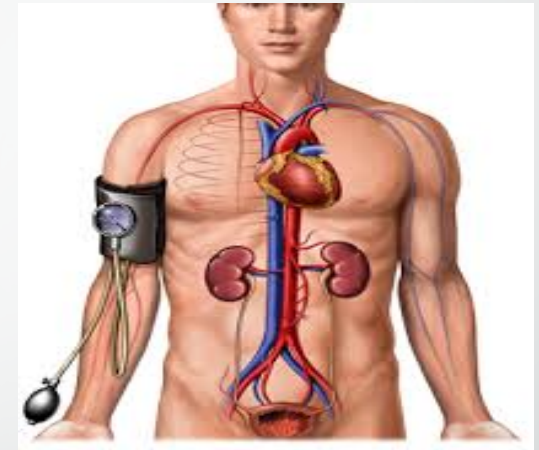


## Cardiovascular Physiology

# Regulation of Blood Pressure



**Dr. Abeer A. Al-Masri, PhD**

*A. Professor,*

*Consultant Cardiovascular Physiologist,*

*Faculty of Medicine, KSU.*



# Lecture Outcomes

List short, intermediate & long- term mechanisms regulating ABP.

Baroreceptors regulatory mechanism of ABP.

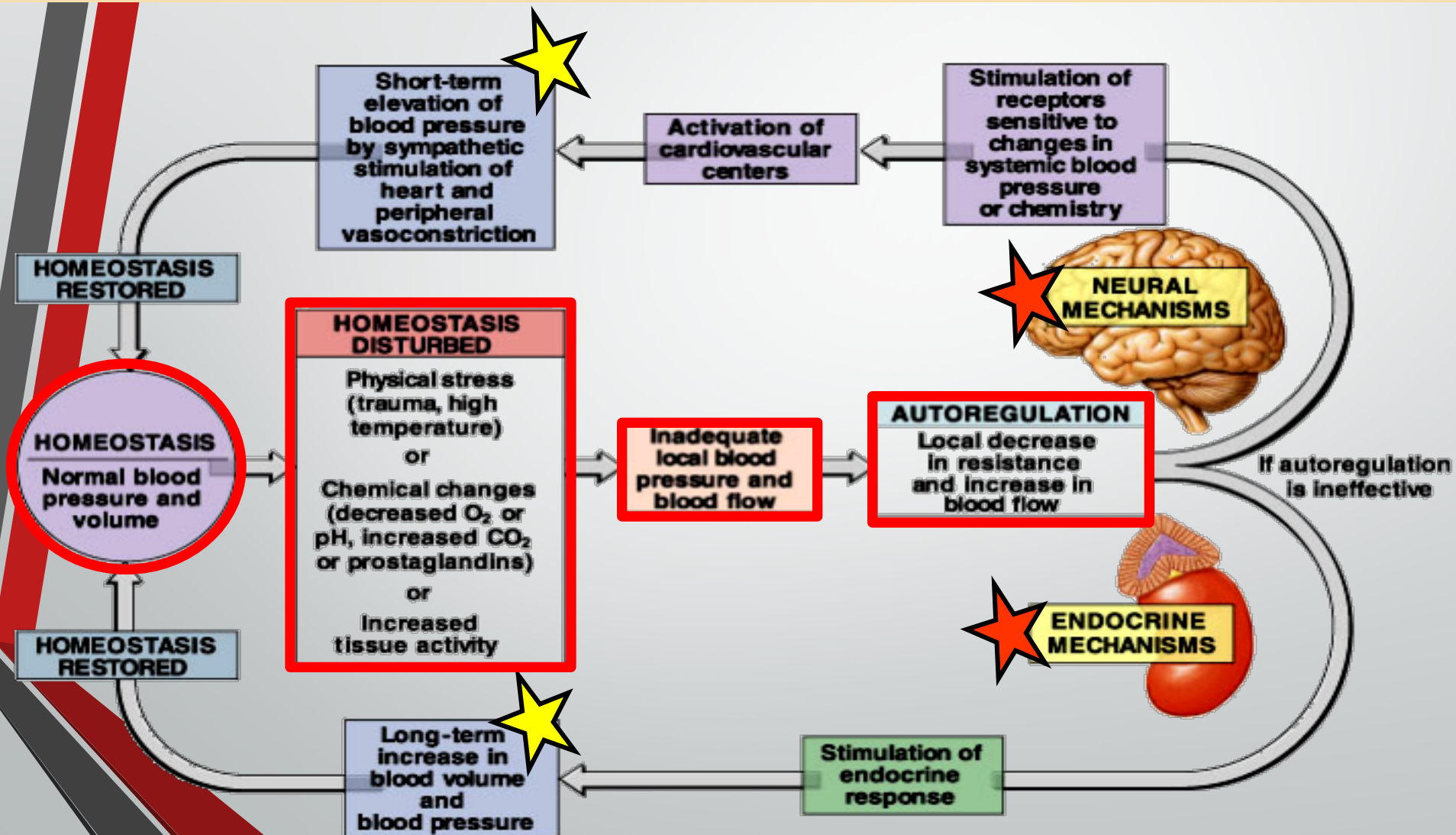
Chemoreceptors regulatory mechanism of ABP.

Role of the kidney in the long- term regulation of ABP.

# Regulation of ABP

- ❑ Maintaining BP is important to ensure a steady blood flow (perfusion) to tissues.
- ❑ Inability to regulate blood pressure can contribute to diseases.
- ❑ In order to regulate the blood pressure, the determining factors have to be regulated:
  - Cardiac output.
  - Peripheral resistance.
  - Blood volume.

# Mechanisms Regulating MAP





# **Neurally- Mediated Regulation of ABP**

**Fast Response  
(Short- Term)**

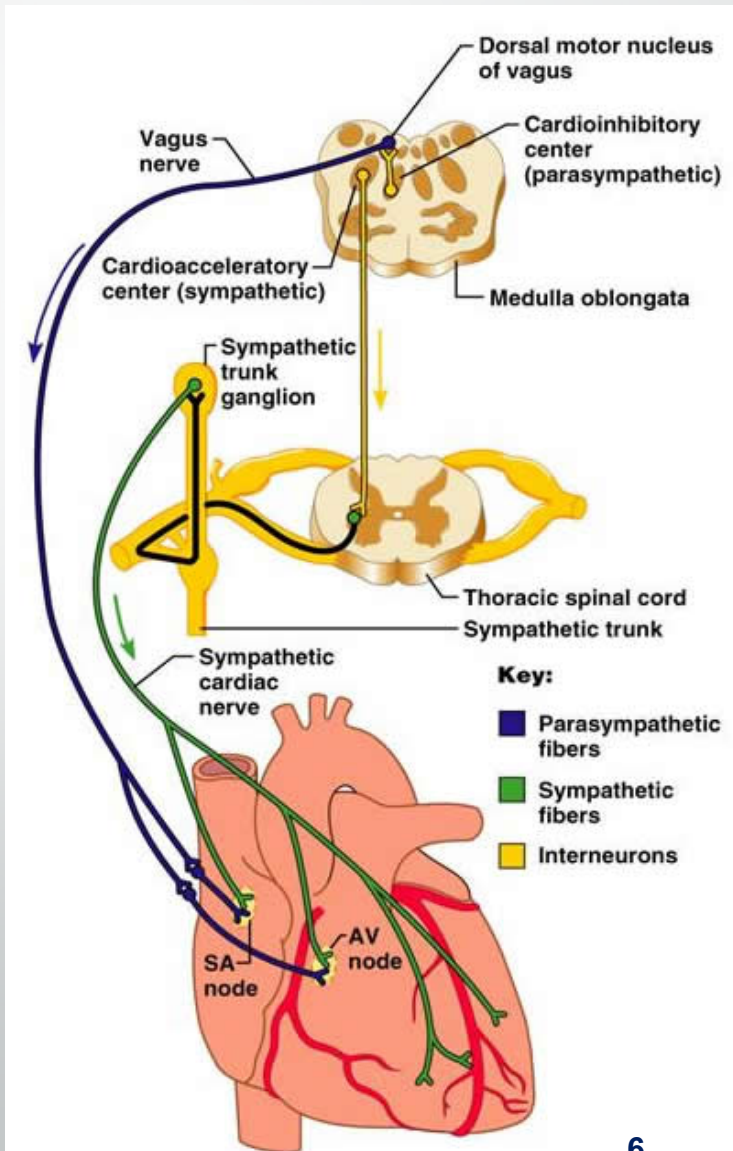
**Concerned in regulating  
Cardiac Output & Peripheral Resistance**

