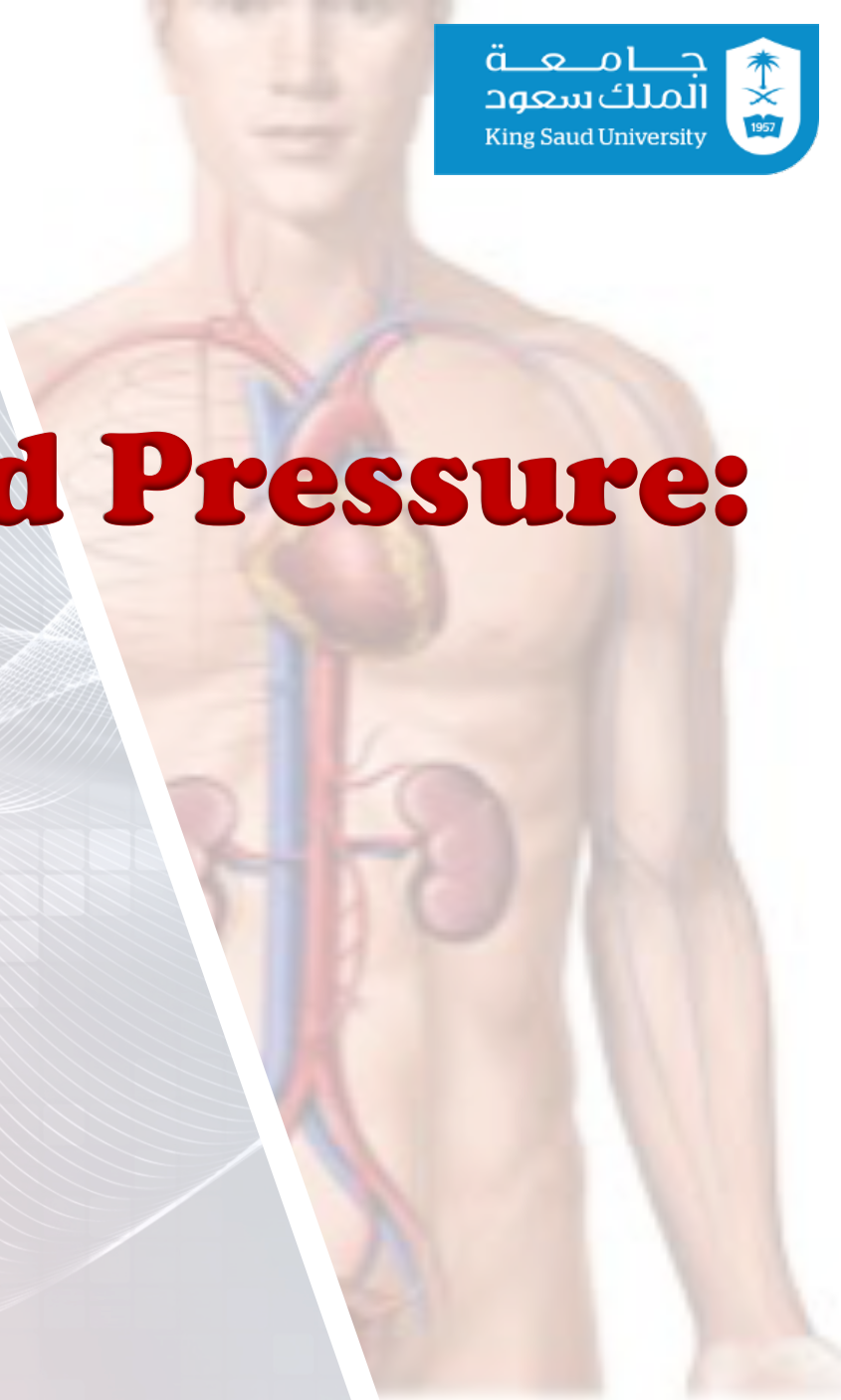
Cardiovascular Physiology

Arterial Blood Pressure: Regulation



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Lecture Outcomes

- Recognize short, intermediate & long- term regulatory mechanisms of ABP.
- Recognize different neural & hormonal mechanisms that regulates ABP.
- Baroreceptors regulatory mechanism of ABP.
- Chemoreceptors regulatory mechanism of ABP.
- Role of Kidney in long- term regulation of ABP.

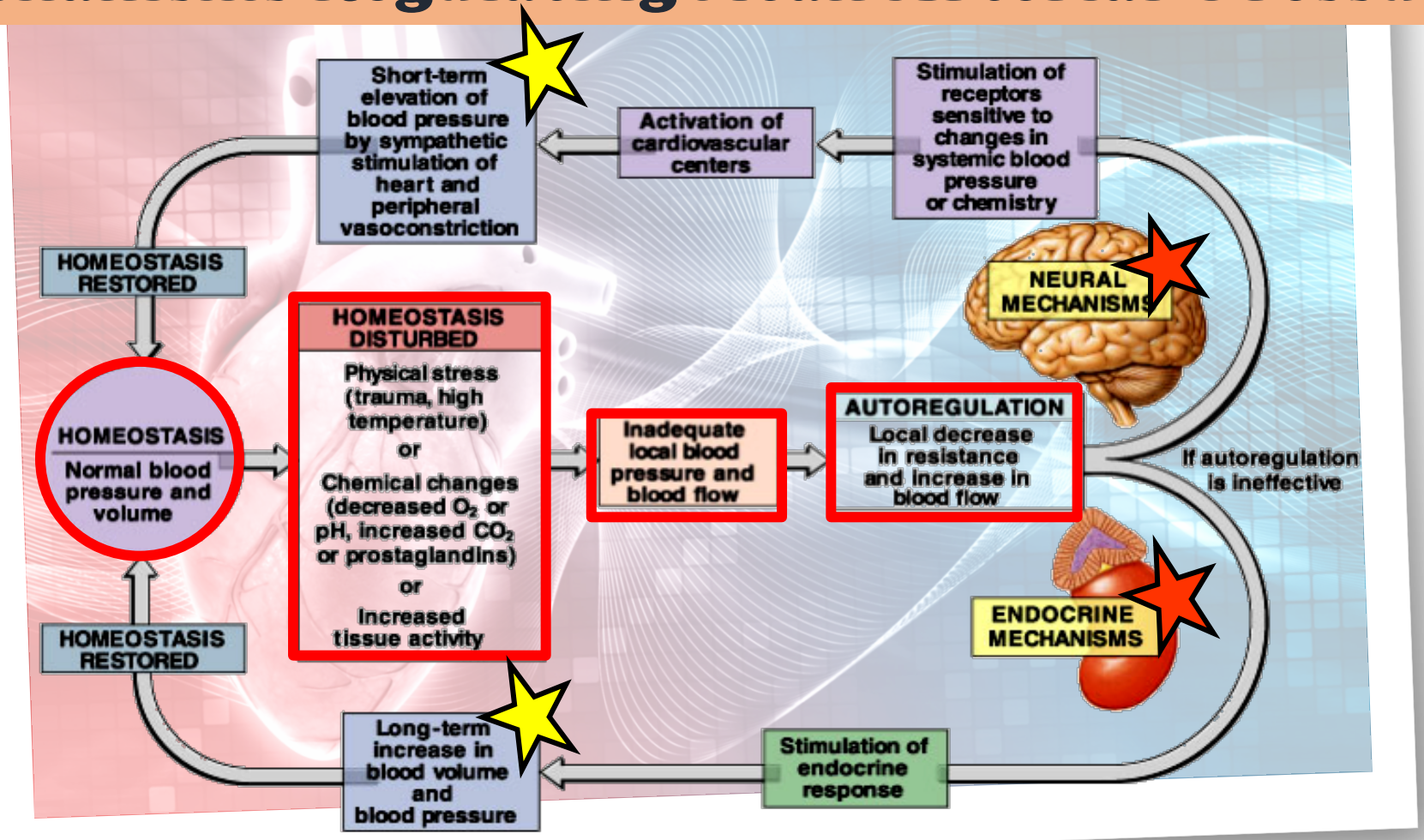
Regulation of Arterial Blood Pressure

- Maintaining BP is important to ensure a steady blood flow (perfusion) to the tissues.
- Inability to regulate blood pressure can contribute to diseases.

