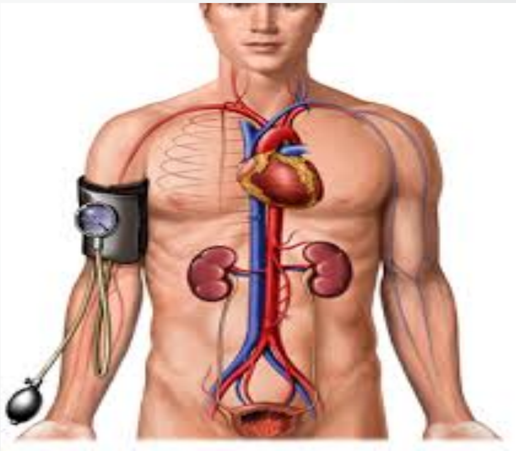
King Saud University

Cardiovascular Physiology

Regulation of Blood Pressure



Dr. Abeer A. Al-Masri, PhD

A. Professor,

Consultant Cardiovascular Physiologist,

Faculty of Medicine, KSU.

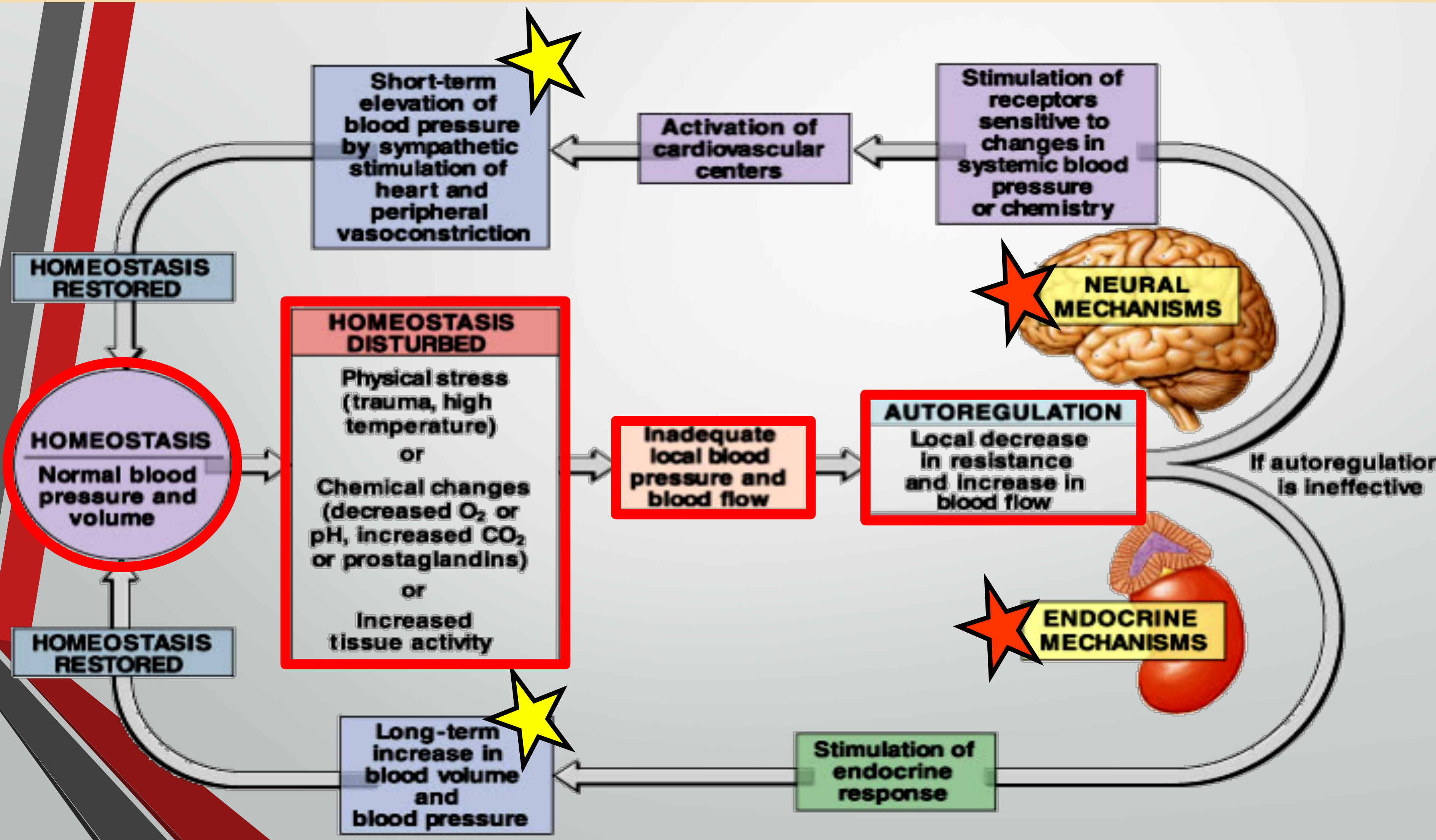
Lecture Outcomes

- 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 CO & PR

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 Reflex mechanisms for Maintaining Normal ABP:

- Baroreceptors reflex
- Chemoreceptors reflex
- Atrial stretch receptor reflex
- Thermo-receptors
- Pulmonary receptors