# Rapidly Acting Control Mechanisms:

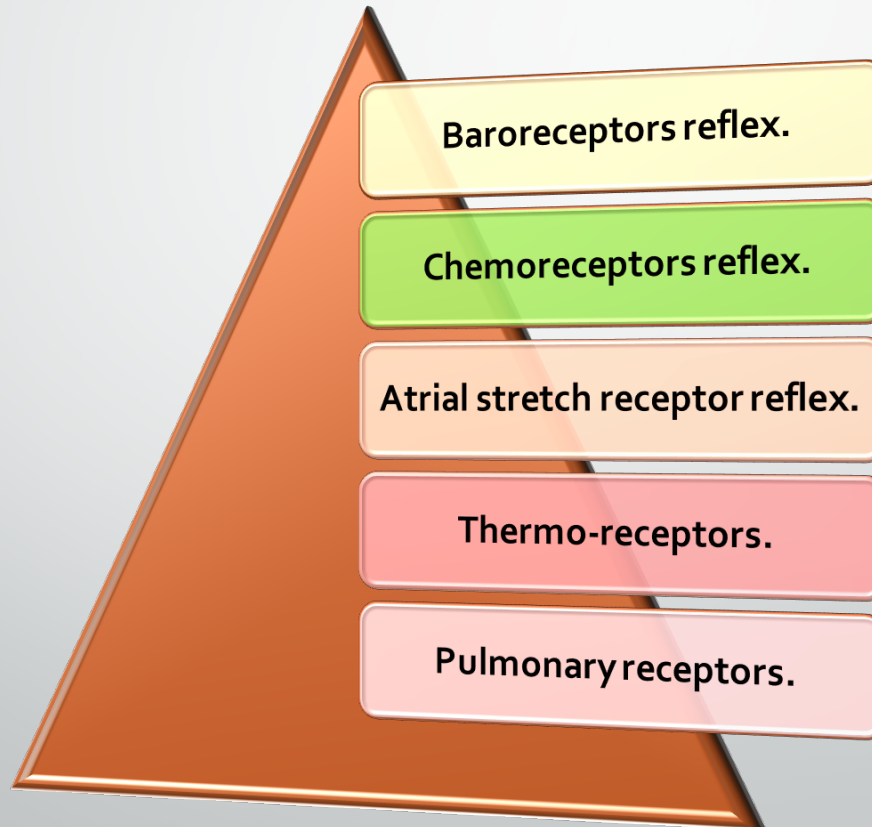
- ❑ Acts within seconds/ minutes.
- ❑ Concerned by regulating CO & PR.
- ❑ Reflex mechanisms that act through autonomic nervous system:

## ➤ 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

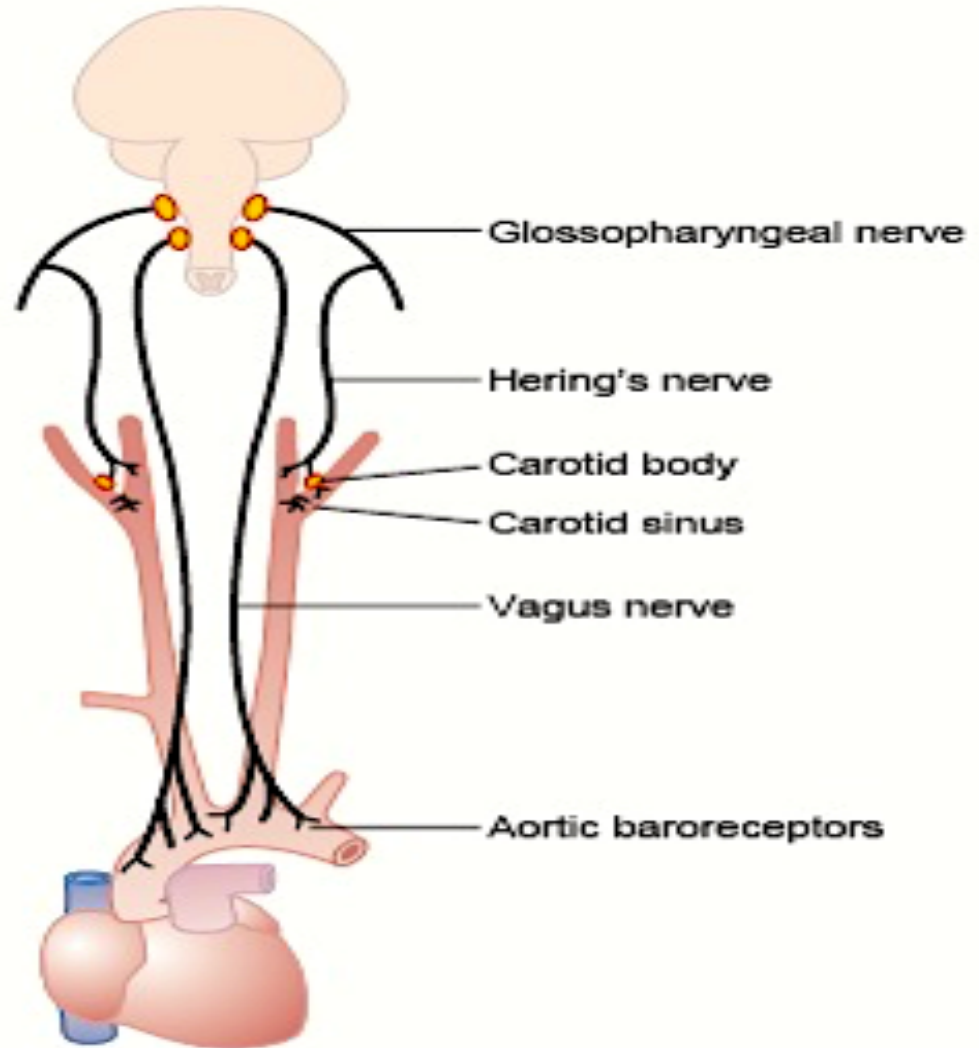
Mechano-stretch receptors.

Located in the wall of carotid sinus & aortic arch.

