REGULATION OF EXTRACELLULAR FLUID VOLUME

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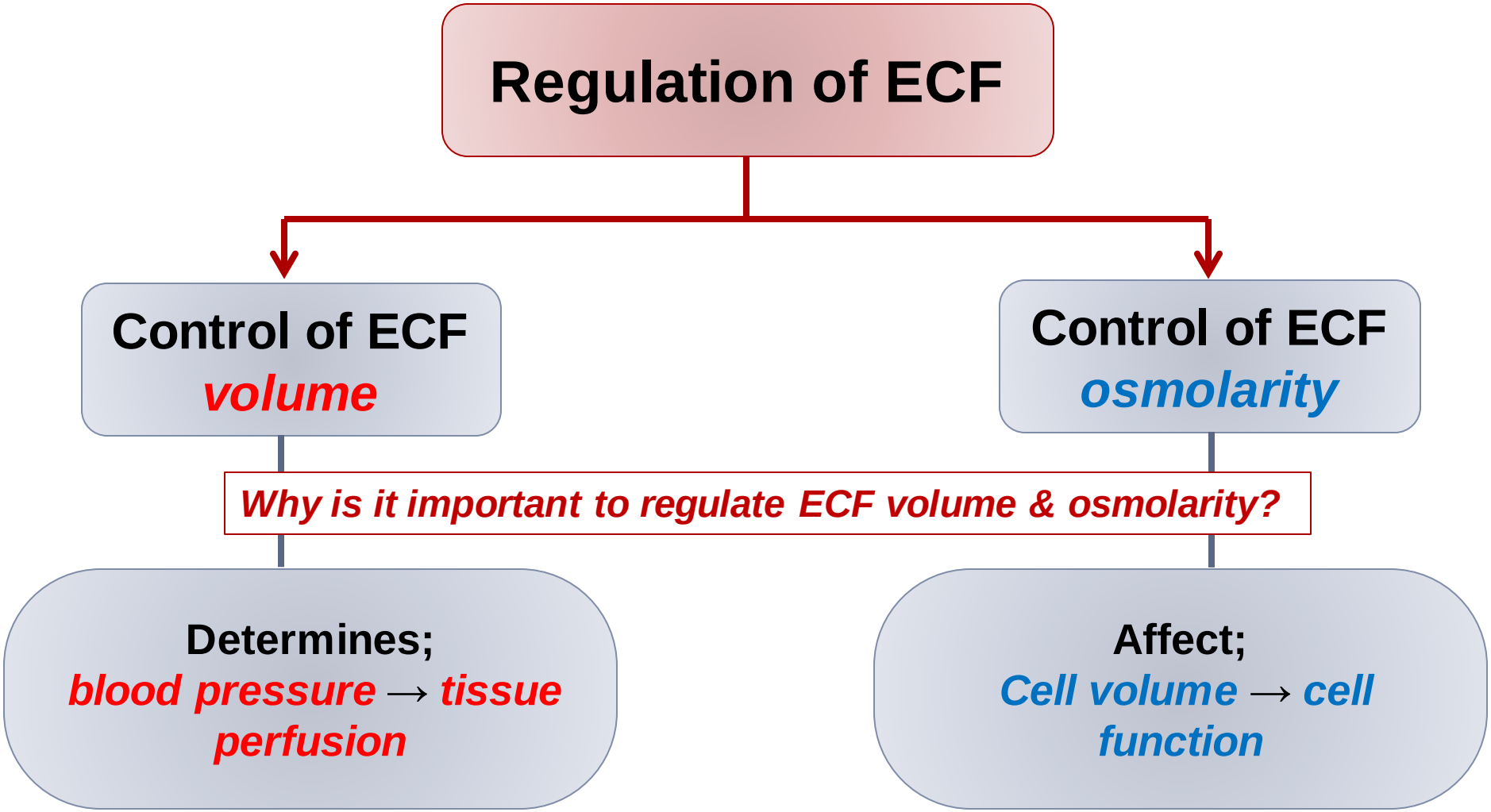
Objectives

- 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 Na^+ in the late distal tubules.

