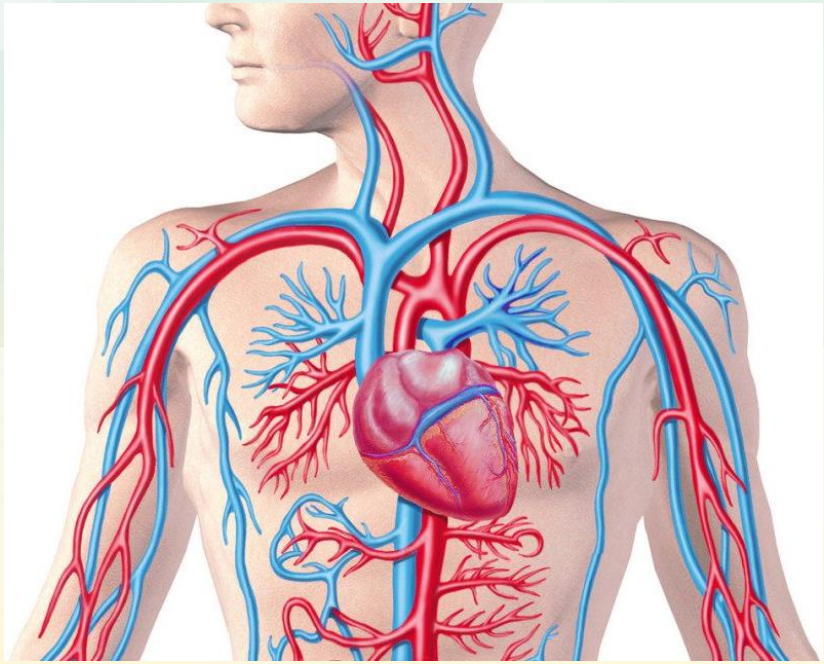
السلام عليكم ورحمة الله وبركاته

Physiology of Cardiovascular System



Regulation of Arterial Blood Pressure

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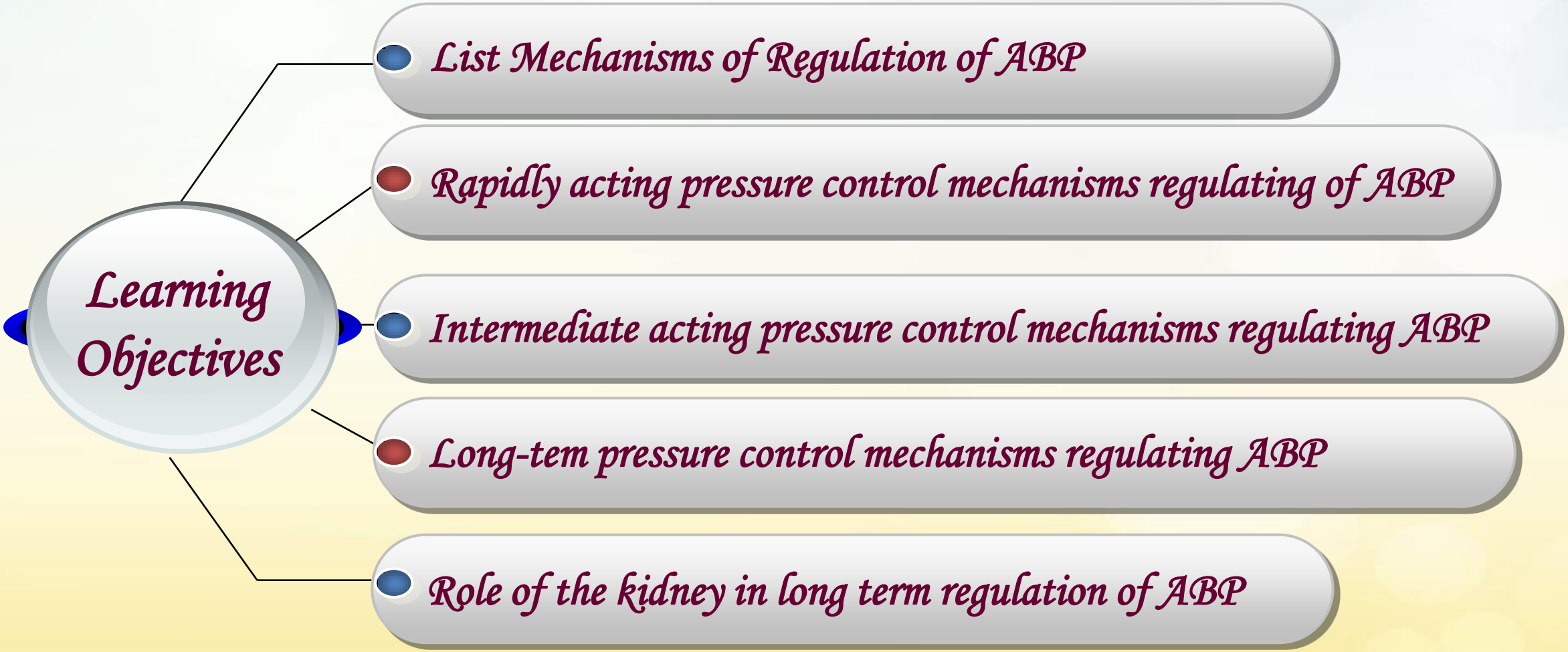

Learning Objectives
List Mechanisms of Regulation of ABP
Rapidly acting pressure control mechanisms regulating of ABP
Intermediate acting pressure control mechanisms regulating ABP
Long-tem pressure control mechanisms regulating ABP
Role of the kidney in long term regulation of ABP

Regulation of ABP

1. Maintaining BP is important to ensure a steady blood flow (perfusion) to tissues.

2. Inability to regulate blood pressure can contribute to diseases.

3. In order to regulate the blood pressure, the determining factors have to be regulated:

4. * Cardiac output.
   * Peripheral resistance.
   * Blood volume.

Mechanisms of Regulation of ABP

I- Rapidly acting pressure control mechanisms: act rapidly, within sec or min

- ✓The baroreceptor reflex
- ✓The chemoreceptor reflex
- ✓The CNS ischemic response

II- Intermediate acting pressure control mechanism: respond over min or hrs

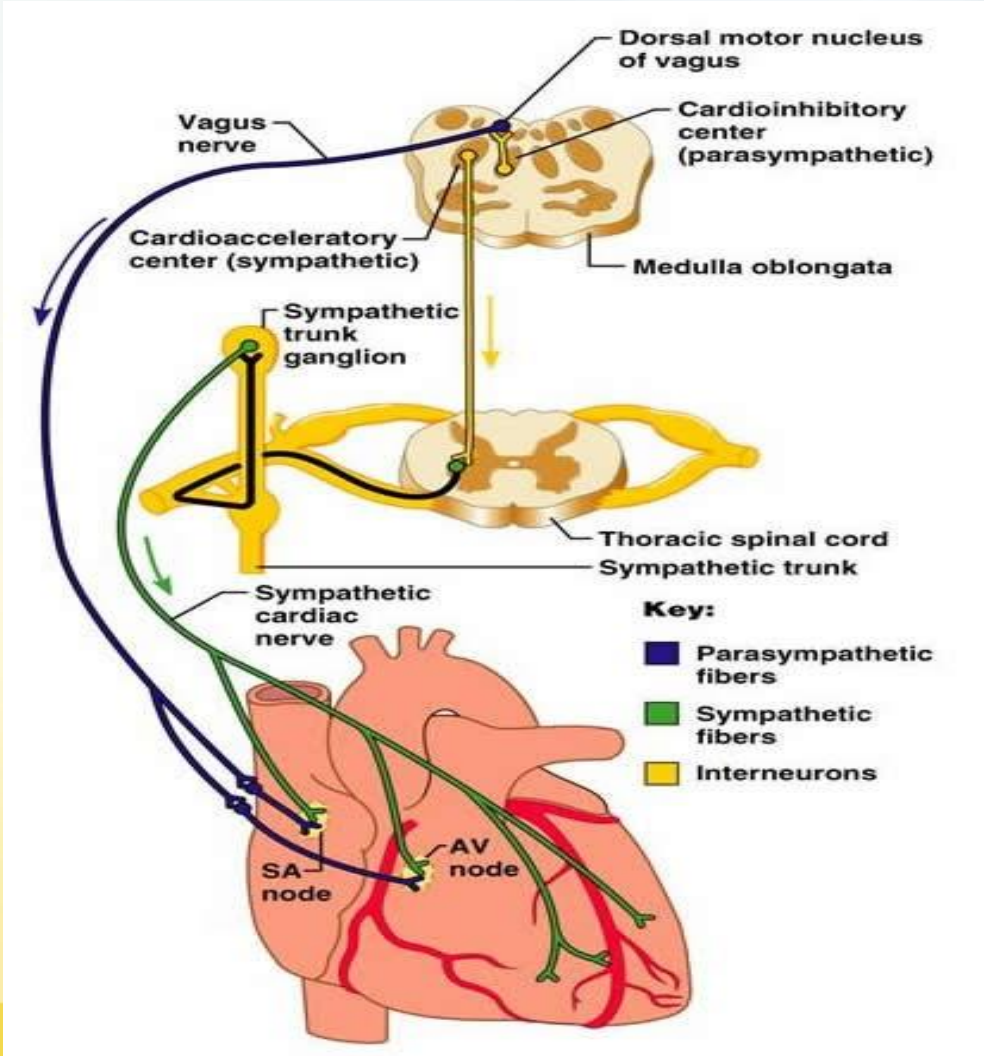
- ✓The renin-angiotensin vasoconstrictor mechanism
- ✓Stress relaxation mechanism
- ✓Capillary fluid shift

III- Long-term pressure control mechanisms: act over hr. or days

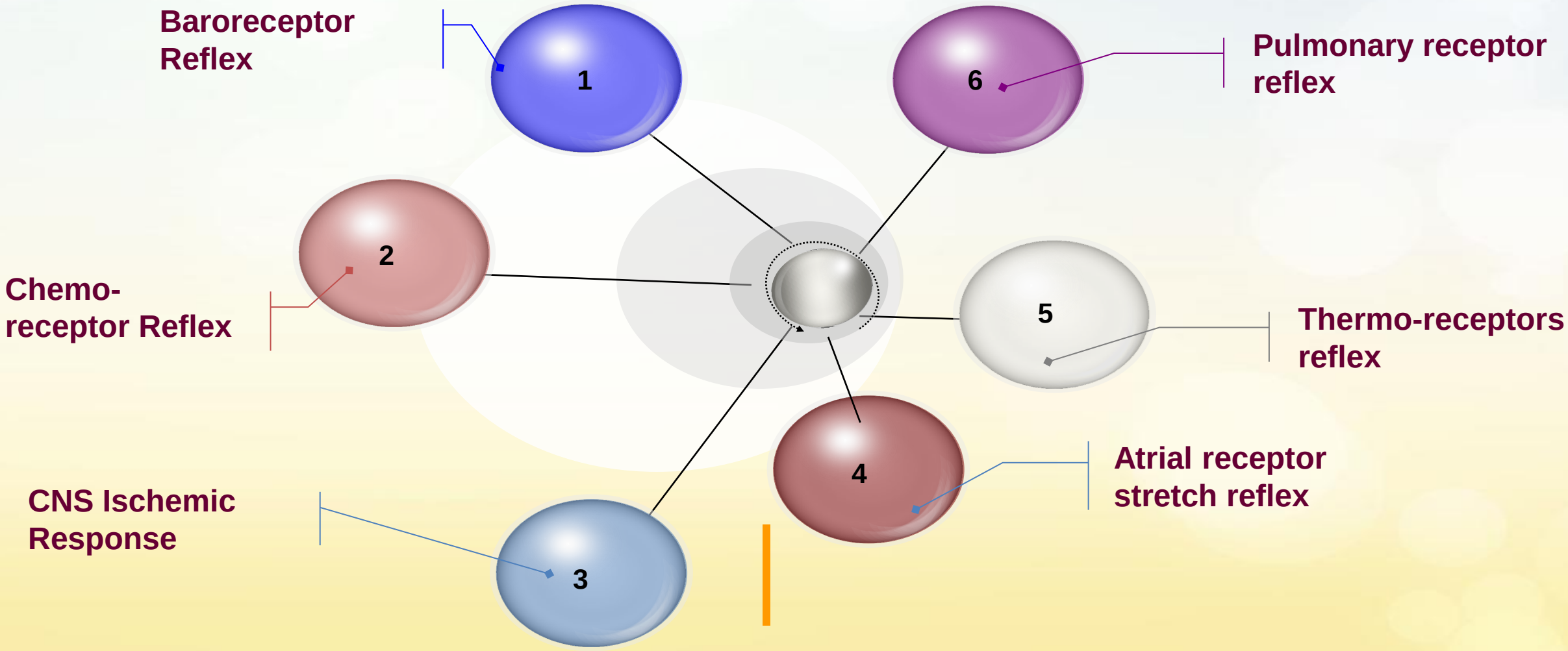
- ✓ The renin-angiotensin -aldosterone vasoconstrictor mechanism
- ✓ Anti-diuretic hormone (ADH), or vasopressin mechanism
- ✓ Atrial natriuretic peptide hormone
- ✓ Erythropoietin

Rapidly Acting Pressure Control Mechanisms for Regulation of ABP

- ✓ Fast response, acts within seconds/minutes, short-term.
- ✓ Concerned in regulating CO & PR.
- ✓ Neurally (Reflex)- mediated that act through autonomic nervous system.
- ✓ CV Centers in Medulla Oblongata:
  - Cardioacceleratory Center (VMC) Sympathetic nervous system.
  - Cardioinhibitory Center (CIC), Parasympathetic nervous system.