Fast & neurally mediated

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

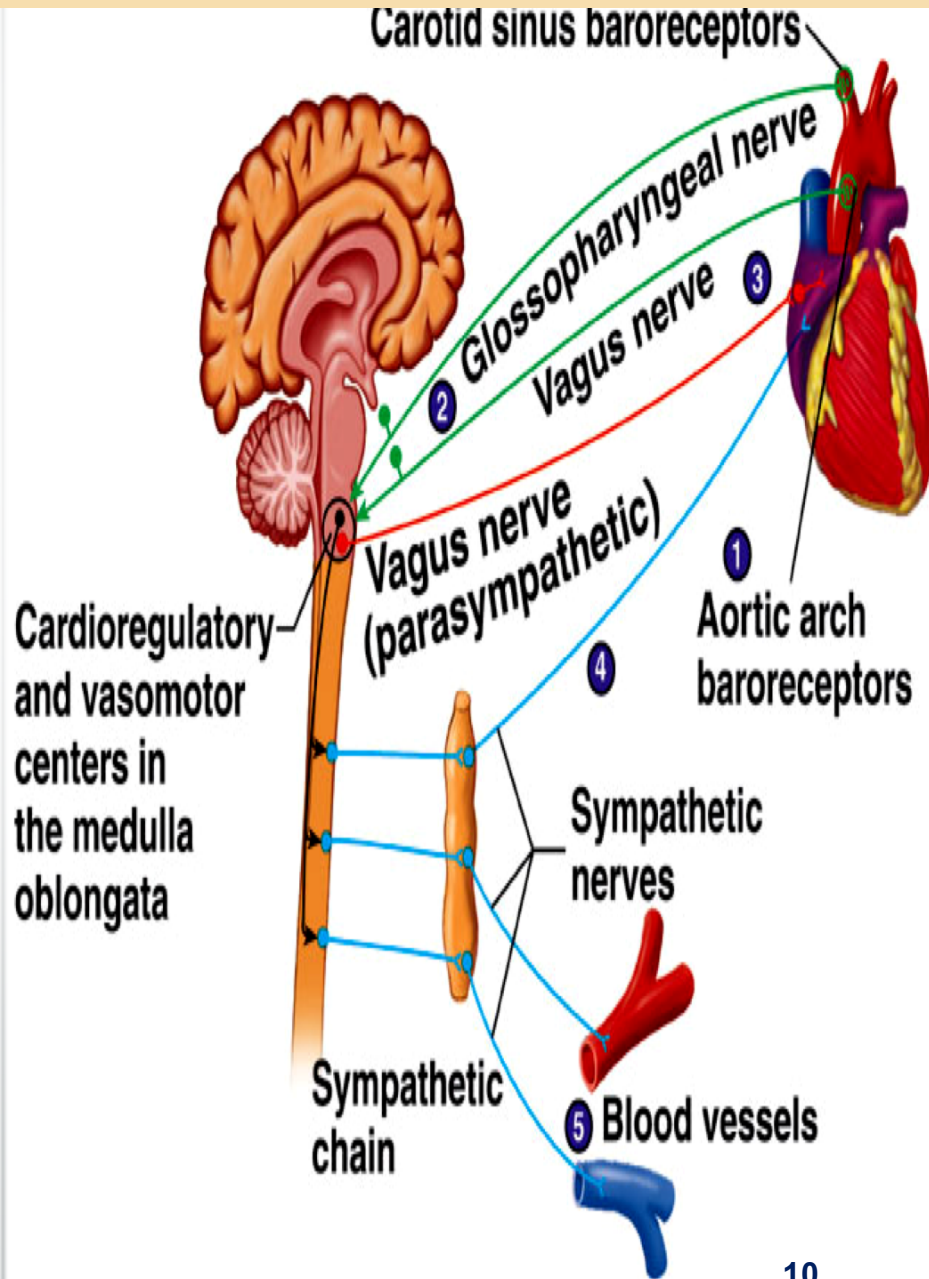
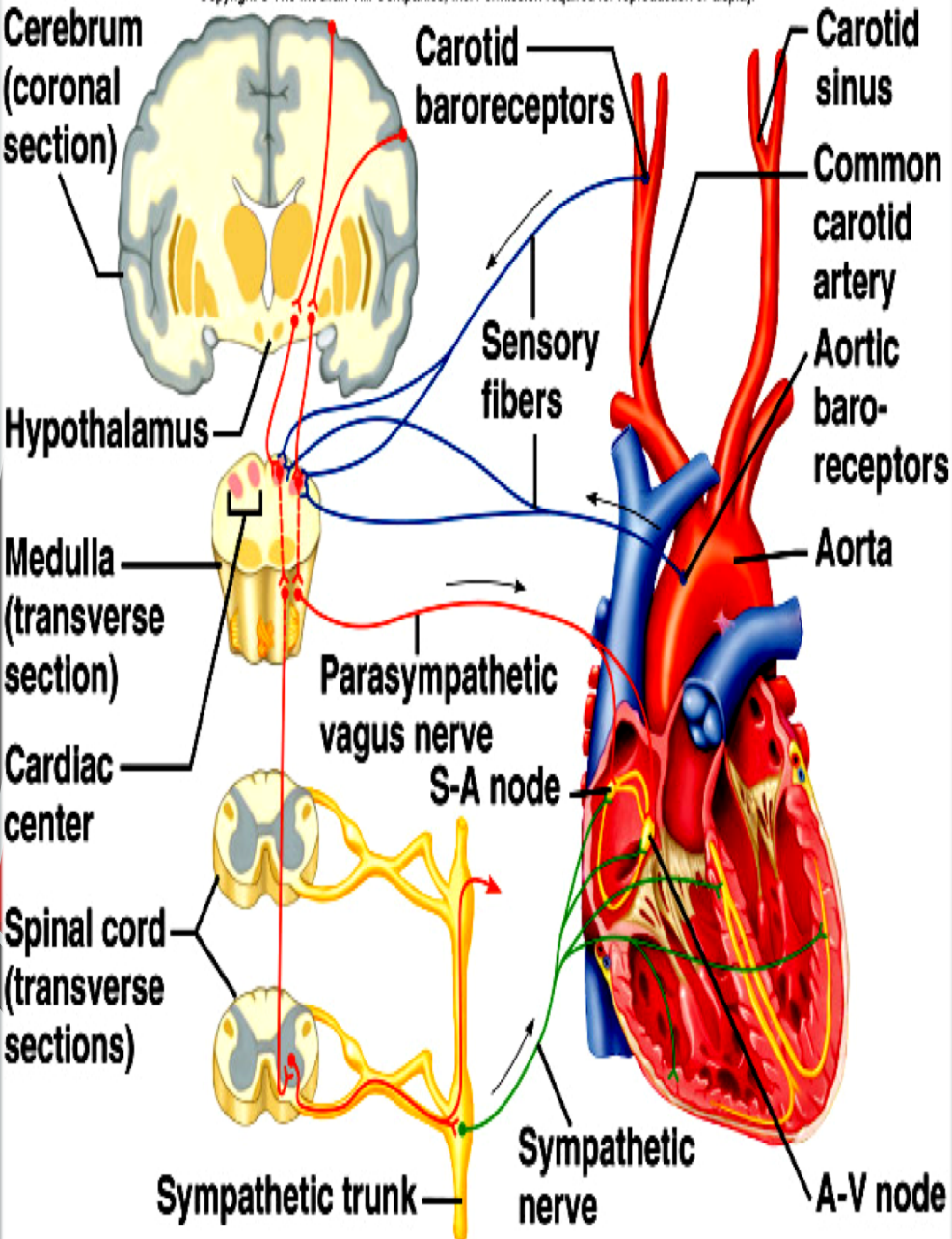
Stimulated in response to blood pressure changes



