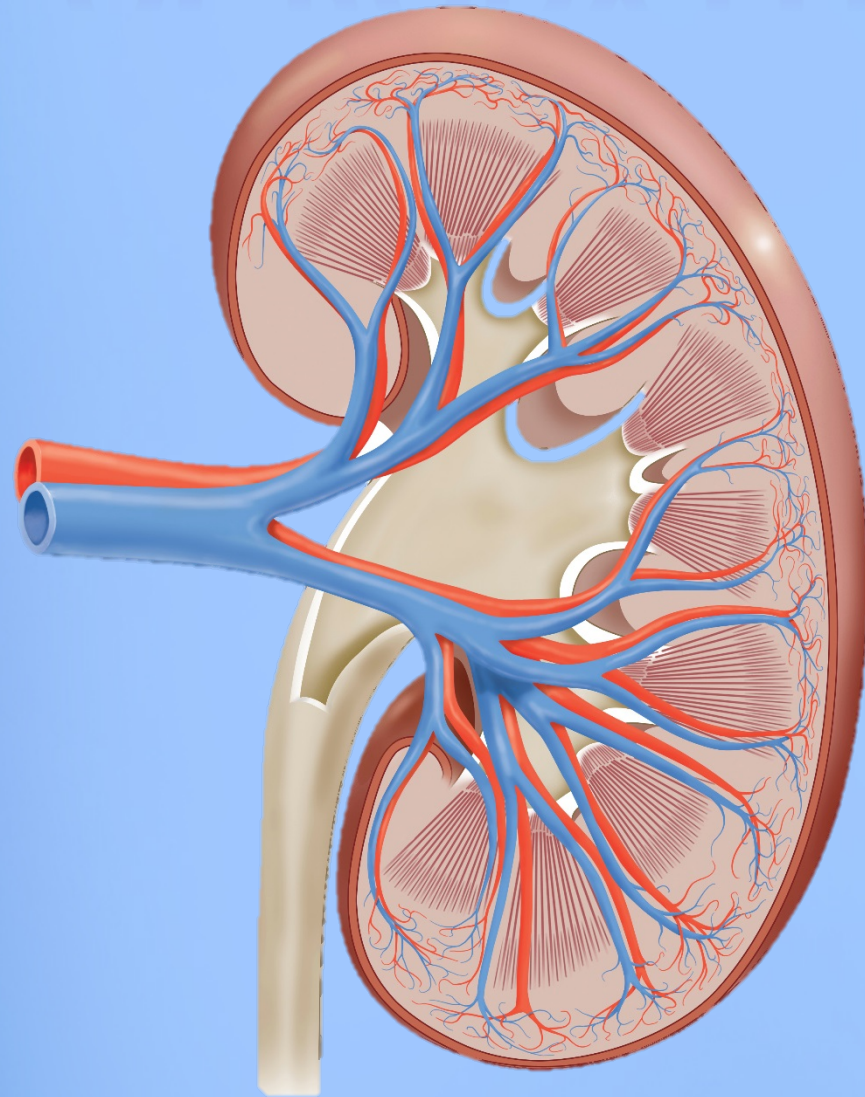


# 7

## RENAL REGULATION OF BODY FLUID



Renal Block

# Objectives

Identify and describe the role of the Sensors and Effectors in the renal regulation of body fluid volume & osmolality

Identify the site and describe the influence of aldosterone on reabsorption of Na<sup>+</sup> in the late distal tubules.

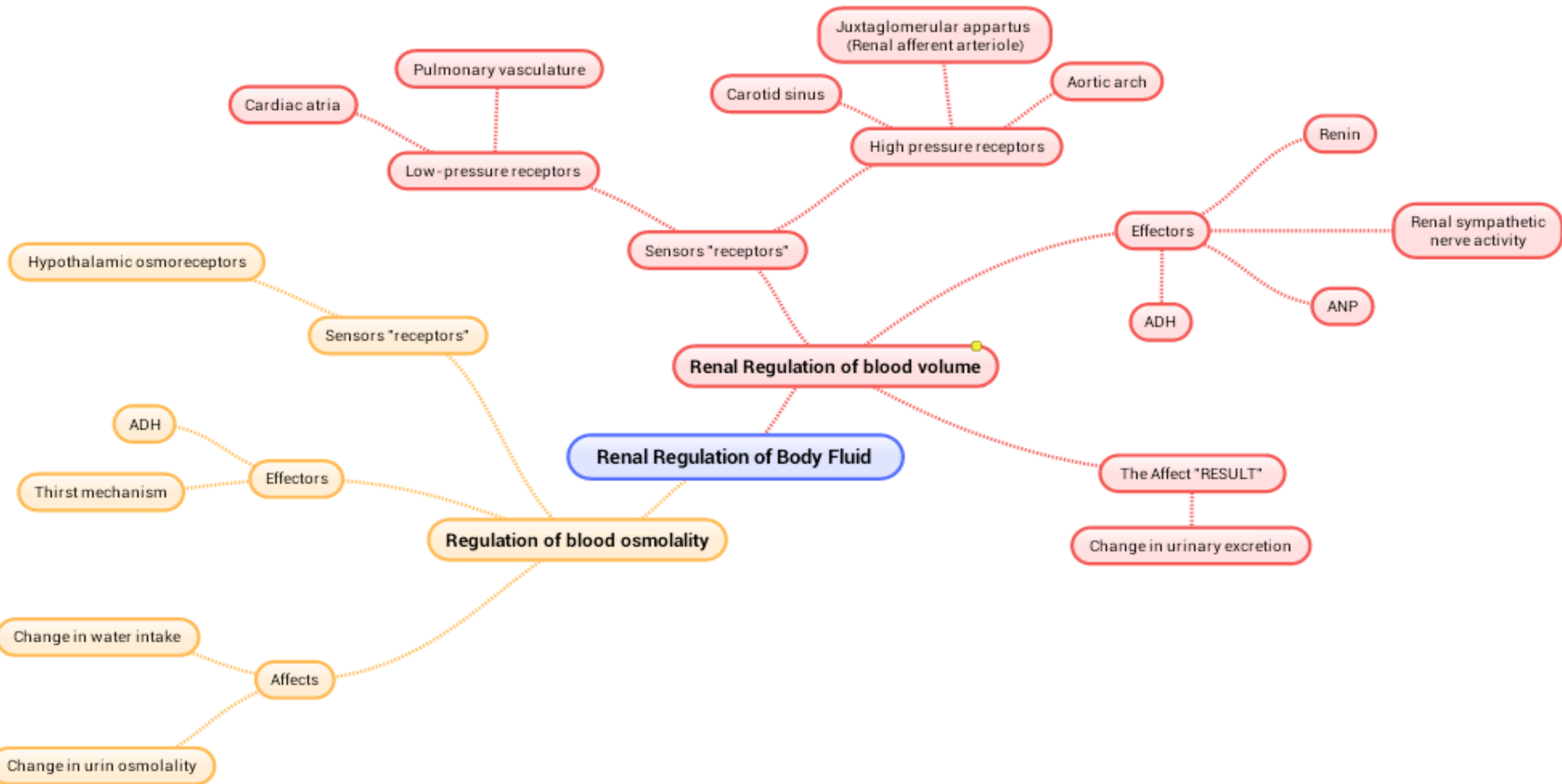
Describe the role of the kidney in regulation of body fluid volume & osmolality