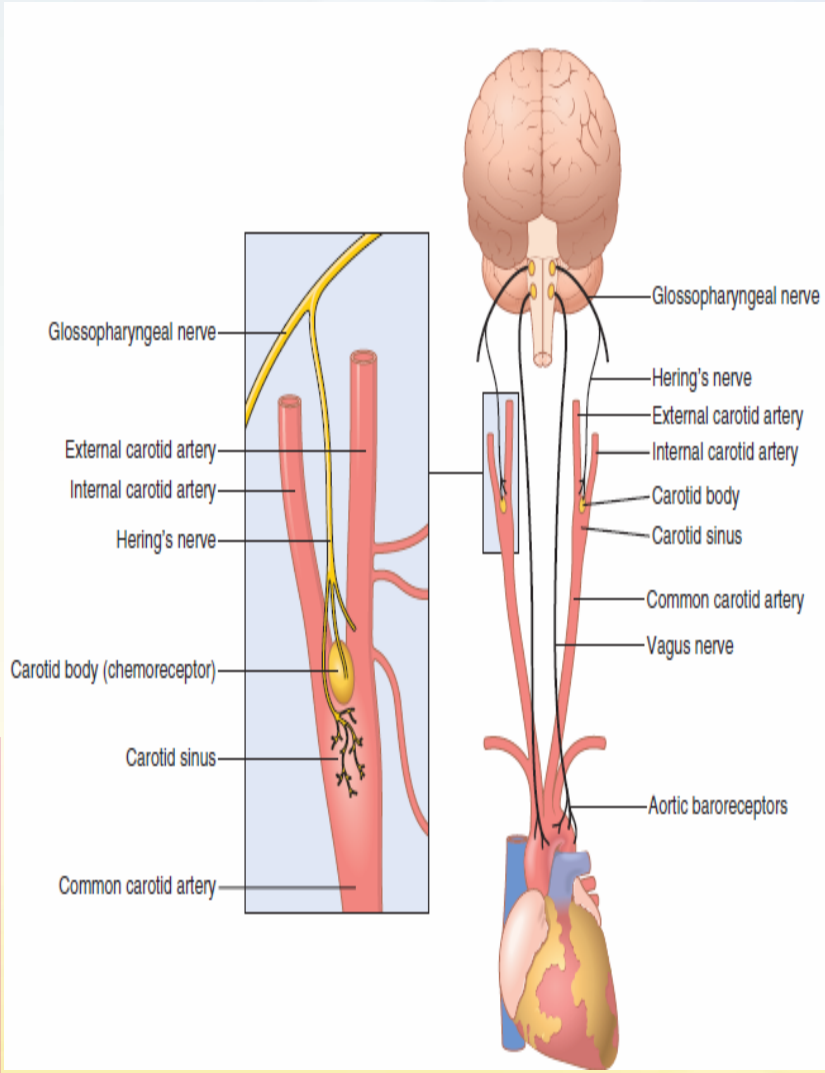
Short Term ABP Regulatory Reflex mechanisms:-



1- The Baroreceptor Reflex

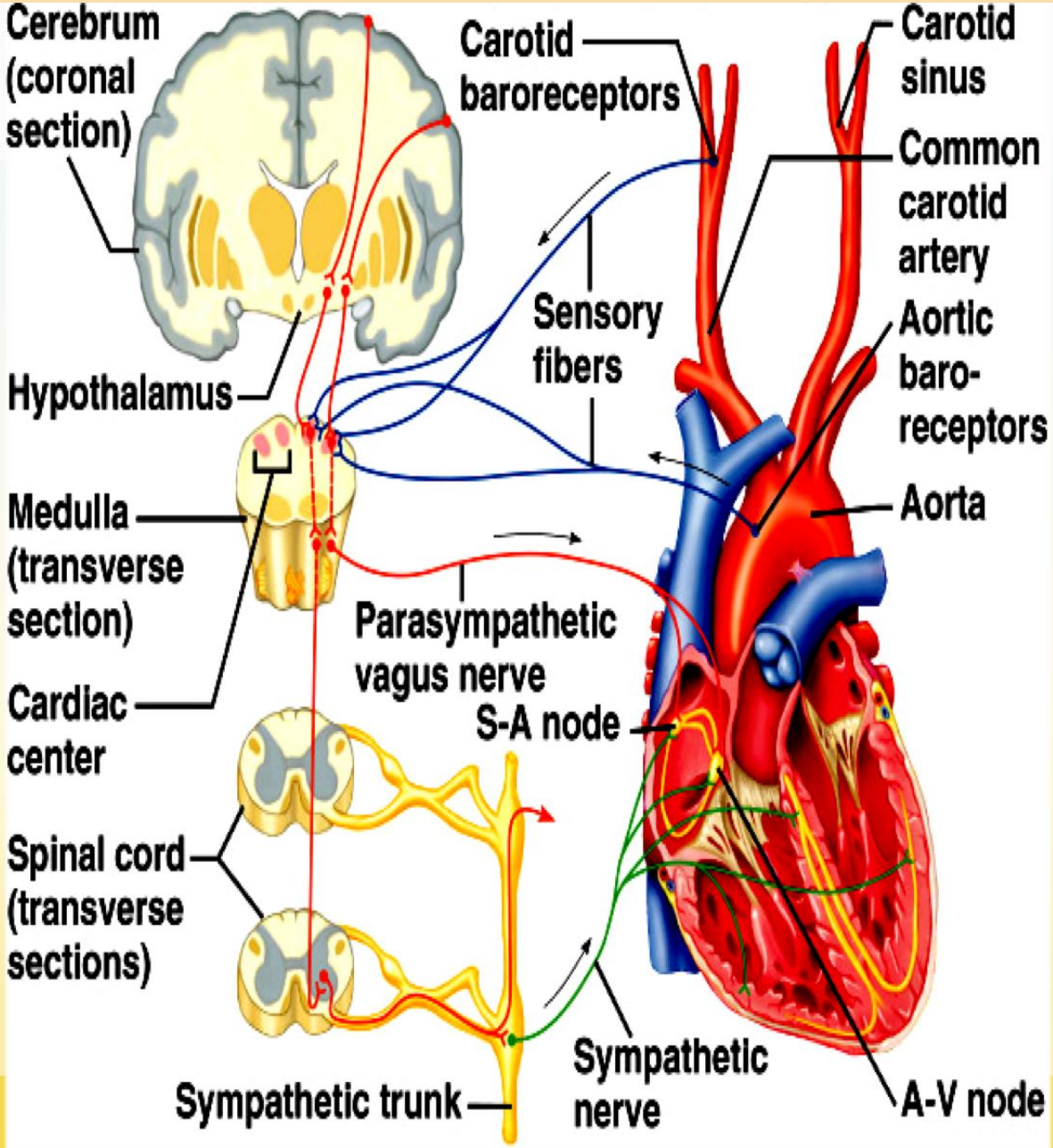
- Baroreceptor are mechano-stretch receptors.
- Located in the wall of aortic arch & carotid sinus.
- Connected to CVC through vagus & Hering's N (branch of glossopharyngeal)
- Provide fast, powerful moment-to-moment control of ABP.

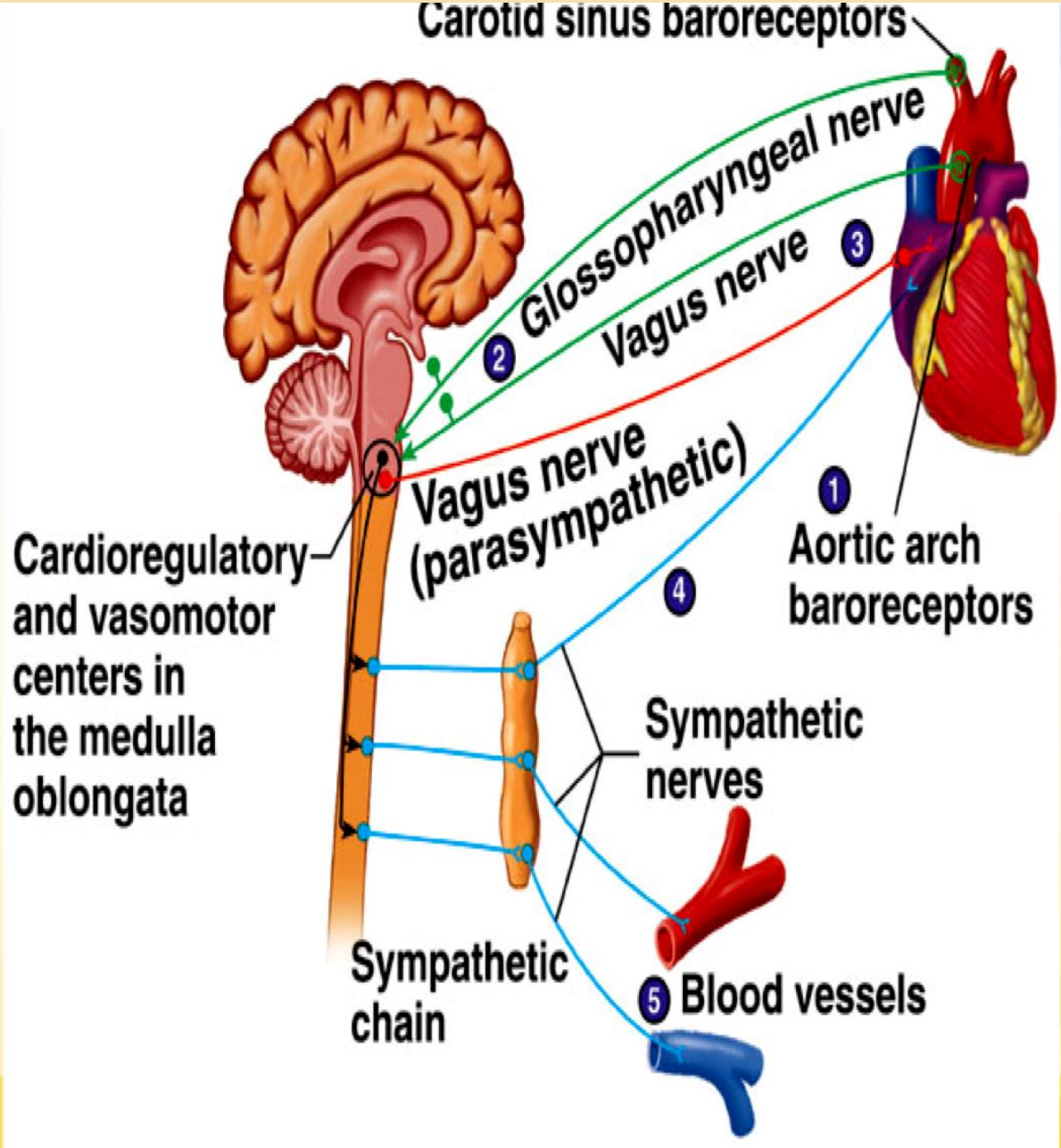
- Respond much more to a rapidly changing pressure than to a stationary pressure.
- Unimportant in long-term ABP regulation as they tend to reset in 1 to 2 days to the high pressure level they are exposed



