

# REGULATION OF EXTRACELLULAR FLUID VOLUME

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# Objectives

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- Identify and describe the role of the sensors and effectors in the renal regulation of body fluid volume.
- Describe the role of the kidney in regulation of body fluid volume.
- Identify the site and describe the influence of aldosterone on reabsorption of  $\text{Na}^+$  in the late distal tubules.

# Introduction

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## Regulation of ECF

Control of ECF  
*volume*

Control of ECF  
*osmolarity*

*Why is it important to regulate ECF volume & osmolarity?*

Determines;  
*blood pressure* → *tissue perfusion*

Affect;  
*Cell volume* → *cell function*

# Introduction

## Regulation of ECF

ECF **volume** is regulated by

Adjusting **total body Na<sup>+</sup> content**

*This is the focus of this lecture*

**Na<sup>+</sup> Excretion**

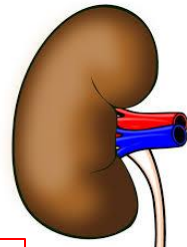
ECF **osmolarity** is regulated by

Adjusting **total body water content**

*This was discussed in the last lecture*

**Water Excretion**

The two systems use different;  
Sensors  
Hormonal transducers  
Effectors

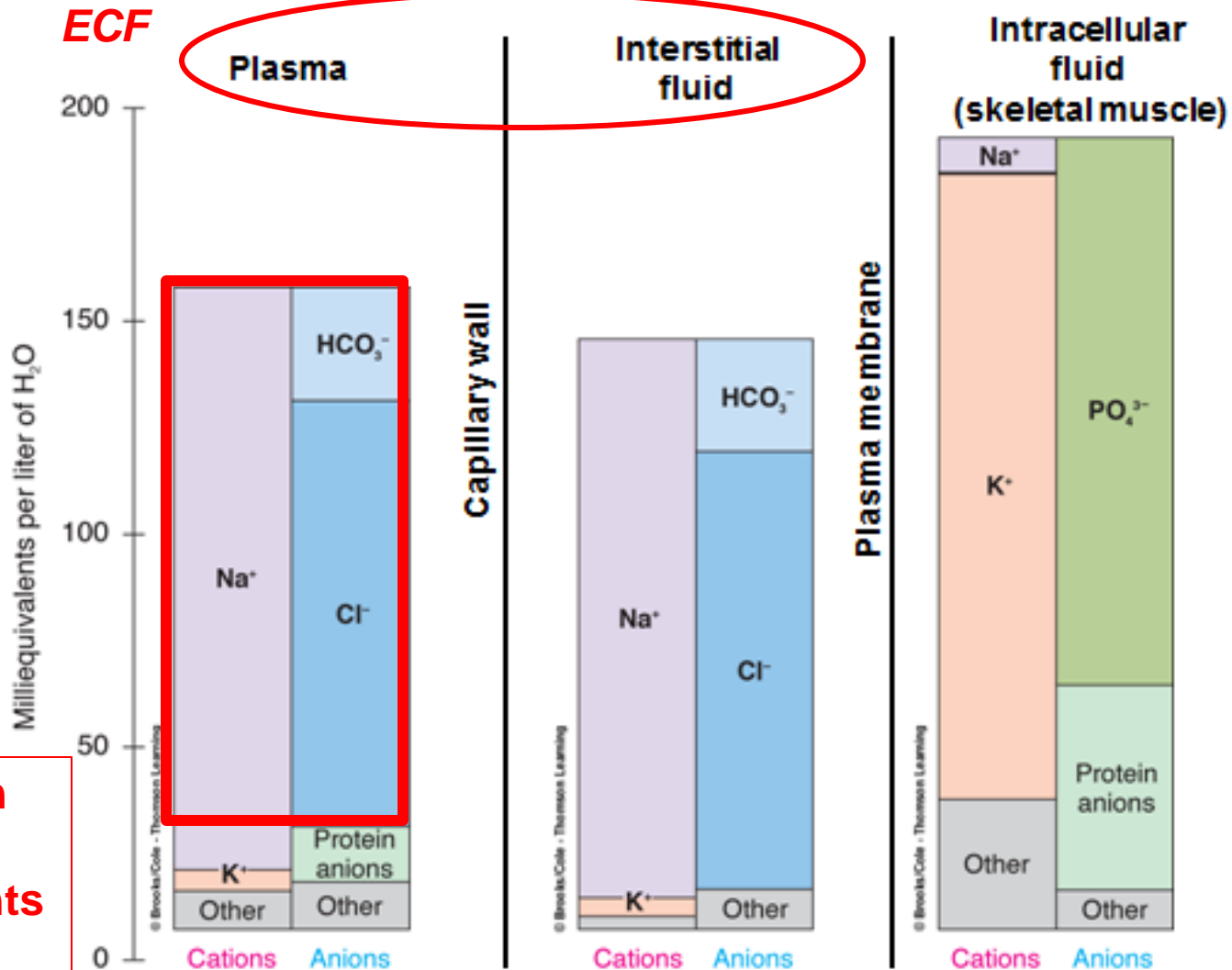


urine

*Why does the body regulate ECF volume  
by adjusting body Na<sup>+</sup> content??*