Understand the role of ADH in the reabsorption of water and urea

# Abbreviations

<b>ADH</b>	Antidiuretic hormone
<b>ECF</b>	Extracellular fluid
<b>ECV</b>	Effective Circulating Volume
<b>ANF</b>	Atrial natriuretic factor
<b>ANP</b>	ATRIAL NATRIURETIC PEPTIDE
<b>PCT</b>	Proximal convoluted tubules
<b>AVP</b>	arginine vasopressin

# Mind map



# BLOOD VOLUME REGULATION:

Blood volume remains exactly constant despite extreme changes in daily fluid intake and the reason for that is :

1- slight change in blood volume → marked change in cardiac output

2- a slight change in cardiac output → large change in blood pressure

3- slight change in blood pressure → large change in URINE OUTPUT .

Renal regulation of Extra Cellular Volume Is a reflex mechanism in which variables reflecting total body sodium and ECV are monitor by appropriate sensor (receptors)

Regulation of ECF volume =  
Regulation of body Na+= Regulation BP

Thus, regulation of Na<sup>+</sup> also dependent upon baroreceptors.



## Sensors

1- Carotid sinus

2- Volume receptors  
(large vein, atria,  
intrarenalartery)

## Effectors

1- Rennin angiotensin,  
aldosterone.