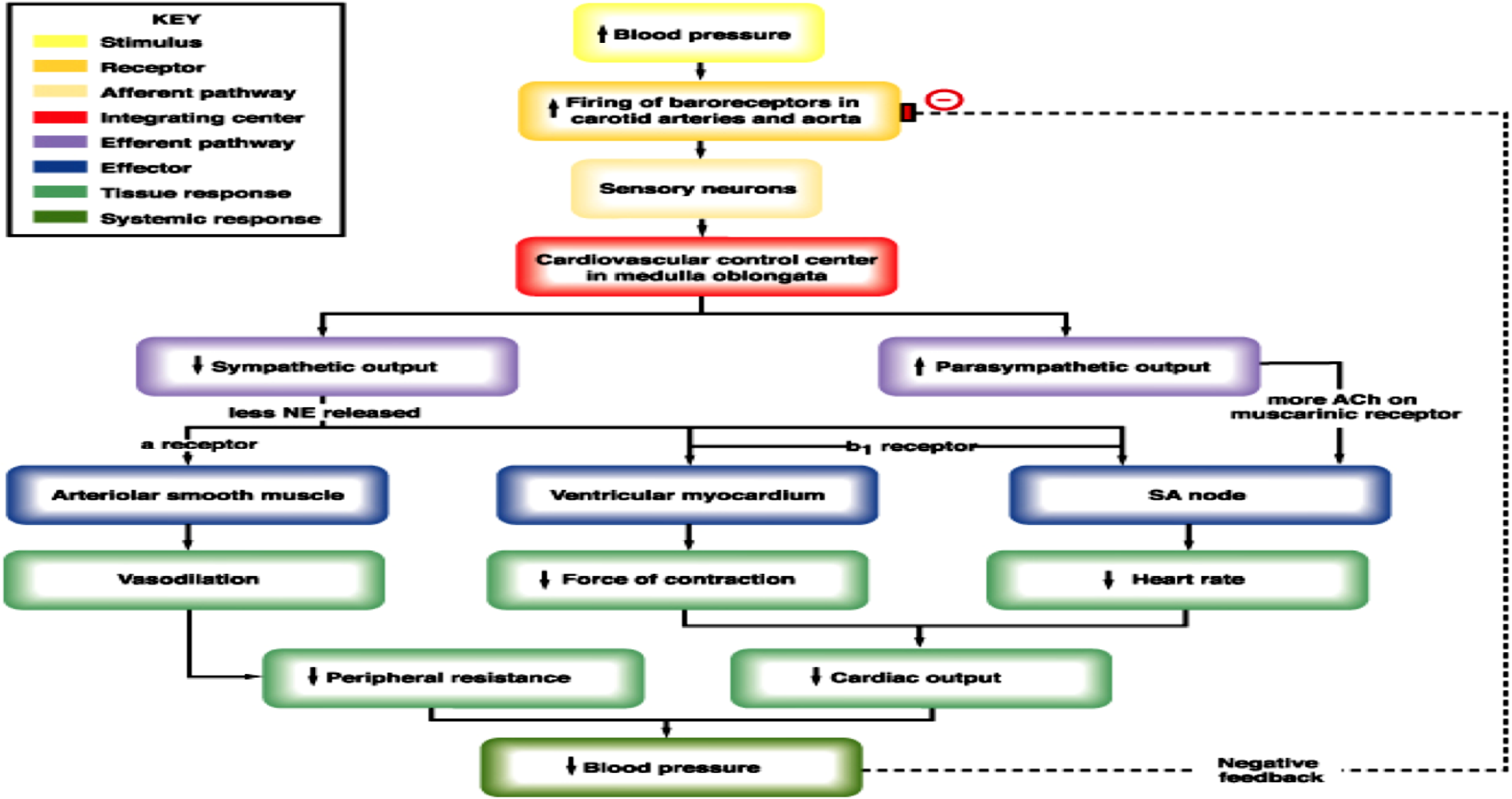
The baroreceptor system for controlling arterial pressure

The Baroreceptors

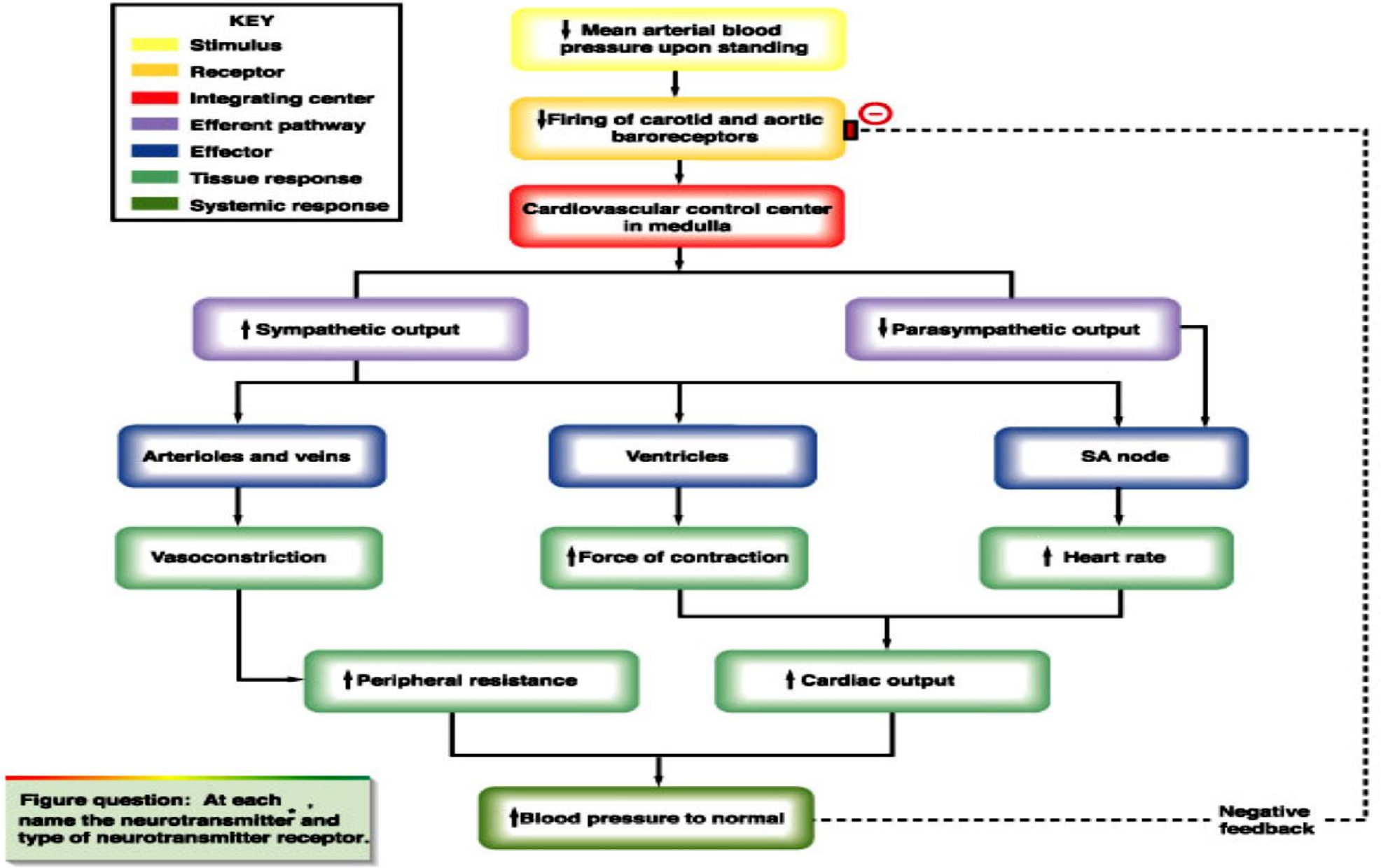




Baroreceptor Reflex in Response to High Mean ABP



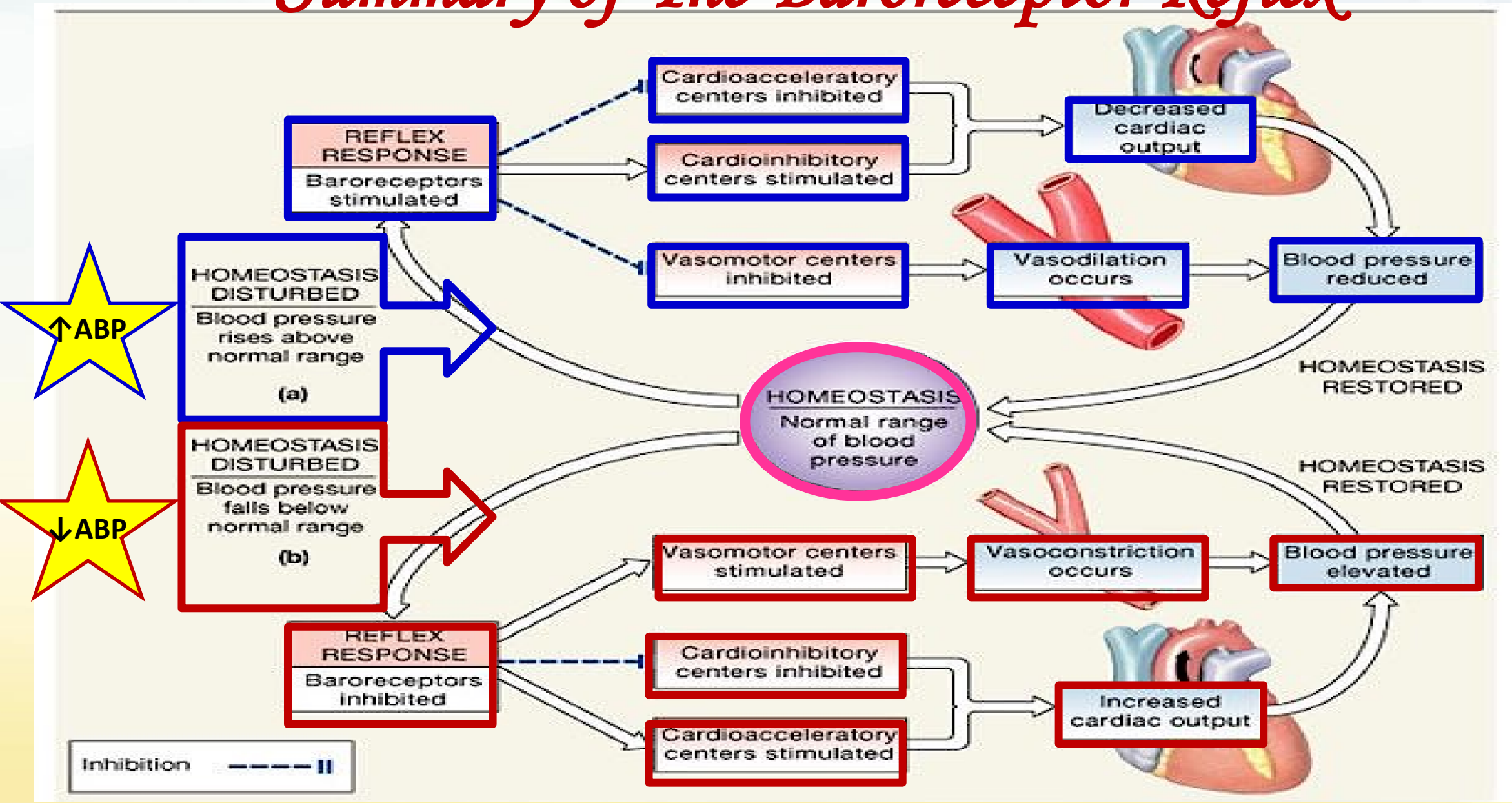
Baroreceptor Reflex in Response to Low Mean ABP



Baroreceptor Reflex Mechanism During Changes in Body Posture

- ✓ **Immediately on standing, ABP in the head & upper part of the body tends to fall ? … Can 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.**