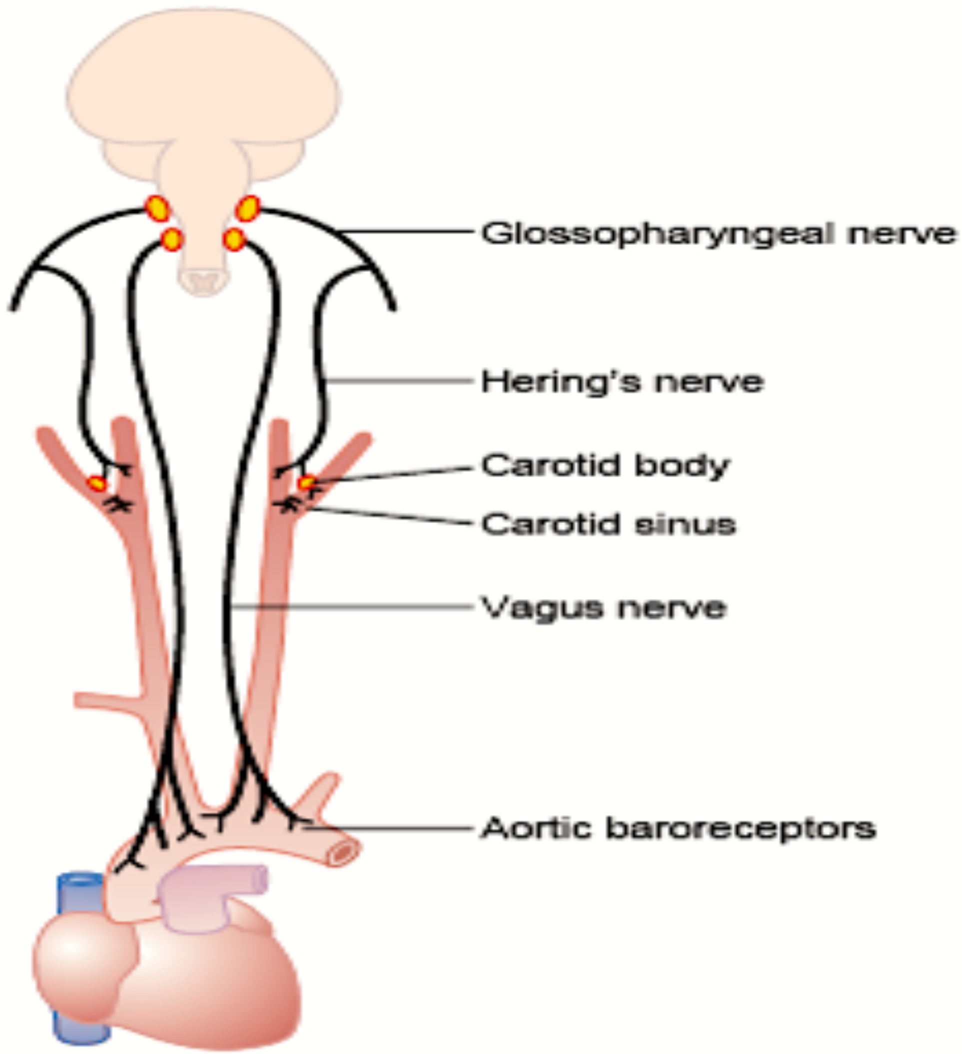
Baroreceptor Reflex

Mechano-stretch receptors located in the wall of carotid sinus & aortic arch

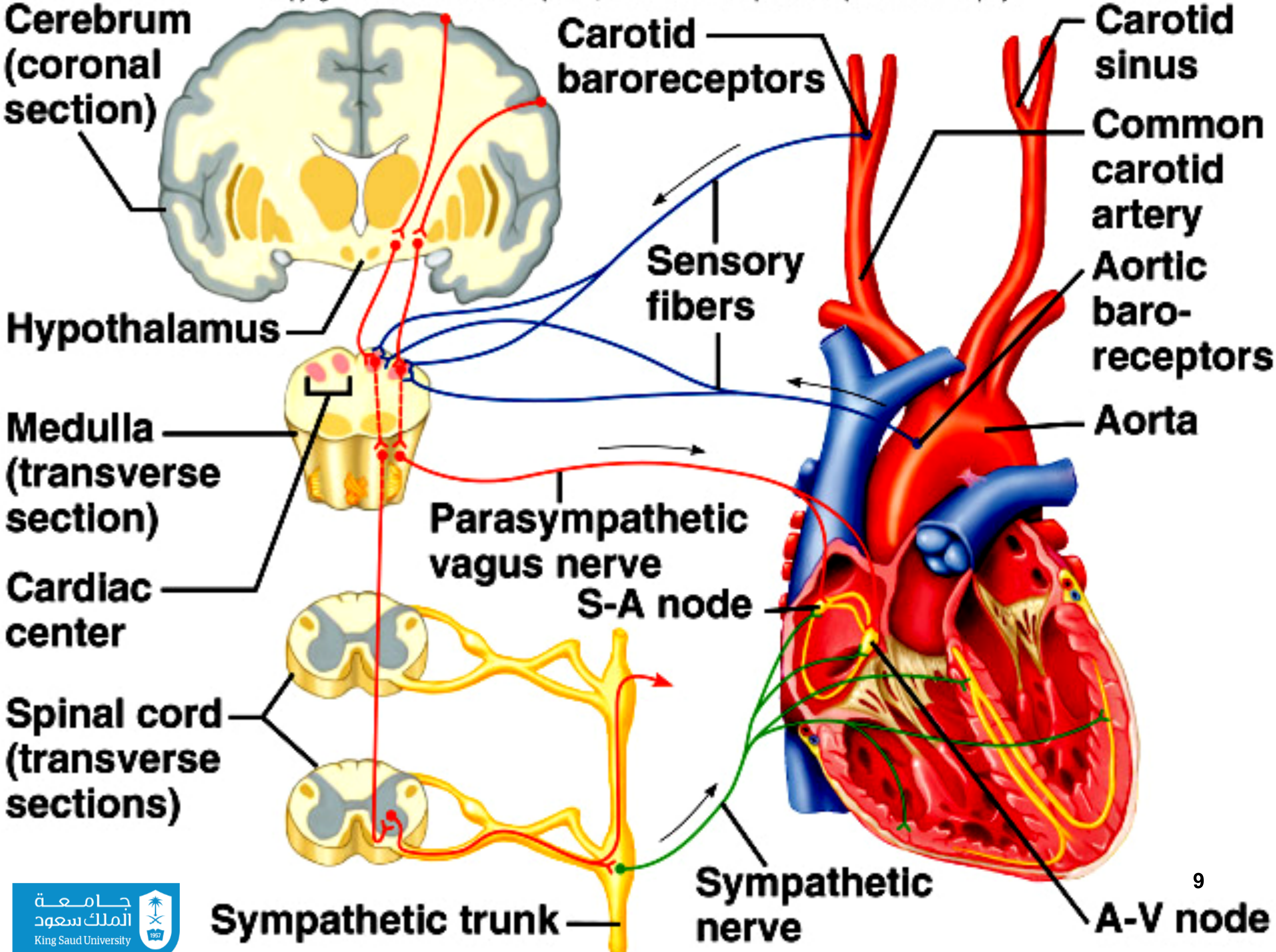
Fast, neurally mediated

Provide powerful moment-to-moment control of arterial pressure

Stimulated in response to BP changes



The baroreceptor system for controlling arterial pressure.



