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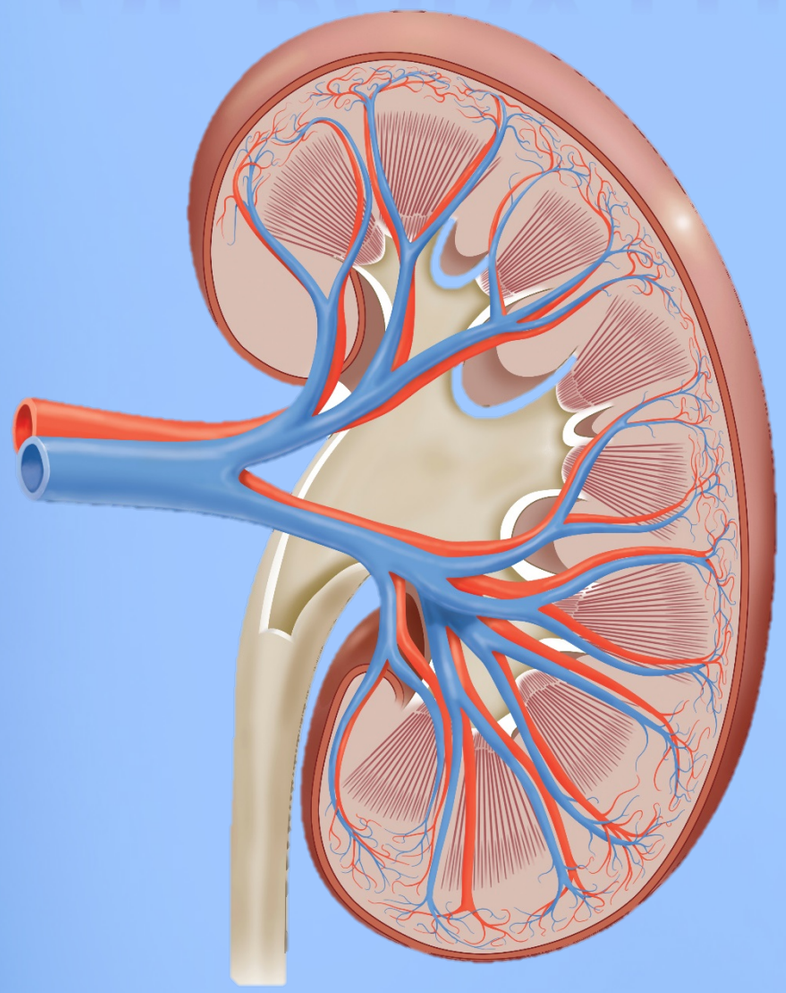
RENAL REGULATION OF BODY FLUID



Renal Block

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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+ 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