Introduction



Introduction

Regulation of ECF

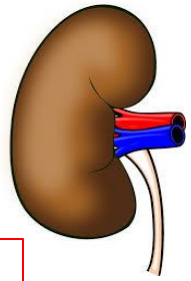
ECF *volume* is regulated by

Adjusting *total body Na^+ content*

ECF *osmolarity* is regulated by

Adjusting *total body water content*

The two systems use different;
Sensors
Hormonal transducers
Effectors



urine

This is the focus of this lecture

***Na^+* Excretion**

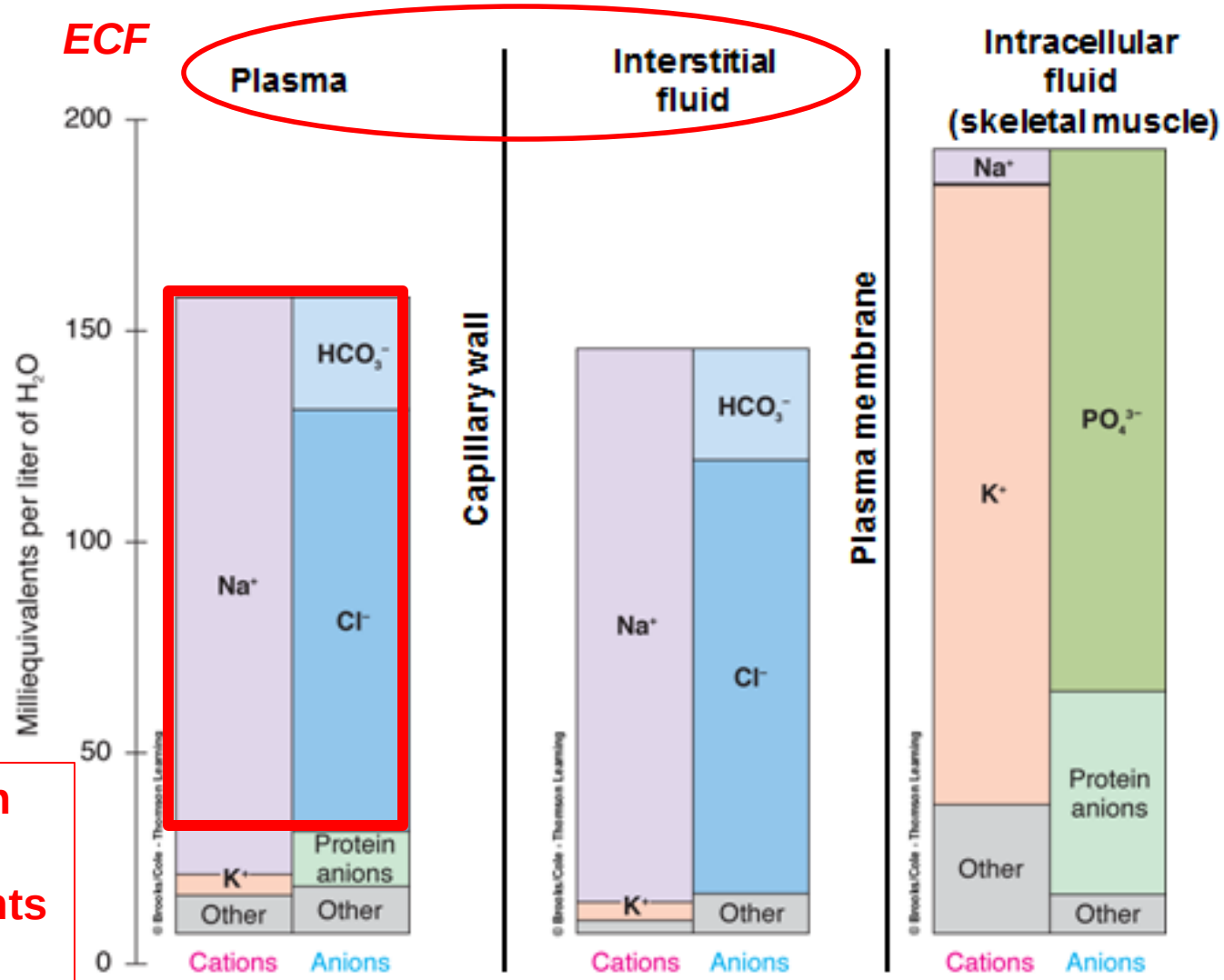
***Water* Excretion**

This was discussed in the last lecture

Why does the body regulate ECF volume by adjusting body Na^+ content??

Let's revise a few concepts!

Electrolyte Composition of Body Fluids



[Figure 15-2; Sherwood]

The main osmotic constituents of ECF

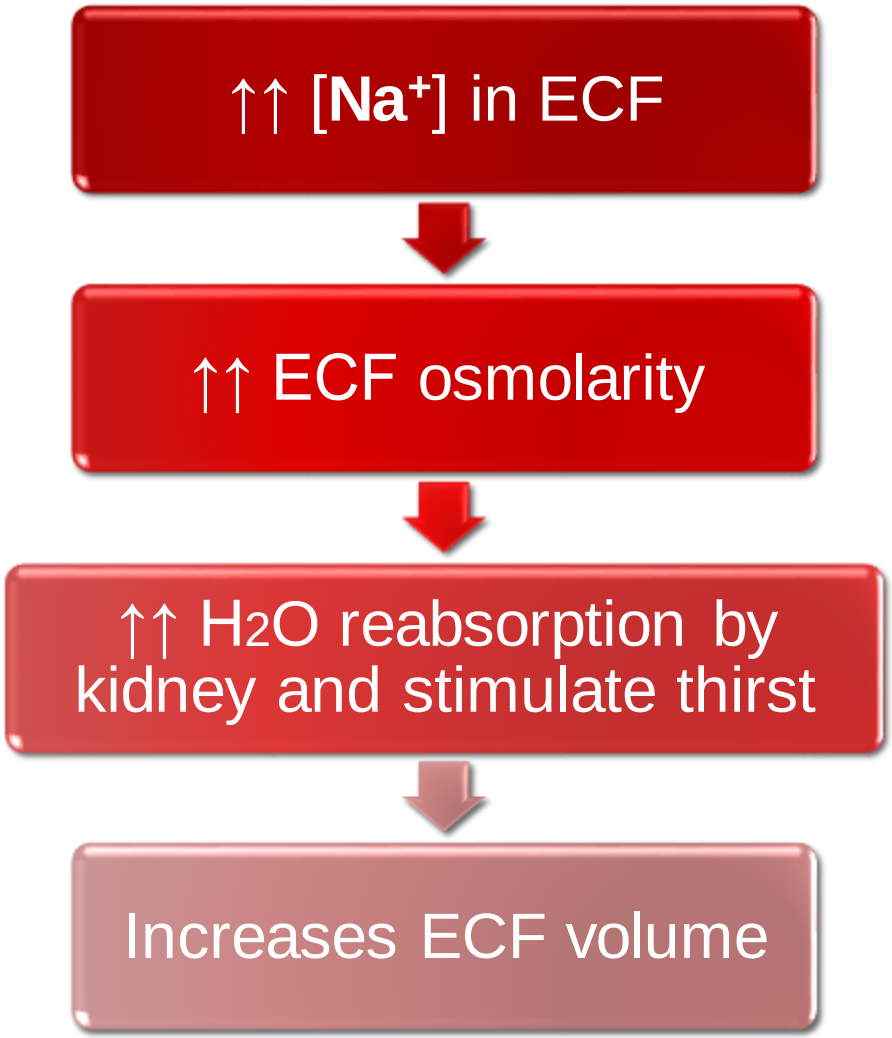
ECF Volume

- The most abundant cation in ECF is **Na^+**
- The most abundant anions in ECF are **Cl^-** and **$HCO3^-$**
- ***The body regulates ECF volume by monitoring and adjusting total body content of Na^+***
- ***ECF volume is closely linked to Na^+ balance… How??***