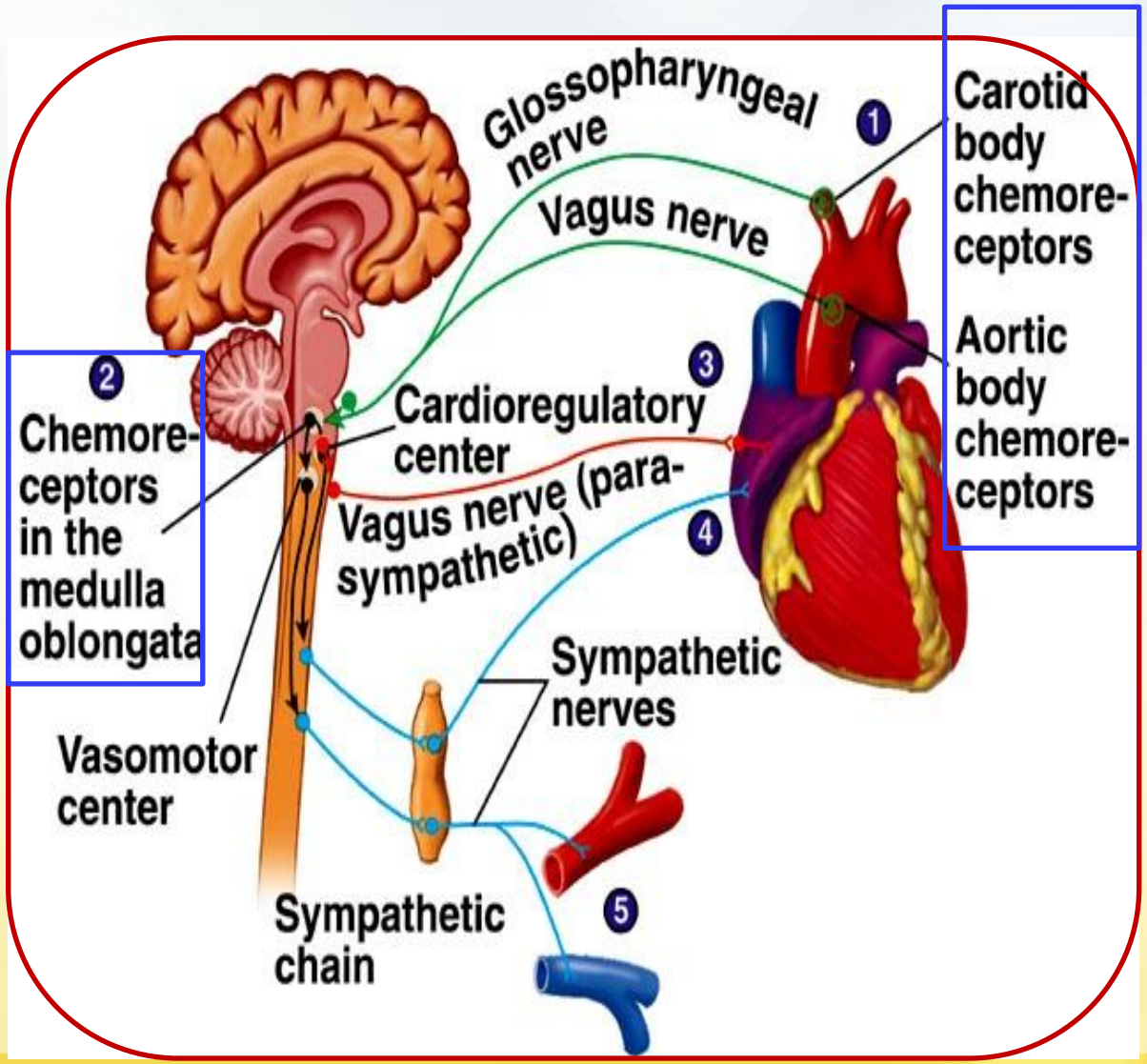
Summary of The Baroreceptor Reflex



2- Chemoreceptor Reflex

Closely associated with the baroreceptor pressure control system.

It operates in much same way as the baroreceptor reflex, EXCEPT that chemoreceptors are chemo-sensitive cells instead of stretch receptors.



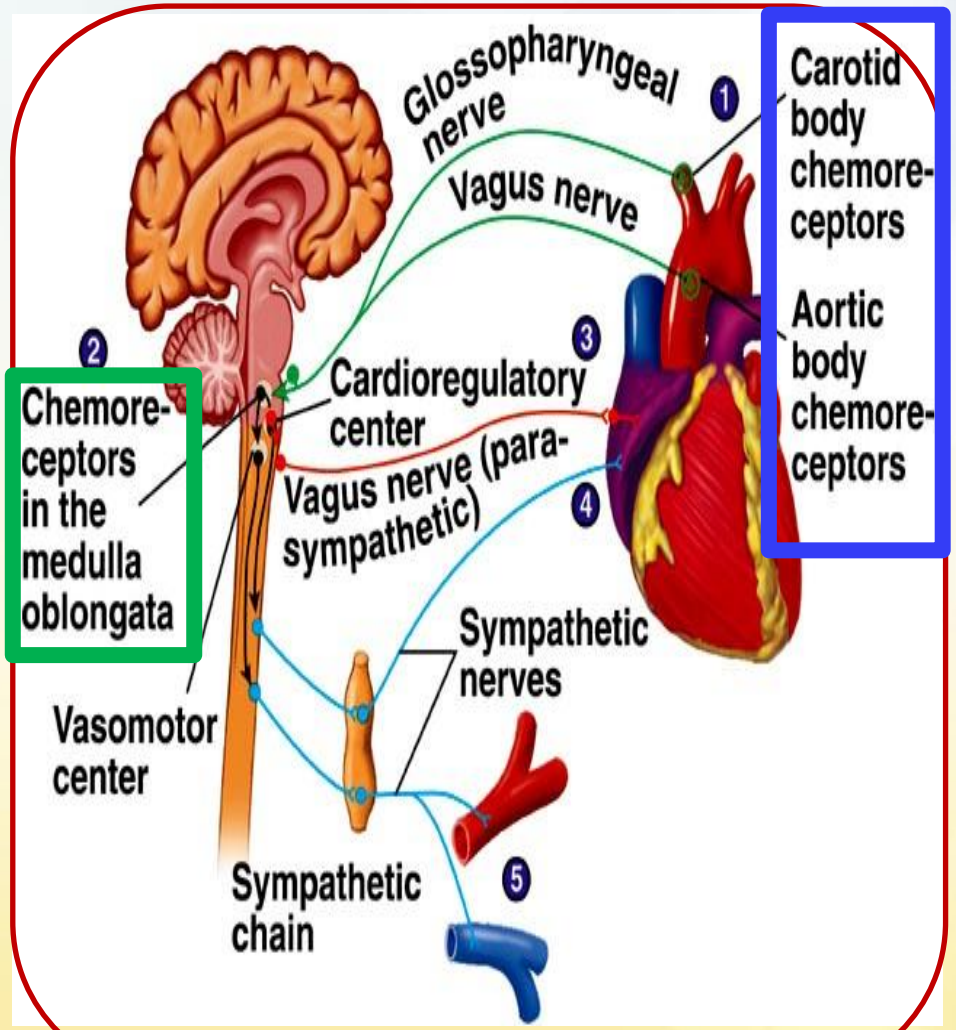
What Are The types of Chemoreceptor

1. ***Peripheral chemoreceptors:***

- 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.

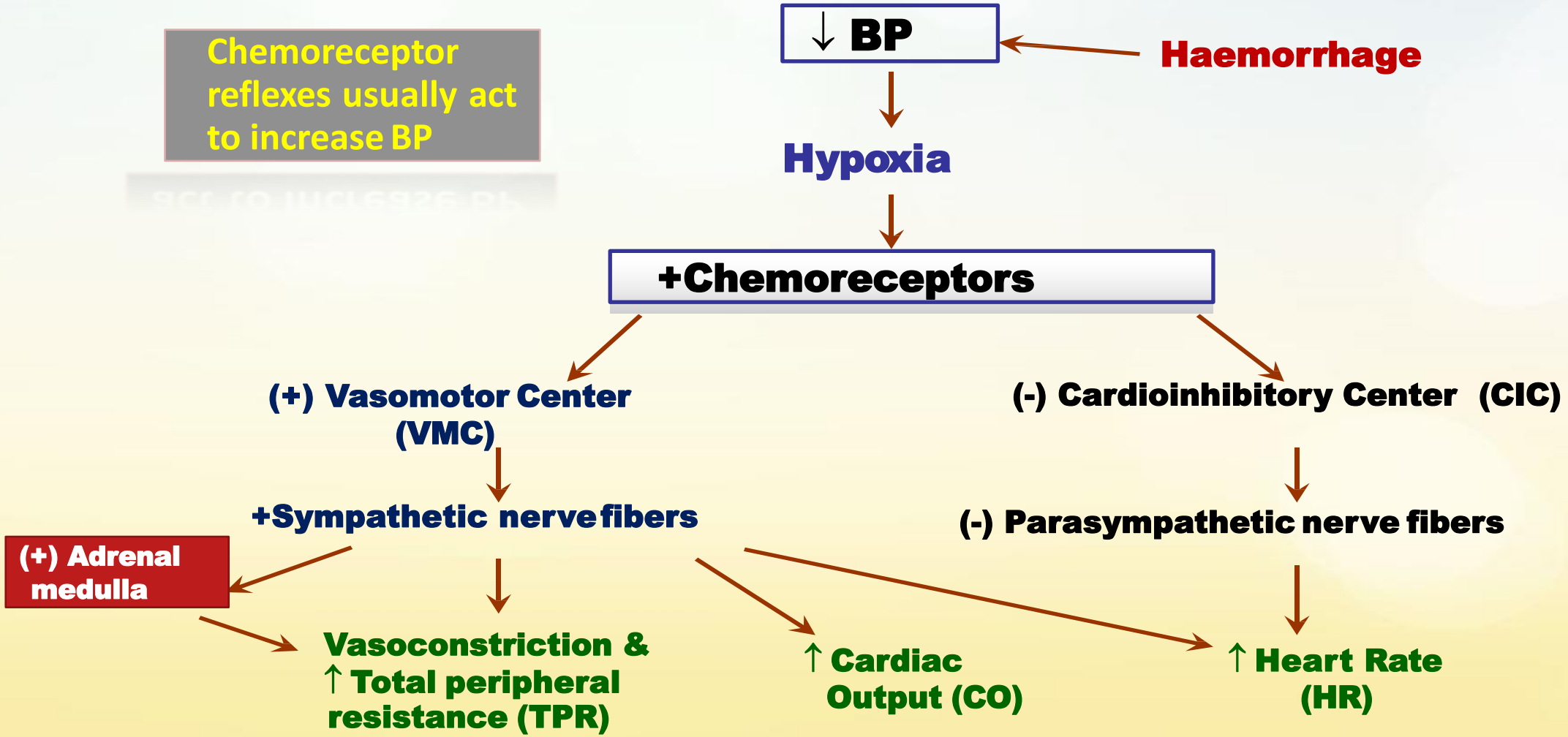
2. ***Central Chemoreceptors:***

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



The Chemoreceptor Reflex

Chemoreceptor reflexes usually act to increase BP



3- CNS Ischemic Response

"Last ditch stand" pressure control mechanism

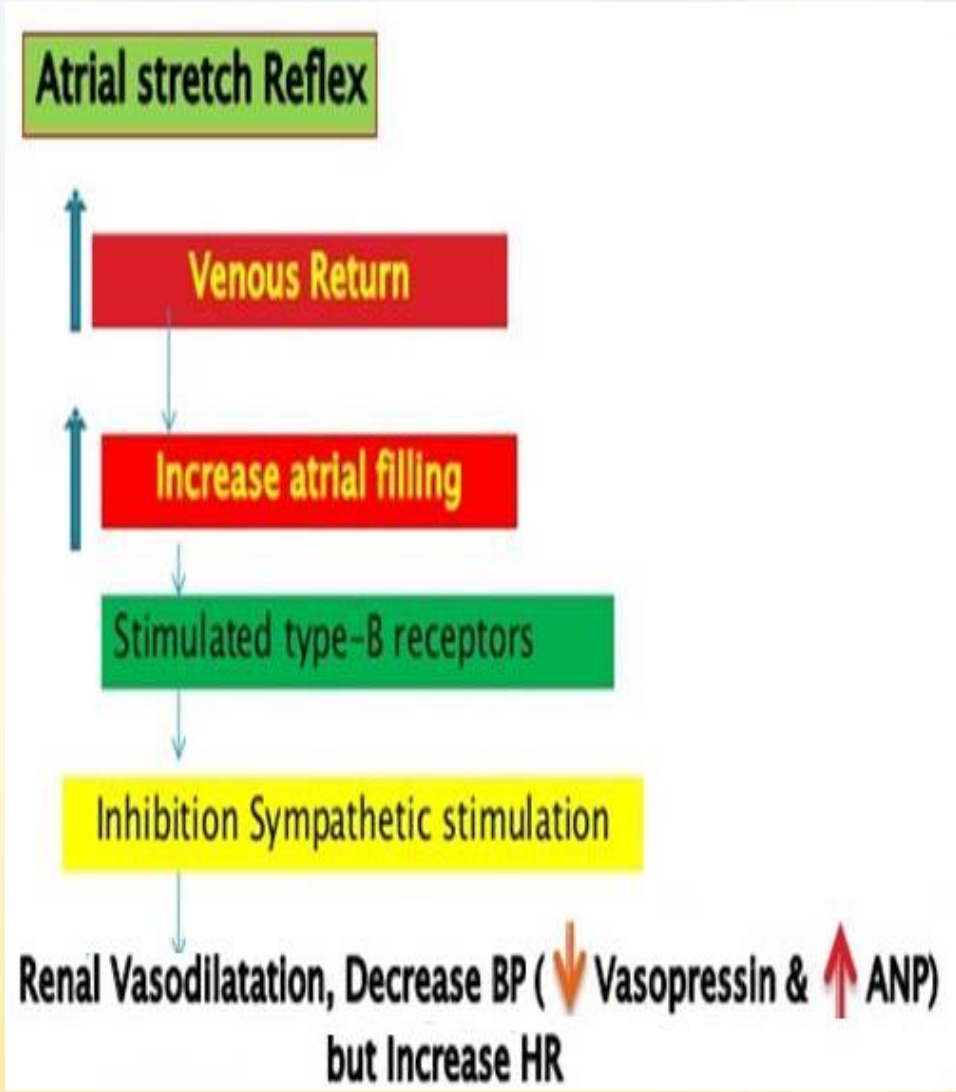
- ✓It is not one of the normal mechanisms for regulating ABP.
- ✓It operates principally as an emergency pressure control system to prevent further decrease in ABP.
- ✓It acts rapidly & very powerfully whenever blood flow to the brain ↓ dangerously close to the lethal level, when ABP falls down to 60 mm Hg and below.
- ✓↓ Blood flow, greatly ↑the concentration of CO_2 in the vasomotor center.
- ✓This has an extremely potent effect in stimulating the sympathetic vasomotor nervous control areas in the brain's medulla.