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

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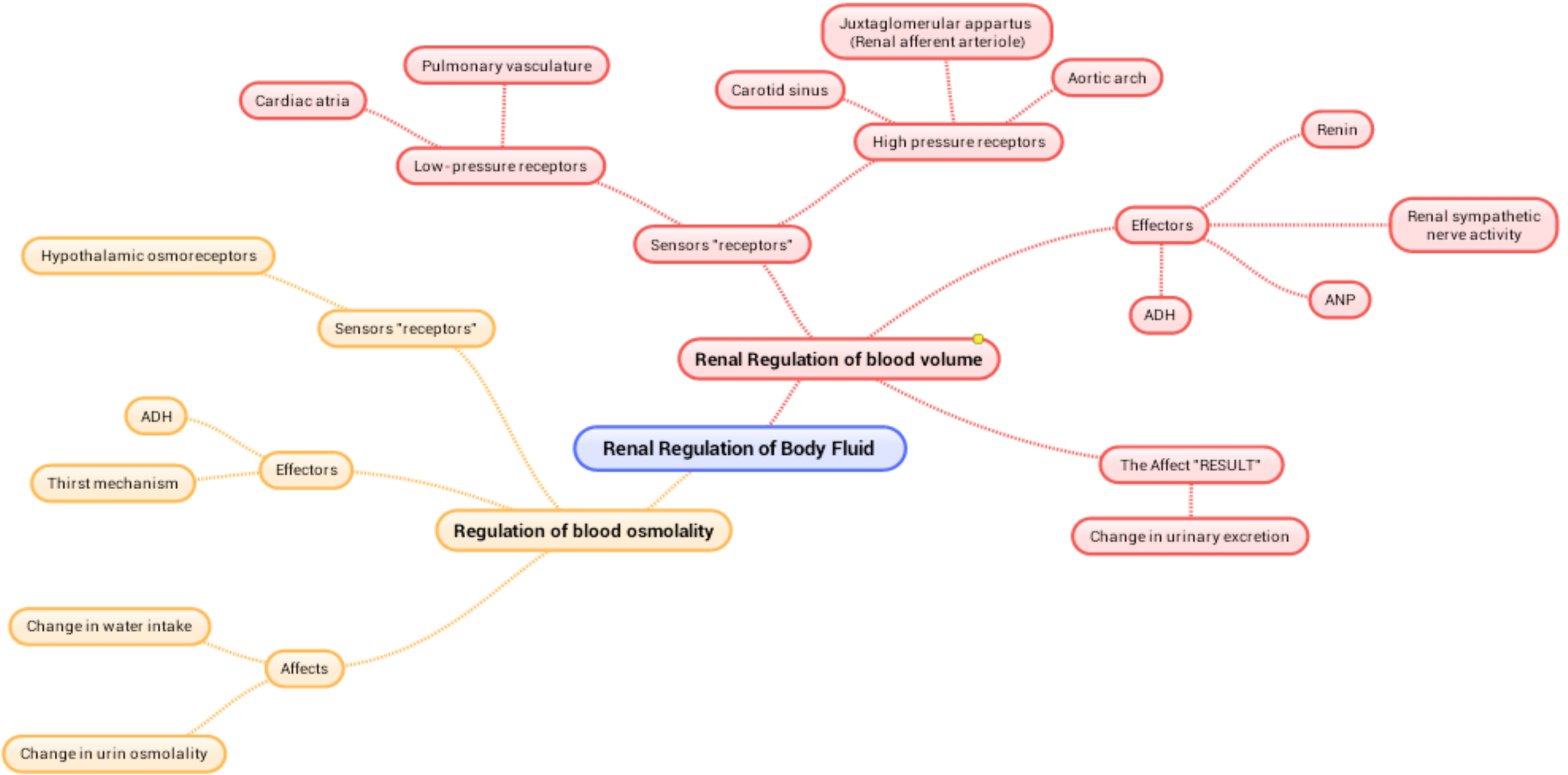
Mind map



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BLOOD VOLUME REGULATION :

Blood volume remains <u>exactly constant</u> 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+ also dependent upon baroreceptors.

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Con. Blood Volume regulation :

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 NA+ and water excretion either by increasing it or decreasing it) .