**Let's revise a few concepts!**

# Electrolyte Composition of Body Fluids



The main osmotic constituents of ECF

[Figure 15-2; Sherwood]

# ECF Volume

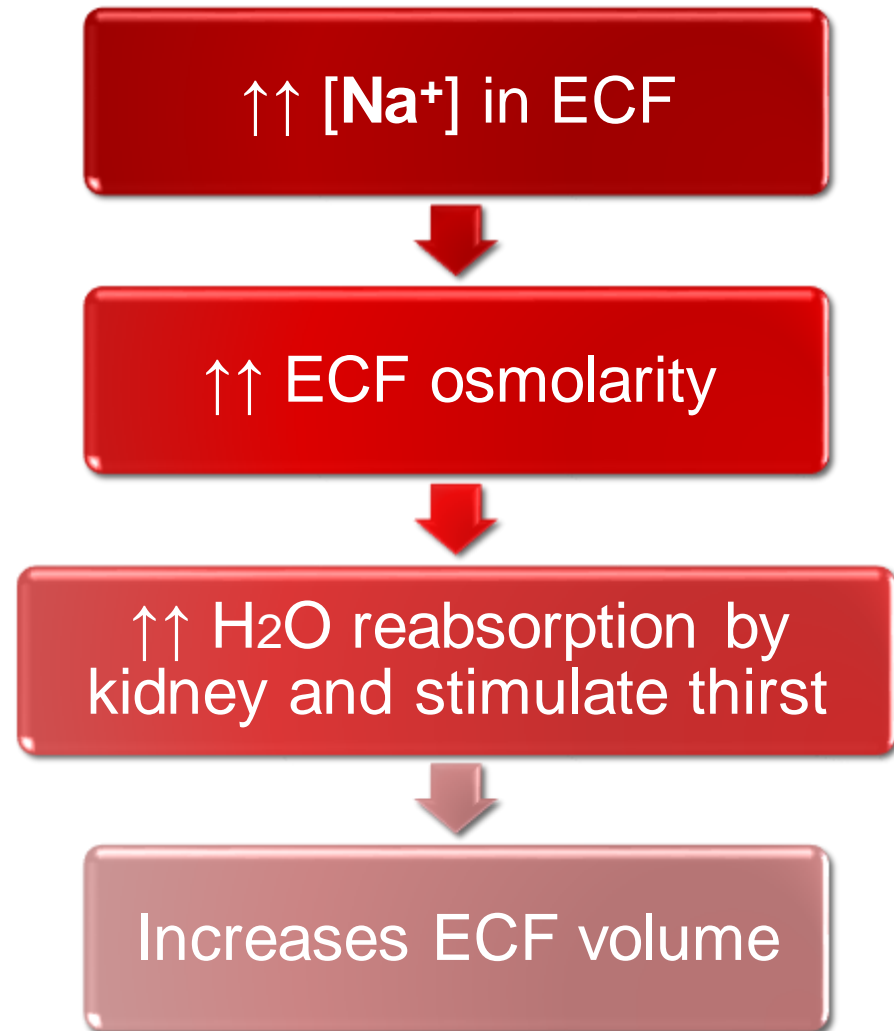
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- The most abundant cation in ECF is **Na<sup>+</sup>**
- The most abundant anions in ECF are **Cl<sup>-</sup>** and **HCO<sub>3</sub><sup>-</sup>**
- *The body regulates ECF volume by monitoring and adjusting total body content of Na<sup>+</sup>*
- *ECF volume is closely linked to Na<sup>+</sup> balance... How??*

# Why is $\text{Na}^+$ Content the Main Determinant of ECF Volume?

$\text{Na}^+$  and its associated anions are the **main osmotic constituents** of ECF volume.

When  $\text{Na}^+$  salts move, water must follow.





