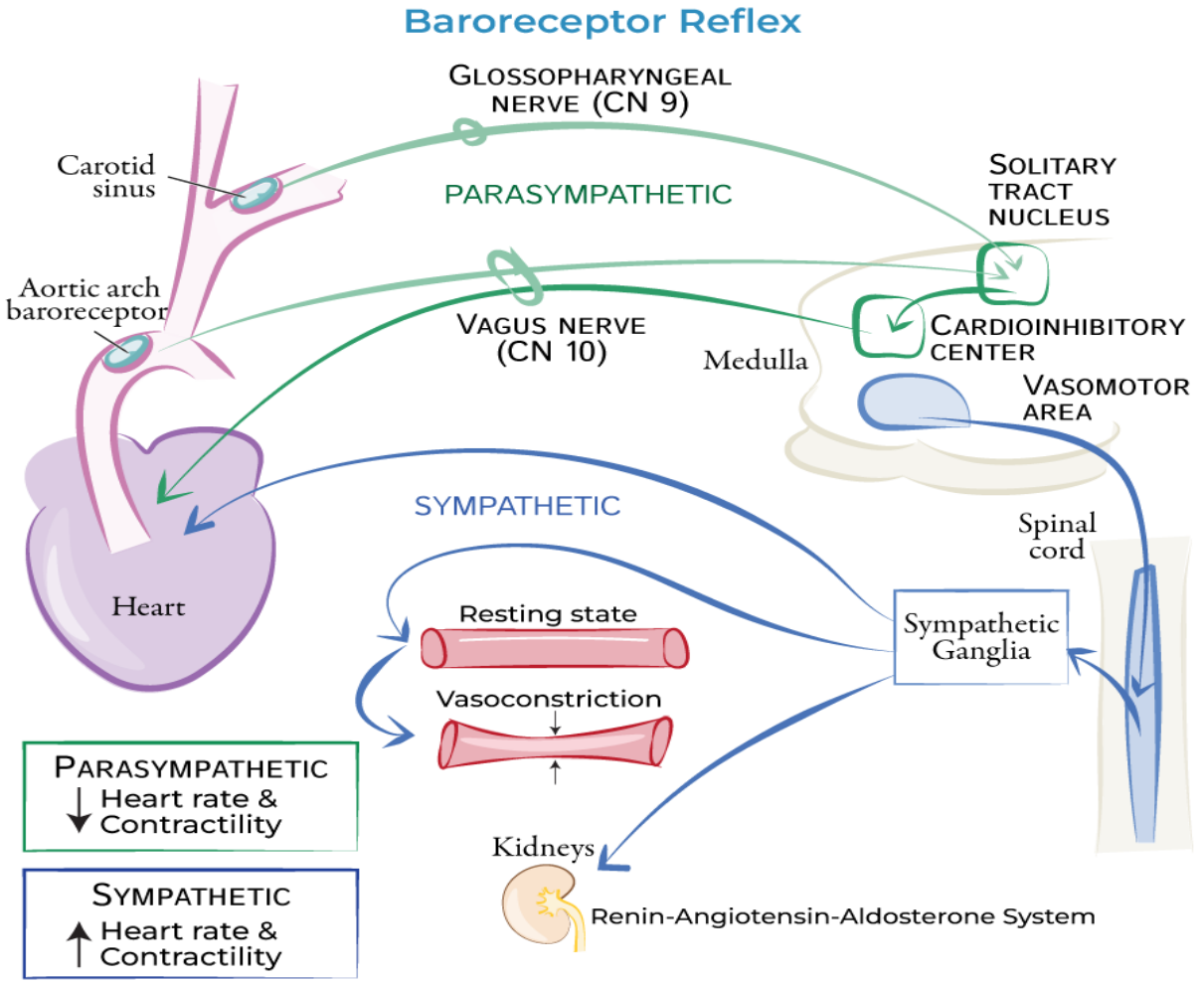
Brain Region	Function
Medullary Cardiovascular Centre	Main autonomic control hub
– Cardioacceleratory center	Stimulates sympathetic nerves
– Cardioinhibitory center	Stimulates vagus nerve
Hypothalamus	Integrates emotional & thermal influences
Cerebral Cortex	Affects HR via emotions, stress, anticipation