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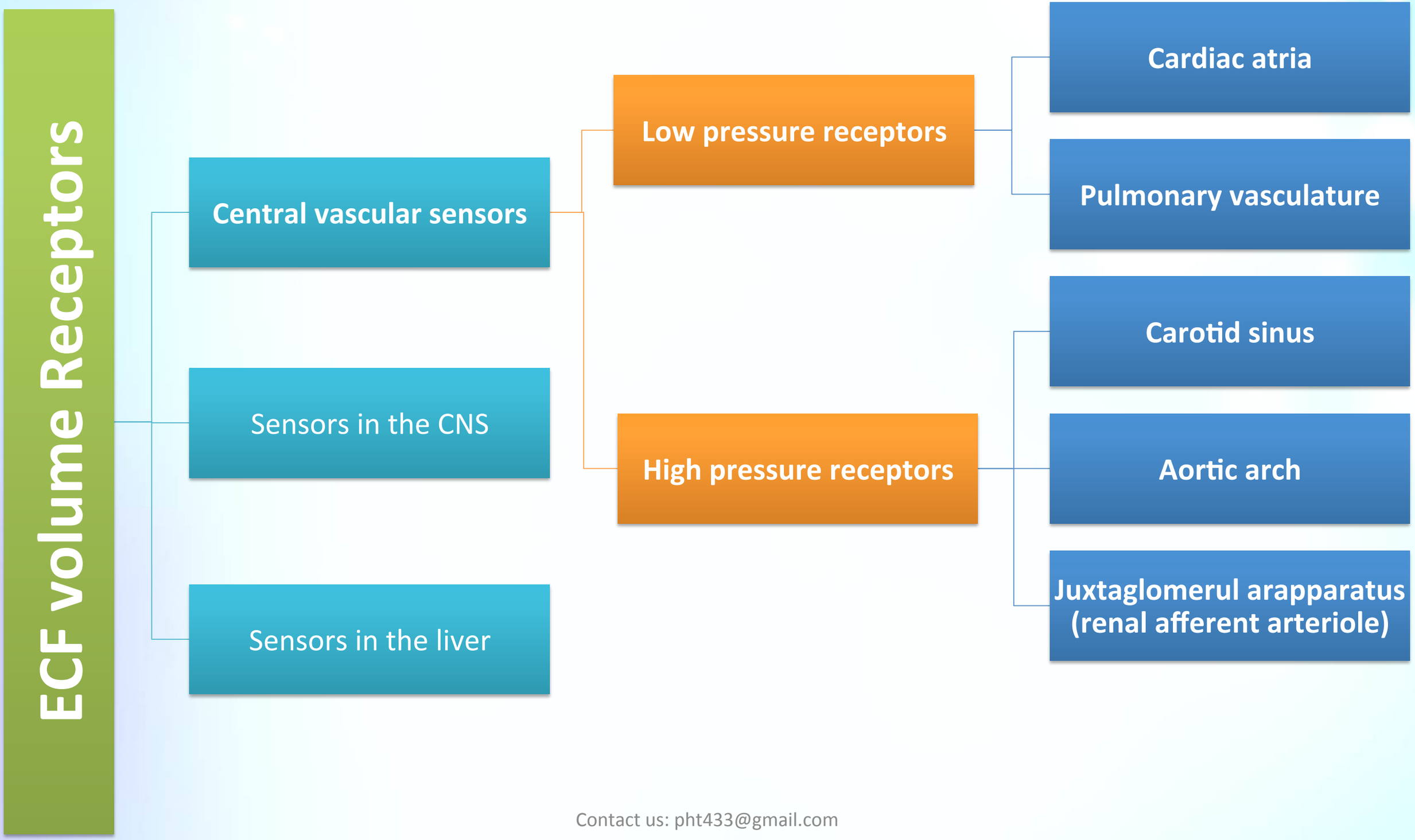
Con. Blood Volume regulation :



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Con. Blood Volume regulation :

The Effectors				
	Rennin	**Renal sympathetic nerve**	**ATRIAL NATRIURETIC PEPTIDE (ANP)**	**ADH**
Stimulated By	**Renin is released into plasma when plasma Na+ 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**
Affects	**Renin eventually gives Angiotensin II which acts on adrenal cortex releasing aldosterone which increase NA+ reabsorption (reabsorb Na+ = 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+ reabsorption so increase Na+ 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