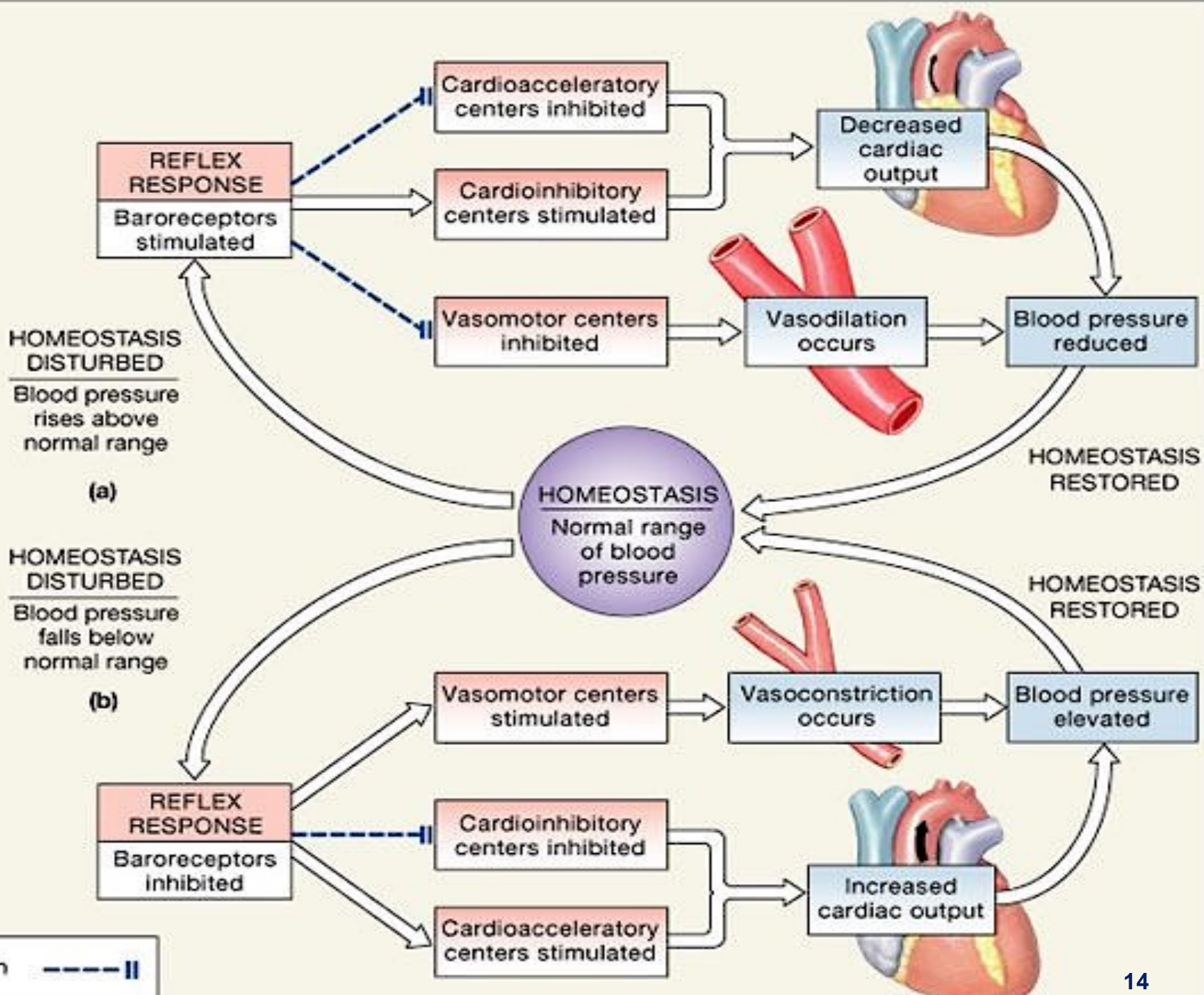
The baroreceptor system for controlling arterial pressure.