PROTOTYPE — Integration & Reflex Regulation

Reflex Mechanisms

1.Baroreceptor Reflex

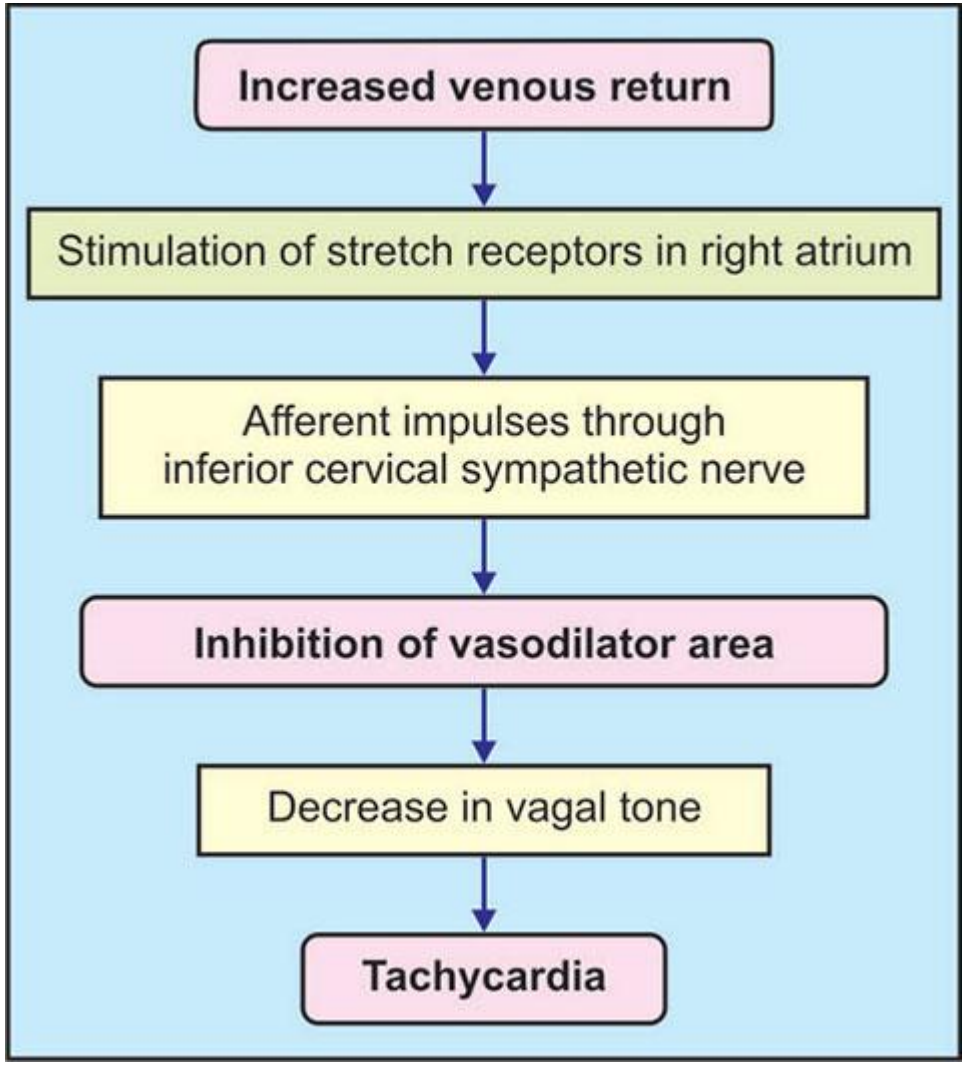
1. Location: Carotid sinus & aortic arch.
2. ↑ BP → ↑ baroreceptor firing → activates **vagal (parasymp)** → ↓ HR.
3. ↓ BP → ↓ firing → activates **sympathetic** → ↑ HR.
4. **Clinical use:** Carotid massage slows tachycardia.



PROTOTYPE — Integration & Reflex Regulation

Bainbridge Reflex

- Triggered by ↑ venous return → atrial stretch → ↑ HR.
- Helps prevent venous congestion.