Why is Na^+ Content the Main Determinant of ECF Volume?

Na^+ and its associated anions are the **main osmotic constituents** of ECF volume.

When **Na^+** salts move, water must follow.



Sodium Balance

Input

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

Output

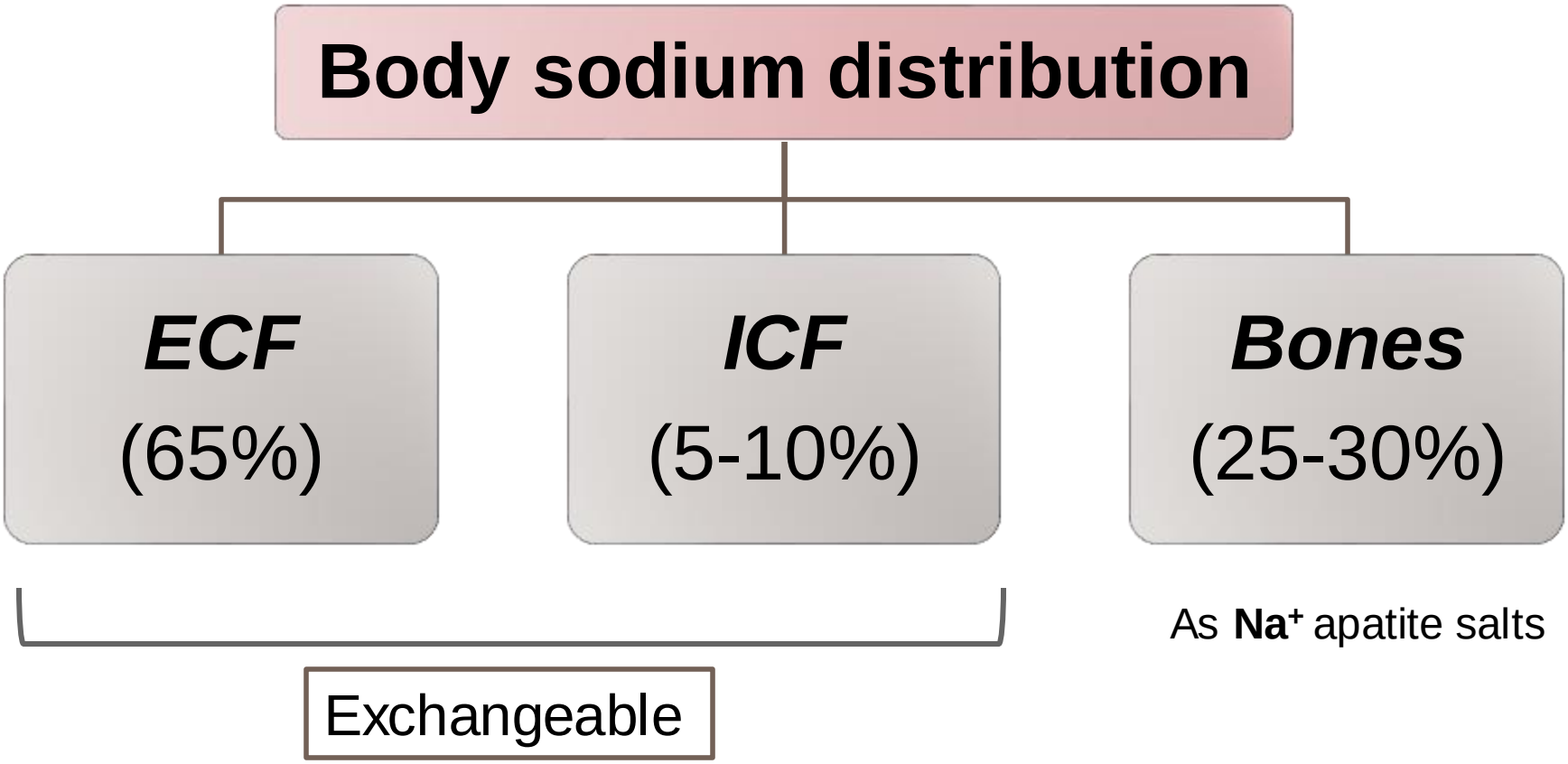
- Kidney (most important).

- GI loss
- Sweat

} Minor pathways under normal conditions

(Preston & Wilson. Lippincott's illustrated reviews Physiology)

Sodium Distribution in the Body



(Boron & Boulpaep. Medical Physiology)

ECF VOLUME REGULATION

ECF Volume Regulation

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

What Does the Body Sense?