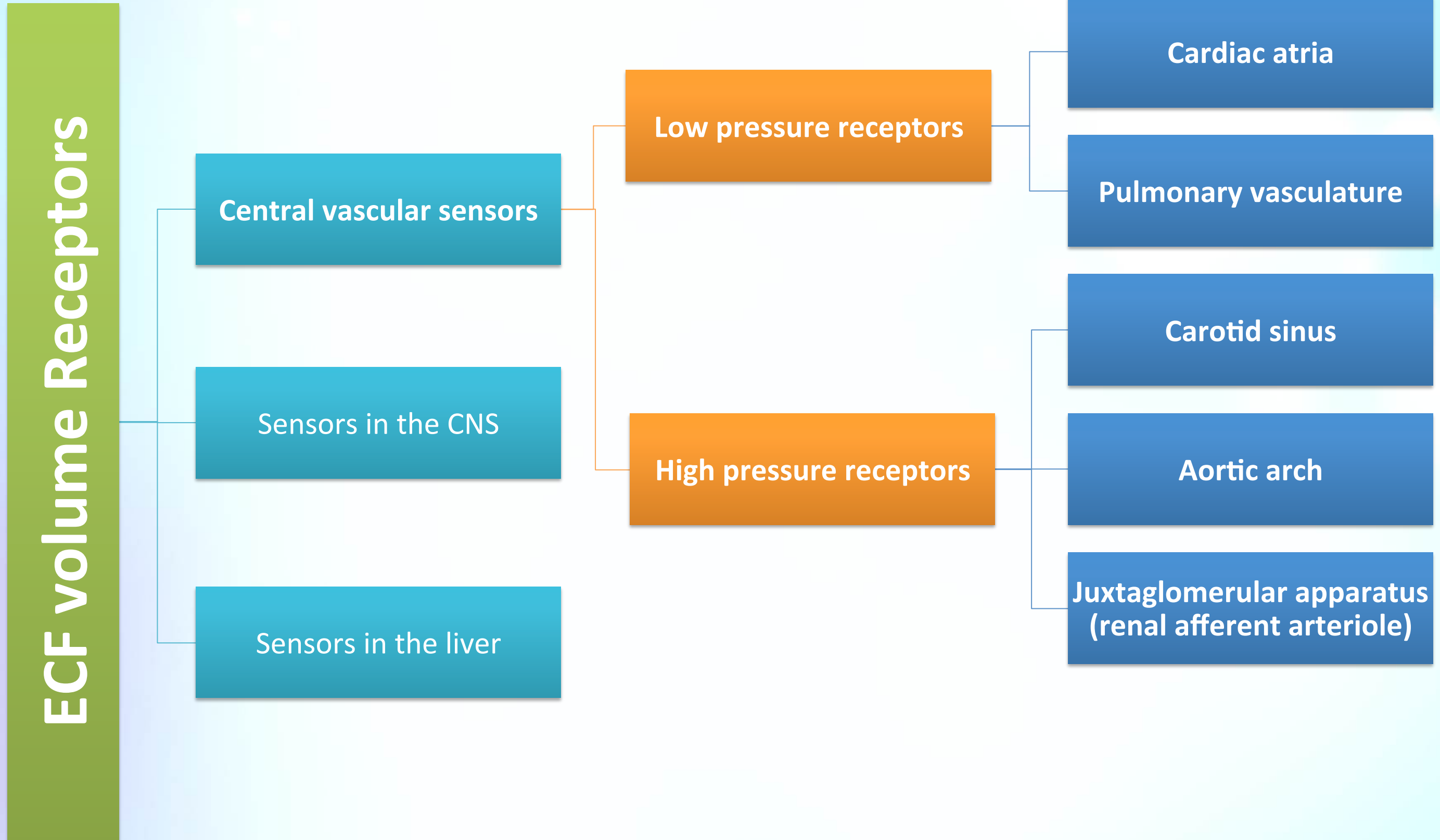
2- ADH

3- Renal sympathetic  
nerve

4- ANP

## Affecting

Urinary Na excretion.  
( the result will cause  
a change in  $\text{Na}^+$  and  
water excretion either  
by increasing it or  
decreasing it ) .



**ECF volume Receptors**

Central vascular sensors

Sensors in the CNS

Sensors in the liver

Low pressure receptors

High pressure receptors

Cardiac atria

Pulmonary vasculature

Carotid sinus

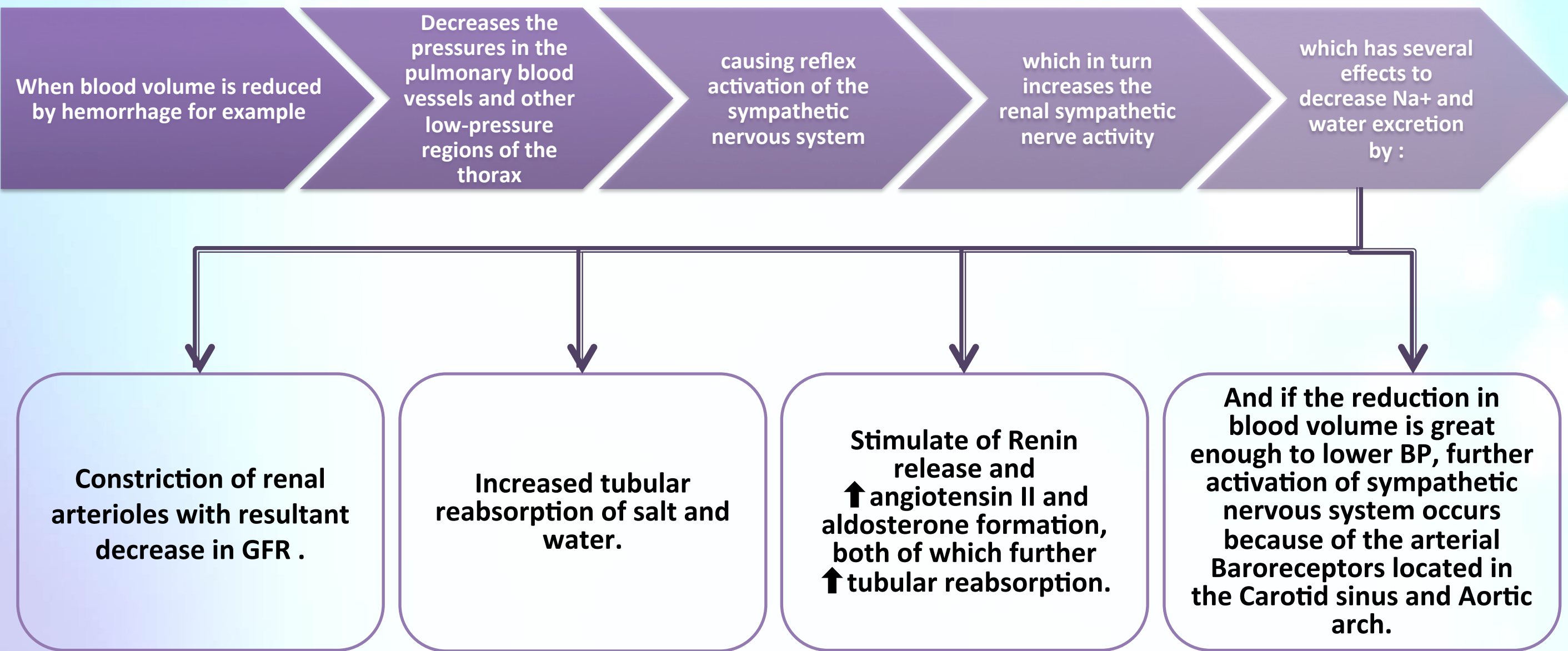
Aortic arch

Juxtaglomerular apparatus (renal afferent arteriole)