# Sodium Balance

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## Input

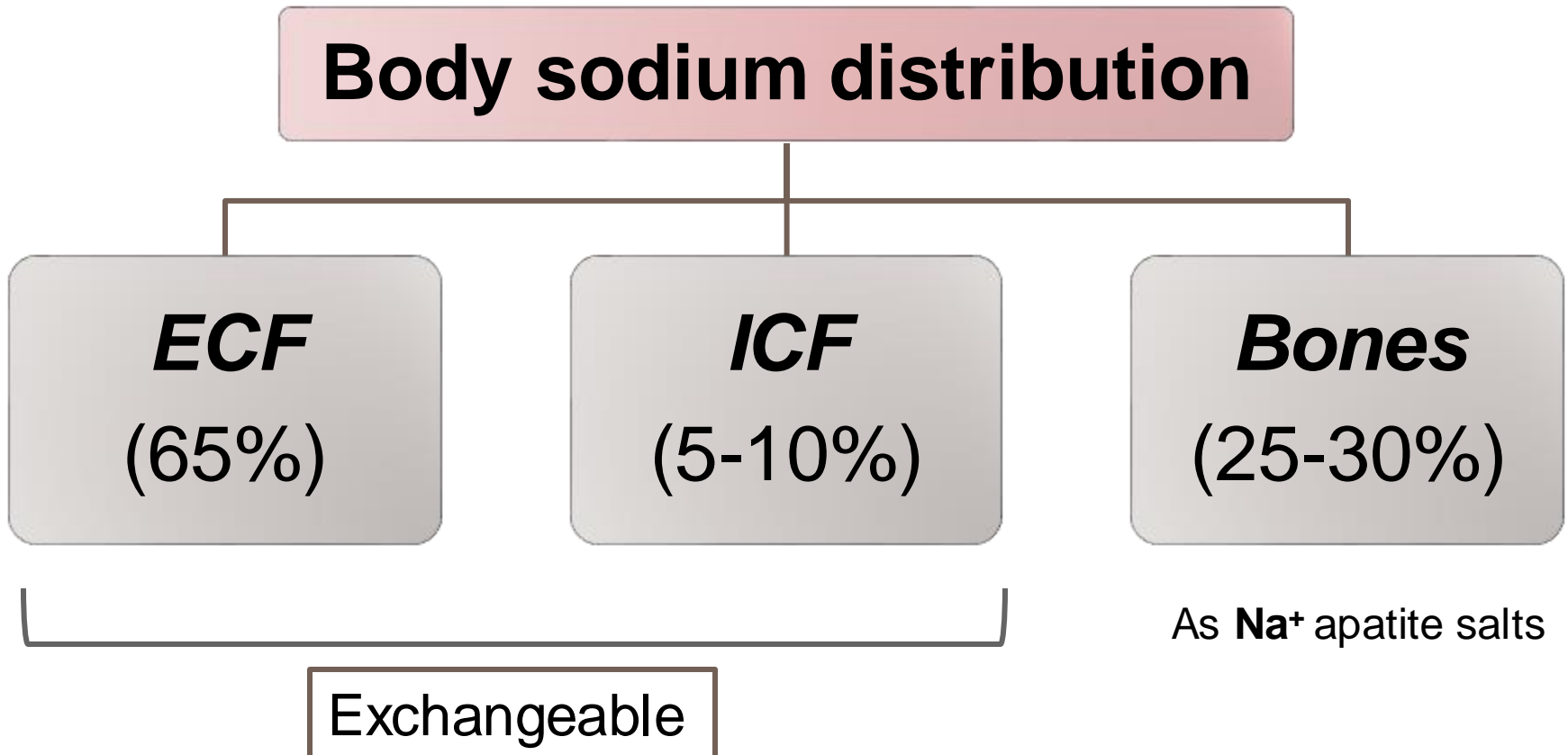
- Dietary intake;
  - RDA = 1.5-2.3 g/day
  - Actual content in western diet = 7g/day

## Output

- Kidney (most important).
  - GI loss
  - Sweat
- } Minor pathways under normal conditions

# Sodium Distribution in the Body