Other Vasomotor Reflexes

4- <u>Atrial stretch receptor reflex</u>:

↑ Venous return (↑ Blood volume) ⇒ ++ atrial stretch receptors ⇒ :-

- (+) ANP release ⇒ reflex vasodilatation of renal vessels, diuresis and natriuresis
- (-) ADH ⇒ water diuresis
- Stretch of SA node ⇒ ↑ HR (the Bainbridge Reflex)



5- Thermo-receptors reflex: (in skin/hypothalamus)

- Exposure to heat ⇒ vasodilatation.
- Exposure to cold ⇒ vasoconstriction.

6- **Pulmonary receptors reflex:**

- Lung inflation ⇒ vasoconstriction.

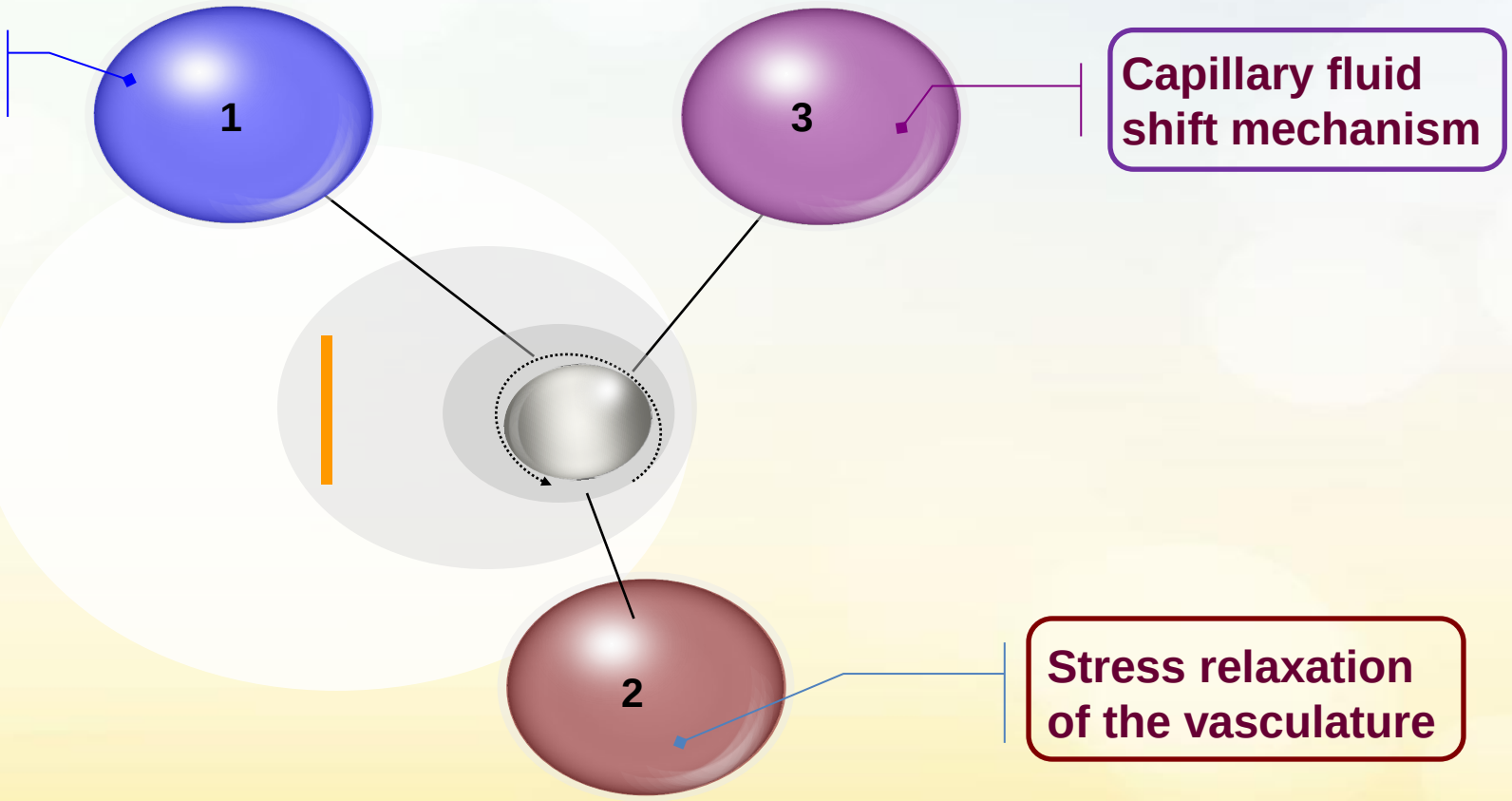
Intermediate Acting Pressure Control Mechanisms for Regulation of ABP

- ✓ Activated within 30 min to several hr.
- ✓ Includes:-
  - The Renin-Angiotensin vasoconstrictor mechanism
  - Stress relaxation of the vasculature
  - Capillary fluid shift

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

Intermediate acting pressure control mechanisms include:

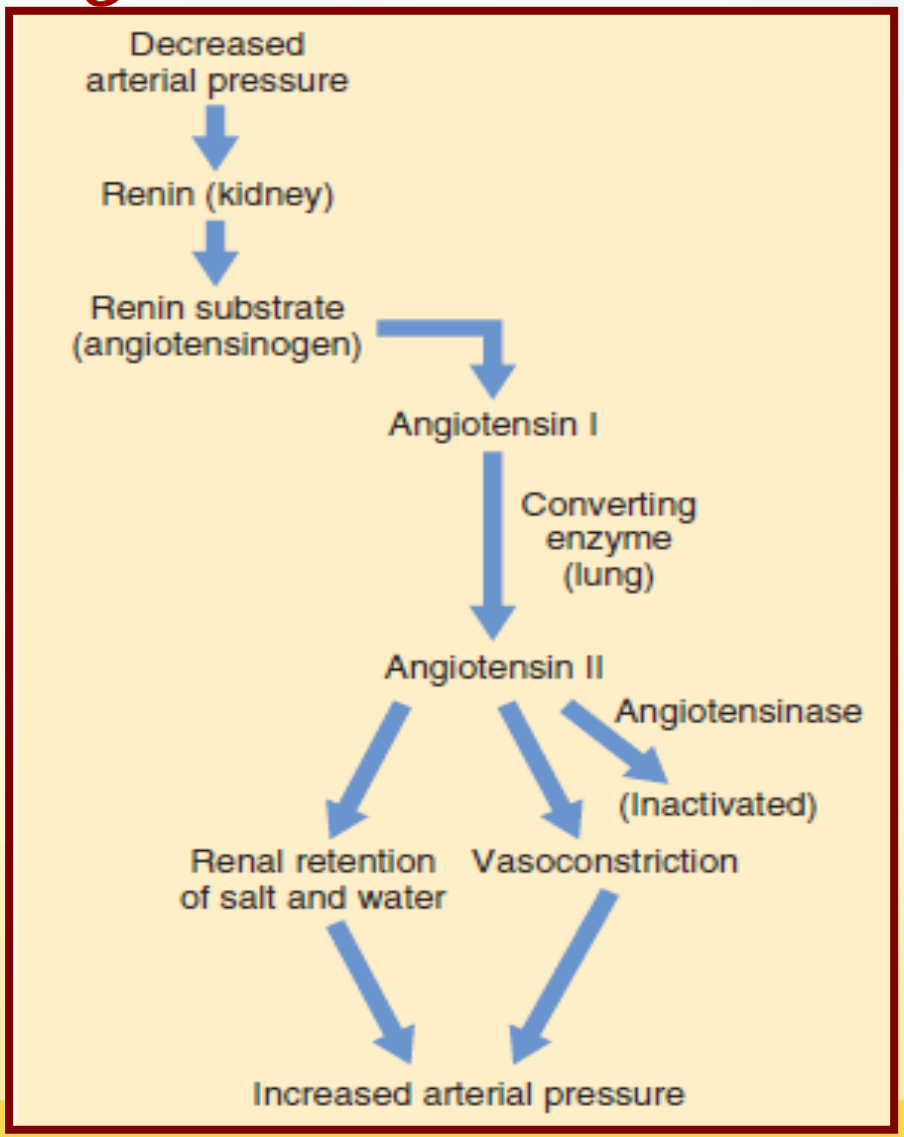
The Renin-Angiotensin–vasoconstrictor mechanism



Capillary fluid shift mechanism

Stress relaxation of the vasculature

1.Renin-Angiotensin vasoconstrictor mechanism

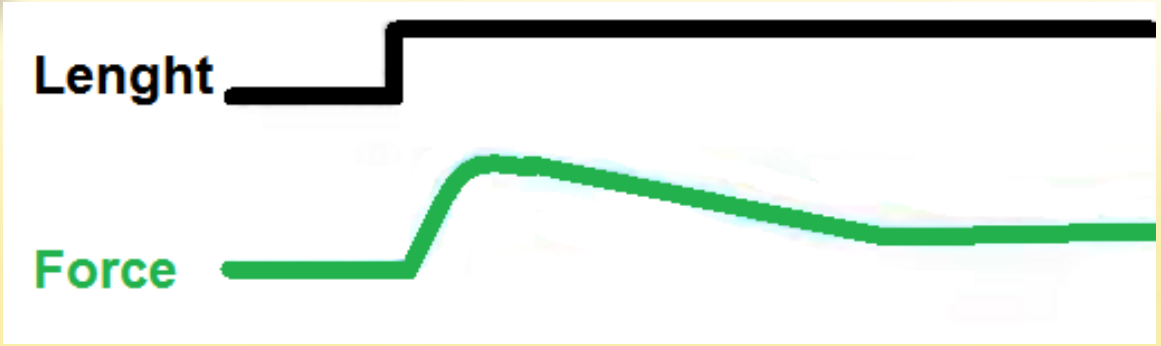


2. Stress-Relaxation Mechanism

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.

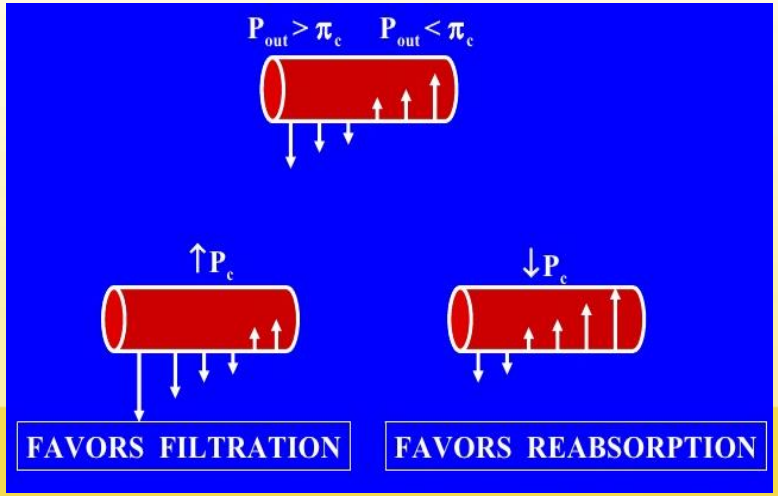
This continuing stretch of the vessels can serve as an intermediate-term pressure "buffer."