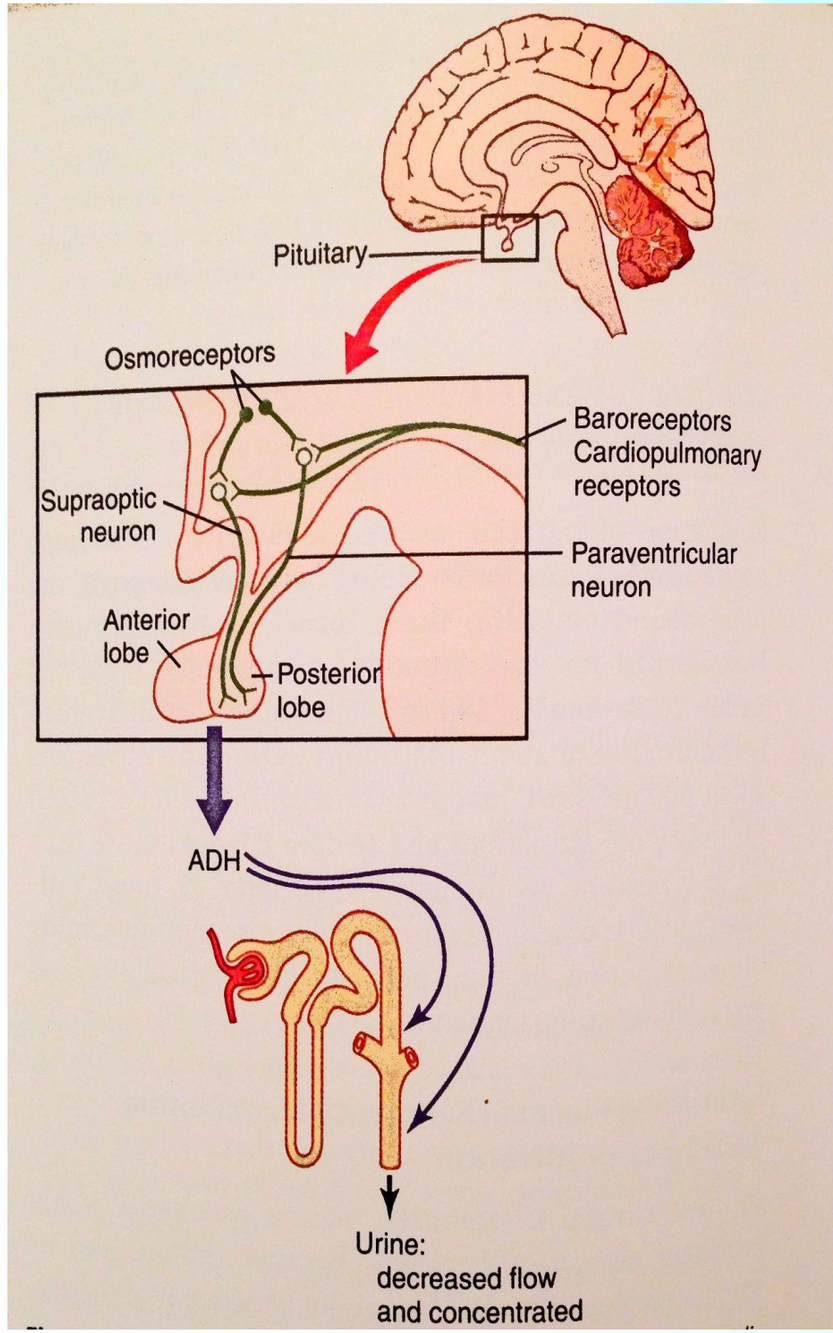
which has several effects to decrease Na+ and water excretion by :

- 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 Extra Cellular Osmolality Is a reflex mechanism in which a changing plasma osmolality is monitor by :	appropriate sensor (Osmoreceptors) Hypothalmus osmoreceptor.
Control of ECF osmolality done by two mechanism :	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

⬆ECF osmolarity

Shrinking of special nerve cells called **osmoreceptor**

-located in: the **anterior hypothalamus** near the supraoptic nuclei

Shrinkage of the osmoreceptor cells causes them to fire

sending nerve signals to additional nerve cells in the supraoptic nuclei

---

which then relay these signals down the stalk of the pituitary gland to the posterior pituitary

stimulate the release of ADH.