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# ECF VOLUME REGULATION

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# ECF Volume Regulation

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- What does the body sense?
- What are the sensors?
- How does it execute its action? What are the effectors?

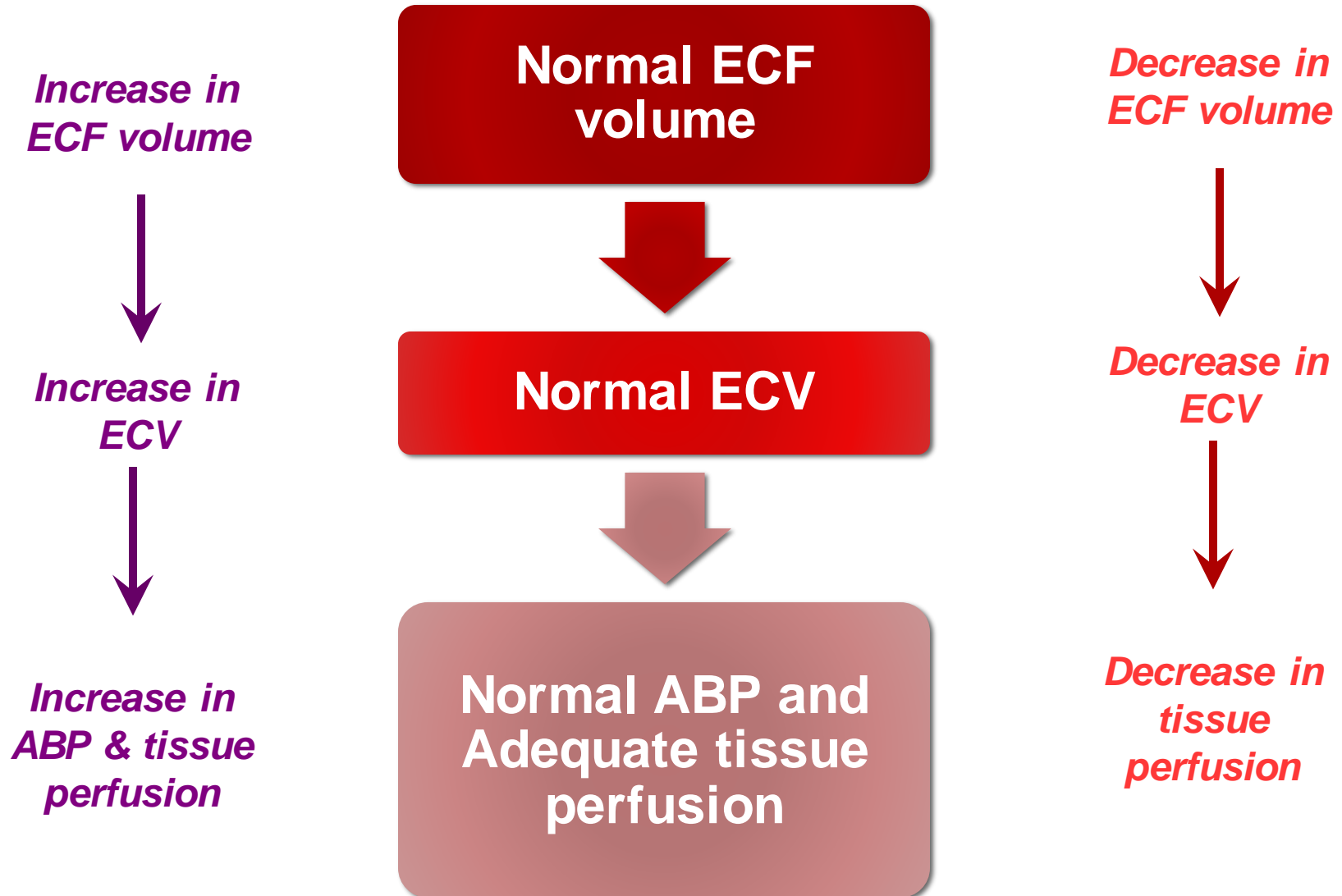
# What Does the Body Sense?