- The body does not sense ECF volume per se! But it senses ***Effective circulating volume (ECV).***

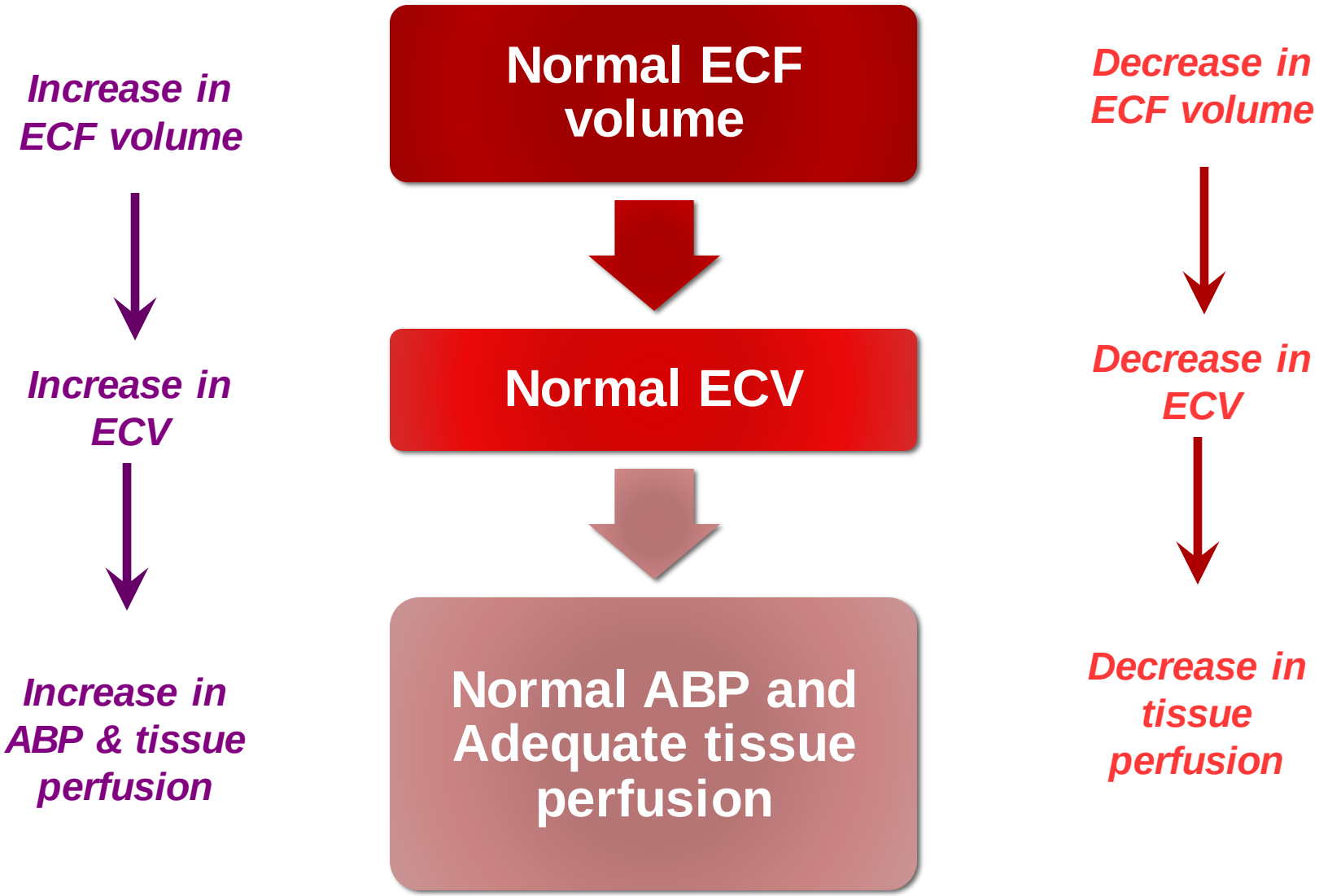
- **Effective circulating volume (ECV)** = a functional blood volume that reflects the extent of tissue perfusion in specific regions, as evidenced by the pressure in their blood vessels.

- In short, ECV reflects adequacy of circulation. Fullness and pressure in the vessels.

- Usually changes in ECV parallel those of ECF volume.

(Boron & Boulpaep. Medical Physiology)

Effective Circulating Volume



What are the Sensors?