# Con. Blood Volume regulation :

The Effectors				
	Renin	Renal sympathetic nerve	ATRIAL NATRIURETIC PEPTIDE (ANP)	ADH
Stimulated By	Renin is released into plasma when plasma Na <sup>+</sup> or BP or blood volume decreases .	Decrease in ECV	Over stretch of the atria, which can result from excess blood volume .	Osmoreceptors sense an increase in plasma osmolarity. Or decrease in BP or blood volume. Or drugs: Morphine, Nicotine, cyclophosphamide
<u>Affects</u>	Renin eventually gives Angiotensin II which acts on adrenal cortex releasing aldosterone which increase Na <sup>+</sup> reabsorption (reabsorb Na <sup>+</sup> = reabsorb water).	stimulate Na absorption by direct tubular effect mediated through alpha-receptors on renal tubules (mainly PCT) to correct for low ECV	Increase GFR and decrease Na <sup>+</sup> reabsorption so increase Na <sup>+</sup> excretion (natriuresis) and water excretion (diuresis) in urine and eventually correcting for the increase in ECV .	Causes a permeability of collecting duct to water through pores called aquaporin-2 , which increase water reabsorption.

# Con. Blood Volume regulation :



When blood volume is reduced by hemorrhage for example

Decreases the pressures in the pulmonary blood vessels and other low-pressure regions of the thorax

causing reflex activation of the sympathetic nervous system

which in turn increases the renal sympathetic nerve activity

which has several effects to decrease Na+ and water excretion by :

**Constriction of renal arterioles with resultant decrease in GFR .**

**Increased tubular reabsorption of salt and water.**

**Stimulate of Renin release and ↑ angiotensin II and aldosterone formation, both of which further ↑ tubular reabsorption.**

**And if the reduction in blood volume is great enough to lower BP, further activation of sympathetic nervous system occurs because of the arterial Baroreceptors located in the Carotid sinus and Aortic arch.**



# Renal Osmoregulation

Osmolality is determined by:

The amount of extracellular NaCl and water which depends upon balance between intake and excretion of these substances.

Renal regulation of Extracellular Osmolality is a reflex mechanism in which a changing plasma osmolality is monitored by:

appropriate sensor (Osmoreceptors) Hypothalamus osmoreceptor.

Control of ECF osmolality done by two mechanisms:

1. Osmoreceptor – ADH mechanism.
2. Thirst mechanism.

Release of ADH

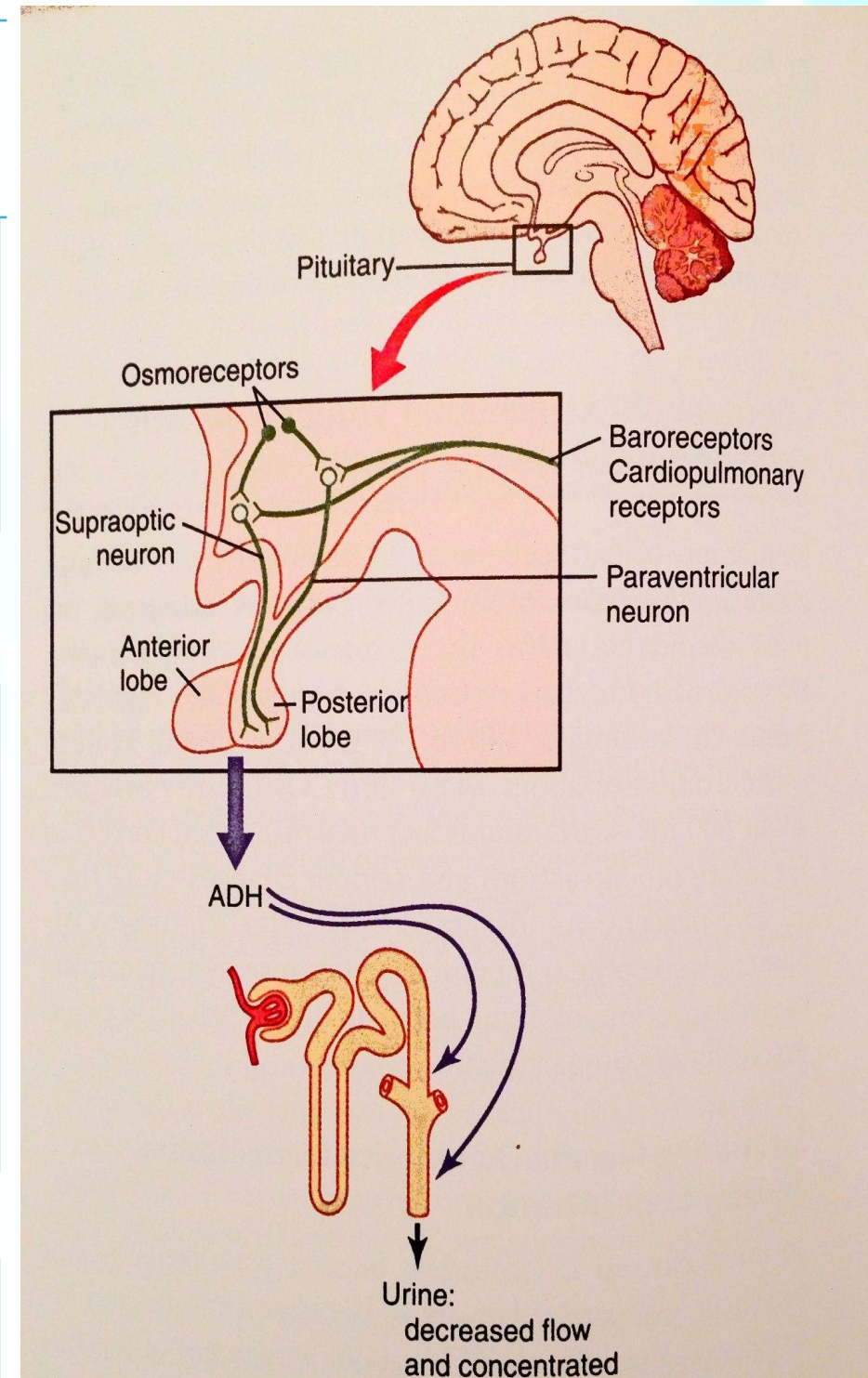
- ✓ Osmotic stimuli ( change in serum osmolality )
  1. through osmoreceptor
- ✓ Non osmotic stimuli
  1. Atrial Baroreceptor reflex.
  2. Chemoreceptor reflex.
  3. Whenever BP or blood volume decreases.