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- The body does not sense ECF volume per se! But it senses **Effective circulating volume (ECV)**.
- **Effective circulating volume (ECV)** = a functional blood volume that reflects the extent of tissue perfusion in specific regions, as evidenced by the pressure in their blood vessels.
- In short, ECV reflects adequacy of circulation. Fullness and pressure in the vessels.
- Usually changes in ECV parallel those of ECF volume.

# Effective Circulating Volume

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# What are the Sensors?

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- Changes in ECV are sensed by baroreceptors.
  - Low-pressure baroreceptors.
  - High-pressure baroreceptors.

**Table 40-2** ECF Volume Receptors

"Central" Vascular Sensors

*Low-Pressure Sensors (very important)*

Cardiac atria

Pulmonary vasculature

*High-Pressure Sensors (less important)*

Carotid sinus

Aortic arch

Juxtaglomerular apparatus (renal afferent arteriole)

Sensors in the CNS (*less important*)

Sensors in the Liver (*less important*)

# What are the Effectors?

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Change in ECV (ECF volume)



Affects ECV sensors  
*Baroreceptors*



This generates 4 distinct hormonal/neural pathways

RAAS

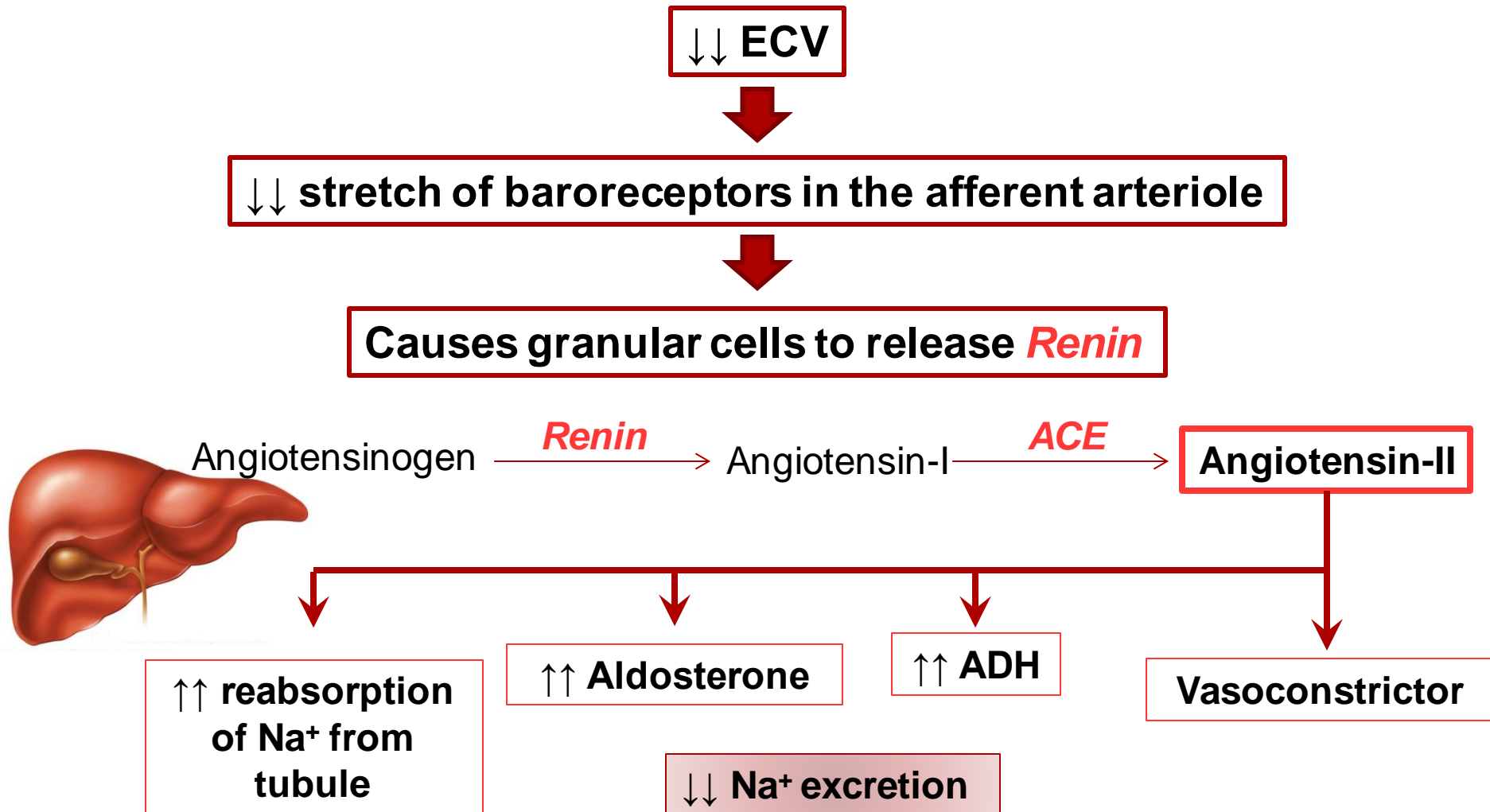
Sympathetic  
NS

ADH

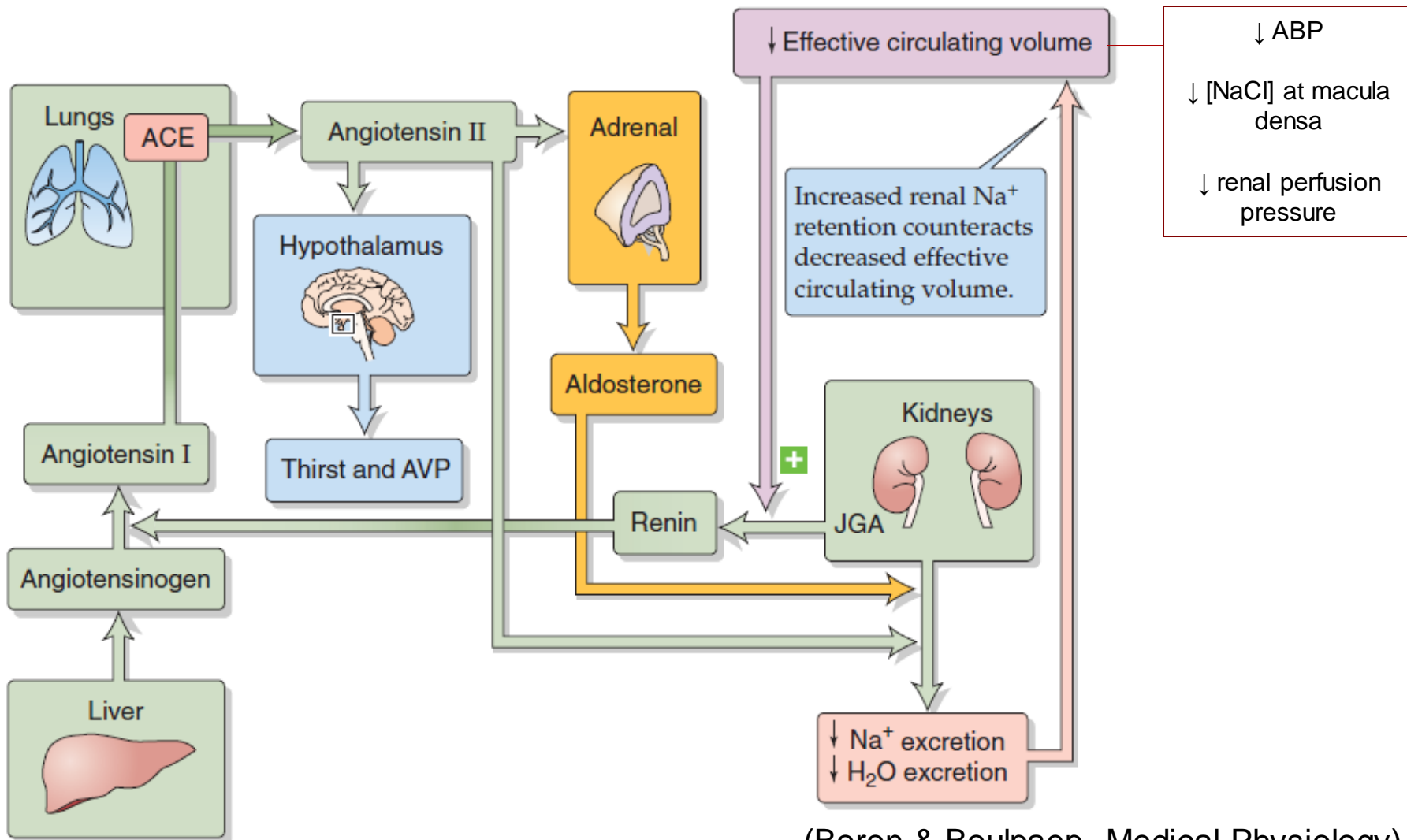
ANP



# The Renin-Angiotensin-Aldosterone System (RAAS)



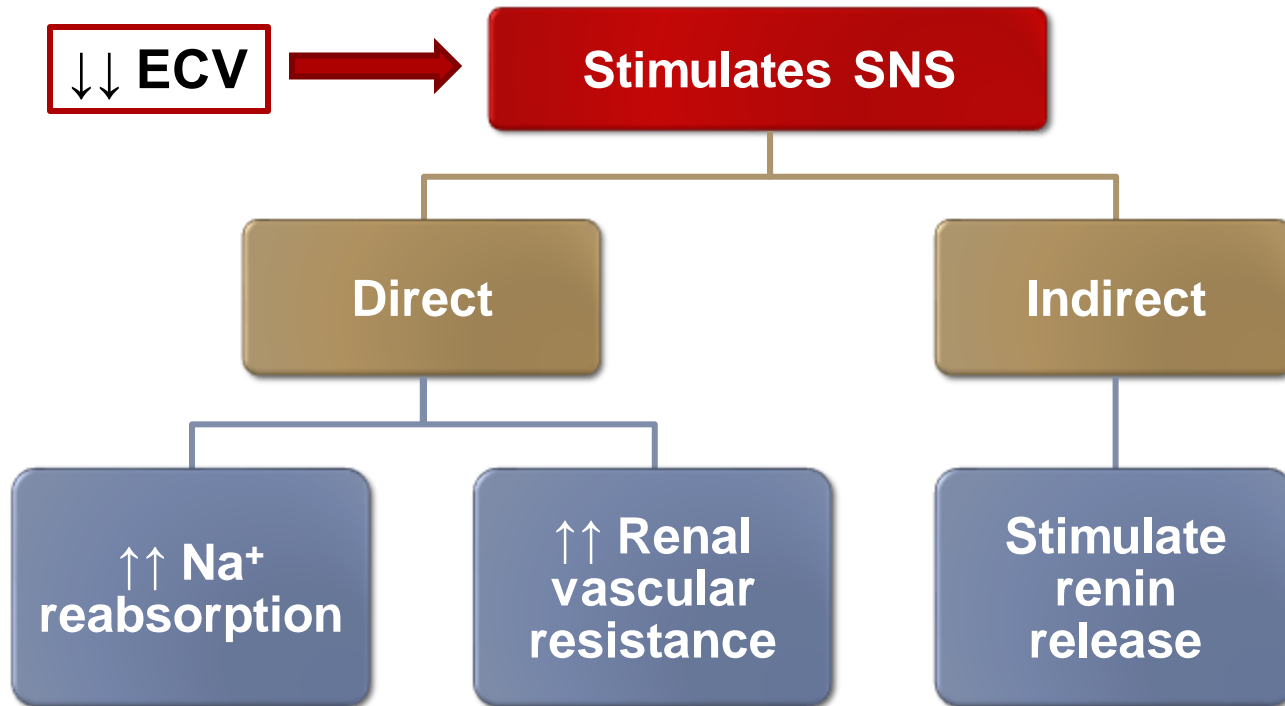
# The Renin-Angiotensin-Aldosterone System (RAAS)



(Boron & Boulpaep. Medical Physiology)

# Sympathetic Nervous System (SNS)

Its role is thought to be especially important during stressful conditions, e.g. hemorrhage.



# Atrial Natriuretic Peptide (ANP)

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- ANP promotes *natriuresis* (Na<sup>+</sup> excretion).
- Secreted by atrial myocytes in response to stretch.