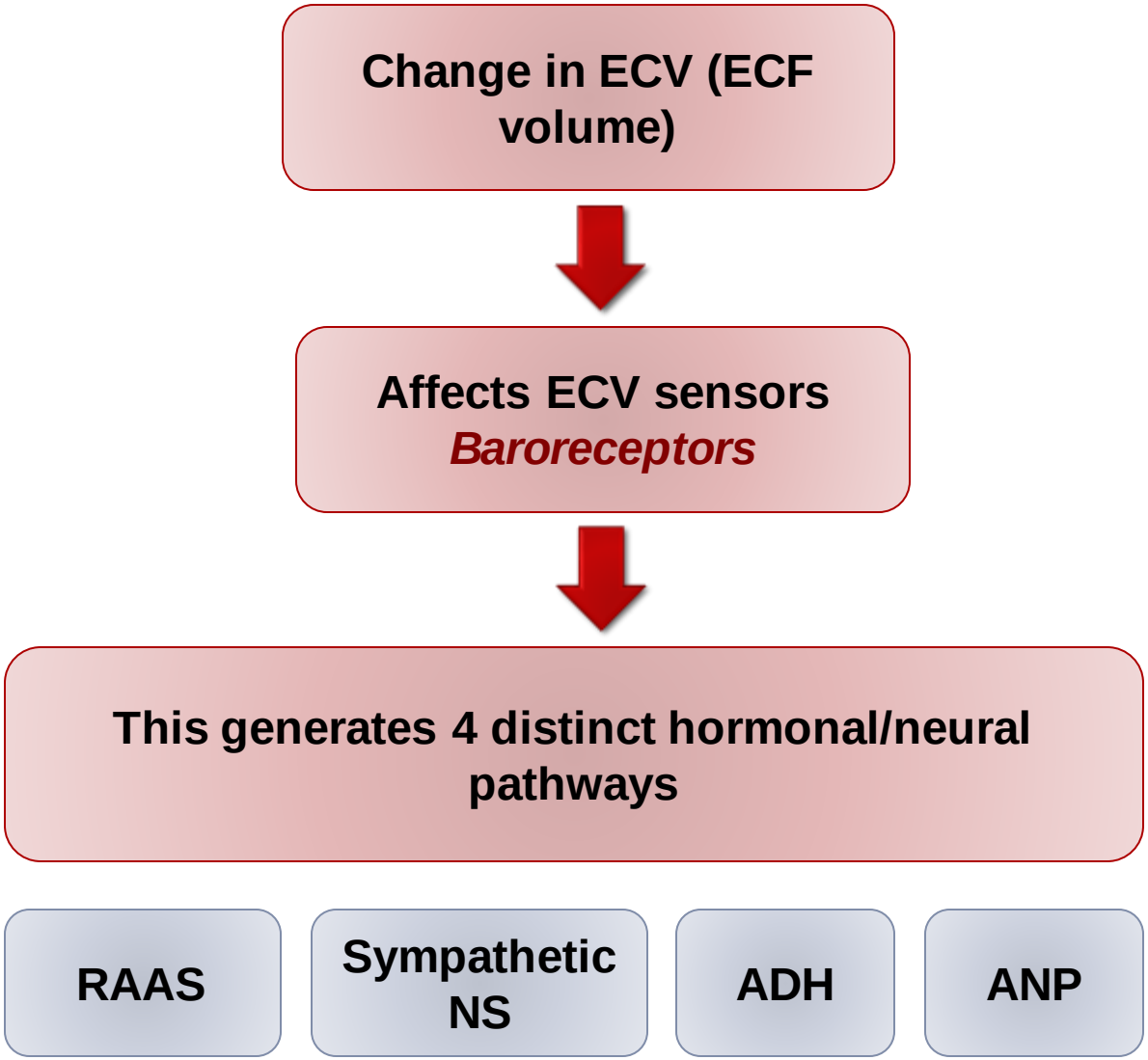
- Changes in ECV are sensed by baroreceptors.
  - Low-pressure baroreceptors.
  - High-pressure baroreceptors.

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*)

(Boron & Boulpaep. Medical Physiology)

What are the Effectors?



The Renin-Angiotensin-Aldosterone System (RAAS)

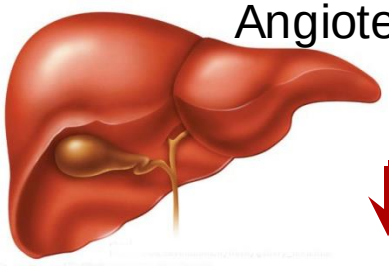
↓↓ ECV

↓

↓↓ stretch of baroreceptors in the afferent arteriole

↓

Causes granular cells to release *Renin*



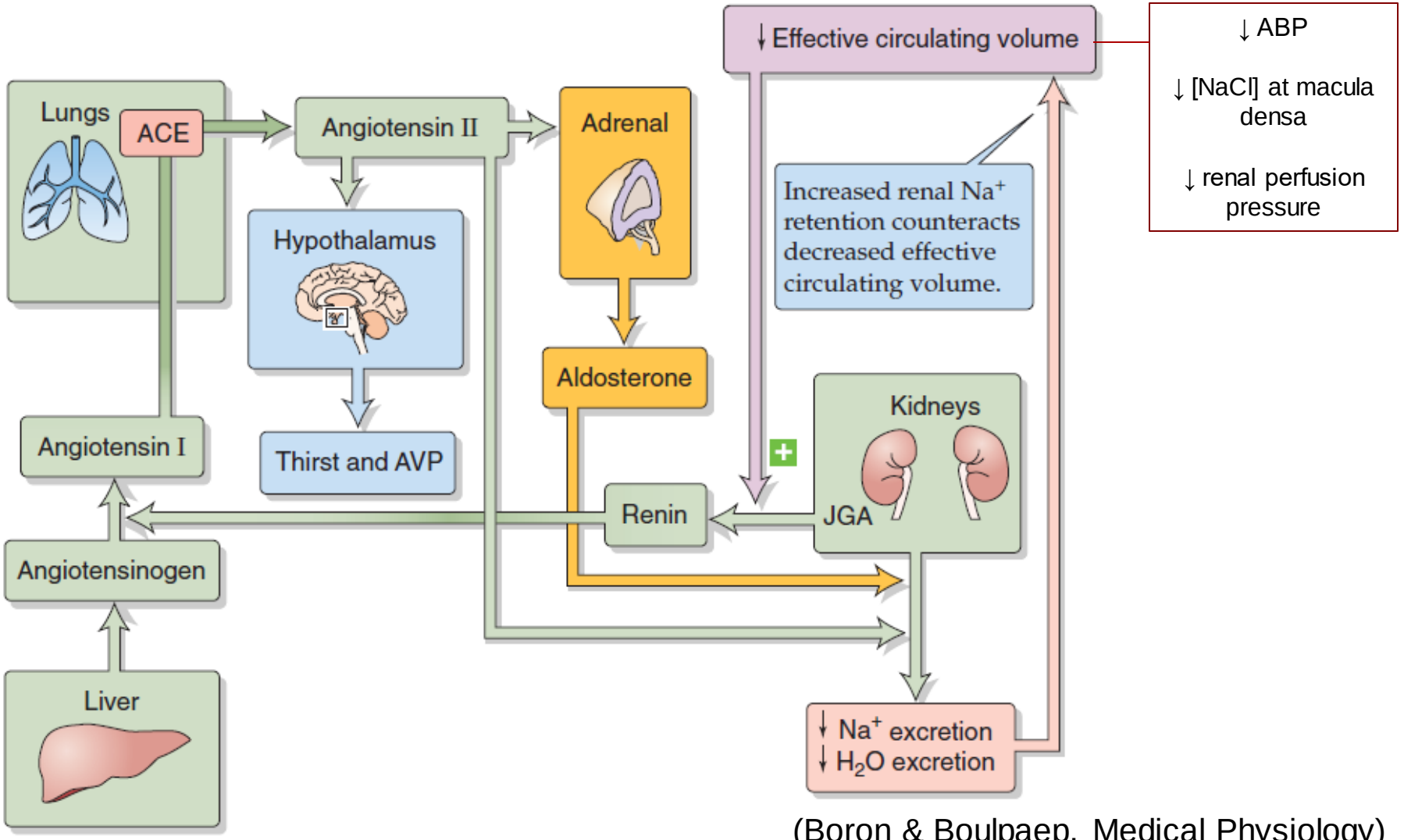
Angiotensinogen —*Renin*→ Angiotensin-I —*ACE*→ **Angiotensin-II**