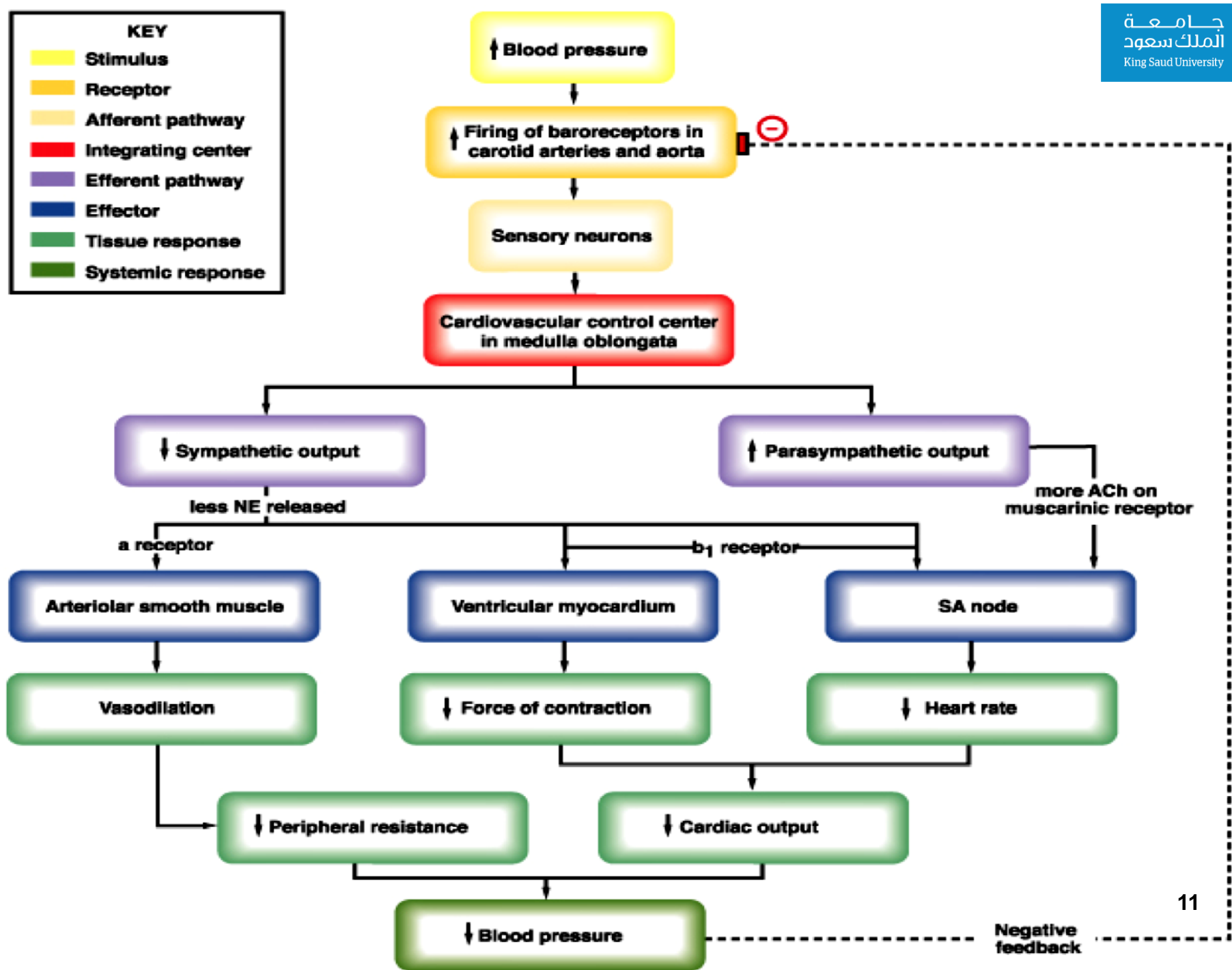


# Baroreceptor Reflex









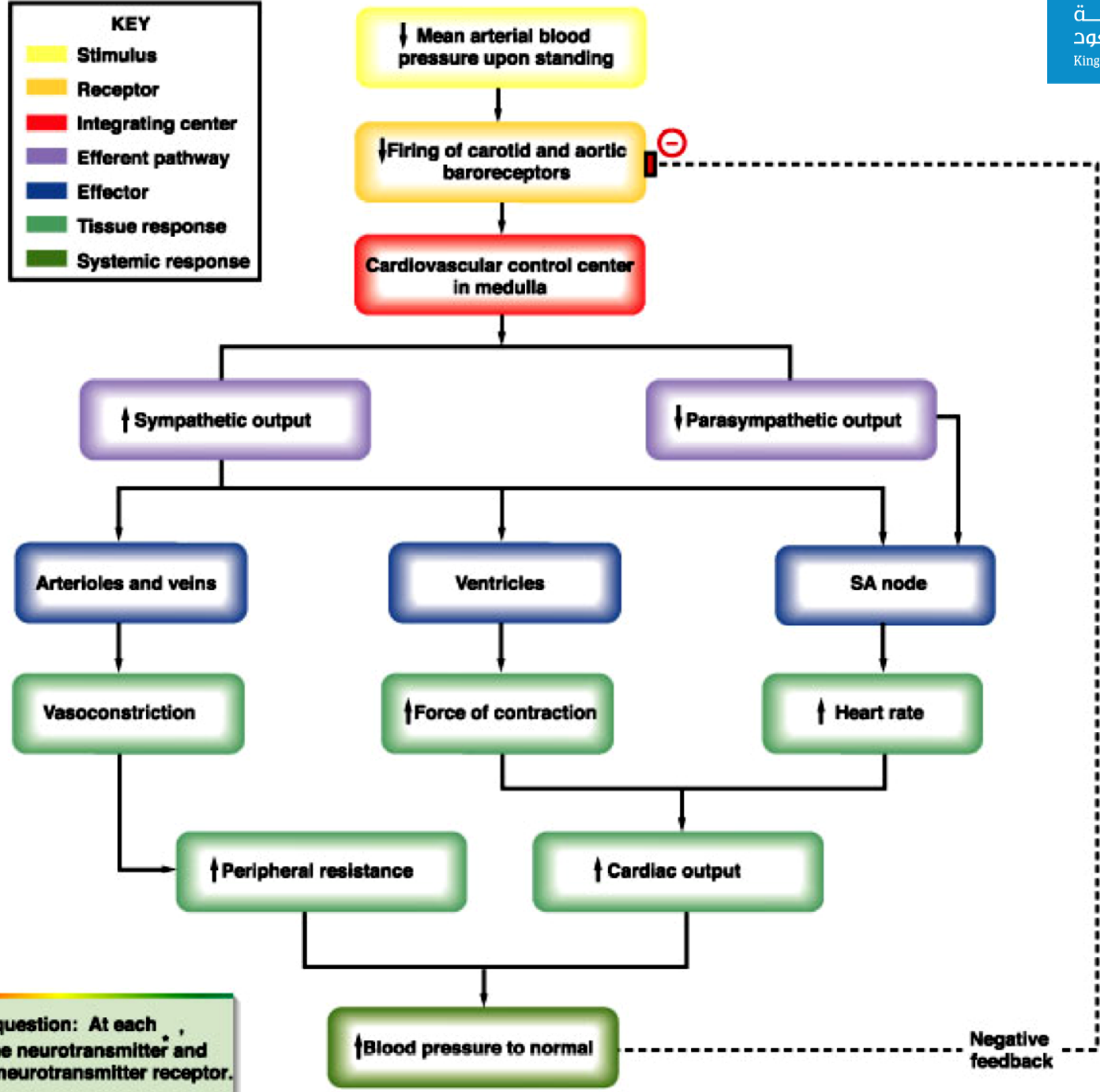
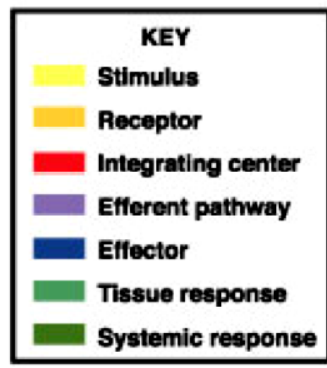


Figure question: At each , name the neurotransmitter and type of neurotransmitter receptor.

# Baroreceptor Reflex Mechanism During Changes in Body Posture

- ❑ Immediately on standing, AP 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

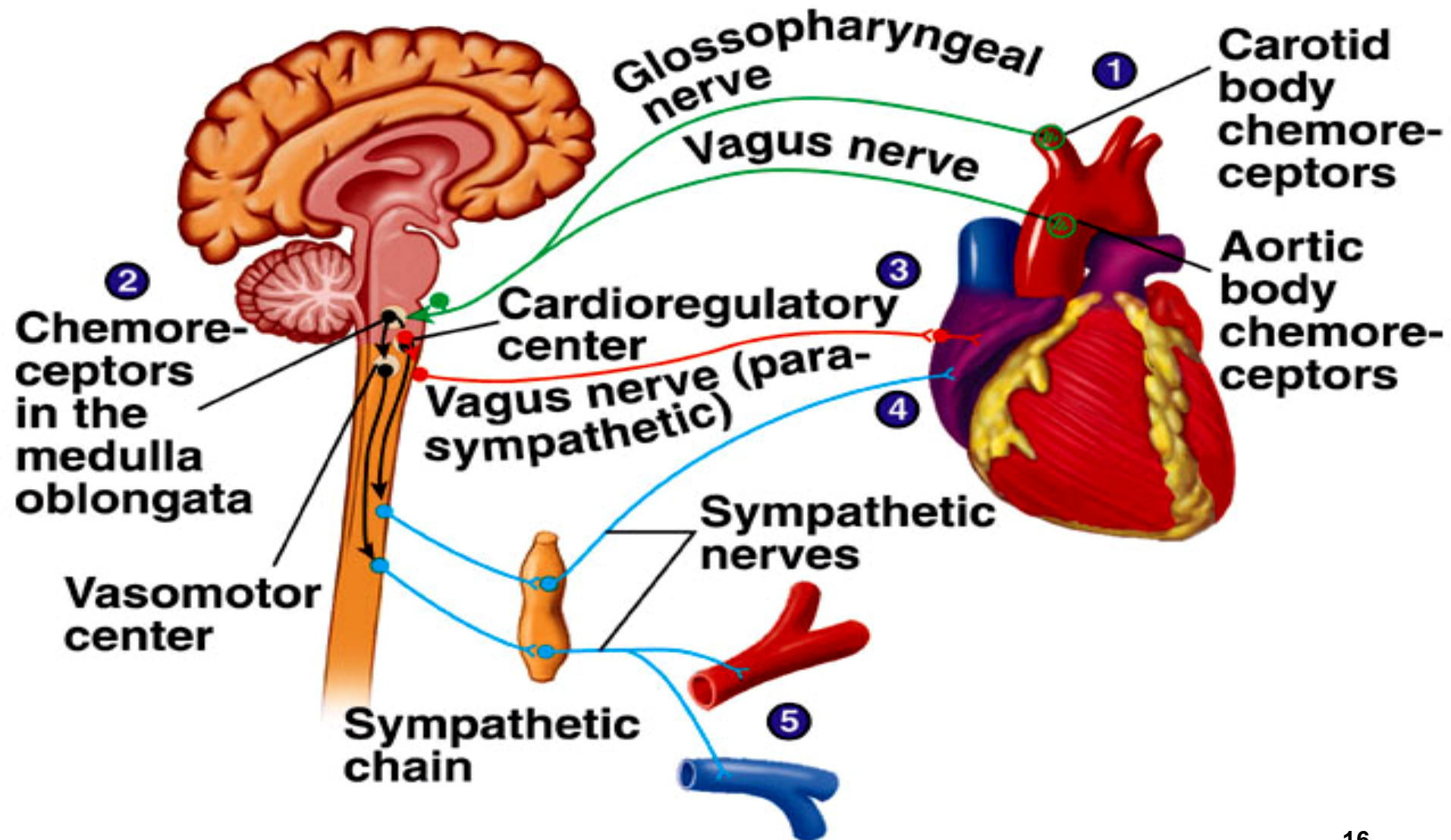
## ❑ **Peripheral chemoreceptors:**

- Sensory receptors located in carotid & aortic bodies.
- Sensitive to O<sub>2</sub> lack (↓), CO<sub>2</sub> (↑ or ↓), & pH (↓ or ↑.)
- Chemoreceptors' stimulation excite nerve fibers, along with baroreceptor fibers.