In order to regulate the blood pressure, determining factors should be regulated:

- Cardiac Output.
- Peripheral Resistance.
- Blood Volume.

Mechanisms Regulating Mean Arterial Pressure



Neurally- Mediated Regulation of ABP

Fast Response
(Short- Term)

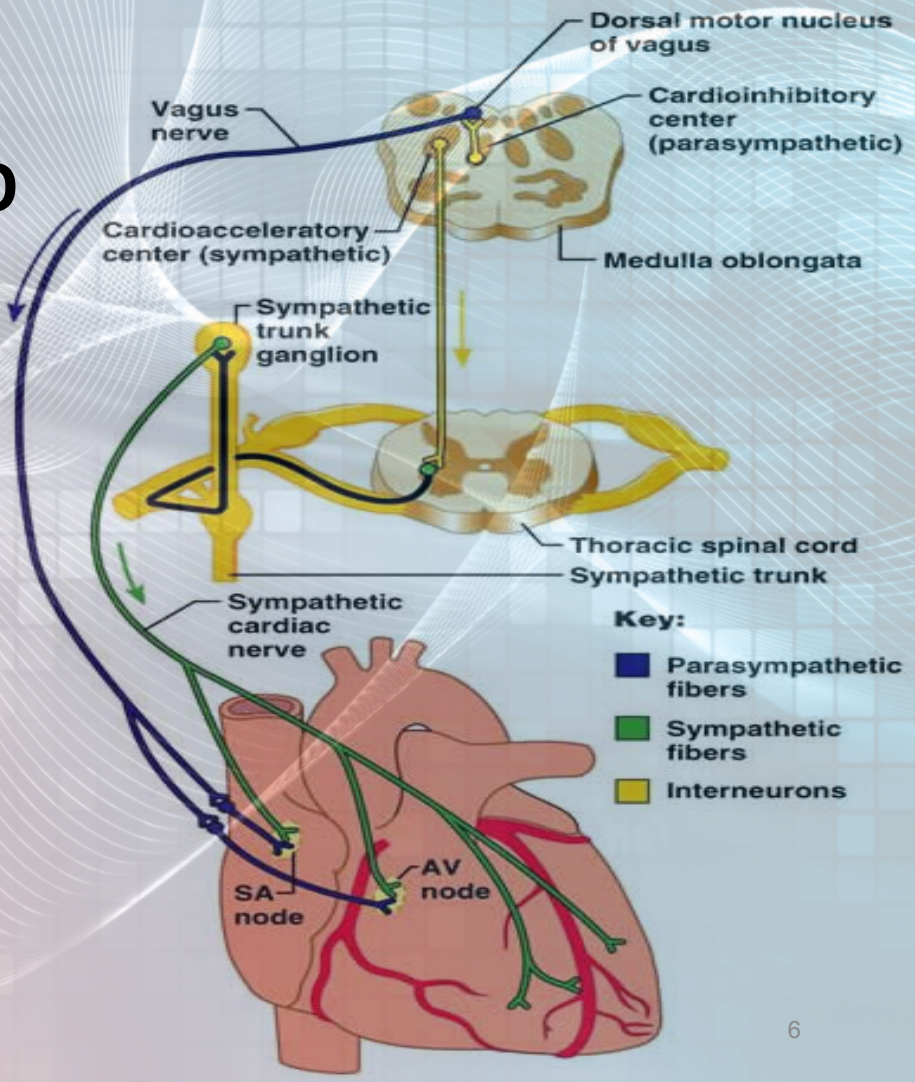
Concerned in regulating
Cardiac Output & Peripheral Resistance

Rapidly Acting Control Mechanisms

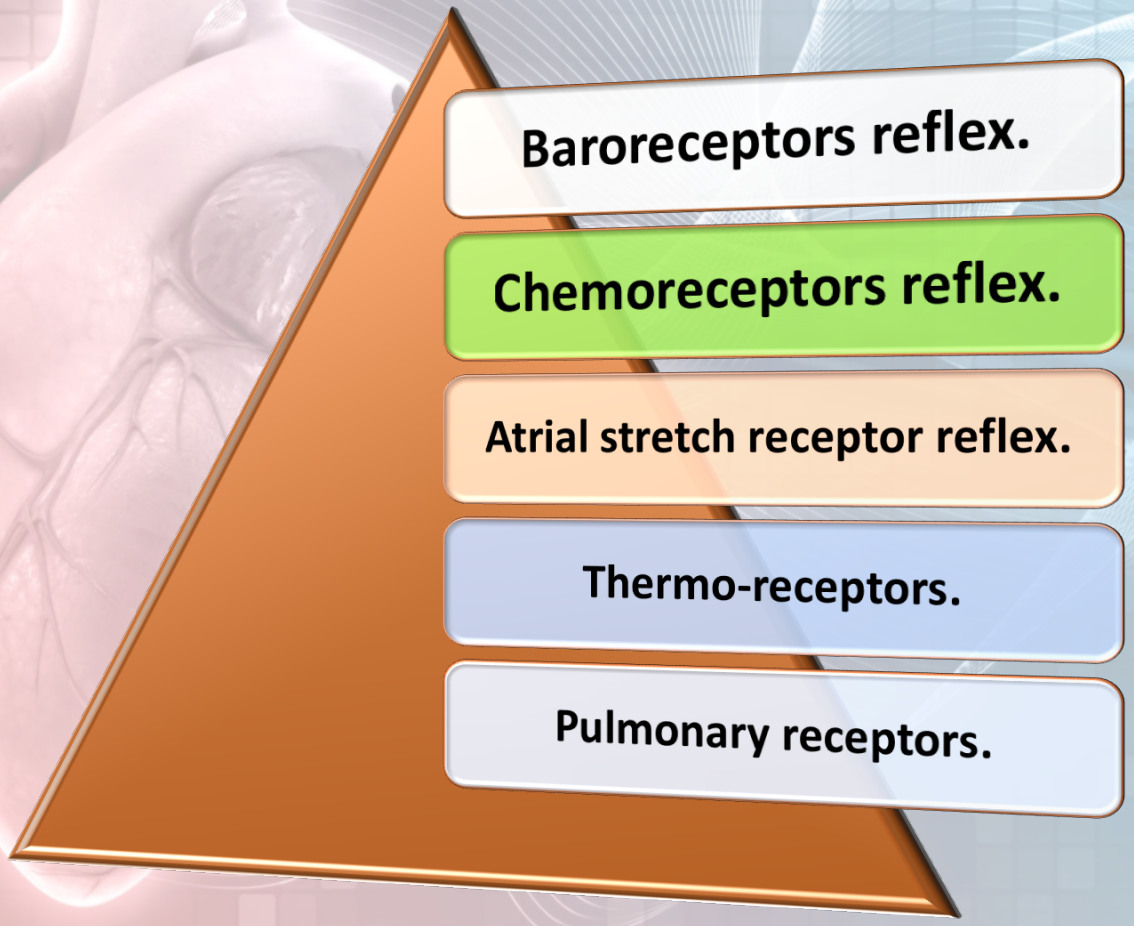
- Acts within sec/min.
- Concerned in regulating CO & PR.
- Reflex mechanisms that act through autonomic nervous system:

Centers in Medulla Oblongata:

- Vasomotor Center (VMC)
  … Sympathetic nervous system.
- Cardiac Inhibitory Center (CIC)
  … Parasympathetic nervous system.