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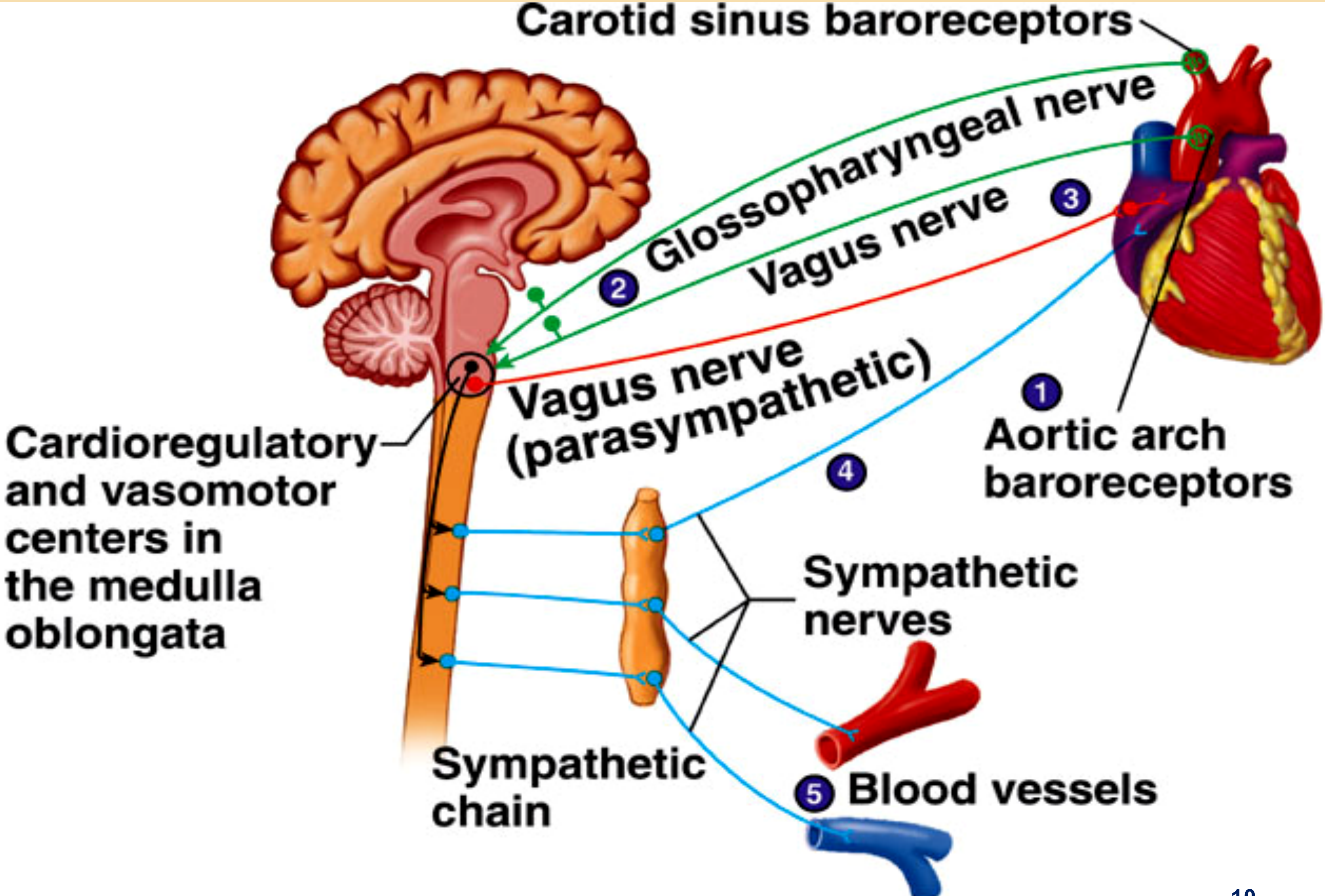
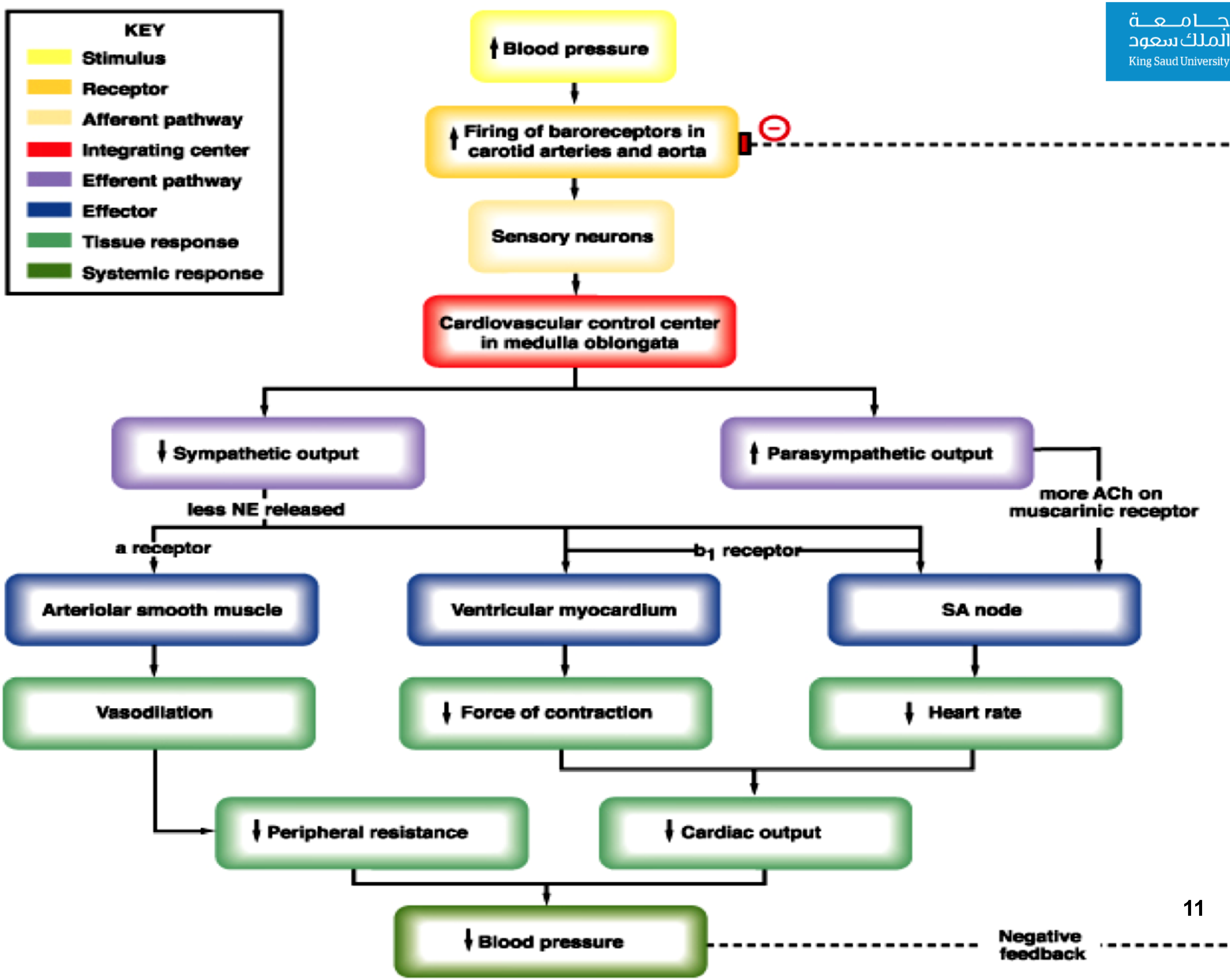
Baroreceptor Reflex