3. Capillary Fluid Shift Mechanism

Movement of fluid between interstitial spaces & capillaries

When capillary pressure ↑ too high, fluid is lost out of circulation into the tissues (filtration), reducing blood volume as well as all pressures throughout circulation.



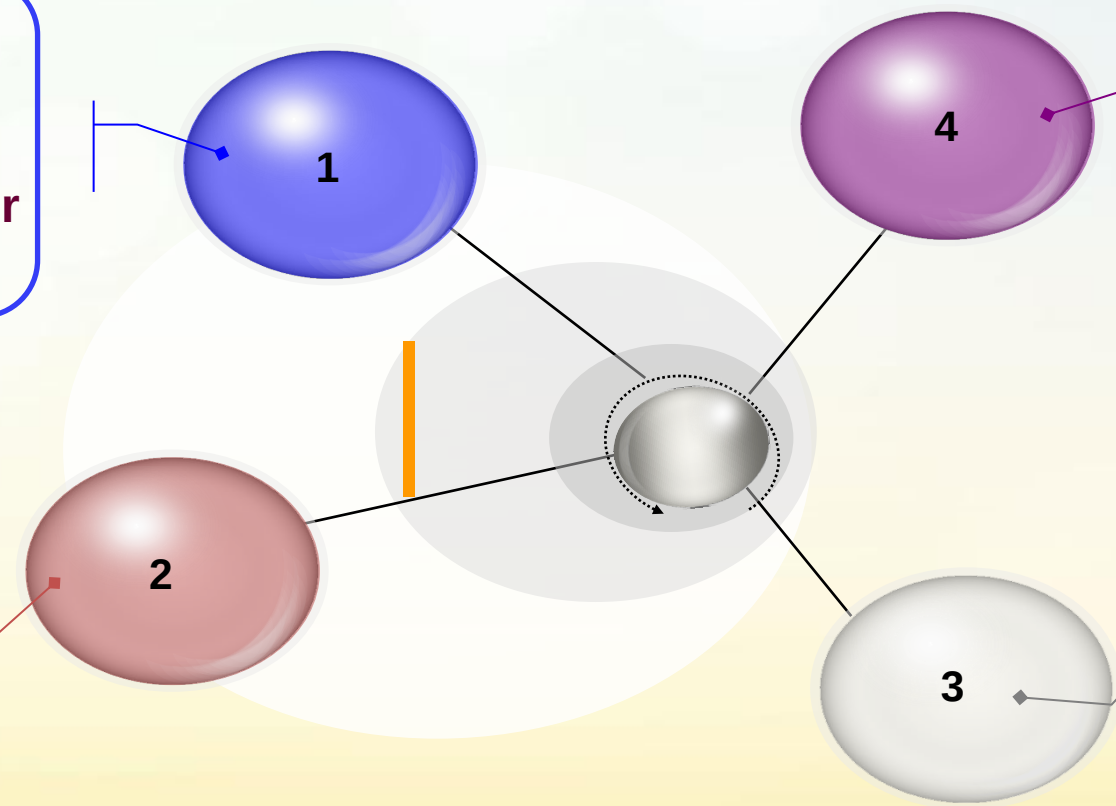
Conversely, when capillary pressure ↓ too low, fluid reabsorption from tissues into the circulation, increase blood volume & pressures throughout circulation.

Long Acting Pressure Control Mechanisms for Regulation of ABP

- ✓ **Hormonally- Mediated Regulation of ABP**
- ✓ **Slow response, takes over few hours to begin showing significant response.**
- ✓ **Concerned in regulating blood volume (Mainly renal): acts if BP is too low**

Long acting pressure control mechanisms include:

The Renin-Angiotensin – Aldosterone Vasoconstrictor Mechanism

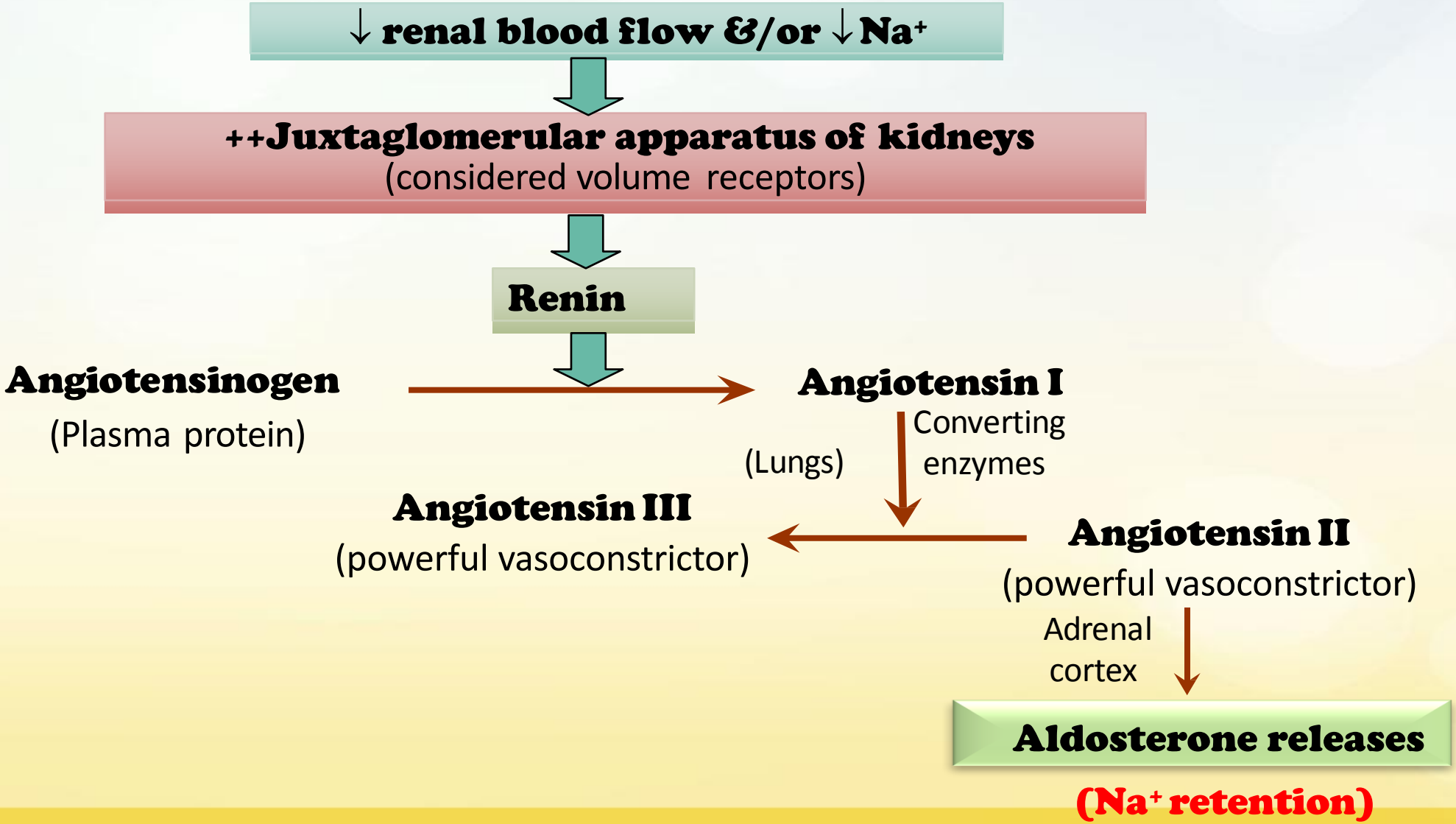


Erythropoietin (EPO)

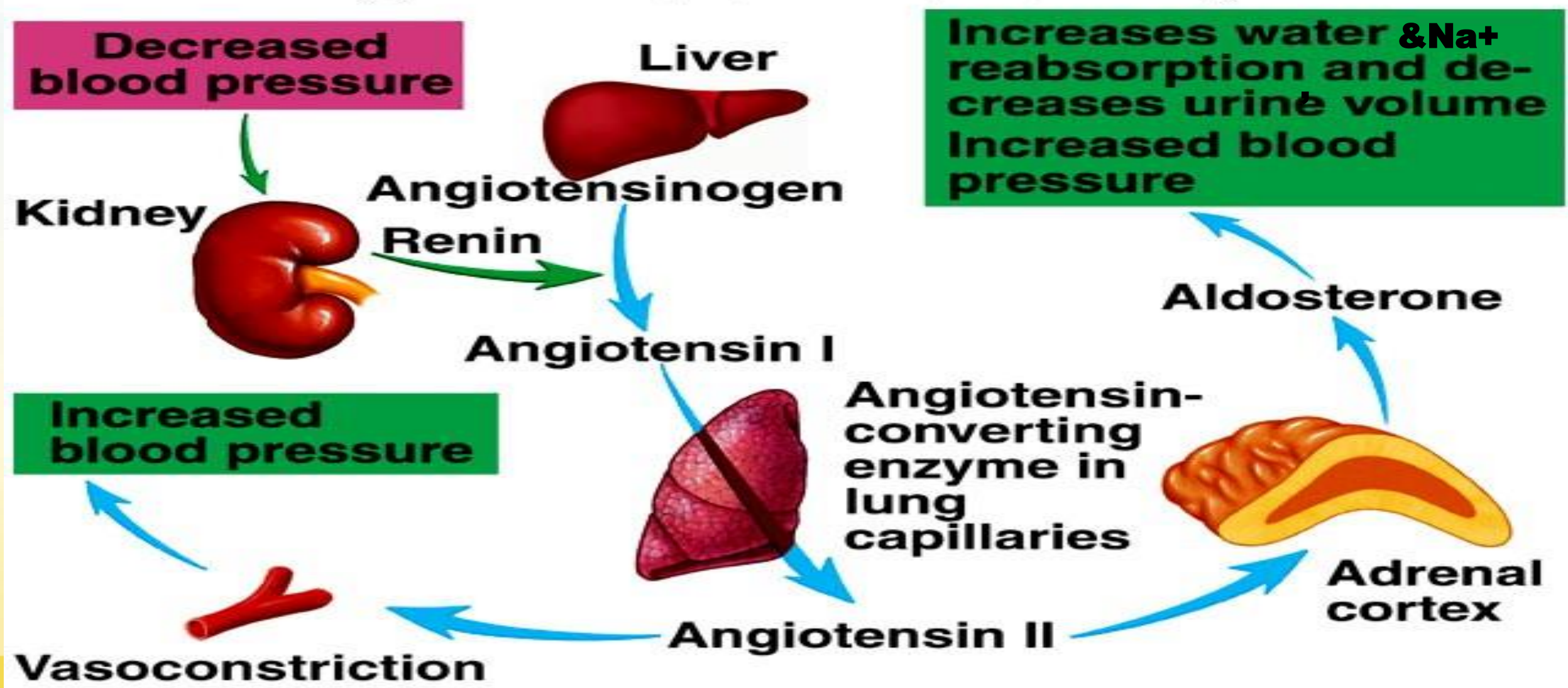
Vasopressin [Anti-diuretic hormone (ADH)] Mechanism

Atrial Natriuretic Peptide (ANP) Mechanism (Low-pressure volume receptors)

1. The Renin-Angiotensin–Aldosterone Vasoconstrictor Mechanism



The Renin-Angiotensin–Aldosterone Vasoconstrictor Mechanism



Functions of Angiotensin II

1. Potent vasoconstrictor
2. It stimulates release of aldosterone
3. Na+ & water reabsorption
4. blood volume and pressure rise