Short Term ABP Regulatory Reflex mechanisms



Baroreceptor Reflex

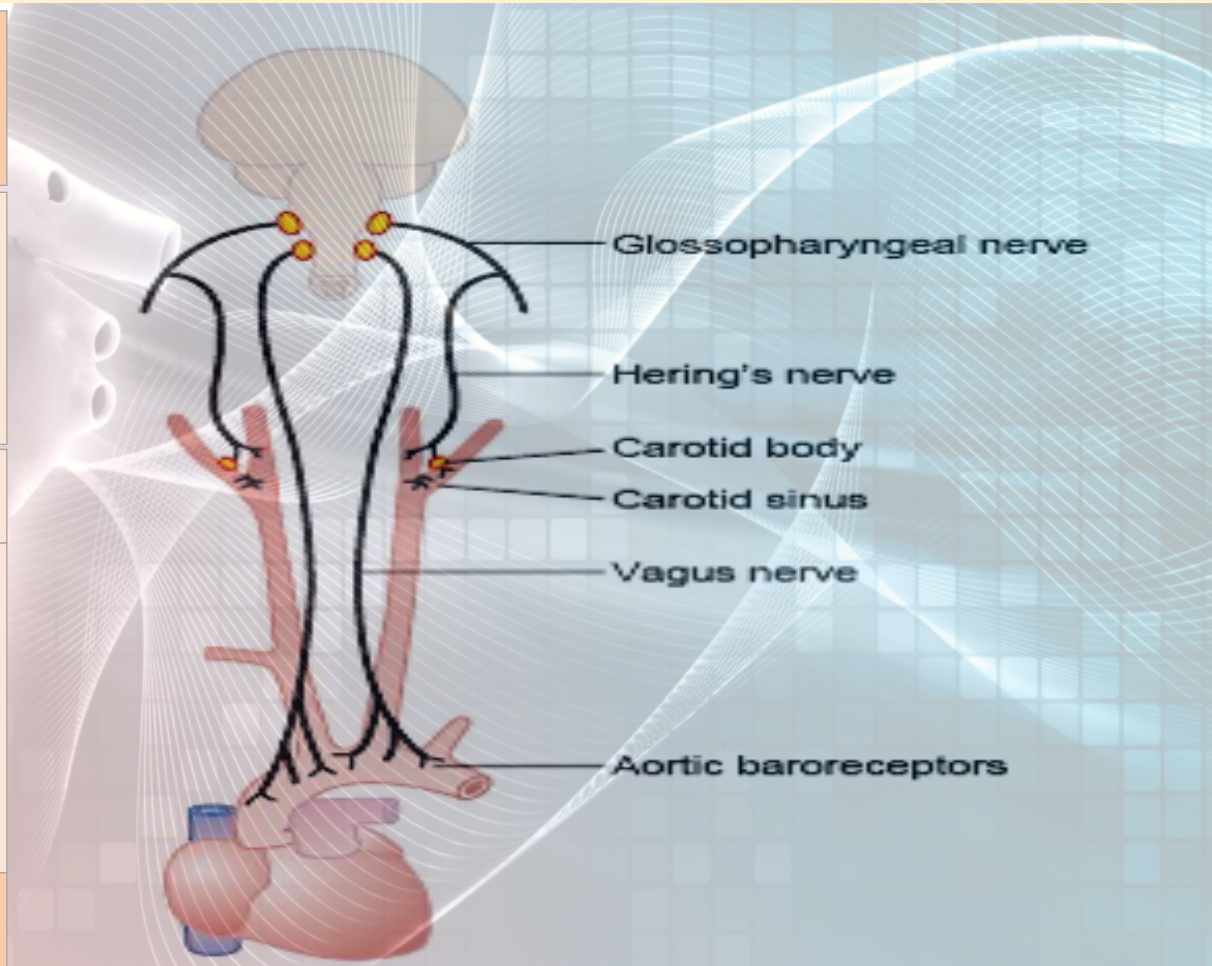
Mechano-stretch receptors.

Located in the wall of carotid sinus & aortic arch.

Fast & neurally mediated

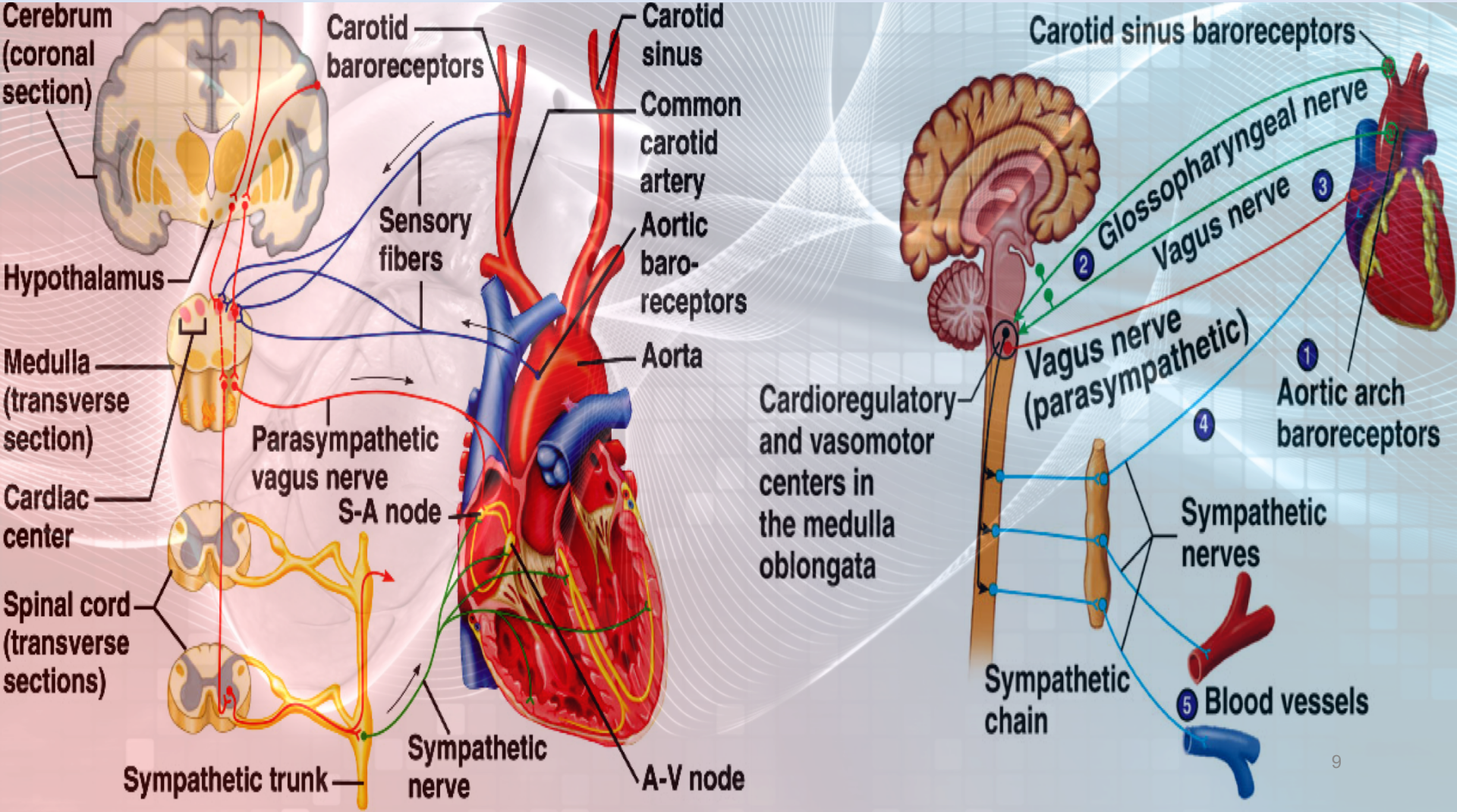
Provide powerful moment-to-moment control of arterial blood pressure