ADH release will

1- ⬆ the reabsorption of water

2-Excrete a small volume of concentrated urine .

Sensors	Effectors	Affects
Hypothalamic	ADH	Urine osmolarity
Osmoreceptors	Thirst	Water Intake

Con. Renal Osmoregulation

What happens if we drink a lot of water ?

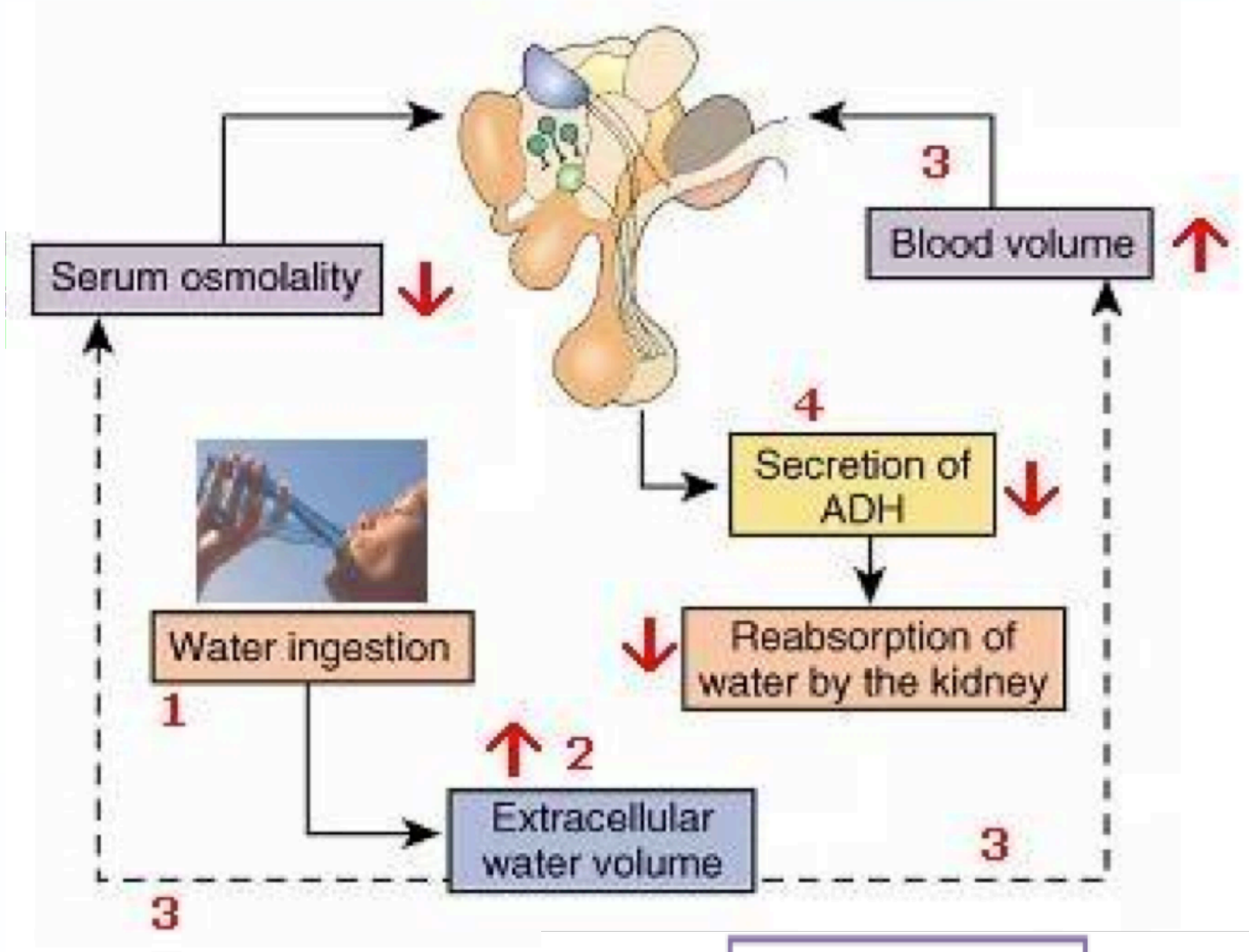
Decrease in osmolarity and decrease in antidiuretic hormone (ADH) secretion.