Normal Plasma Osmolality

290 and for simplification we use 300 mOsm/L.

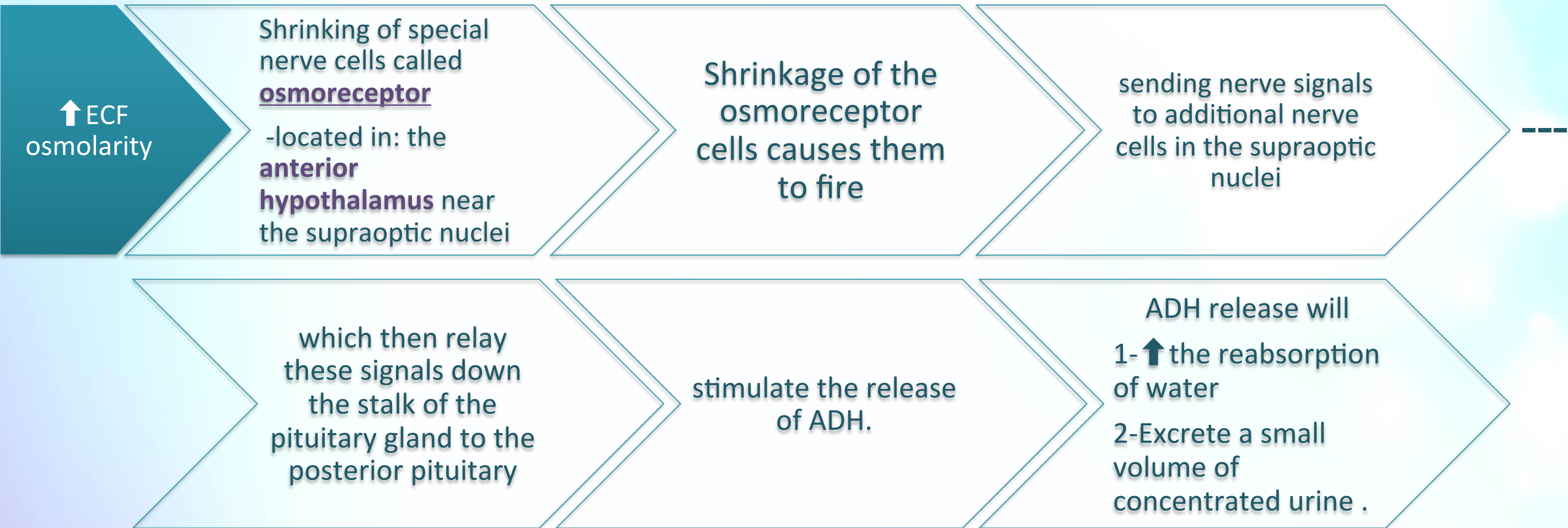
ADH-thirst is the most powerful feedback system in the body for controlling:

1. Extracellular fluid.
2. Osmolality
3. Sodium concentration.



Neuroanatomy of the hypothalamus, where antidiuretic hormone (ADH) is synthesized, and the posterior pituitary gland, where ADH is released