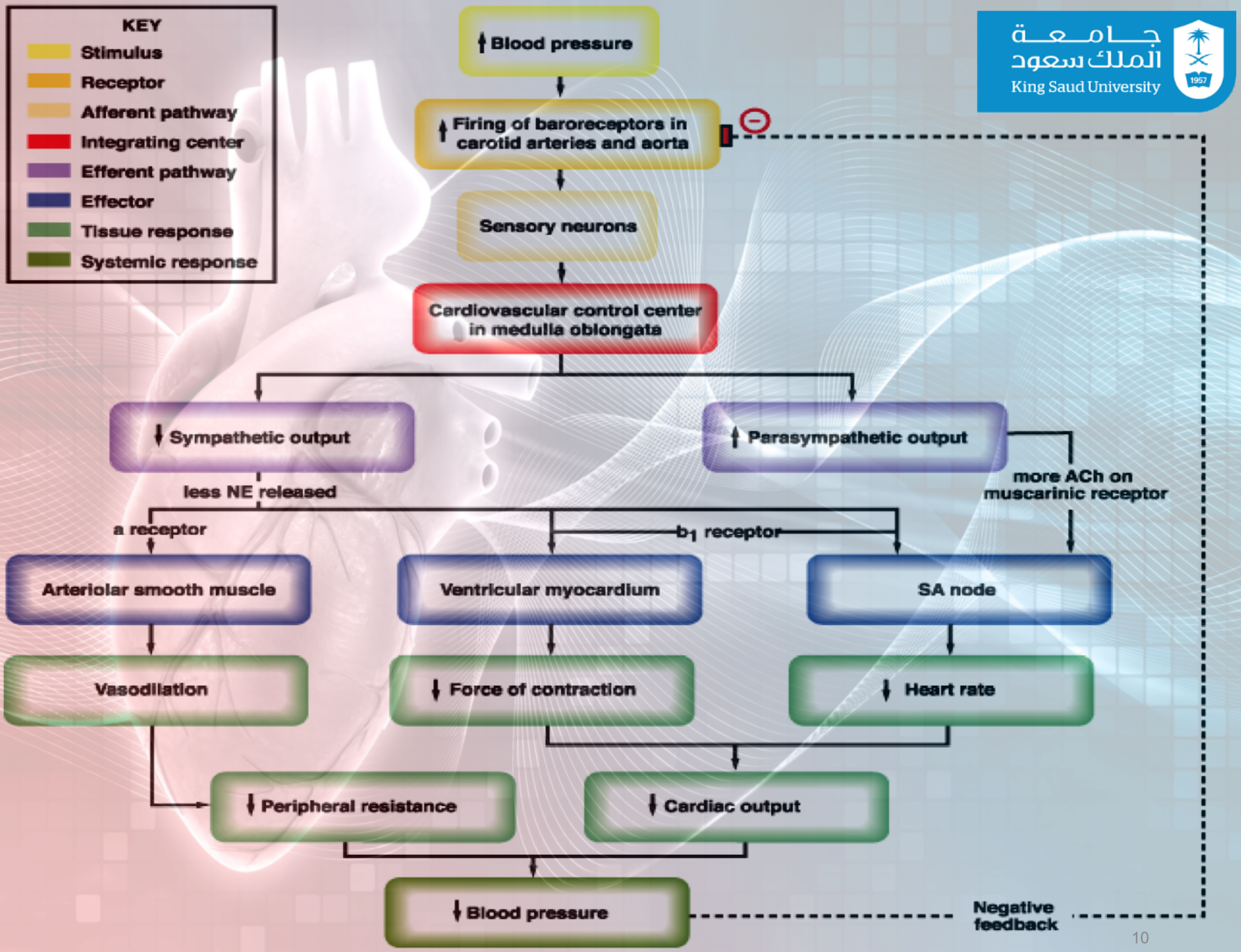
Stimulated in response to blood pressure changes