Leading to an increase in water excretion and urine volume.

Diuresis

-begins 15 minutes after ingestion of H_2O load

-reaches maximum in 40 minutes .



What happens if ECF osmolarity increased?

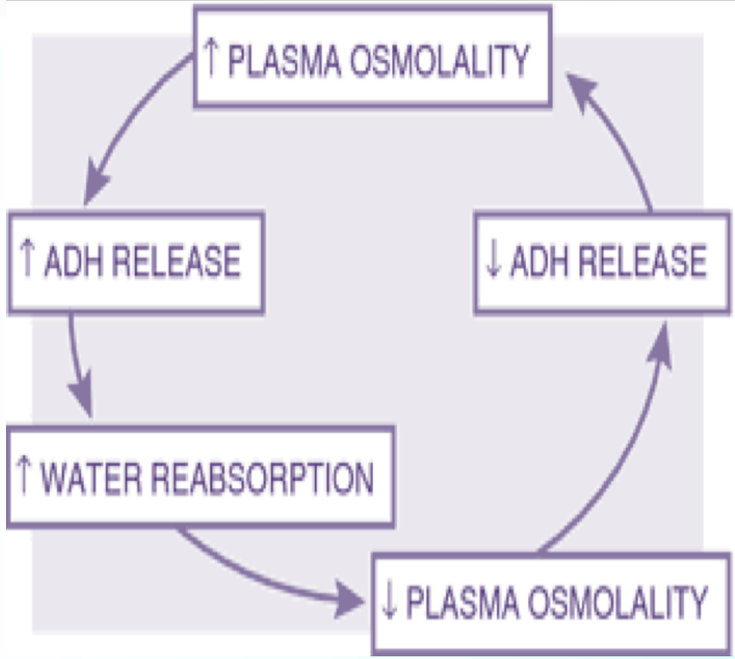
It will happen what we call:

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
Osmotic	
Change in serum osmolarity	⬆ or ⬇ depending on changes in osmolarity (1)
Nonosmotic	
Hemodynamic change associated with low effective arterial blood volume	⬆
Act of drinking especially cooler fluids	⬇
Nausea	⬆
Hypoglycemia	⬆
Renin angiotensin system (AgII)	⬆
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