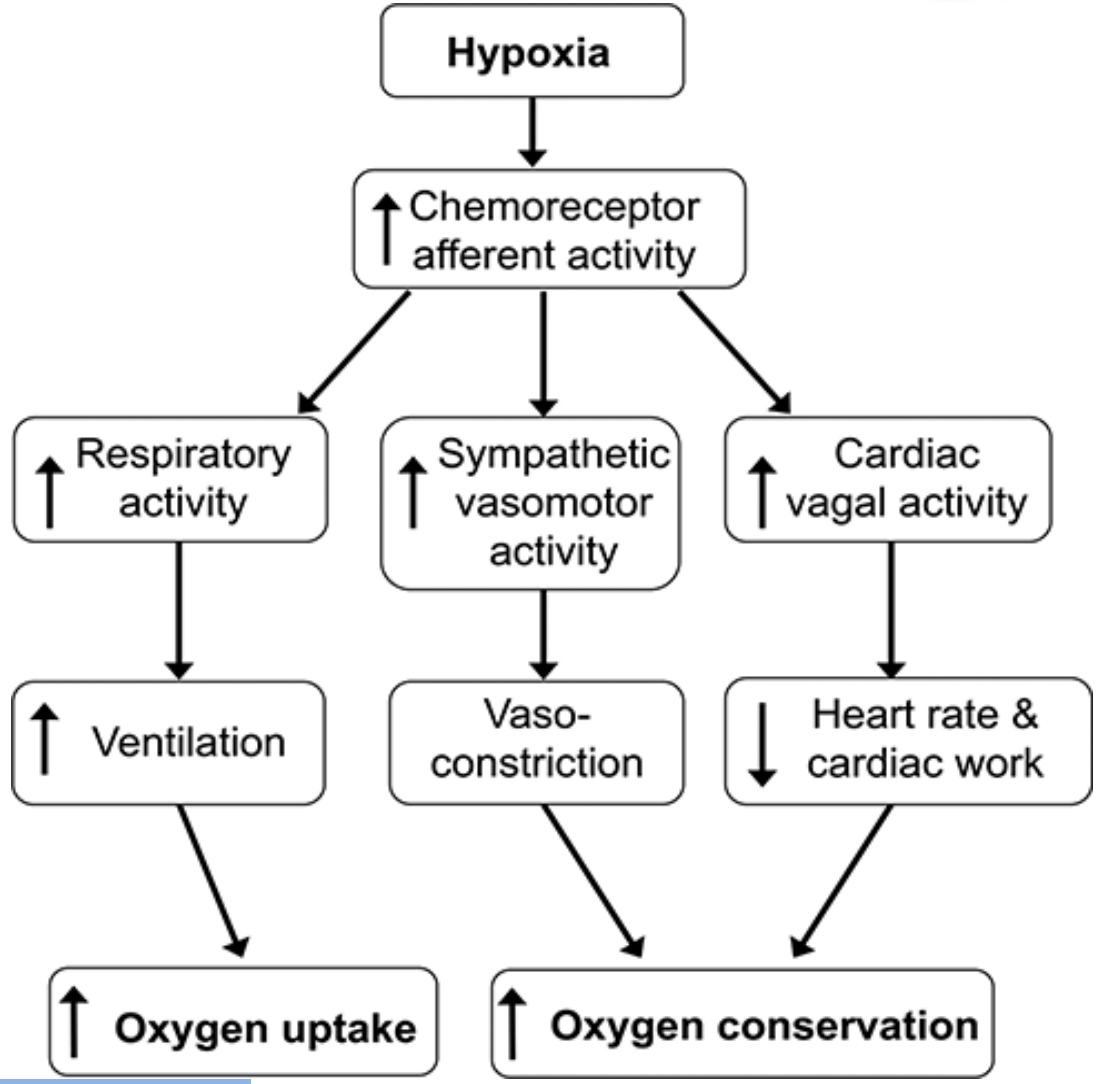
PROTOTYPE — Integration & Reflex Regulation

Chemoreceptor Reflex

- Triggered by ↓ O_2, ↑ CO_2, ↑ H^+ → initially bradycardia, then tachycardia.