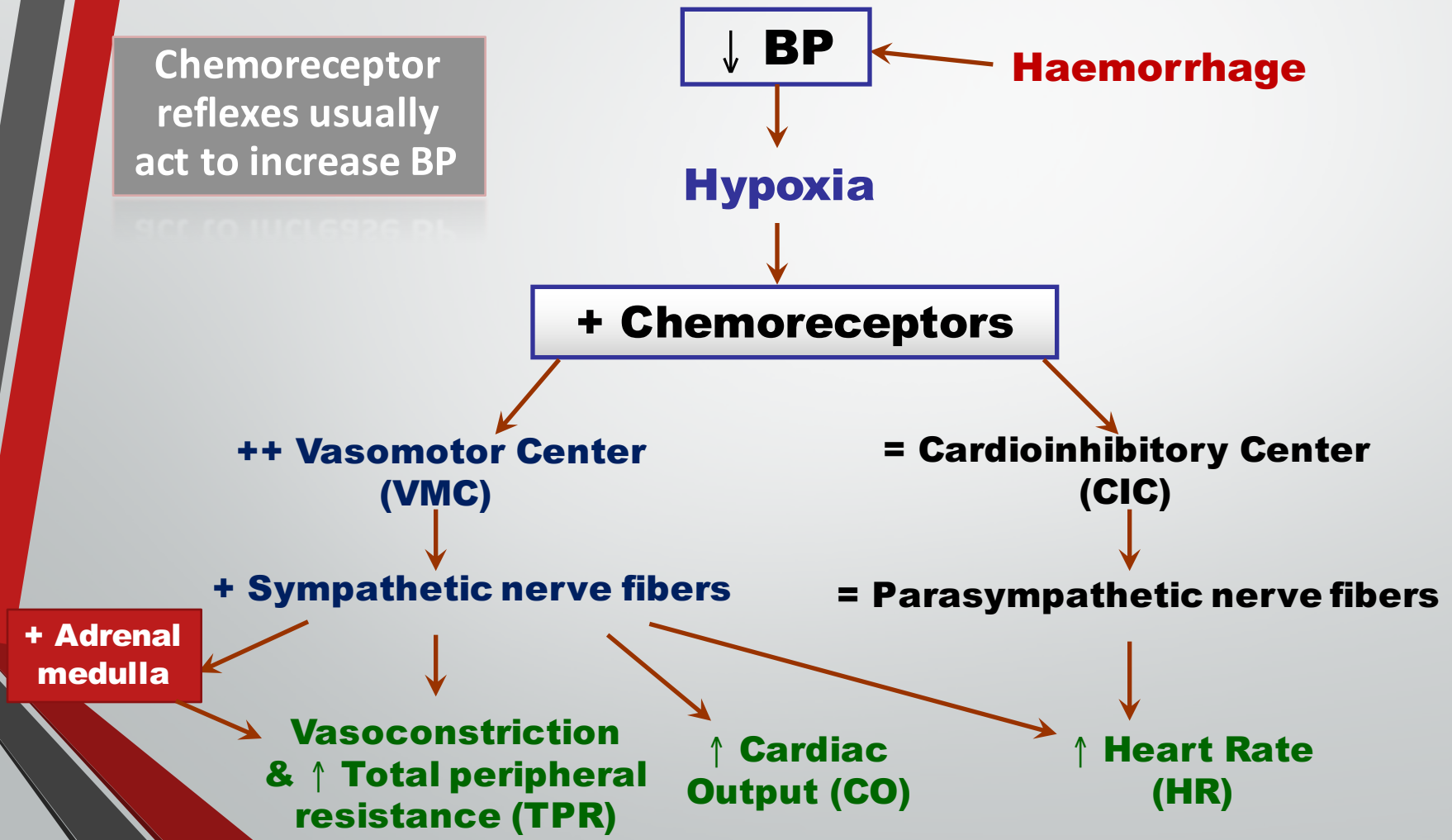
## ❑ **Central Chemoreceptors:**

- Sensory receptors located in the medulla itself.
- Very sensitive to CO<sub>2</sub> excess (↑) & (↓) pH in medulla.

# Peripheral Chemoreceptor Reflex



# Peripheral Chemoreceptor Reflexes



Chemoreceptor reflexes usually act to increase BP

+ Adrenal medulla

# CNS Ischemic Response:

## “Last ditch stand” pressure control mechanism

- ❑ It is not one of the normal mechanisms for regulating 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  $\text{CO}_2$  ↑ greatly.
- ❑ This has an extremely potent effect in stimulating the sympathetic vasomotor nervous control areas in the brain's medulla.



# Effects of pH and Gases on Chemoreceptors' Stimulation

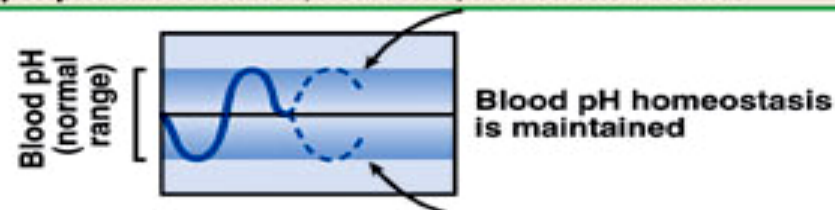
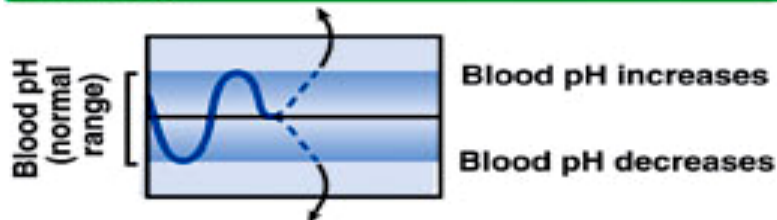
**Chemoreceptor reflex: Medulla oblongata**  
The increase in pH (decrease in CO<sub>2</sub>) is detected by chemoreceptors in the medulla oblongata.

- The vasomotor center decreases sympathetic stimulation of blood vessels.
- The cardiorespiratory center increases parasympathetic and decreases sympathetic stimulation of the heart.

- Vasodilation of blood vessels decreases peripheral resistance.
- Heart rate and stroke volume decrease, resulting in decreased cardiac output.

Blood pH increases (often caused by a decrease in blood CO<sub>2</sub>).

The decrease in blood pH (caused by an increase in blood CO<sub>2</sub>) results from decreased blood flow to the lungs. The decreased blood flow results from the decreased blood pressure and cardiac output caused by decreased peripheral resistance, heart rate, and stroke volume.



Blood pH decreases (often caused by an increase in blood CO<sub>2</sub>) or a large decrease in blood O<sub>2</sub>.

**Chemoreceptor reflex: Carotid and aortic bodies**  
A large decrease in O<sub>2</sub> is detected by chemoreceptors in the carotid and aortic bodies.

- The vasomotor center increases sympathetic stimulation of blood vessels.
- Respiration rate increases, which results in decreased parasympathetic and increased sympathetic stimulation of the heart.

The increase in blood pH (caused by a decrease in blood CO<sub>2</sub>) or increase in blood O<sub>2</sub> results from increased blood flow to the lungs. The increased blood flow results from the increased blood pressure and cardiac output caused by increased peripheral resistance, heart rate, and stroke volume.

- Vasoconstriction of blood vessels increases peripheral resistance.
- Heart rate and stroke volume increase, resulting in increased cardiac output.

**Chemoreceptor reflex: Medulla oblongata**  
A decrease in pH (increase in CO<sub>2</sub>) is detected by chemoreceptors in the medulla oblongata.

The cardiorespiratory center decreases parasympathetic and increases sympathetic stimulation of the heart.

Heart rate and stroke volume increase, resulting in increased cardiac output.

**Central nervous system ischemic response**  
A large decrease in pH (increase in CO<sub>2</sub>) is detected by chemoreceptors.

The vasomotor center increases sympathetic stimulation of blood vessels.

Vasoconstriction of blood vessels increases peripheral resistance.



# Other Vasomotor Reflexes

## 1. Atrial stretch receptor reflex:

↑ Venous Return  $\Rightarrow$  ++ atrial stretch receptors  $\Rightarrow$  reflex vasodilatation & ↓ ABP.

## 2. Thermo-receptors: (in skin / hypothalamus)

- Exposure to heat  $\Rightarrow$  vasodilatation.
- Exposure to cold  $\Rightarrow$  vasoconstriction.

## 3. Pulmonary receptors:

Lung inflation  $\Rightarrow$  vasoconstriction.