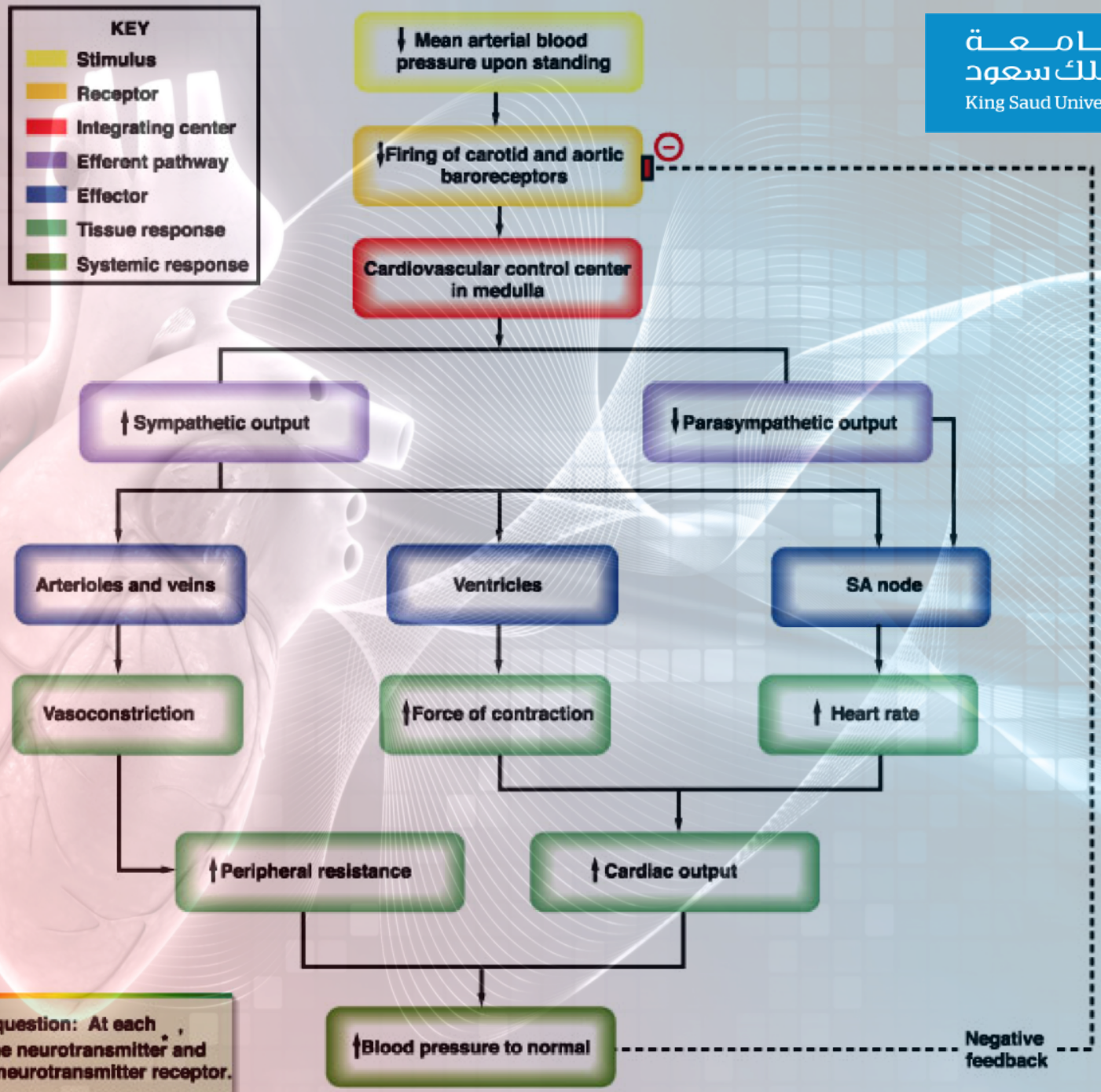


The baroreceptor system for controlling arterial pressure.

Baroreceptor Reflex




KEY
Stimulus
Receptor
Afferent pathway
Integrating center
Efferent pathway
Effector
Tissue response
Systemic response
Blood pressure
Firing of baroreceptors in carotid arteries and aorta
Sensory neurons
Cardiovascular control center in medulla oblongata
Sympathetic output
Parasympathetic output
less NE released
more ACh on muscarinic receptor
a receptor
b1 receptor
Arteriolar smooth muscle
Ventricular myocardium
SA node
Vasodilation
Force of contraction
Heart rate
Peripheral resistance
Cardiac output
Blood pressure
Negative feedback


KEY
Stimulus
Receptor
Integrating center
Efferent pathway
Effector
Tissue response
Systemic response
Mean arterial blood pressure upon standing
Firing of carotid and aortic baroreceptors
Cardiovascular control center in medulla
Sympathetic output
Parasympathetic output
Arterioles and veins
Ventricles
SA node
Vasoconstriction
Force of contraction
Heart rate
Peripheral resistance
Cardiac output
Blood pressure to normal
Negative feedback
Figure question: At each *, name the neurotransmitter and type of neurotransmitter receptor.

Baroreceptor Reflex Mechanism During Changes in Body Posture

- Immediately on standing, arterial pressure in the head & upper part of the body tends to fall … ? cause loss of consciousness.
- Falling pressure at the baroreceptors elicits an immediate reflex, resulting in **strong sympathetic discharge** throughout the body.
- This minimizes the decrease in pressure in the head & upper body.

Chemoreceptor Reflex

- Closely associated with the baroreceptor pressure control system.
- **Chemoreceptor reflex** operates in much same way as the baroreceptor reflex, EXCEPT that chemoreceptors are *chemo-sensitive cells* instead of stretch receptors.

Chemoreceptor Reflexes:
Two Types

Peripheral chemoreceptors:

Periphearl

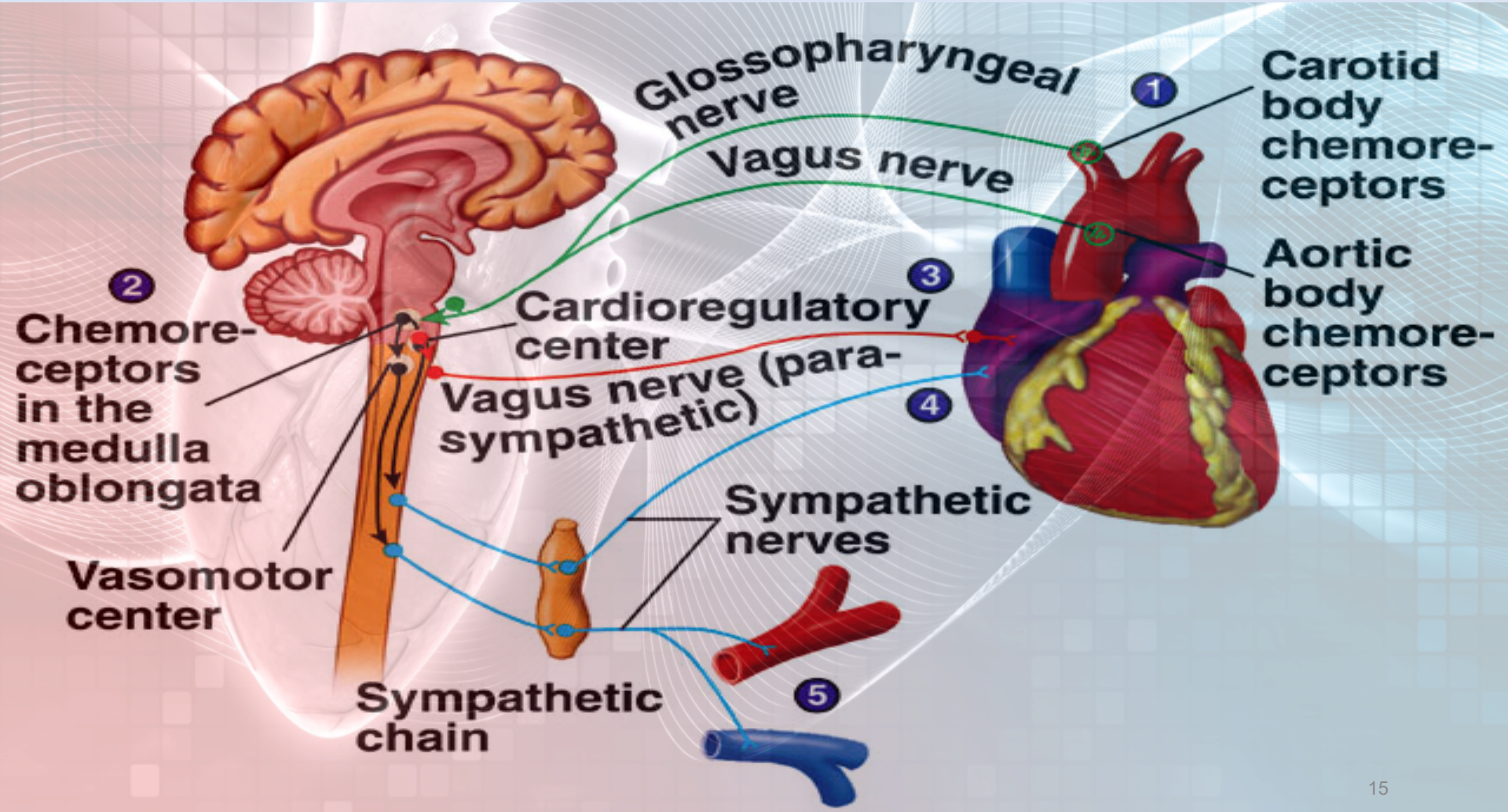
- Sensory receptors located in carotid & aortic bodies.
- Sensitive to O_2 lack (↓), CO_2 (↑ or ↓), & pH (↓ or ↑.)
- Chemoreceptors' stimulation excite nerve fibers, along with baroreceptor fibers.