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

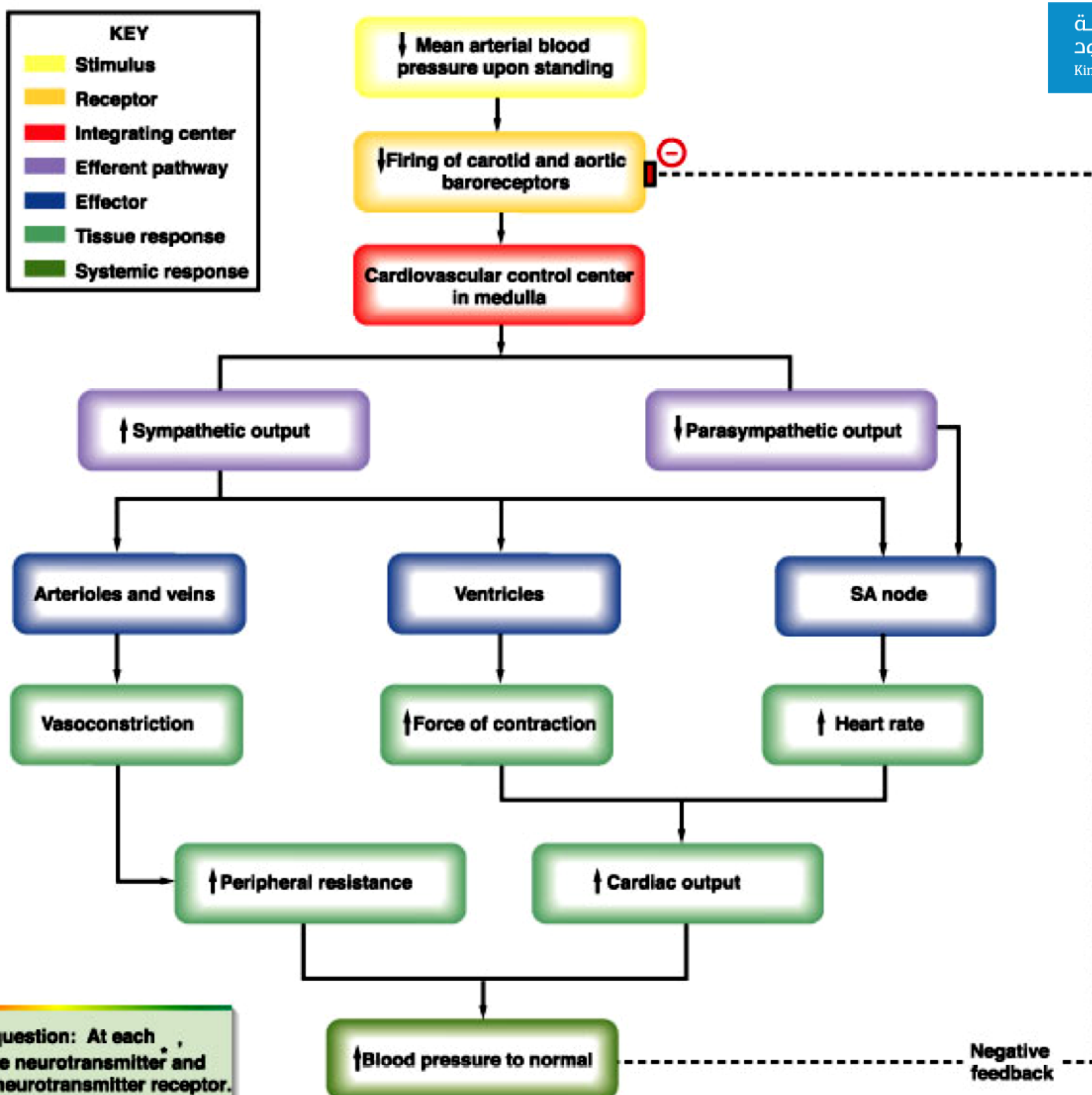


Figure question: At each * , name the neurotransmitter and type of neurotransmitter receptor.