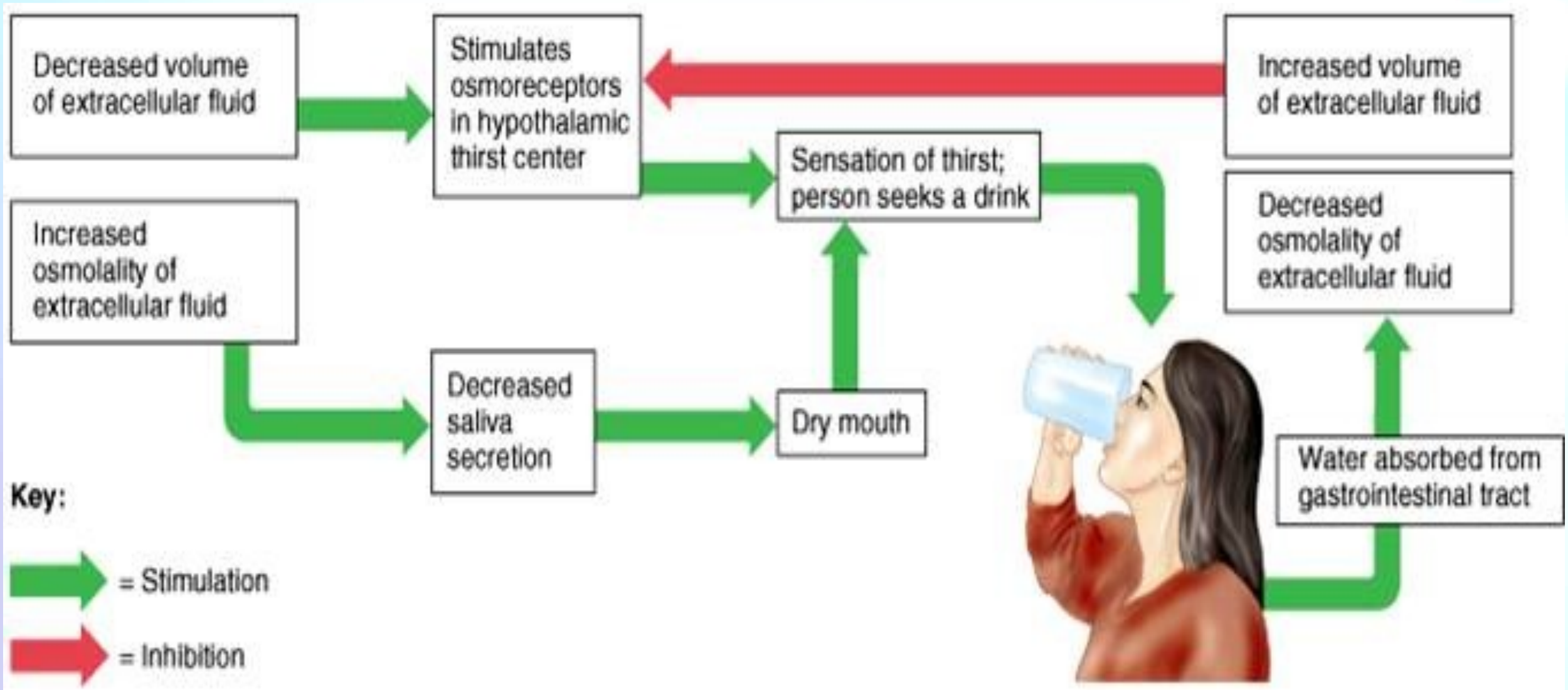
for example:

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 osmolarity.**

Second : Thirst

Thirst mechanism



Con. Second : Thirst

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
1. ⬆ osmolarity ECF. 2. ⬆ Angiotensin II. 3. ⬇ ECF volume. 4. ⬇ blood pressure. 5. Dryness of the mouth.	1. Gastric distention
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+ 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, intrarenalartery)	**Effectors:** 1/ Rennin 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 osmolaity, 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

MCQ

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

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

Q2. Which of the following decrease Na+ reabsorption ?

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

Q3. Osmoreceptors located in :

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

4) Renal regulation of blood volume include :

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

Q5. ADH secreted from :

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

Q6. The action of the aldosterone is to increase:

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

Q7. ADH

A. Increase H2O reabsorption
B. decrease NA reabsorption
C. angiotensin 2 formation
D. Increase Na reabsorption.

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

Ans.

Q1.B … Q2.C … Q3.B … Q4.C

Q5.C … Q6.B … Q7. A … Q8. C

QUASTIONS

Q1. What are the body fluid compartment?

A. Intracellular (inside the cells): contain most of the fluid
B. Extracellular (outside the cell): contain fluid in the:
   1. Blood (vascular)
   2. Interstitium (between cells)

Q2. What does the fluid contain?

A. Water
B. Solutes (Electrolytes – glucose – urea – proteins ..etc)

Q3. What are the pressure in the fluid?