Central Chemoreceptors:

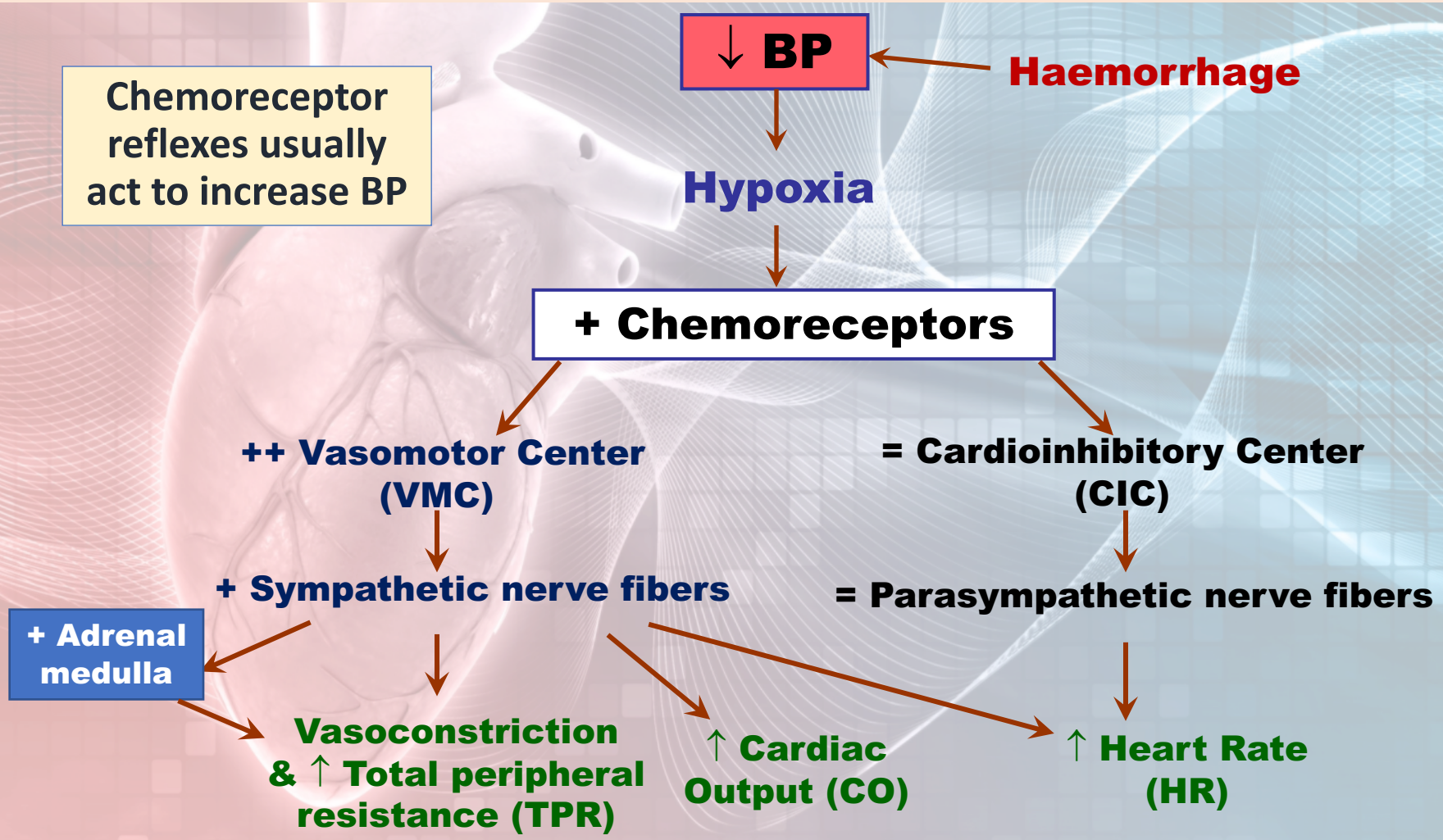
Central

- Sensory receptors located in the medulla itself.
- Very sensitive to CO_2 excess (↑) & (↓) pH in medulla.

Peripheral Chemoreceptor Reflex



Peripheral Chemoreceptor Reflexes



CNS Ischemic Response:

"Last ditch stand" pressure control mechanism

- It is not one of the normal regulatory mechanisms for ABP.
- It operates principally as an **emergency pressure control** system to prevent further decrease in arterial pressure.
- It acts rapidly & very powerfully whenever blood flow to the brain ↓ dangerously close to the lethal level.
- Local concentration of CO_2 ↑ greatly.
- This has an extremely potent effect in stimulating the sympathetic vasomotor nervous control areas in the brain's medulla.

Other Vasomotor Reflexes

1. **Atrial stretch receptor reflex:**

   ↑ Venous Return ⇒ ++ atrial stretch receptors ⇒ reflex vasodilatation & ↓ ABP.

2. **Thermo-receptors:** (in skin / hypothalamus)
   - ❑ Exposure to heat ⇒ vasodilatation.
   - ❑ Exposure to cold ⇒ vasoconstriction.

3. **Pulmonary receptors:**

   Lung inflation ⇒ vasoconstriction.

Hormonally- Mediated Regulation of ABP

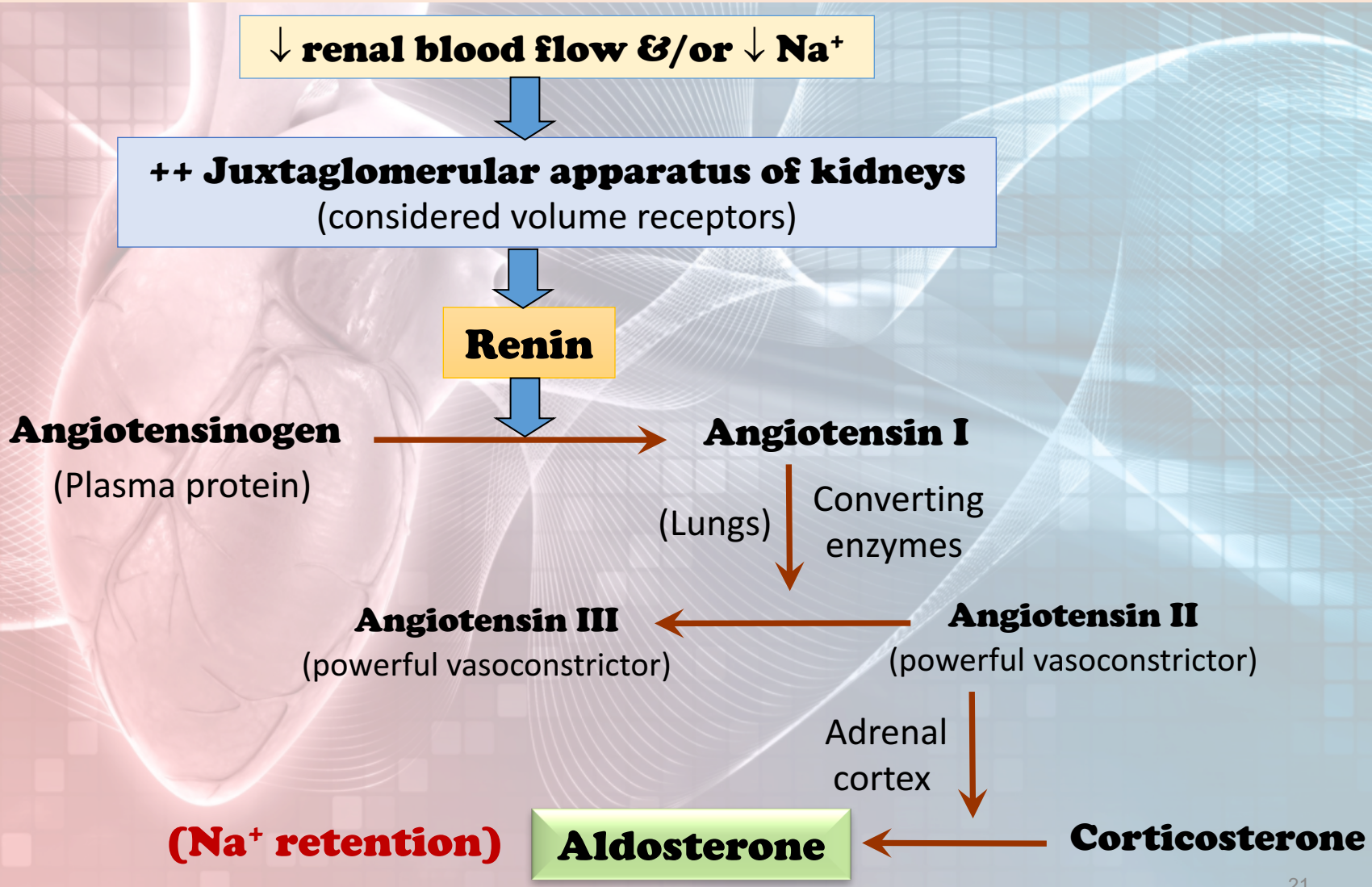
Slow Response
(Long- Term)