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

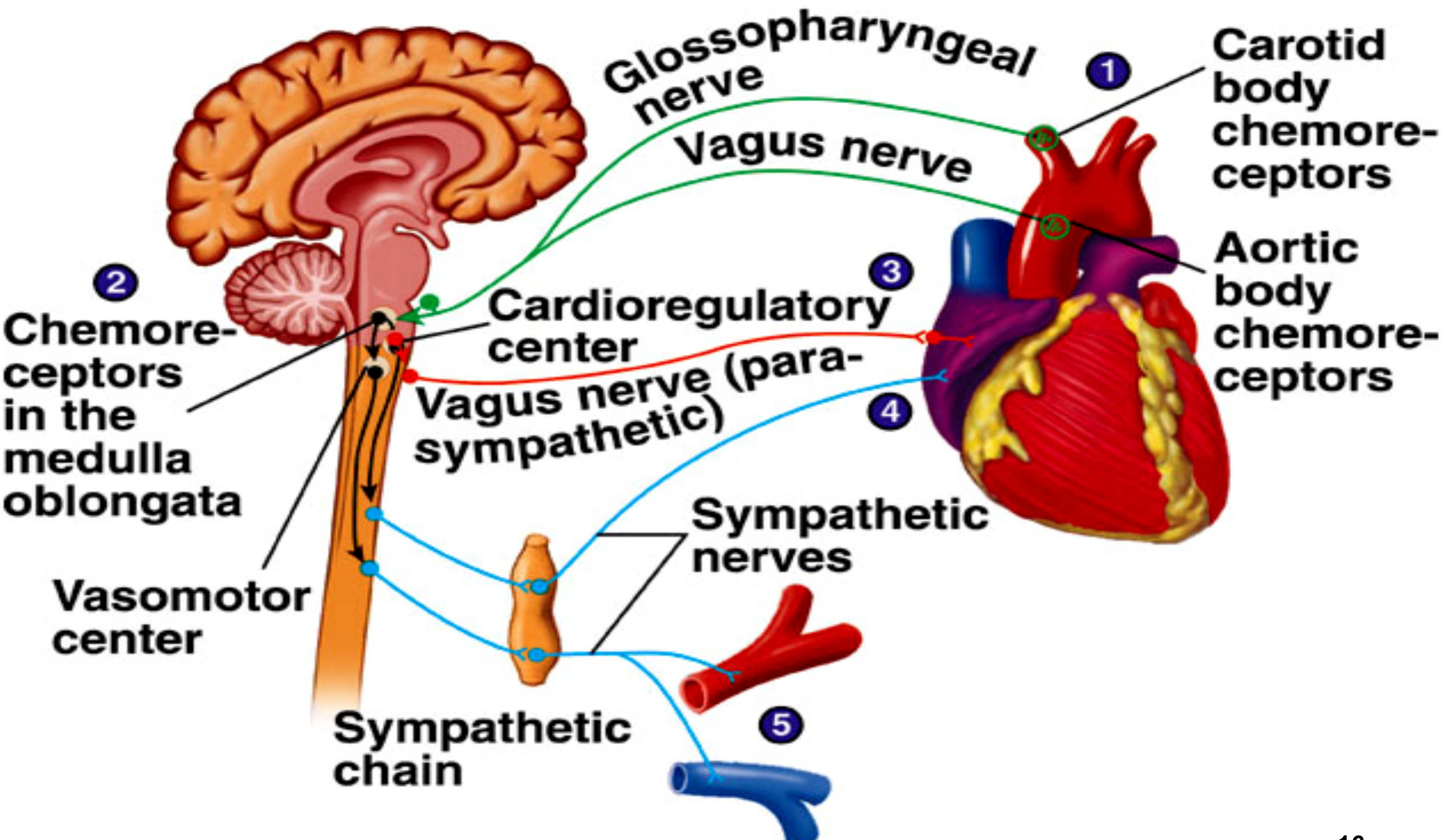
- Closely associated with the baroreceptor pressure control system.

- **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_2 lack (↓), CO_2 (↑ or ↓), & pH (↓ or ↑.)
  - Chemoreceptors' stimulation excite nerve fibers that, along with baroreceptor fibers.
- **Central Chemoreceptors:**
  - Sensory receptors located in the medulla itself.
  - Very sensitive to CO_2 excess (↑) & (↓) pH in medulla.