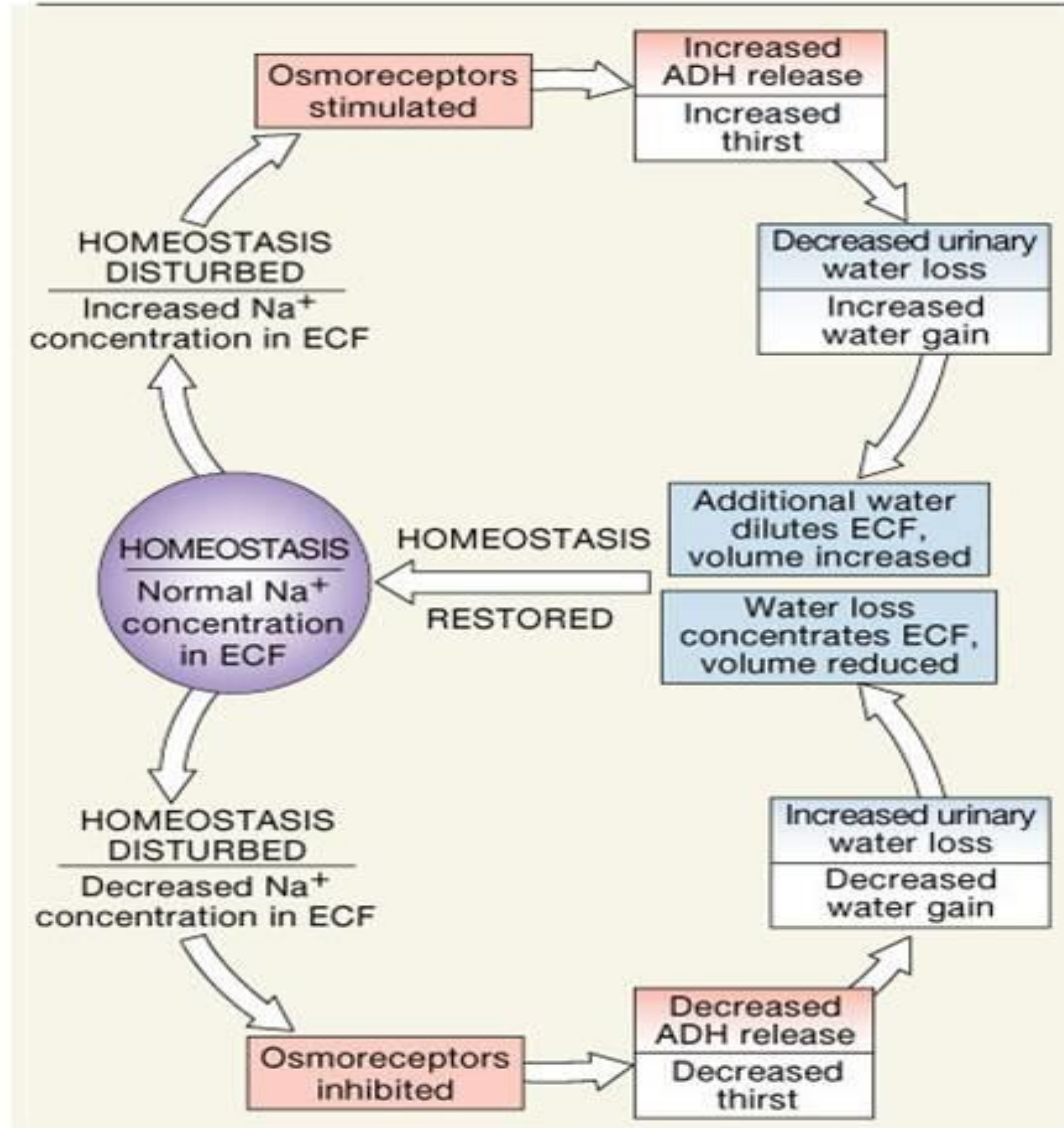


# Antidiuretic Hormone (ADH)

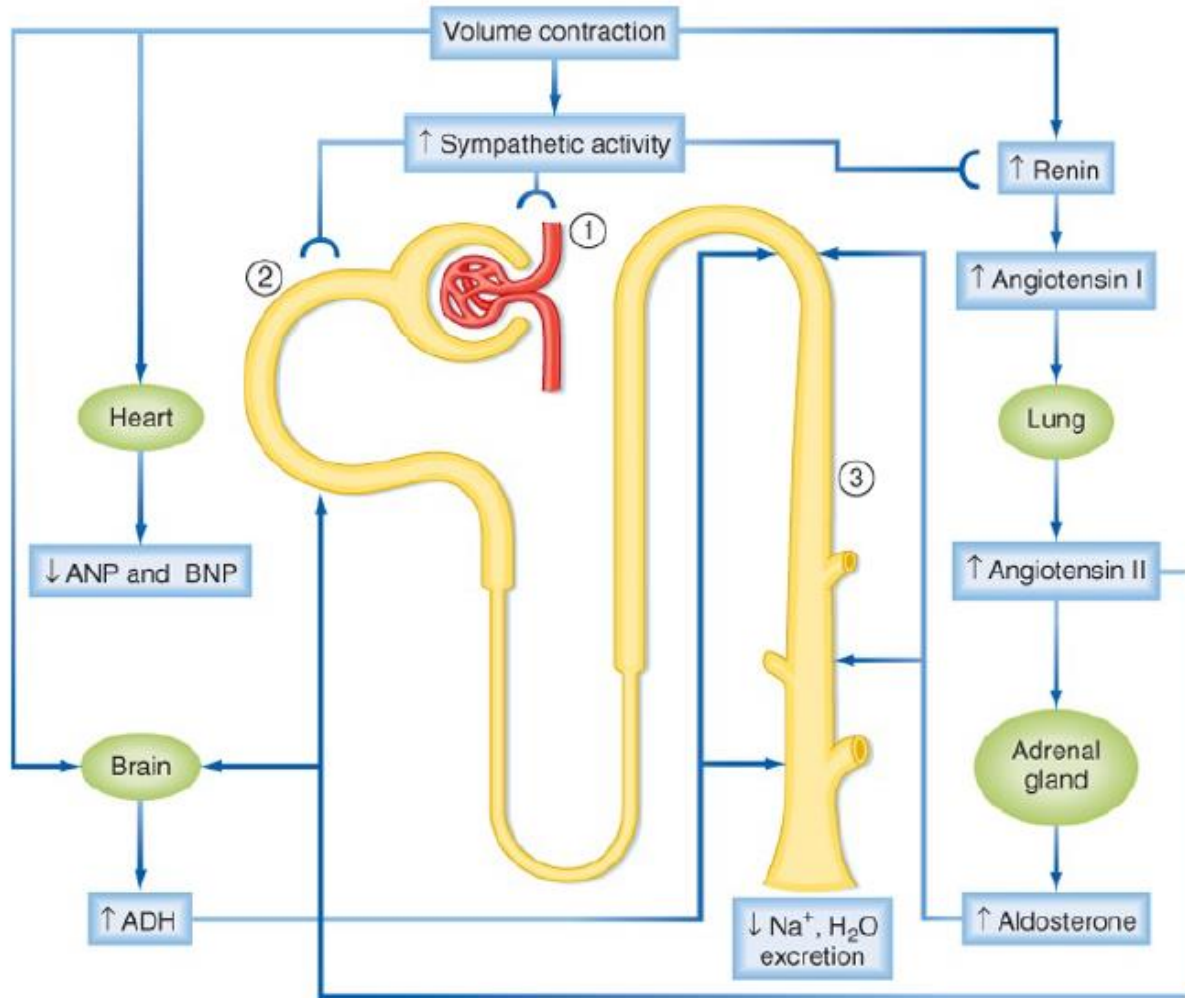
Large ↓↓ in ECV



↑↑ ADH (AVP)