Respiratory Sinus Arrhythmia

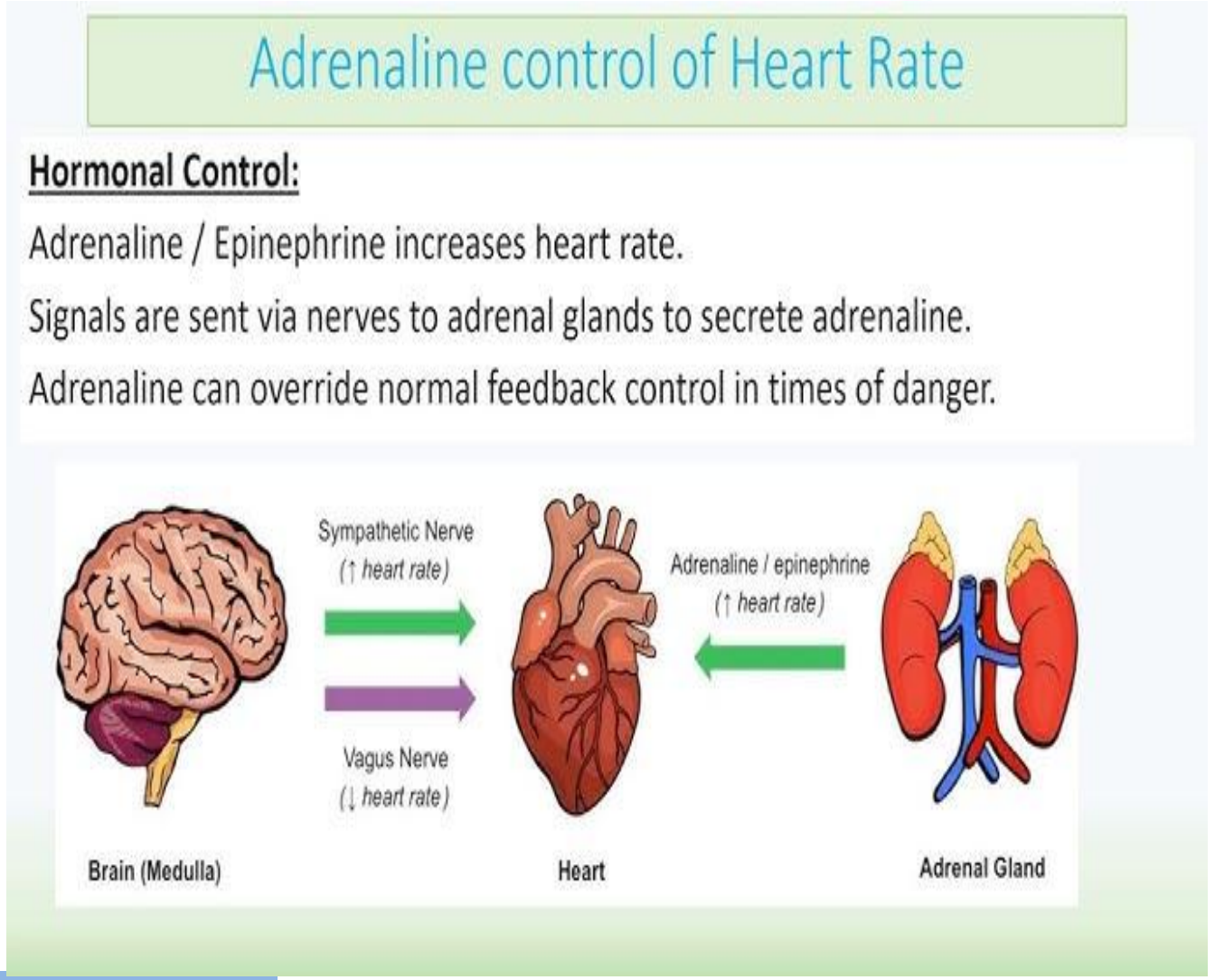
- Inspiration → ↓ vagal tone → ↑ HR.
- Expiration → ↑ vagal tone → ↓ HR.



PROTOTYPE — Integration & Reflex Regulation

Hormonal Influence

- **Epinephrine & Norepinephrine (from adrenal medulla)** → act on β_1 receptors → ↑ HR.
- **Thyroid hormones (T_3, T_4)** → ↑ HR by increasing metabolic activity.
- **Temperature:**
  - Fever → ↑ HR (~10 bpm per 1°C rise).
  - Hypothermia → ↓ HR.



TEST — Clinical and Diagnostic Applications

Condition	ANS Role	Clinical Feature
Sinus tachycardia	↑ Sympathetic	HR > 100 bpm
Sinus bradycardia	↑ Parasympathetic	HR < 60 bpm
Heart block	Excess vagal activity	Prolonged PR or dropped beats
Autonomic failure	Loss of reflex HR control	Orthostatic hypotension
β-blockers	Inhibit sympathetic β_1	↓ HR, ↓ contractility
Atropine	Blocks vagal tone	↑ HR (used in bradycardia)

SUMMARY TABLE

Comparison of Autonomic Nervous System Effects

Characteristic	Sympathetic	Parasympathetic	Baroreceptor Reflex	Bainbridge Reflex
Neurotransmitter	Norepinephrine	Acetylcholine	—	—
Receptor	β_1	M_2	—	—
Site of Action	SA & AV nodes, myocardium	SA & AV nodes	Carotid & aortic receptors	Atrial stretch receptors
Effect on HR	↑ HR, ↑ conduction	↓ HR, ↑ AV delay	Maintains BP–HR balance	↑ HR with ↑ venous return
Example	Exercise, stress	Sleep, rest	Carotid massage	Fluid overload

REFERENCE BOOKS

1. *Guyton & Hall Textbook of Medical Physiology* – Elsevier
2. *Cardiovascular Physiology* – Pappano & Wier
3. *Ganong's Review of Medical Physiology*
4. *Textbook of Physiology* – A.K. Jain / Sembulingam