# First : Osmoreceptor-ADH Feed back system



**Sensors**

- Hypothalamic
- Osmoreceptors

**Effectors**

- ADH
- Thirst

**Affects**

- Urine osmolarity
- Water Intake



# Con. Renal Osmoregulation

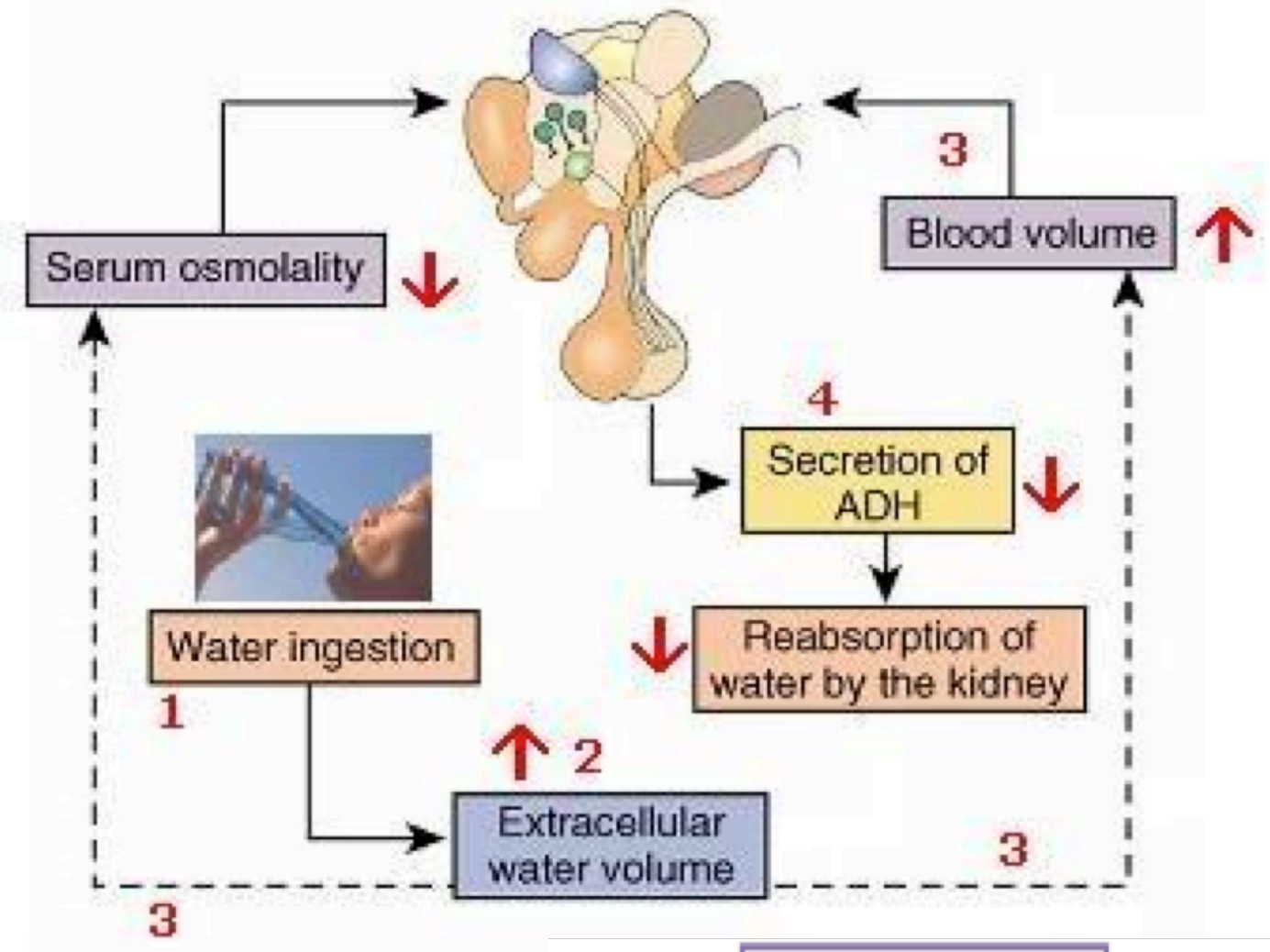
What happens if we drink a lot of water?

Decrease in osmolarity and decrease in antidiuretic hormone (ADH) secretion.

Leading to an increase in water excretion and urine volume.

**Diuresis**

- begins 15 minutes after ingestion of H<sub>2</sub>O load
- reaches maximum in 40 minutes .



What happens if ECF osmolarity increased?

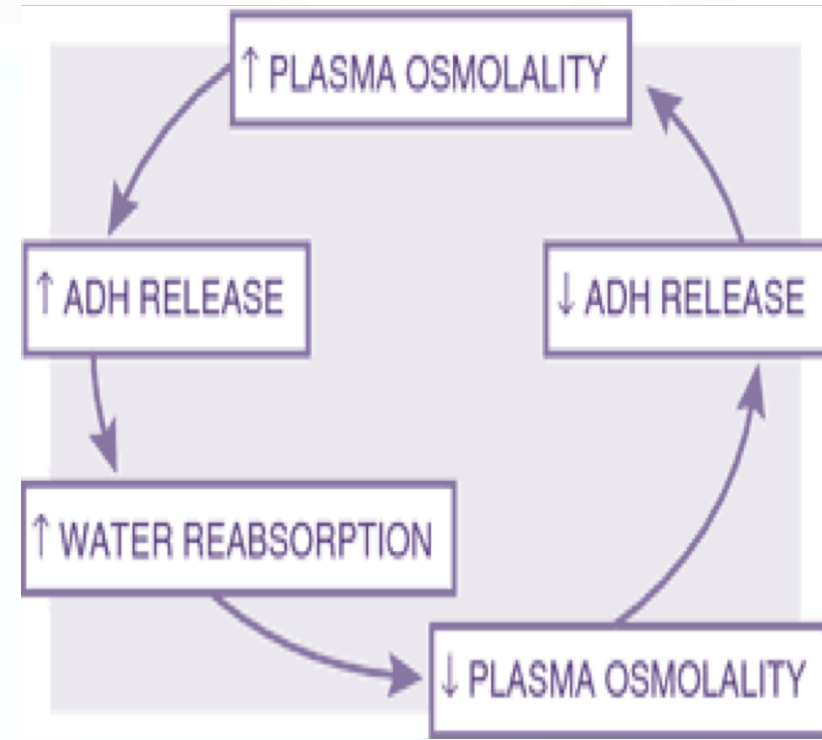
It will happen what we call:

## Osmotic Diuresis

**which is:** The presence of large quantities of unreabsorbed solutes in renal tubules

**Causes:** increase in urine volume ( as in diabetic patient and that's why he has polyuria ).

Increase Sodium concentration → Increase extracellular osmolarity that surrounding the osmoreceptors in the hypothalamus → movement of water from intracellular (osmoreceptors cells) to extracellular → stimulation of osmoreceptors and send signals to posterior pituitary in hypothalamus → release ADH also called (arginine vasopressin)