Peripheral Chemoreceptor Reflex



Peripheral Chemoreceptor Reflexes

Chemoreceptor reflexes usually act to increase BP

Haemorrhage → ↓ BP

↓ BP → Hypoxia → + Chemoreceptors

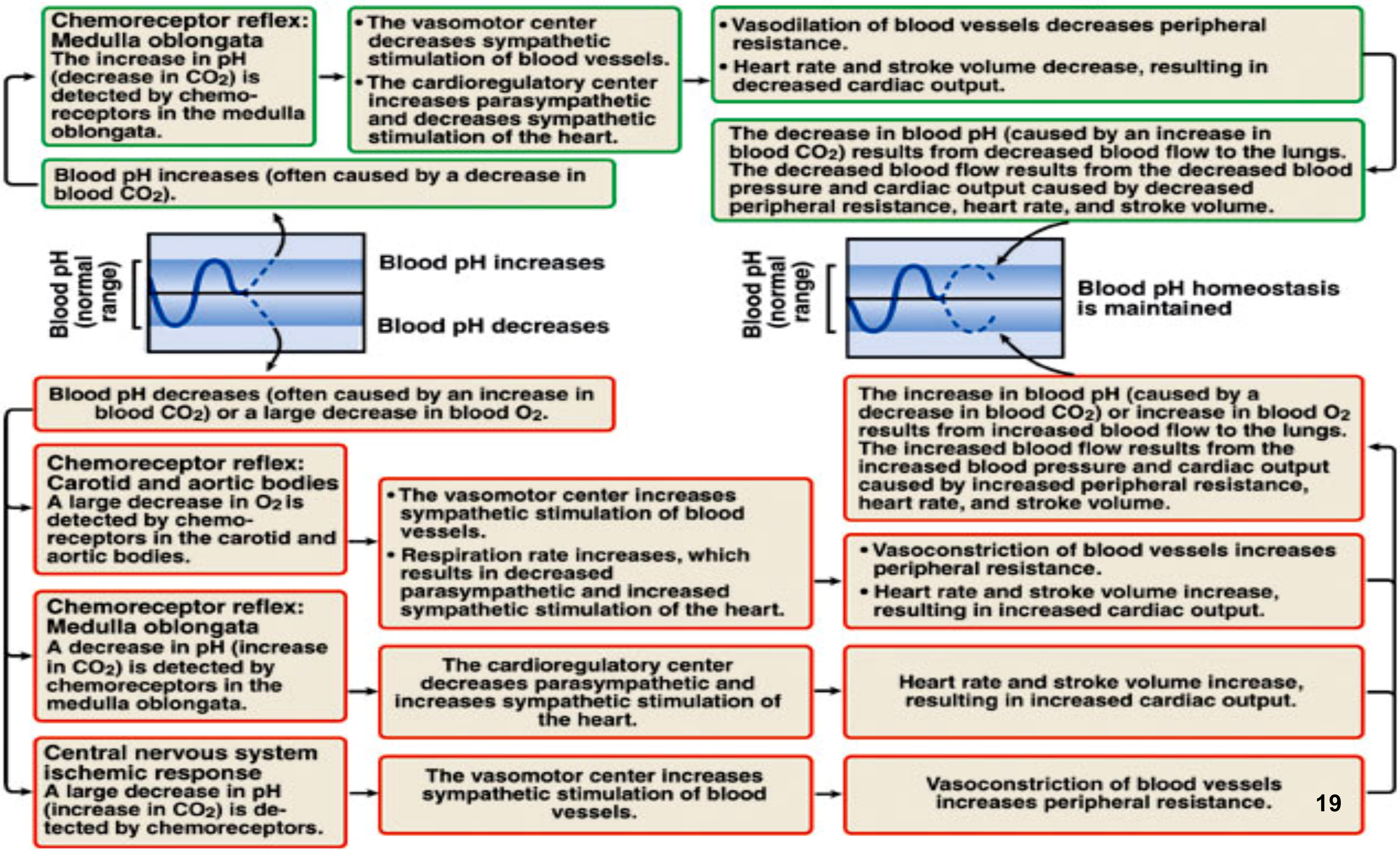
+ Chemoreceptors → ++ V.M.C → + Sympathetic
  - + Sympathetic → + Adrenal medulla
  - + Sympathetic → Vasoconstriction & ↑ TPR
  - + Sympathetic → ↑ CO
  - + Sympathetic → ↑ HR

+ Chemoreceptors → = C.I.C → = Parasympathetic → ↑ HR

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 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



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

↓ renal blood flow &/or ↓ Na^+

⇓

++ Juxtaglomerular apparatus of kidneys
(considered volume receptors)

⇓

Renin

⇓

Angiotensinogen (Plasma protein) → **Angiotensin I**

(Lungs) ↓ Converting enzymes

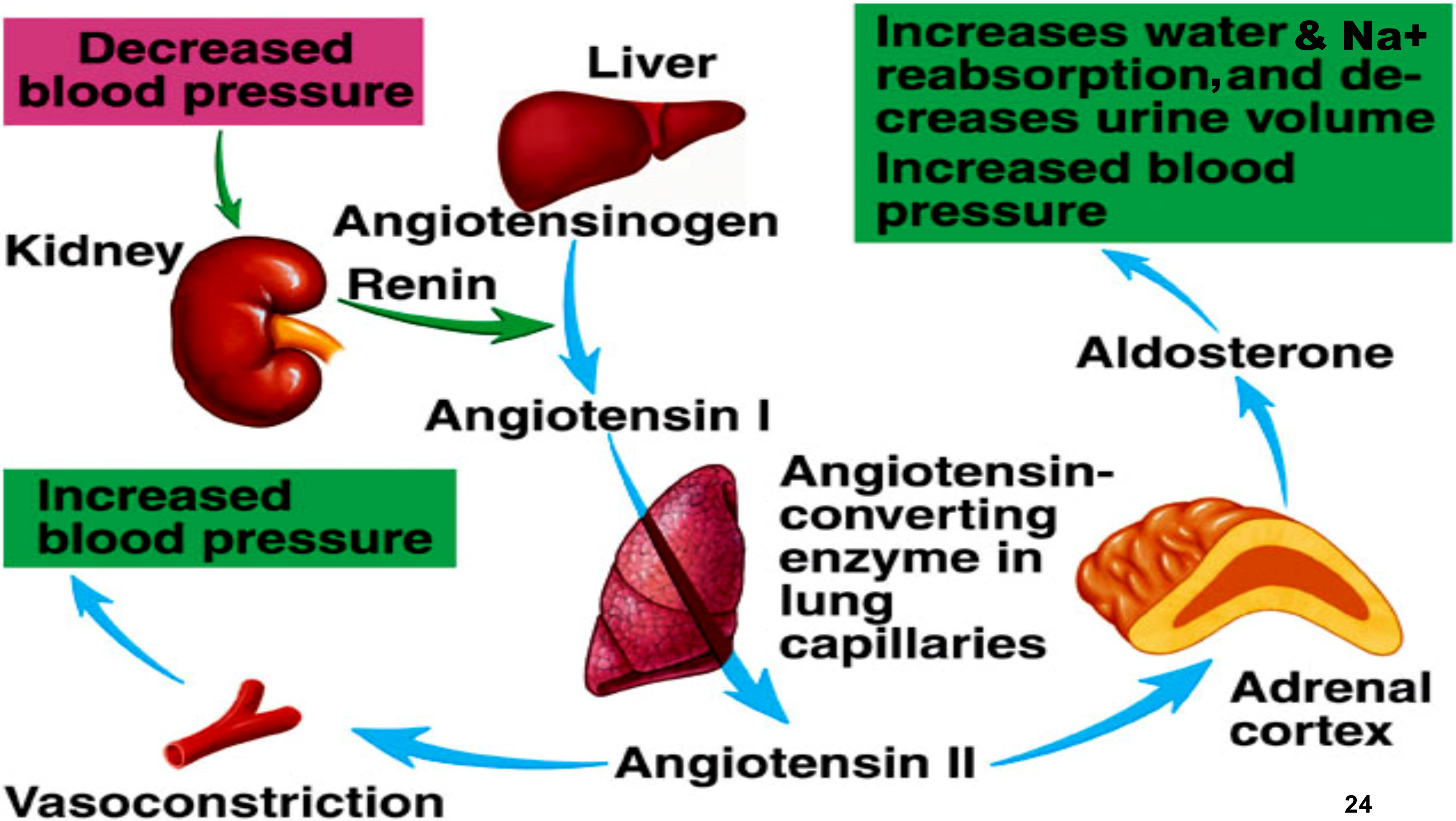
Angiotensin III (powerful vasoconstrictor) ← **Angiotensin II** (powerful vasoconstrictor)