- ↑↑ reabsorption of Na^+ from tubule
- ↑↑ Aldosterone
- ↑↑ ADH
- Vasoconstrictor

↓↓ Na^+ excretion

(Boron & Boulpaep. Medical Physiology)

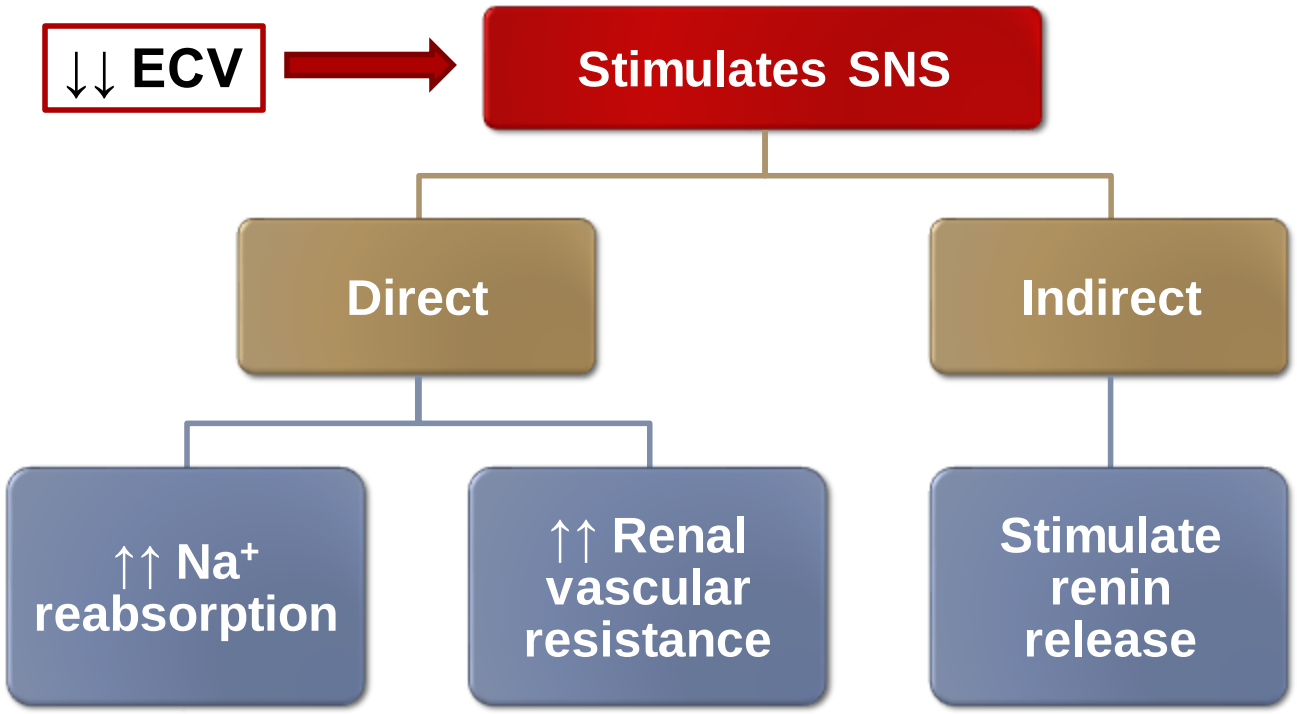
The Renin-Angiotensin-Aldosterone System (RAAS)



(Boron & Boulpaep. Medical Physiology)

Sympathetic Nervous System (SNS)