A. Oncotic pressure created by proteins
B. Osmotic pressure created by electrolytes

Q4. **What is the most dangerous type of edema?**

•Brain edema

Q5. What is the role of Ag II in osmolarity?

Has very weak effect on osmolarity by releasing of aldosterone. The major role of Ag II is maintain Sodium quantity "not osmolarity" in tubules.

Q6. What happened if a person is in dehydrated condition in such a patient that have excessive diarrhea?

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)

Q7. What happened if a person is take high amount of water in short time?

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

Q8. When the edema happened?

•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.

Q9. What is the meaning of Gastric distention decreases thirst?

•Like in obesity people, the volume of their stomach in increased and that allowed taking more amount of food, which contain water. Thus, that will lead to decrease thirst center.

Q10. Where and what ADH does?

•It works on collecting ducts when it binds with V1 receptors and allow water reabsorbation to maintain osmolarity

It works in blood vessels when it binds with V2 receptors in vessels to constrict and increase blood pressure

Note: It only works on vessels when there is loss of 1 or more L of blood and body fluids

Synthesis in: Supraoptic nuclei of hypothalamus

Stored in: Posterior pituitary gland

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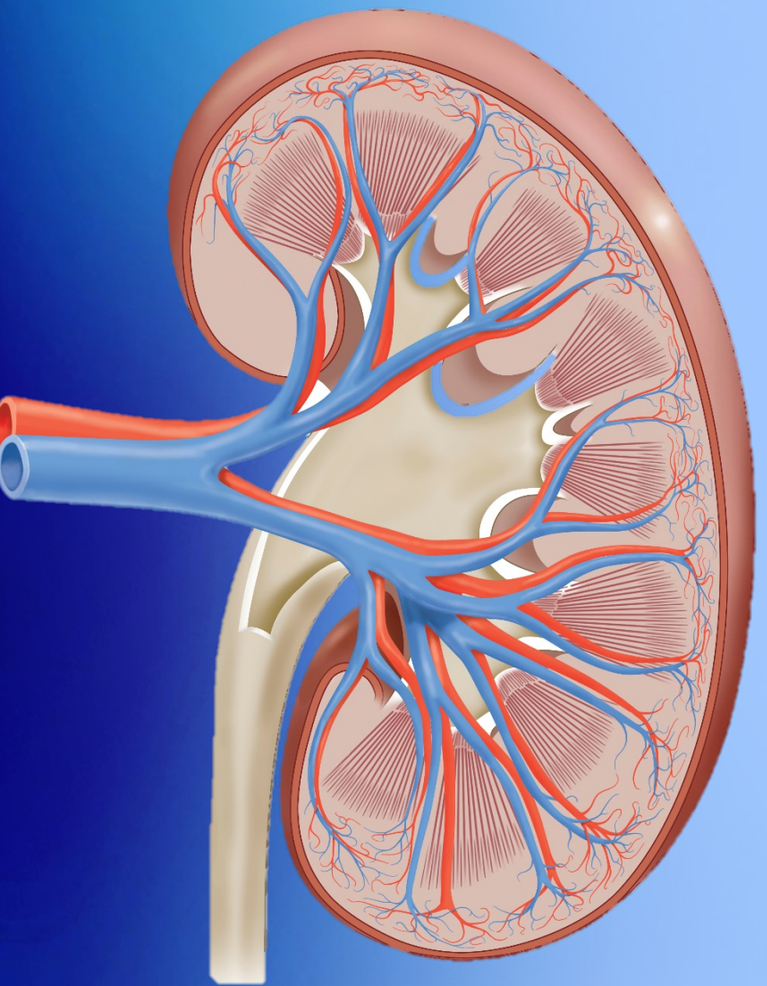
Helpful videos

1.ADH secretion (15:04) here

2.Change in blood osmolality and the result in urine excretion. (10:34) here

It's 11/13 of one of Dr.Najeeb playlist but you don't need to watch the first 10 to understand it .

GOOD LUCK!!



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