# **Hormonally- Mediated Regulation of ABP**

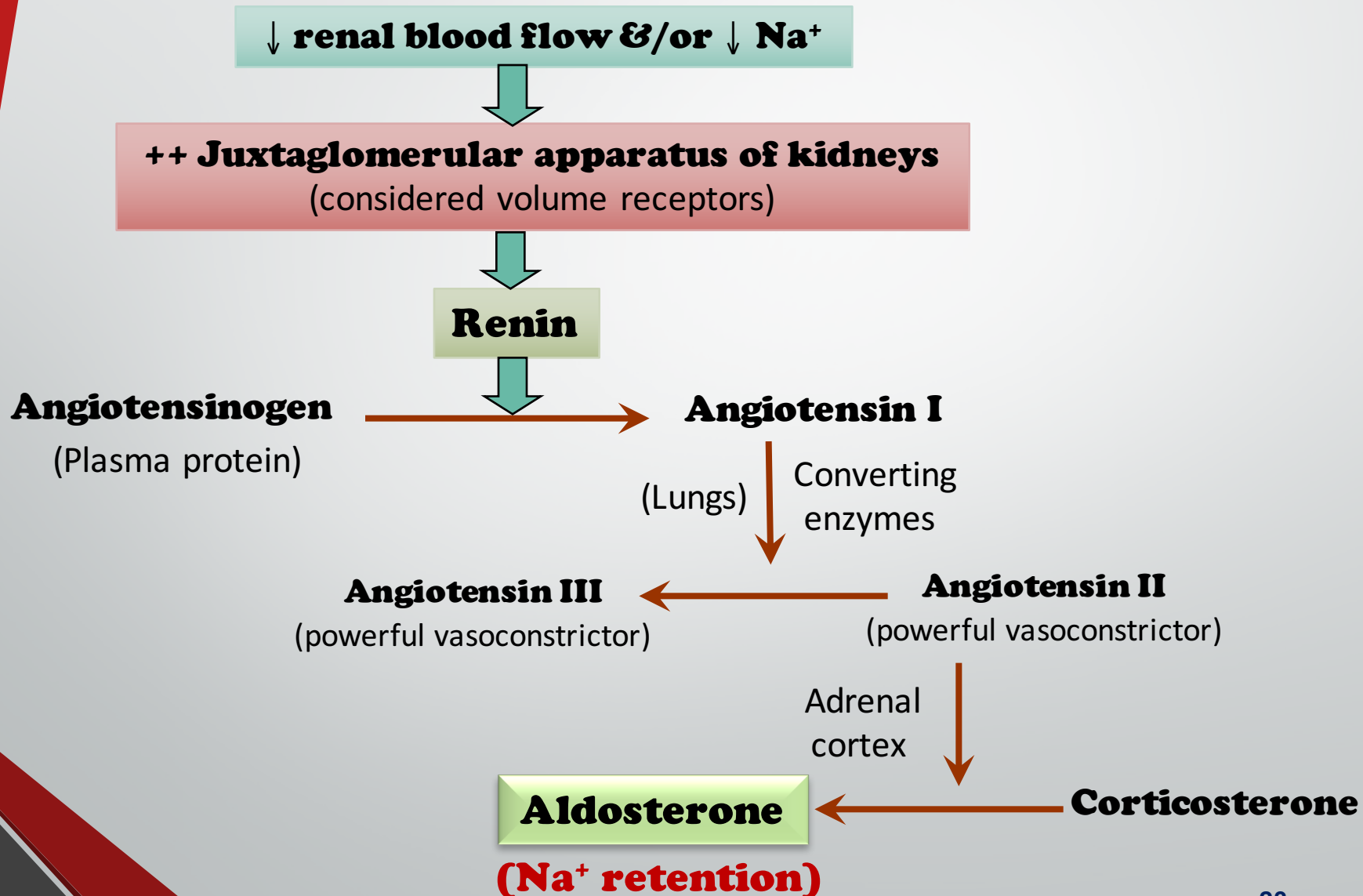
**Slow Response  
(Long- Term)**

**Concerned in regulating blood volume**

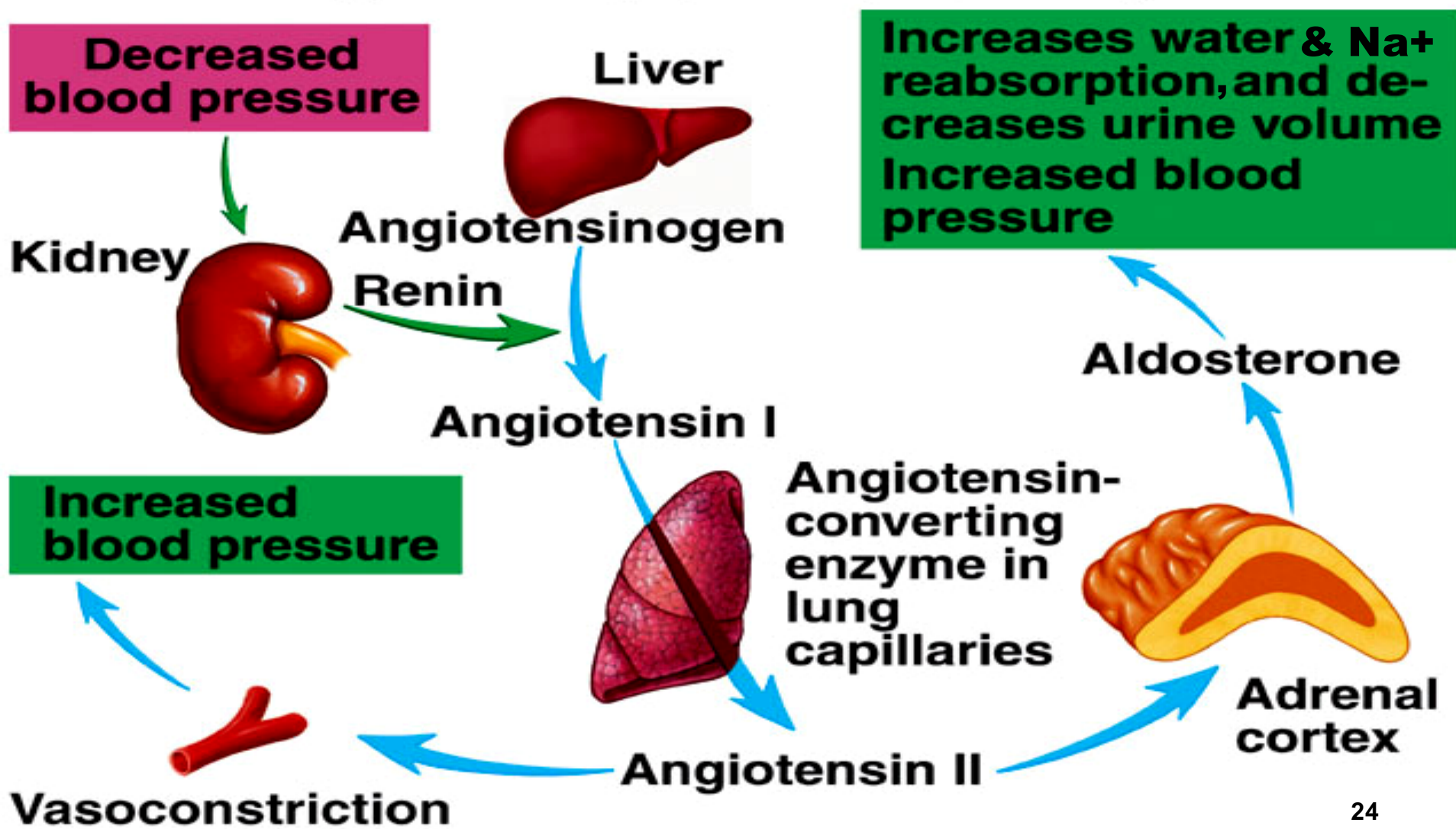
# Long-Term Regulation of ABP

- ❑ 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



# 1. Renin-Angiotensin-Aldosterone Mechanism





## 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.

# Vasopressin (ADH) Mechanism

Osmoreceptors detect increased osmotic pressure

Baroreceptors (aortic arch, carotid sinus) detect decreased blood pressure

Hypothalamic neuron

Posterior pituitary ADH

Increased reabsorption of water

Blood vessel

Kidney

Vasoconstriction

Increased blood volume  
Increased blood pressure

## 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  $\uparrow$  in urinary production, causing a  $\downarrow$  in blood volume & blood pressure.