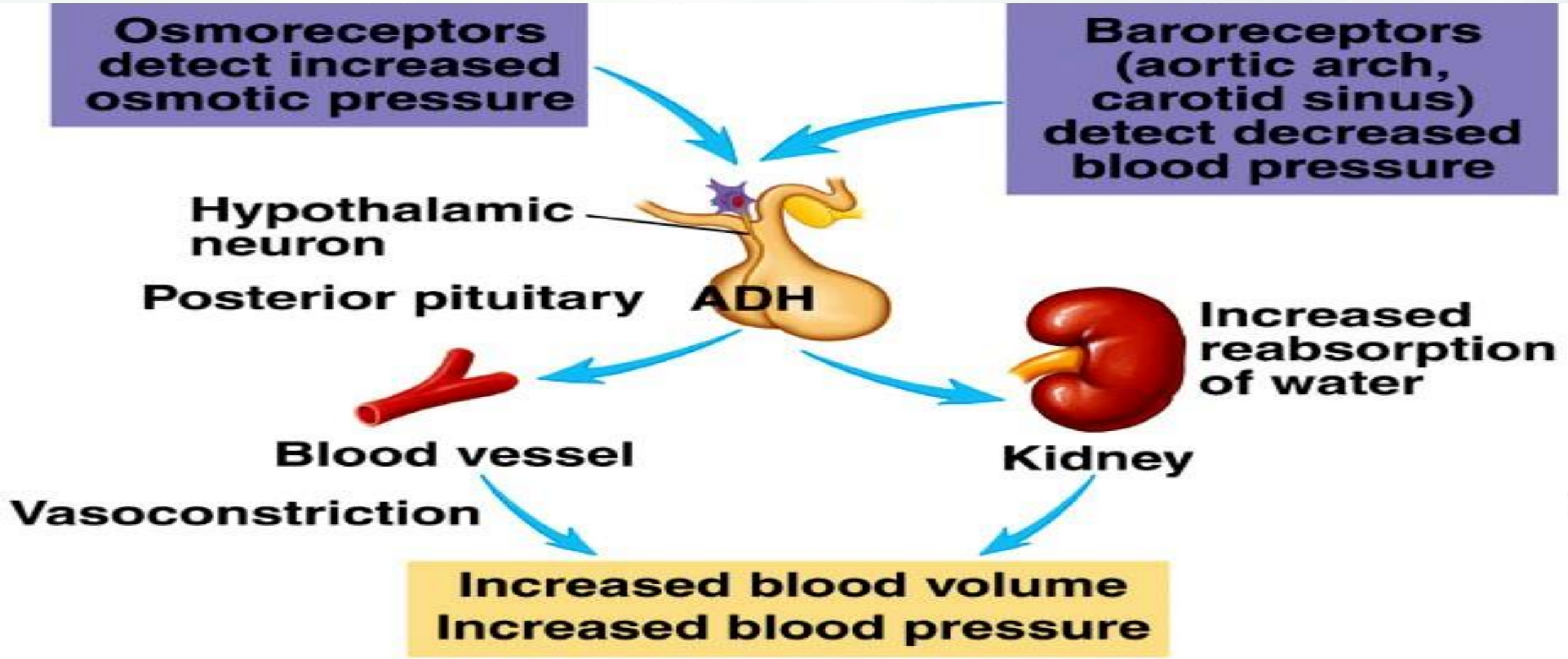
2. Anti-diuretic hormone (ADH), or vasopressin

Hypovolemia & dehydration stimulates Hypothalamic Osmoreceptors.

ADH will be released from posterior pituitary gland:

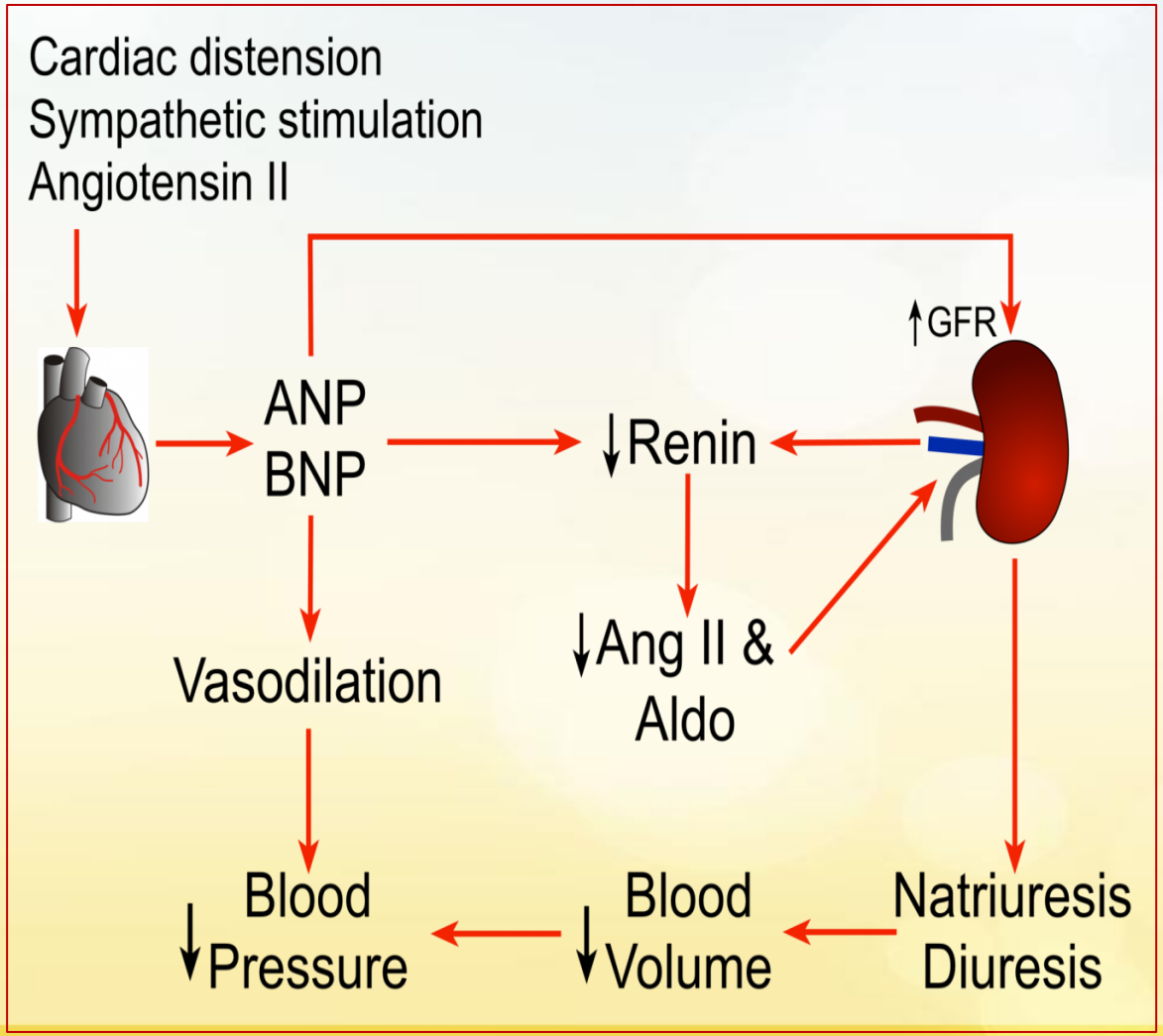
- Promotes water reabsorption at kidney tubules → ↑ blood volume.
- Causes vasoconstriction, in order to ↑ ABP.
- Thirst stimulation.
- Usually when secreted, aldosterone is also secreted.

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



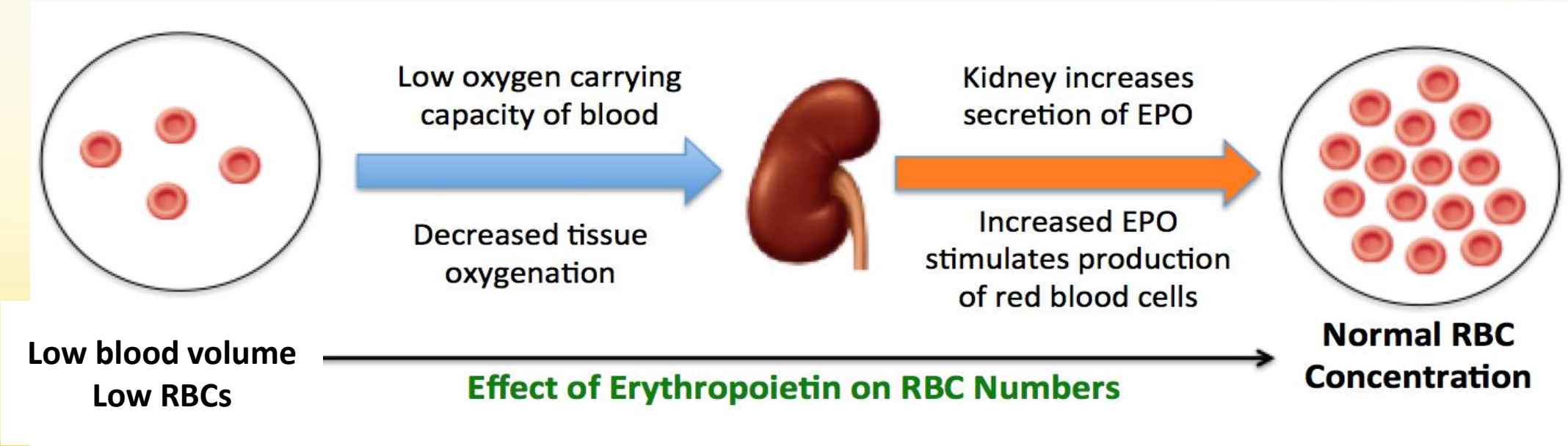
3. Atrial Natriuretic Peptide (ANP) hormone

- Hormone released from cardiac muscle cells (wall of the right atrium) in response to an increase in blood volume (Low-pressure volume receptors).
- Simulates an ↑ in urine output (diuresis) and natriuresis, thus ↓ blood volume & blood pressure.



4. EPO (Erythropoietin)

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



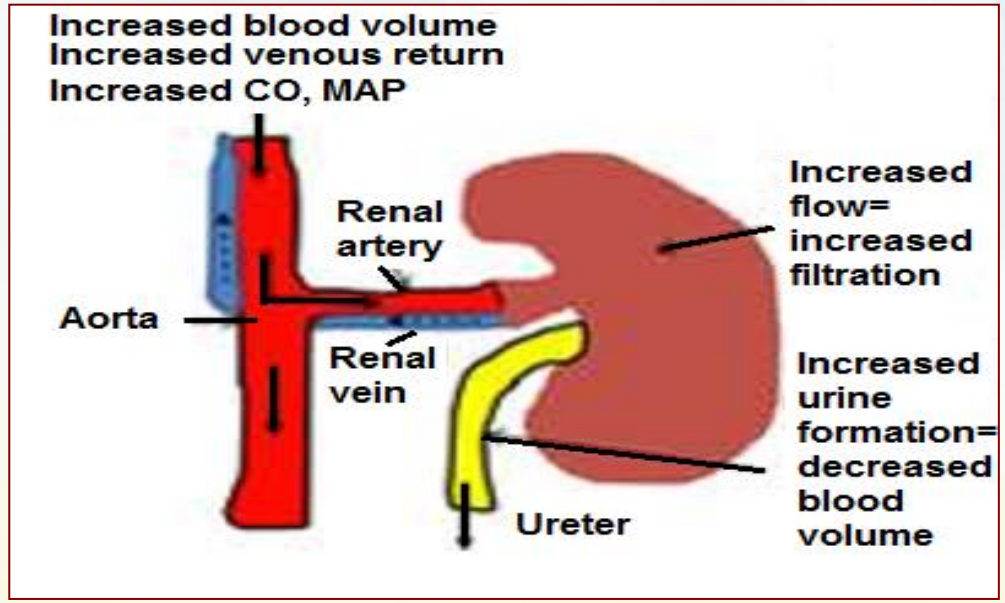
The role of the kidneys in long-term control of ABP

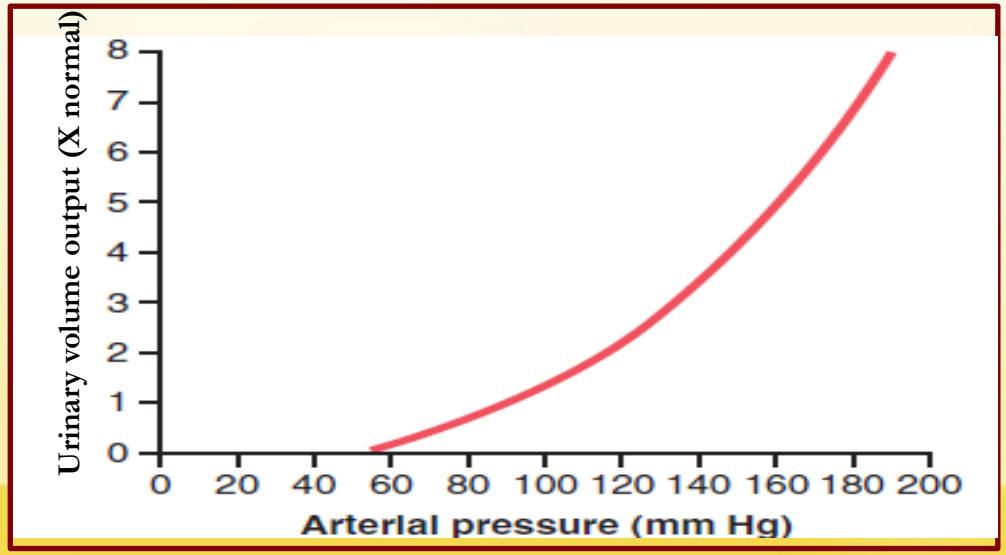
I- The renal–blood volume pressure control mechanism:-

The kidneys regulate ABP by changing blood volume.