# Osmotic vs non-osmotic stimuli effect on ADH

Stimuli	Effect on AVP secretion
<b>Osmotic</b>	
Change in serum osmolarity	↑ or ↓ depending on changes in osmolarity <sup>(1)</sup>
<b>Nonosmotic</b>	
Hemodynamic change associated with low effective arterial blood volume	↑
Act of drinking especially cooler fluids	↓
Nausea	↑
Hypoglycemia	↑
Renin angiotensin system (AngII)	↑
Hypoxia and hypercapnia	↑



**NOTE**

(1) ADH release is rapid when there is a **little** change in the **Osmolality**  
 2. AVP=arginine vasopressin=ADH



# Non-osmotic stimuli releasing ADH

Arterial baroreceptor reflex

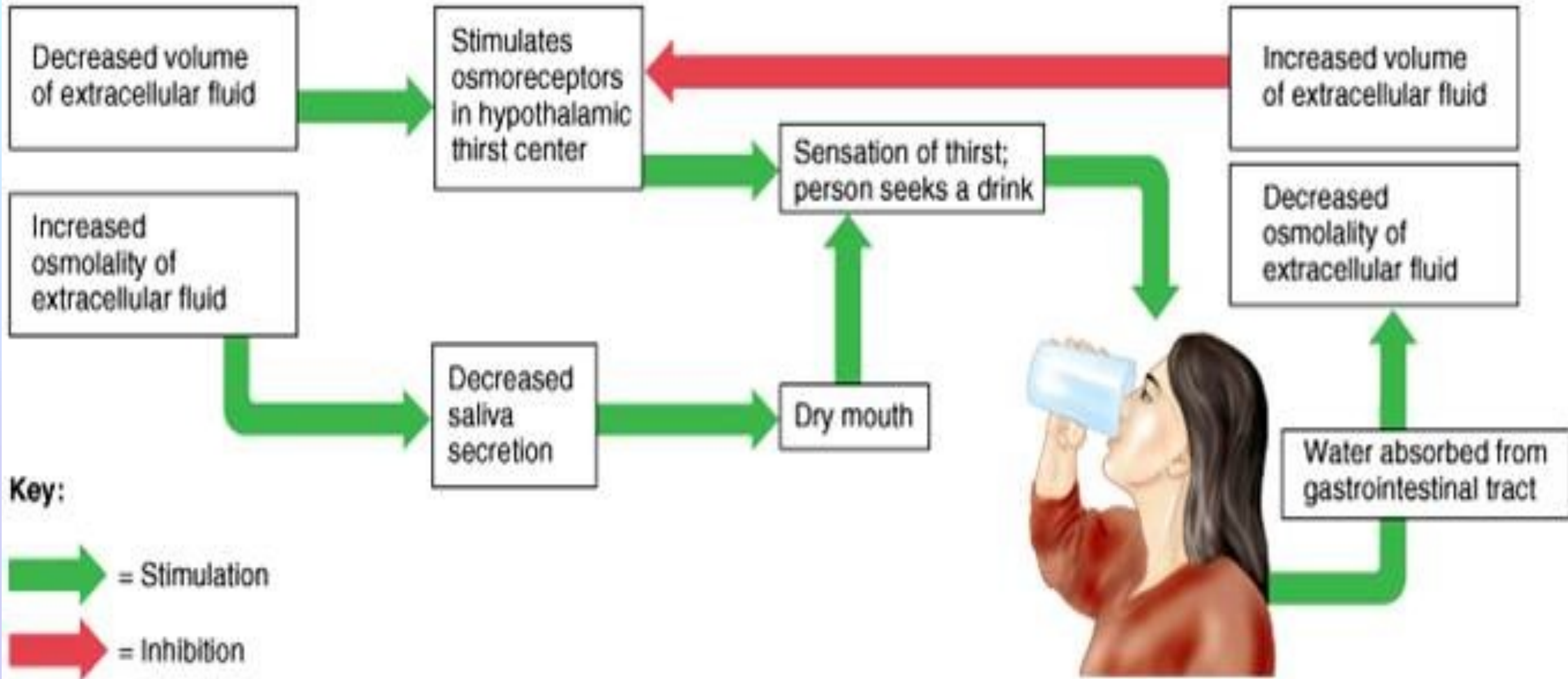
Chemoreceptor reflex

Whenever BP & blood volume reduced, ADH is released water retention by the kidney to restore BP to normal.

- ADH secretion more **sensitive** to small change in **osmolality** than Similar change in **the blood volume**  
**for example:**  
change in the plasma osmolality **only 1%** is sufficient to increase ADH level but by contrast ,after **loss blood volume** ,plasma ADH level do not **change** until **blood volume decrease about 10%**
- Day-to-day regulation of ADH secretion is effected mainly by changes in **plasma osmolality.**

# Second : Thirst

## Thirst mechanism



To stay in balance: water intake = water loss

## Thirst is stimulated by one of the following :

Fluid intake is regulated by thirst mechanism which is stimulated by :

Increase thirst:	Decrease thirst
<ol style="list-style-type: none"><li>1. ↑ osmolarity ECF.</li><li>2. ↑ Angiotensin II.</li><li>3. ↓ ECF volume.</li><li>4. ↓ blood pressure.</li><li>5. Dryness of the mouth.</li></ol>	<ol style="list-style-type: none"><li>1. Gastric distention</li></ol>

Thirst → a high water intake ( if water was available ) → correction to the increase in plasma osmolality by causing a decrease in plasma osmolality .

The desire to thirst is completely satisfied when: Plasma osmolarity, Blood volume, Or both return to normal.

## Role of Ang II & aldosterone

They do not normally play a major role in controlling ECF osmolarity and Na<sup>+</sup> concentration.