↓ Adrenal cortex

Aldosterone ← **Corticosterone**

(Na^+ & water retention)

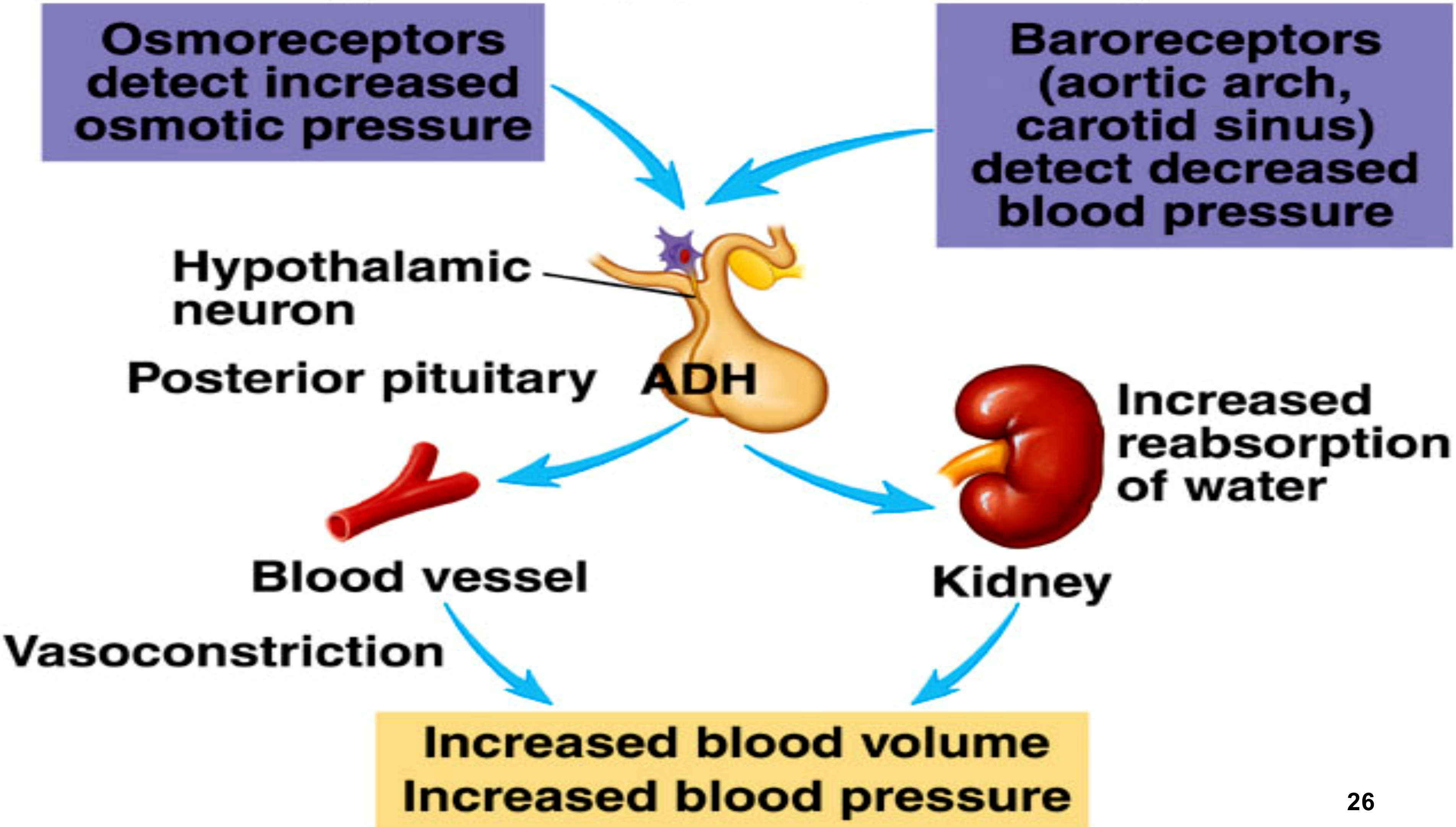
1. Renin–Angiotensin–Aldosterone Mechanism



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



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 <u>increase</u> 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

Slow Response
(Long- Term)