Concerned in regulating blood volume

Long- Term Regulation of ABP

- Hormonally mediated.
- Takes few hours to begin showing significant response.
- **Mainly renal:** acts if BP is too low
  1. Renin-Angiotensin-Aldosterone System.
  2. Vasopressin [Anti-diuretic hormone (ADH)] Mechanism.
- **Others:**
  3. Atrial Natriuretic Peptide Mechanism (Low-pressure volume receptors.)
  4. EPO (erythropoietin.)

1. Renin – Angiotensin Aldosterone System



2. Anti-diuretic hormone (ADH), or vasopressin:

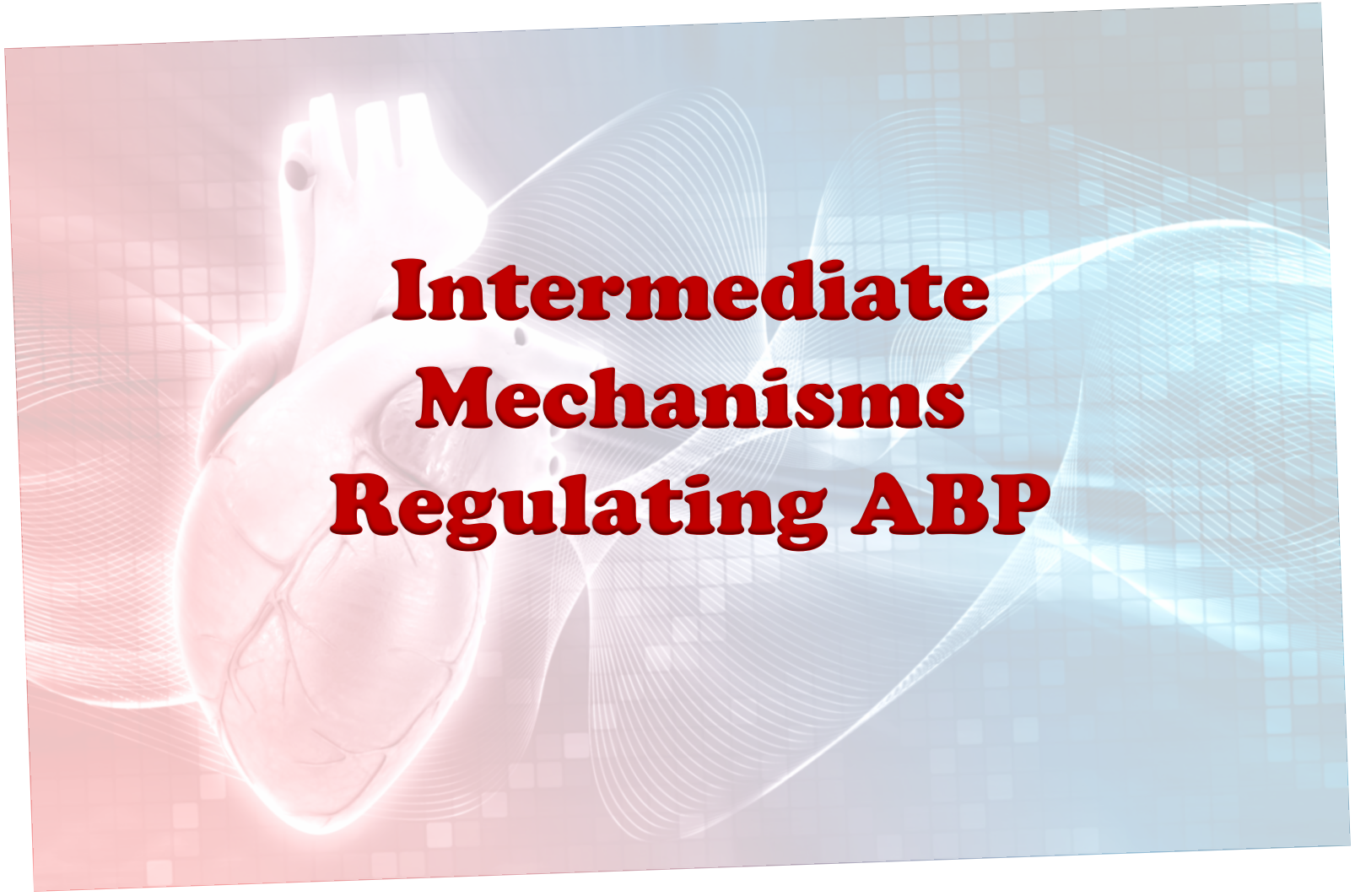
- Hypovolemia & dehydration stimulates Hypothalamic Osmoreceptors.
- ADH will be released from posterior pituitary gland:
  - Promotes water reabsorption at kidney tubules …↑ blood volume.
  - Causes vasoconstriction, in order to ↑ ABP.
- Thirst stimulation.
- Usually, when secreted aldosterone is secreted.

3. Low-pressure volume receptors:

- **Atrial Natriuretic Peptide (ANP) hormone:**
  - Hormone released from cardiac muscle cells (wall of right atrium) as a response to an increase in ABP.
  - Simulates an ↑ in urinary production, causing a ↓ in blood volume & blood pressure.

4. EPO (Erythropoietin)

- Secreted by the kidneys when blood volume is too low.
- Leads to RBCs formation → ↑ blood volume.