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



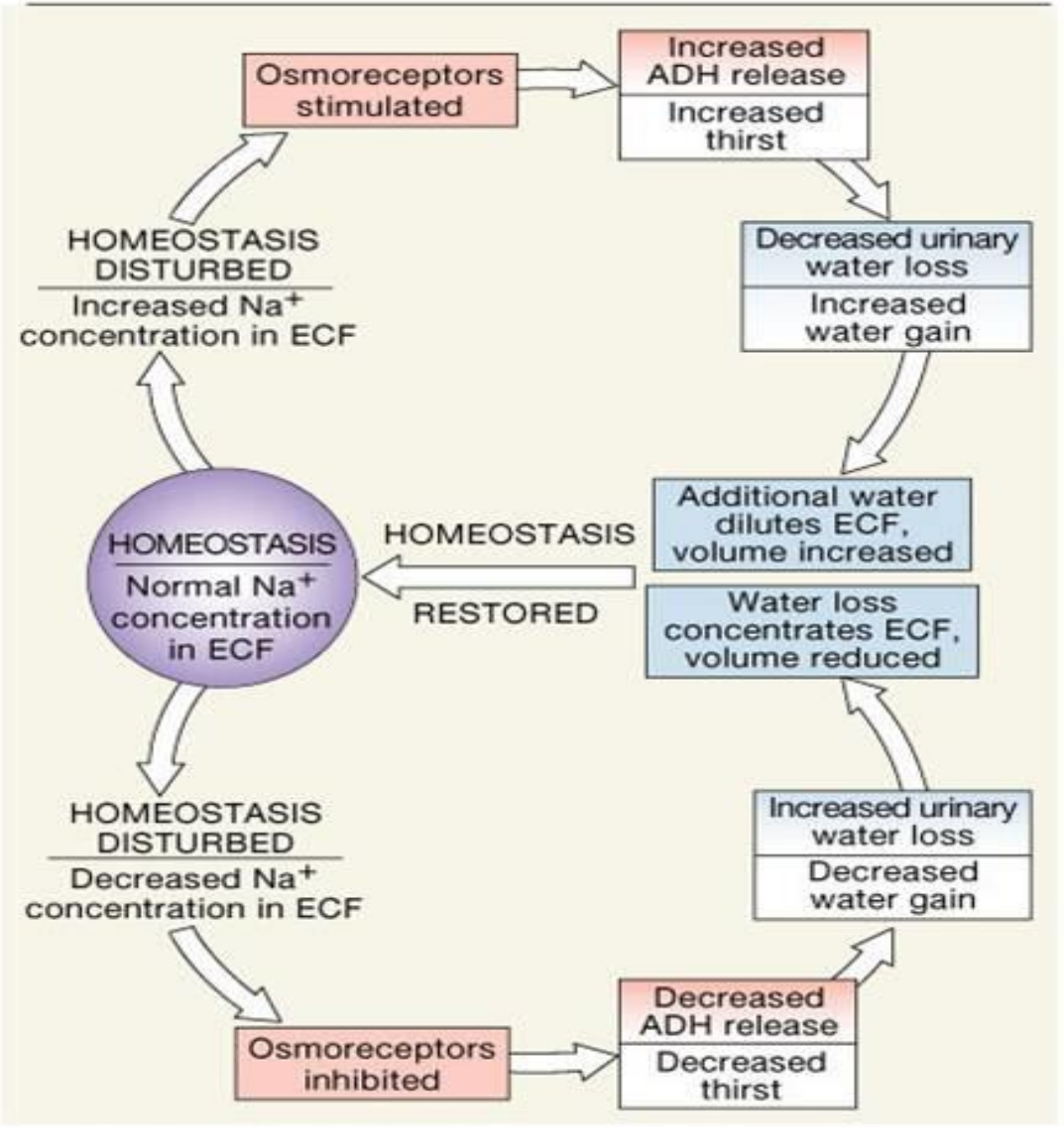
Atrial Natriuretic Peptide (ANP)

- ANP promotes ***natriuresis*** (Na^+ excretion).
- Secreted by atrial myocytes in response to stretch.

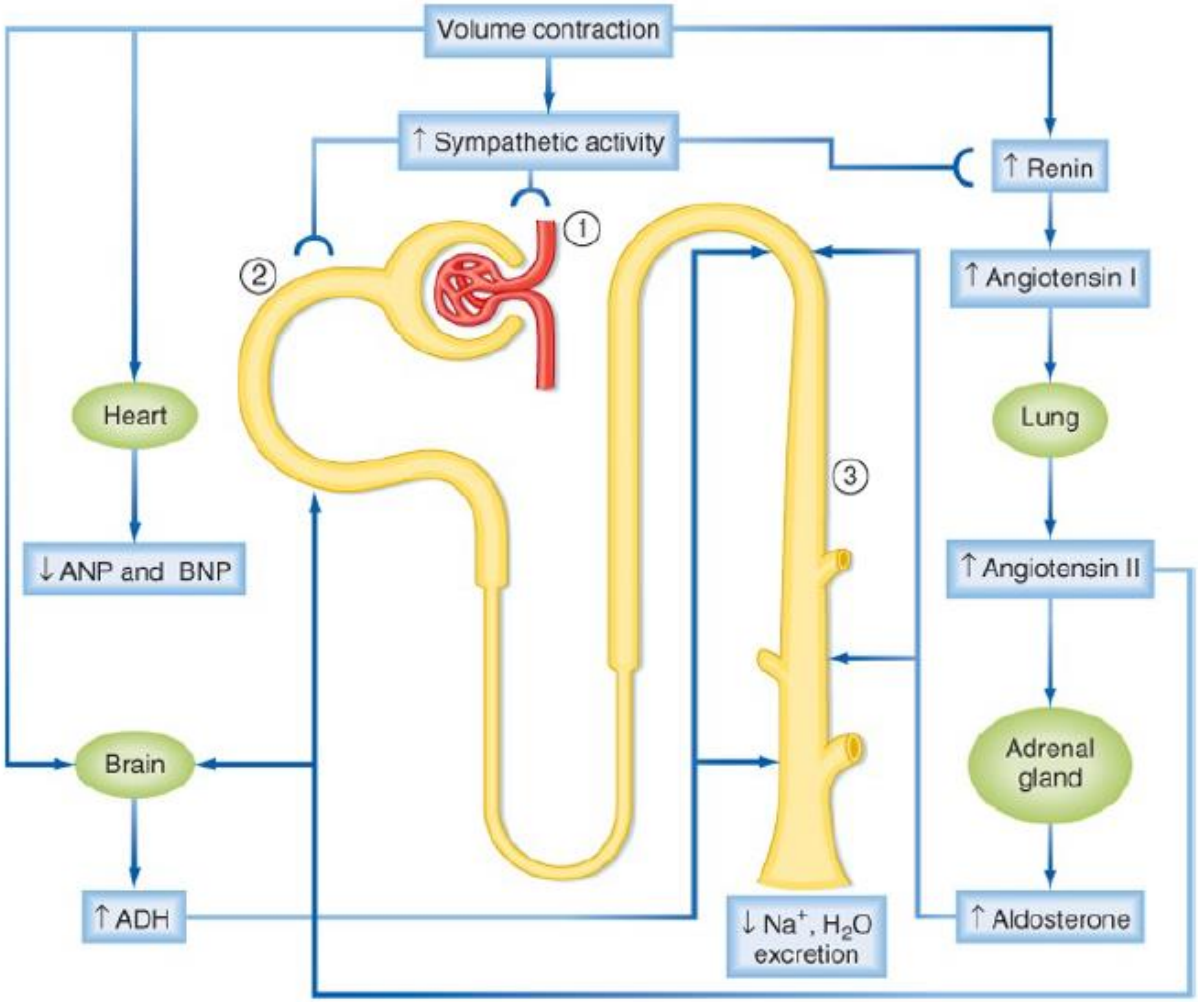
Antidiuretic Hormone (ADH)