Concerned in regulating blood volume

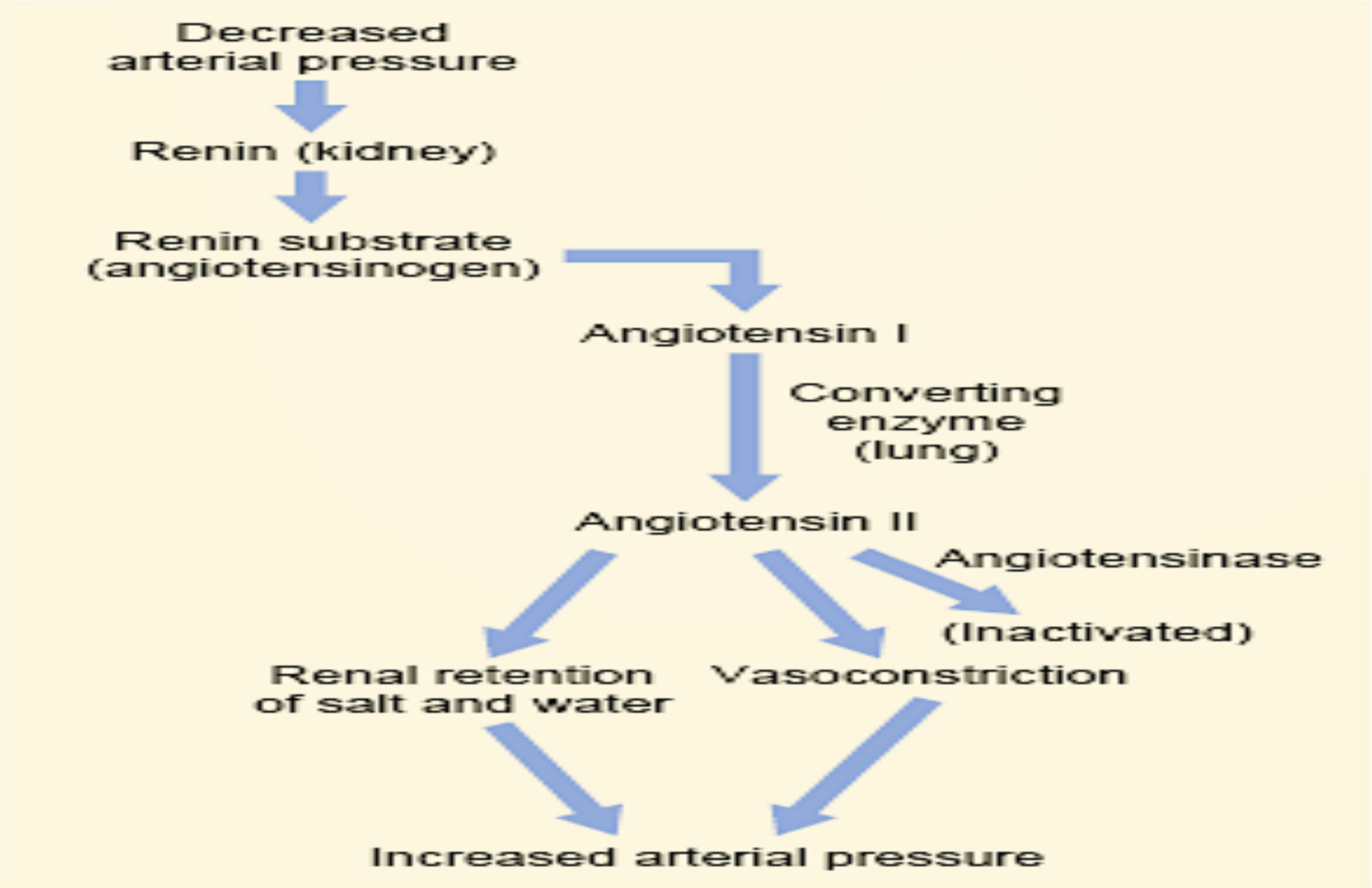
Intermediate Mechanisms:

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. The Renin-Angiotensin System



2. Fluid Shift Mechanism

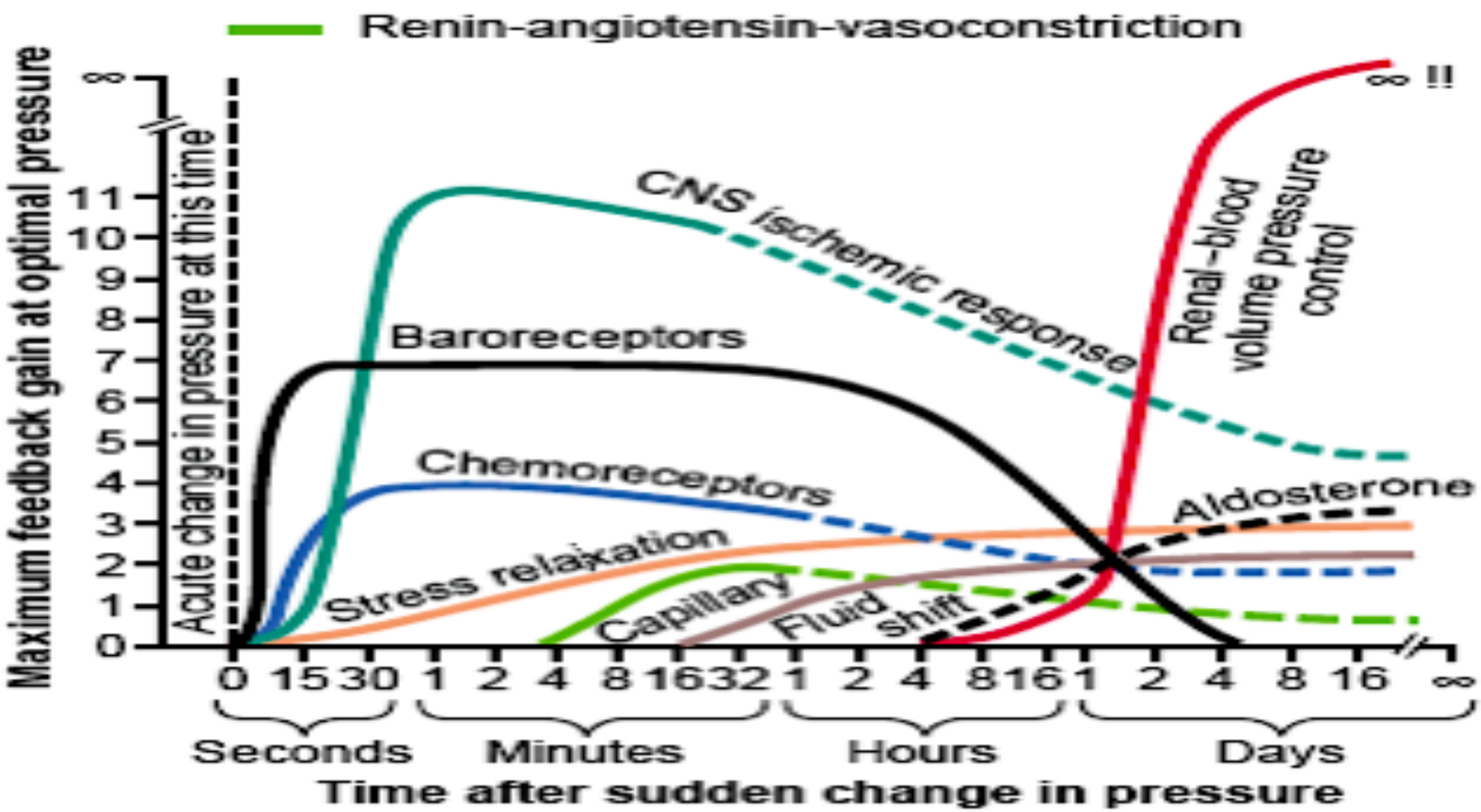
- Movement of fluid from interstitial spaces into **capillaries** in response to ↓ **BP** to maintain blood volume.

- 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