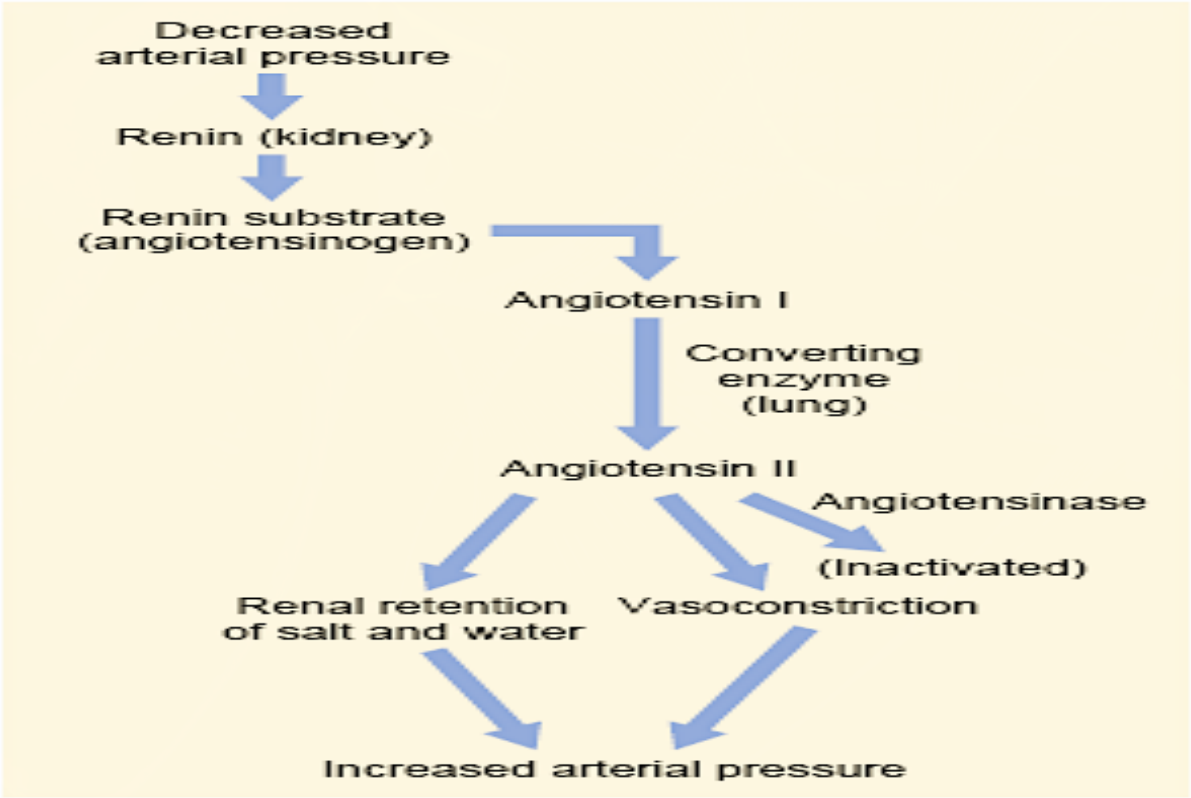
Intermediate Mechanisms Regulating ABP

Intermediate Mechanisms:
Activated within 30 min to several hrs.

1. Renin-angiotensin vasoconstriction mechanism.
2. Stress-relaxation of the vasculature.
3. Fluid Shift mechanism.

- **During this time, the nervous mechanisms usually become less & less effective.**

1. Angiotensin Vasoconstriction System



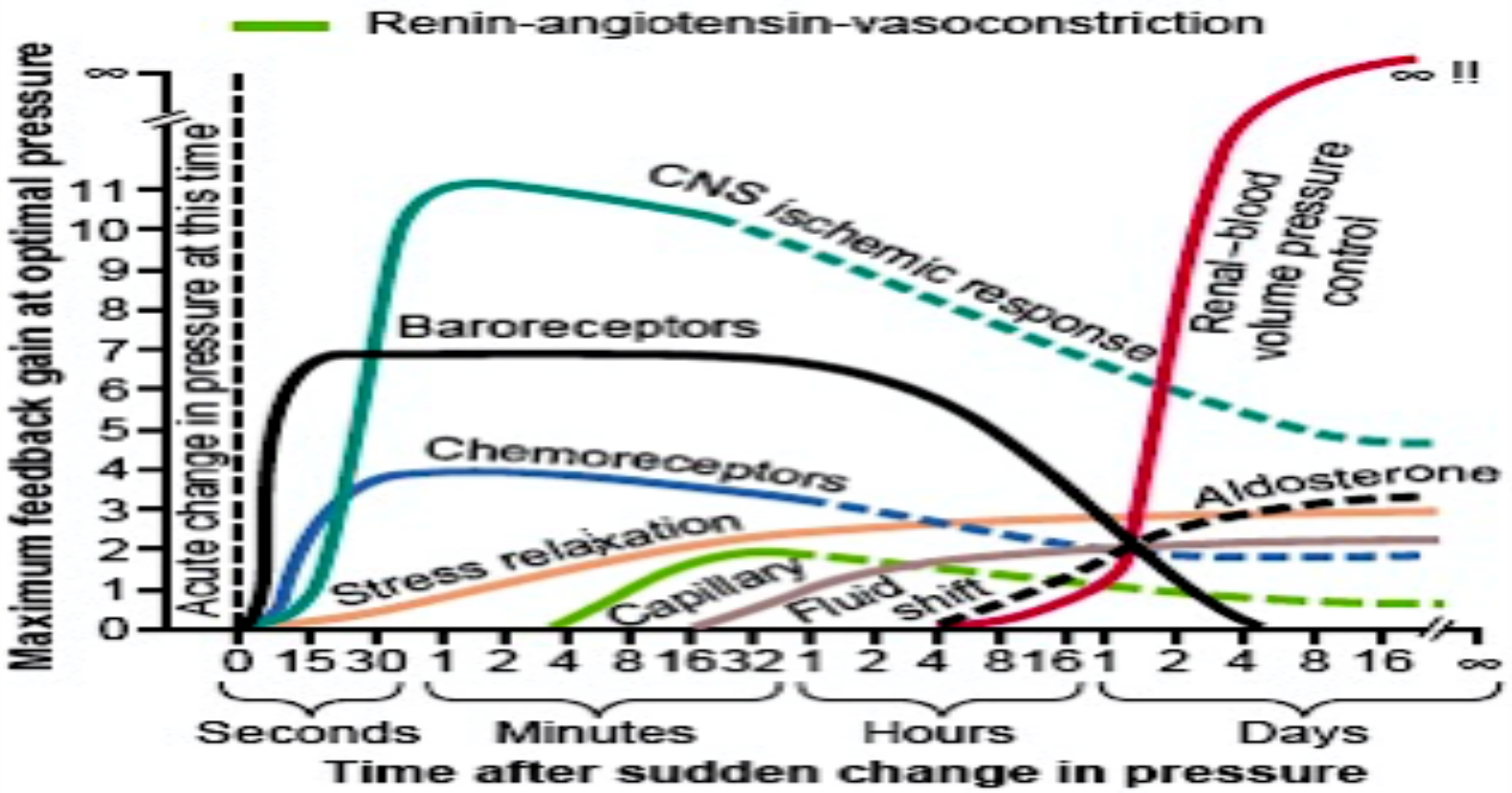
2. Fluid Shift Mechanism

- Movement of fluid from interstitial spaces into **capillaries** in response to ↓ **BP** to maintain blood volume.
- Conversely, when **capillary pressure ↑ too high**, fluid is lost out of circulation into the tissues, reducing blood volume as well as all pressures throughout circulation.

3. Stress-Relaxation Mechanism

- Adjustment of blood vessel smooth muscle to respond to changes in blood volume.
- When pressure in blood vessels becomes **too high**, they become stretched & keep on stretching more & more for minutes or hours; resulting in fall of pressure in the vessels toward normal.
- This continuing stretch of the vessels can serve as an intermediate-term pressure “buffer.”

control mechanisms at different time intervals after onset of a disturbance to the arterial pressure.



Thank You