Their major role is to: absorb sodium through distal convoluted tubules →  
1.greater extracellular fluid volume  
2.and sodium quantity.



# Summary

Identify and describe the role of the Sensors and Effectors in the renal regulation of body fluid volume & osmolality

**Sensors:** Carotid sinus and Volume receptors (large vein, atria, intrarenal artery)

**Effectors:** 1/ Renin, angiotensin, aldosterone. 2/ Renal sympathetic nerve. 3/ ADH. 4/ ANF

**Affecting urinary excretion.**



Describe the role of the kidney in regulation of body fluid volume & osmolality

## Renal Osmoregulation :

Sensors: Hypothalamic osmoreceptors

Effectors: ADH, Thirst

Affects: Urine osmolality, Water Intake

## Osmotic and non Osmotic stimuli

### Regulation of ADH secretion

Increase ADH	Decrease ADH
↑ Plasma osmolarity	↓ Plasma osmolarity
↓ Blood volume	↑ Blood volume
↓ Blood pressure	↑ Blood pressure
Nausea	
Hypoxia	

### Control of thirst

Increase Thirst	Decrease Thirst
↑ Plasma osmolarity	↓ Plasma osmolarity
↓ Blood volume	↑ Blood volume
↓ Blood pressure	↑ Blood pressure
↑ Angiotensin II	↓ Angiotensin II
Dryness of mouth	Gastric distention



**Q1. Which of the following is a low-pressure receptor ?**

- A. Renal afferent arterioles.
- B. Pulmonary vasculature.
- C. Carotid Sinus.
- D. Aortic Arch.

**Q5. ADH secreted from :**

- A. Supraoptic Nuclei .
- B. Anterior hypothalamus
- C. Posterior pituitary .
- D. adrenal cortex.

**Q2. Which of the following decrease Na+ reabsorption ?**

- A. Renin.
- B. Renal Sympathetic nerve.
- C. ATRIAL NATRIURETIC PEPTIDE (ANP).
- D. ANTI DUERTIC HORMONE (ADH).

**Q6. The action of the aldosterone is to increase:**

- A. Na elimination
- B. Na reabsorption
- C. K reabsorption
- D. Cl excretion

**Q3. Osmoreceptors located in :**

- A. Supraoptic Nuclei .
- B. Anterior hypothalamus.
- C. Posterior pituitary .
- D. adrenal cortex.

**Q7. ADH**

- A. Increase H<sub>2</sub>O reabsorption
- B. decrease NA reabsorption
- C. angiotensin 2 formation
- D. Increase Na reabsorption.

**4) Renal regulation of blood volume include :**

- A. change in Urine excretion.
- B. change in water intake.
- C. Both.
- D. None.

**Q8. Which of the following is increase thirst stimulation:**

- A. decrease in plasma osmolarity
- B. Increase blood volume
- C. Dryness of the mouth
- D. Gastric distention

# QUESTIONS

<p><b>Q1. What are the body fluid compartment?</b>  <b>A.</b> Intracellular (inside the cells): contain most of the fluid  <b>B.</b> Extracellular (outside the cell): contain fluid in the:              1. Blood (vascular)              2. Interstitium (between cells)</p>	<p><b>Q6. What happened if a person is in dehydrated condition in such a patient that have excessive diarrhea?</b>          Increase Sodium concentration → Increase extracellular osmolarity that surrounding the osmoreceptors in the hypothalamus → movement of water from intracellular (osmoreceptors cells) to extracellular → stimulation of osmoreceptors and send signals to posterior pituitary in hypothalamus → release ADH also called (arginine vasopressin)</p>
<p><b>Q2. What does the fluid contain?</b>  <b>A.</b> Water  <b>B.</b> Solutes (Electrolytes – glucose – urea – proteins ..etc)</p>	<p><b>Q7. What happened if a person is take high amount of water in short time?</b>          Decrease Sodium concentration → decrease extracellular osmolarity that surrounding the osmoreceptors in the hypothalamus → movement of water from extracellular to intracellular (osmoreceptors cells) → stimulation of osmoreceptors and send signals to posterior pituitary in hypothalamus → decrease ADH</p>
<p><b>Q3. What are the pressure in the fluid?</b>  <b>A.</b> Oncotic pressure created by proteins  <b>B.</b> Osmotic pressure created by electrolytes</p>	<p><b>Q8. When the edema happened?</b>          •When there are inappropriate secretion of ADH that will lead to hypo-osmolar condition of ECF and sodium concentration will be 120 mEq/L and below.</p>
<p><b>Q4. What is the most dangerous type of edema?</b>          •Brain edema</p>	<p><b>Q9. What is the meaning of Gastric distention decreases thirst?</b>          •Like in obesity people, the volume of their stomach is increased and that allowed taking more amount of food, which contain water. Thus, that will lead to decrease thirst center.</p>
<p><b>Q5. What is the role of Ag II in osmolarity?</b>          Has very weak effect on osmolarity by releasing of aldosterone. The major role of Ag II is maintain Sodium quantity “not osmolarity” in tubules.</p>	<p><b>Q10. Where and what ADH does?</b>          •It works on collecting ducts when it binds with V1 receptors and allow water reabsorption to maintain osmolarity          It works in blood vessels when it binds with V2 receptors in vessels to constrict and increase blood pressure  <b>Note: It only works on vessels when there is loss of 1 or more L of blood and body fluids</b>          Synthesis in: Supraoptic nuclei of hypothalamus          Stored in: Posterior pituitary gland</p>