- ✓ An increase in arterial pressure of only a few mm Hg can double renal output of water (pressure diuresis), as well as double the output of salt (pressure natriuresis), thus returning the pressure back toward normal.

- ✓ When blood pressure falls, the kidneys retain body water, increasing blood volume and returning the pressure back toward normal.

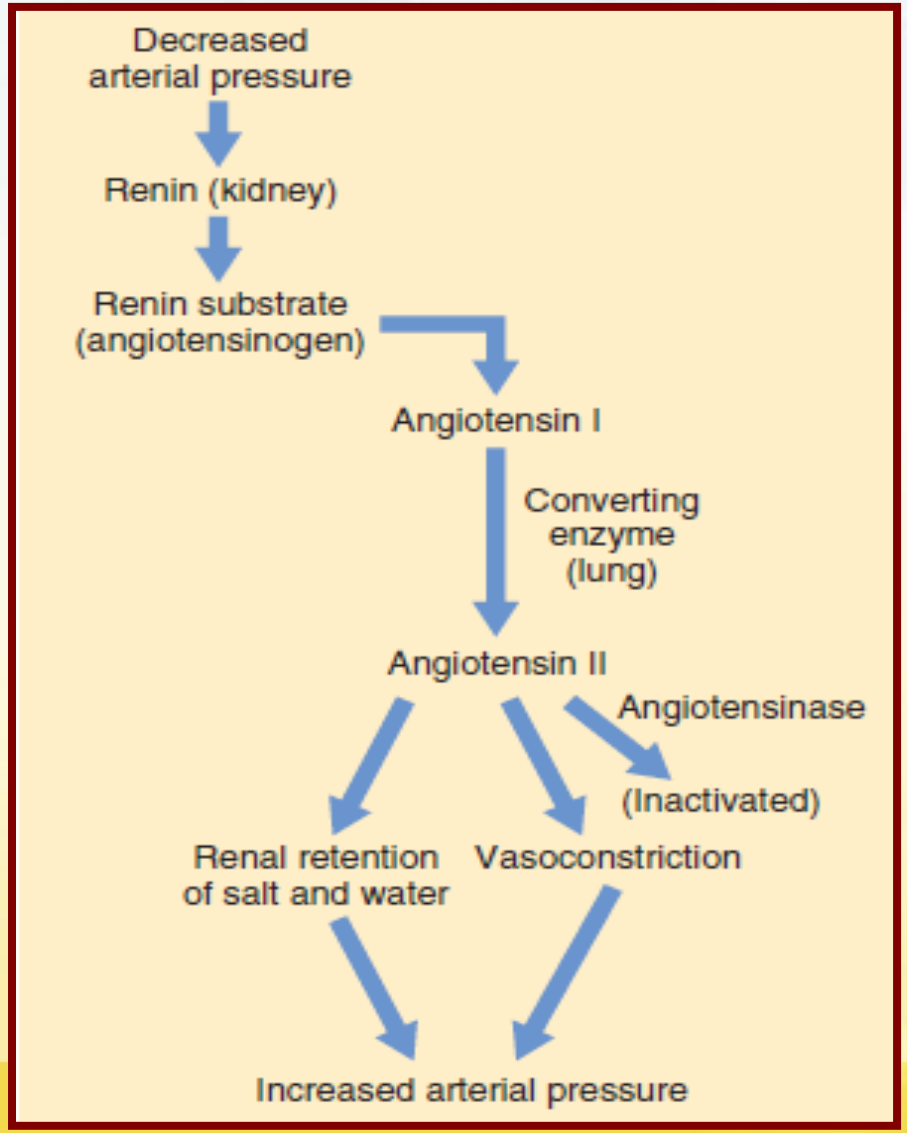




The role of the kidneys in long-term control of ABP…Cont.

II- Renin-Angiotensin–Aldosterone vasoconstrictor mechanism:-

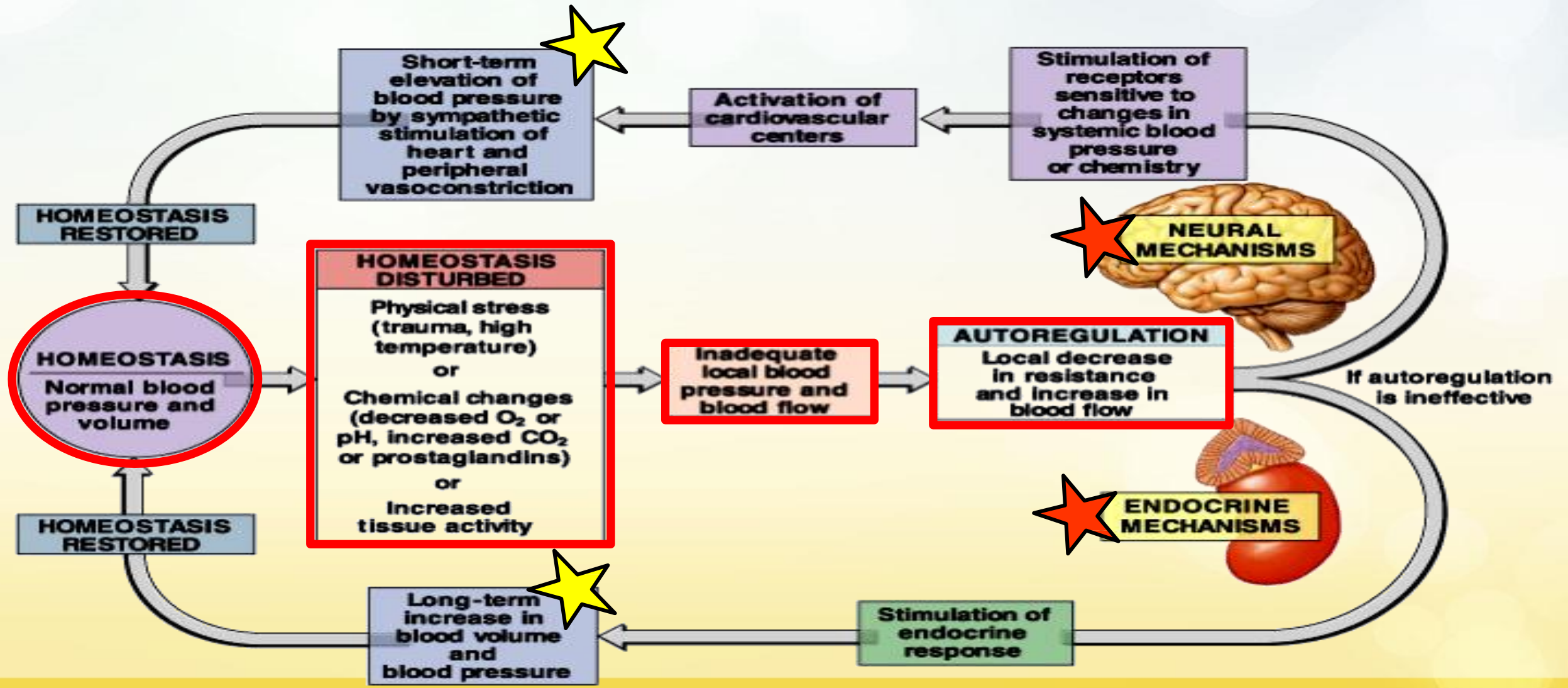
- ✓ In addition, the kidneys have more important role in Renin-Angiotensin–Aldosterone vasoconstrictor mechanism when ABP falls (as mentioned before).
- ✓ Renal mechanisms for ABP control take a few hours to begin showing significant response. Yet, it eventually develops a feedback gain for control of ABP nearly equal to infinity.



Summary of pressure control mechanisms of ABP

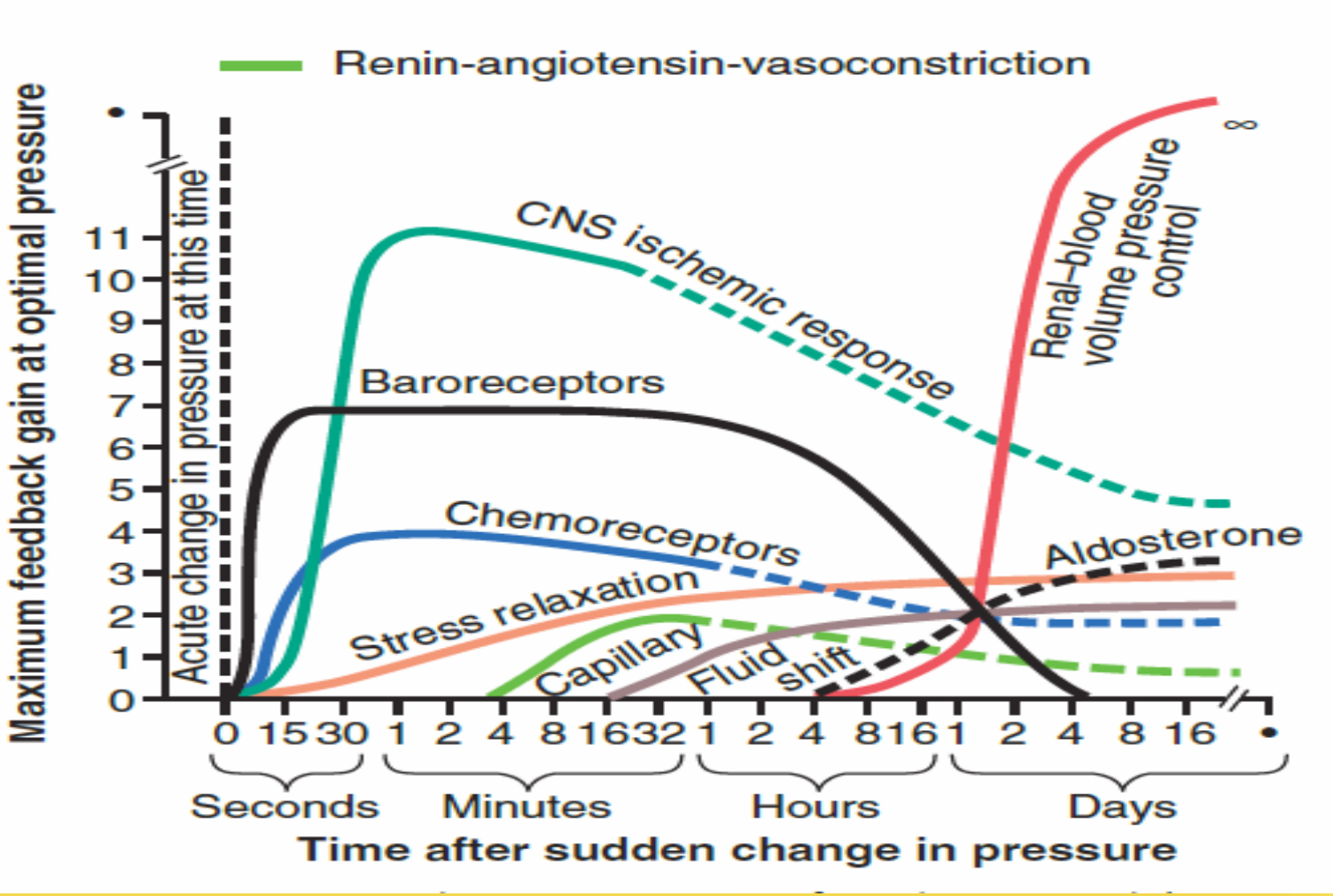
1. **Arterial pressure control begins with the lifesaving measures of the nervous pressure controls.**
2. **Continues with the sustaining characteristics of the intermediate pressure controls.**
3. **Finally, is stabilized at the long-term pressure level by the renal–body fluid mechanism.**
4. **The long-term mechanism has multiple interactions with renin-angiotensin-aldosterone system, nervous system and other factors that provide special ABP control capabilities.**

Summary of pressure control mechanisms of ABP



Potency of Various Arterial Pressure Control Mechanisms at Different Time Intervals After The Onset of a Disturbance to ABP

Note especially the infinite gain (∞) of the renal body fluid pressure control mechanism that occurs after a few weeks' time.




THANK YOU!