## 4. EPO (Erythropoietin)

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

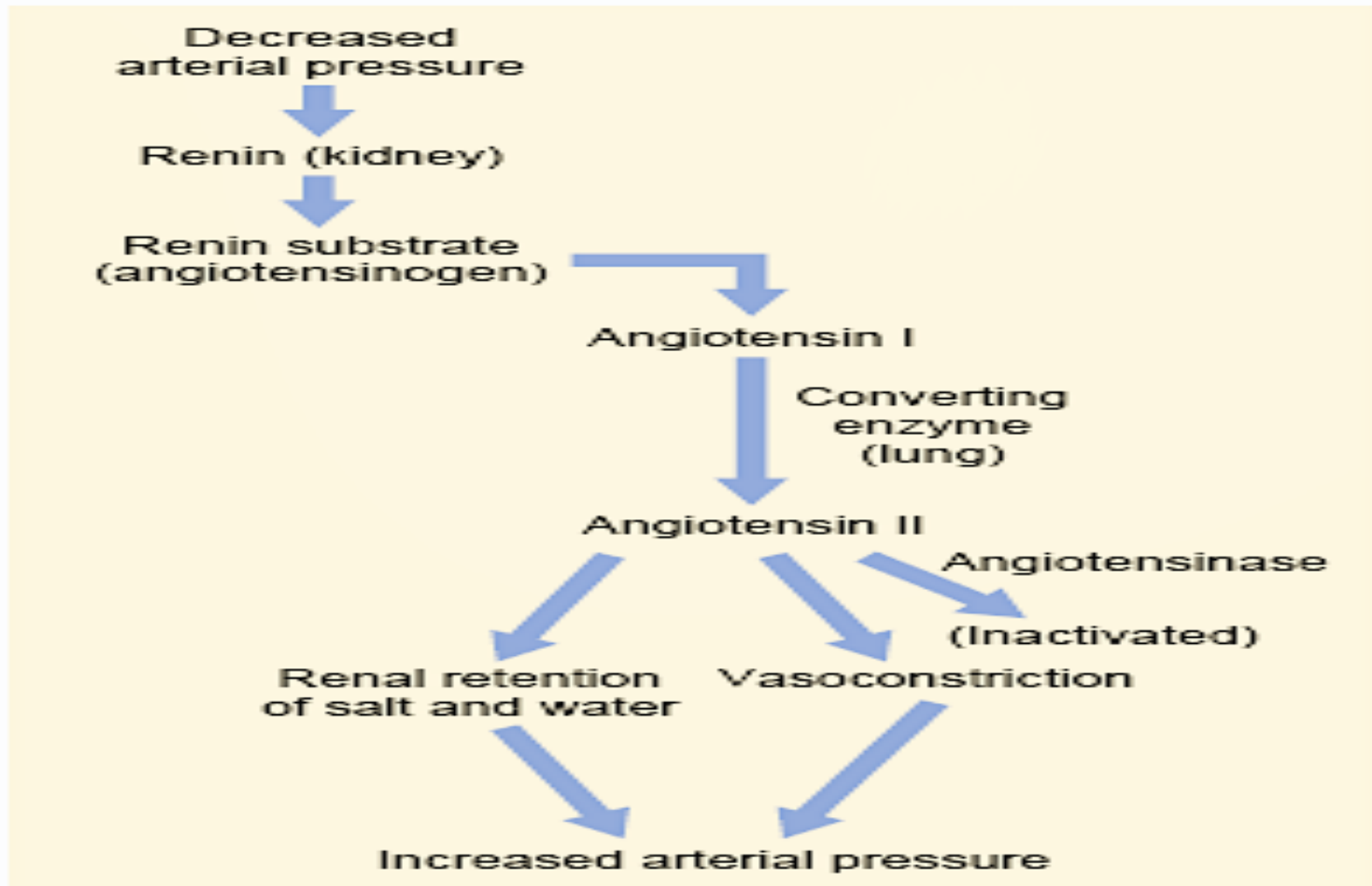
# **Intermediate Mechanisms Regulating ABP**



# **Intermediate Mechanisms:** **Activated within 30 min to several hrs.**

- 1.** Renin-angiotensin vasoconstrictor 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



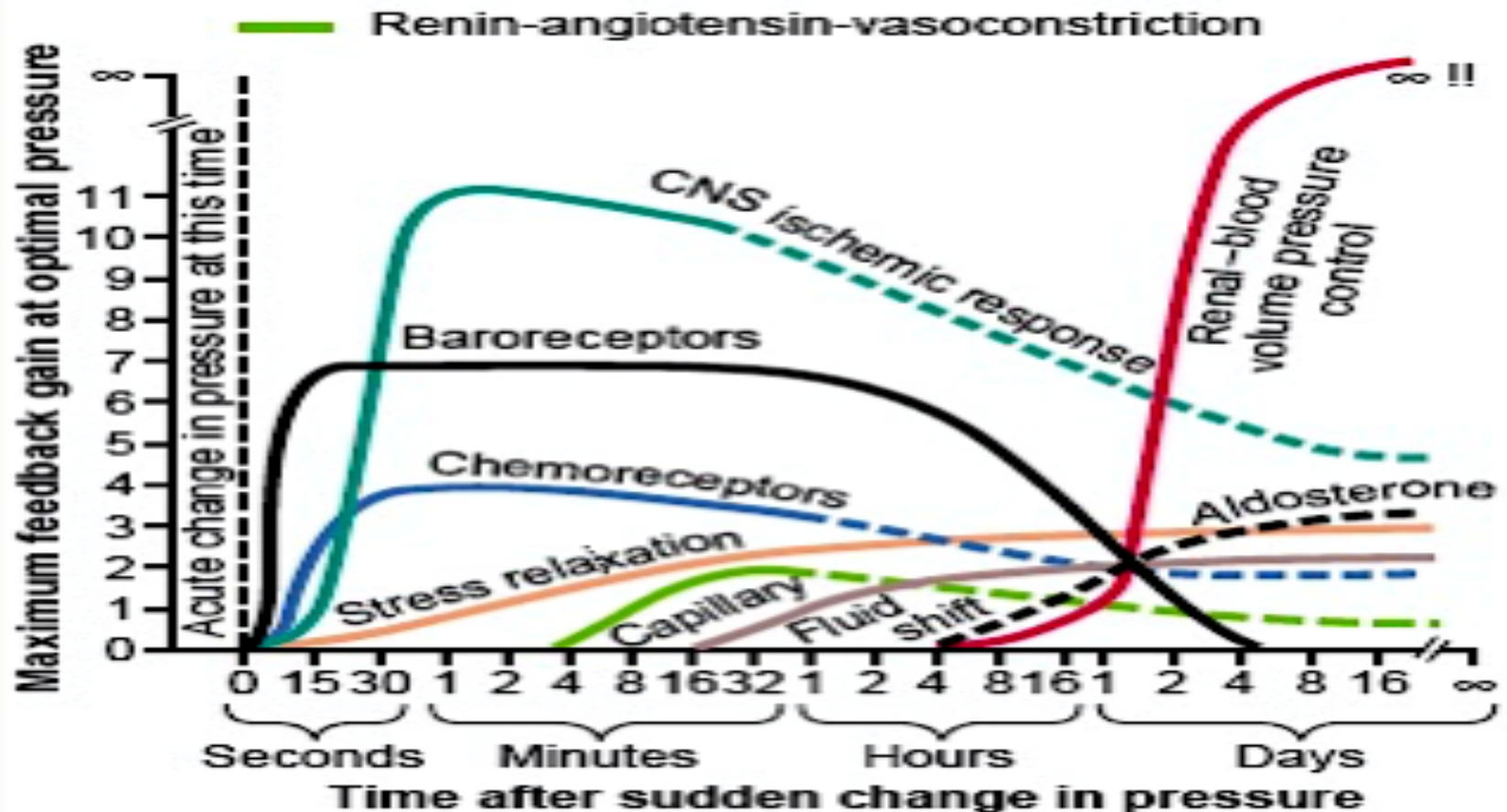
## 2. Fluid Shift Mechanism

- ❑ Movement of fluid from interstitial spaces into **capillaries** in response to  $\downarrow$  **BP** to maintain blood volume.
- ❑ Conversely, when **capillary pressure**  $\uparrow$  **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*