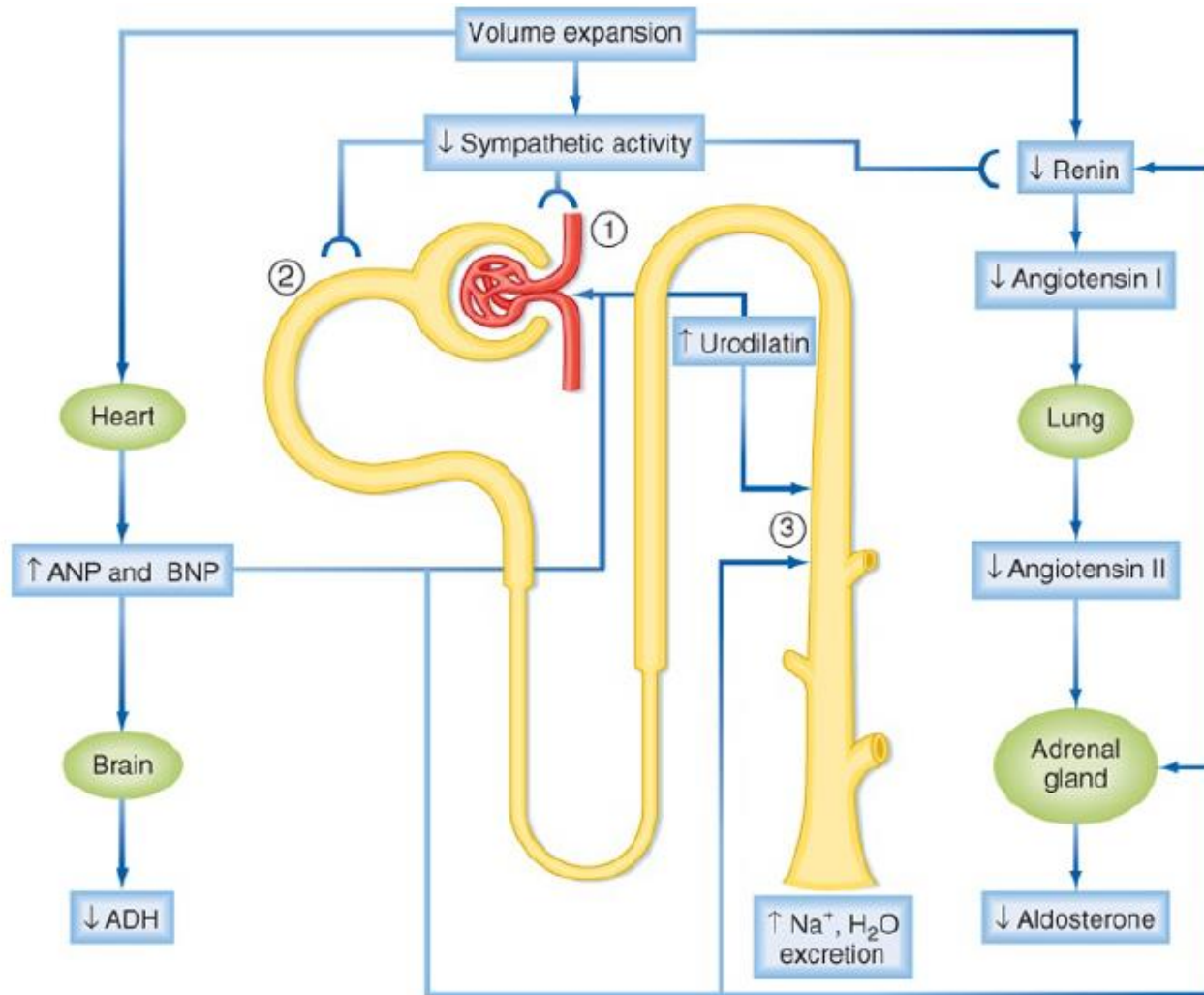


# Summary



$$\downarrow U_{Na^+} \dot{V} = \downarrow GFR \times P_{Na^+} - \uparrow TR$$

# Summary



$$\uparrow U_{Na^+} \dot{V} = \uparrow GFR \times P_{Na^+} - \downarrow R$$

# Final Note

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- Although, under physiologic conditions, the body regulates plasma volume & plasma osmolarity independently.
- Severe derangements in fluid & electrolyte balance may challenge the system by presenting two conflicting changes in osmolarity and volume.
- In general, *the body defends volume at the expense of osmolarity.*



**THANK YOU**

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