Large ↓↓ in ECV

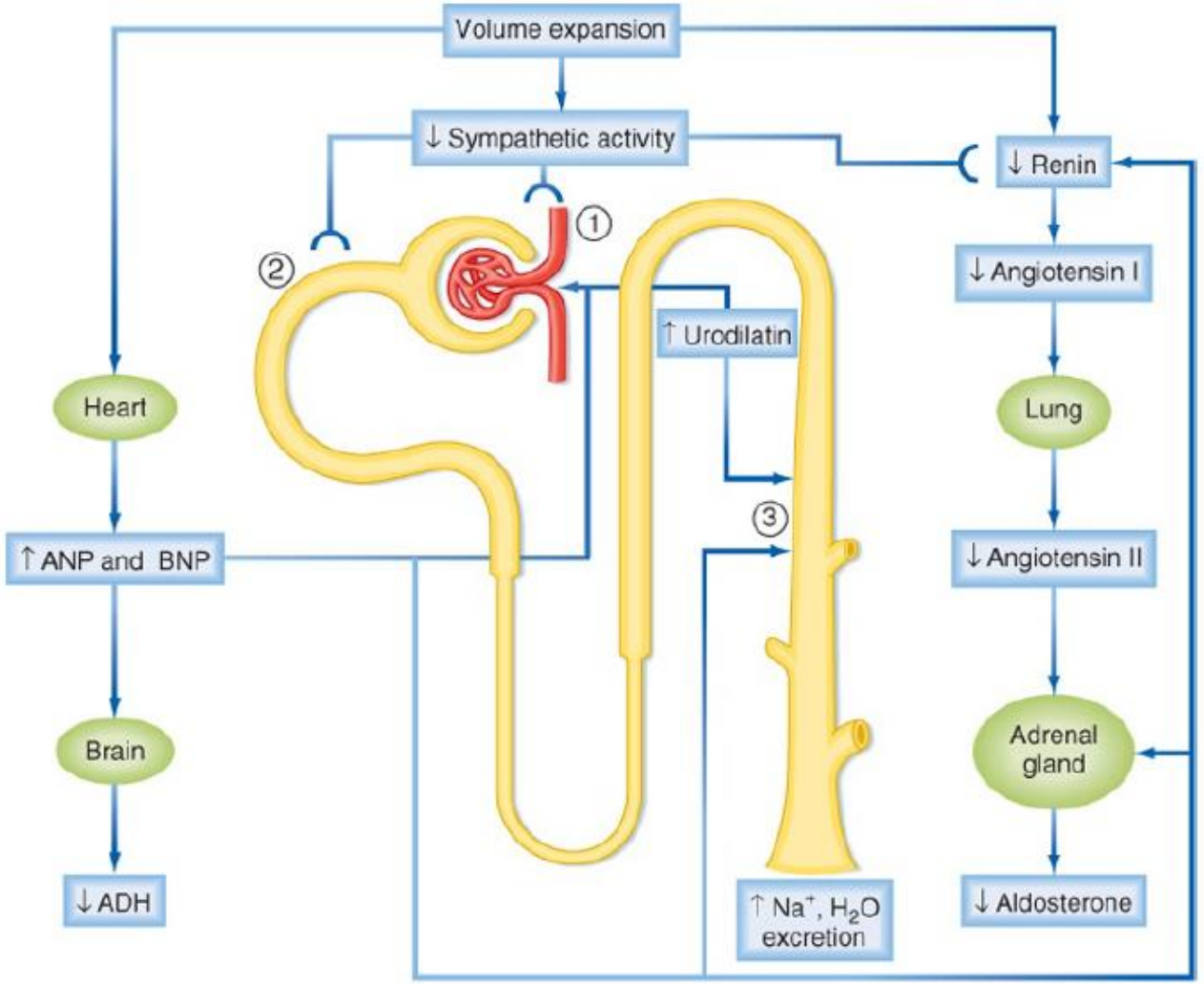
↑↑ ADH (AVP)



Summary



Summary



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

Final Note

- 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