# Water And Electrolytes

# Balance

# And

# Imbalance

# In Human Body

## Body Water

- **Water** is the **chief constituent of human body.**

- Water is the **chief solvent of body.**

- Water **comprises 60-70%** of total body weight

- **Human body cannot exist without Water** the**.**

# Sources Of Body Water

## Exogenous Sources Of Water

- **Drinking Water ,Beverages** -1000-1500 ml

- **Water from Cooked Foods**

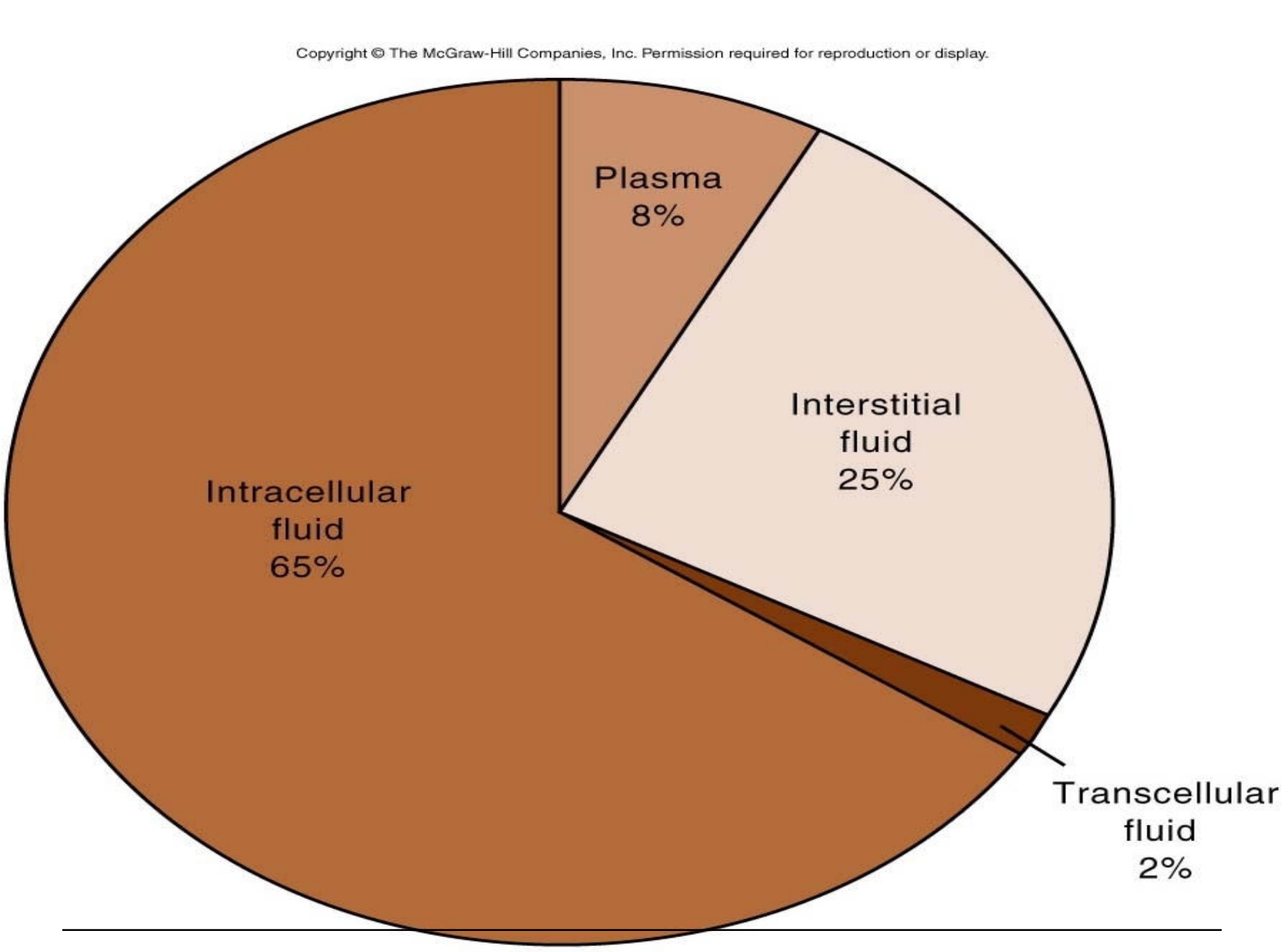
- **Water intake** through mouth is **highly variable 1-5 Litres** this depend on :
  - **Social habits**
  - **Climatic condition**

## Endogenous Sources Of Water

- **Metabolic Water - 400 ml**
- Produced during **metabolism oxidation of food substances.**

**(At end of ETC Process)**

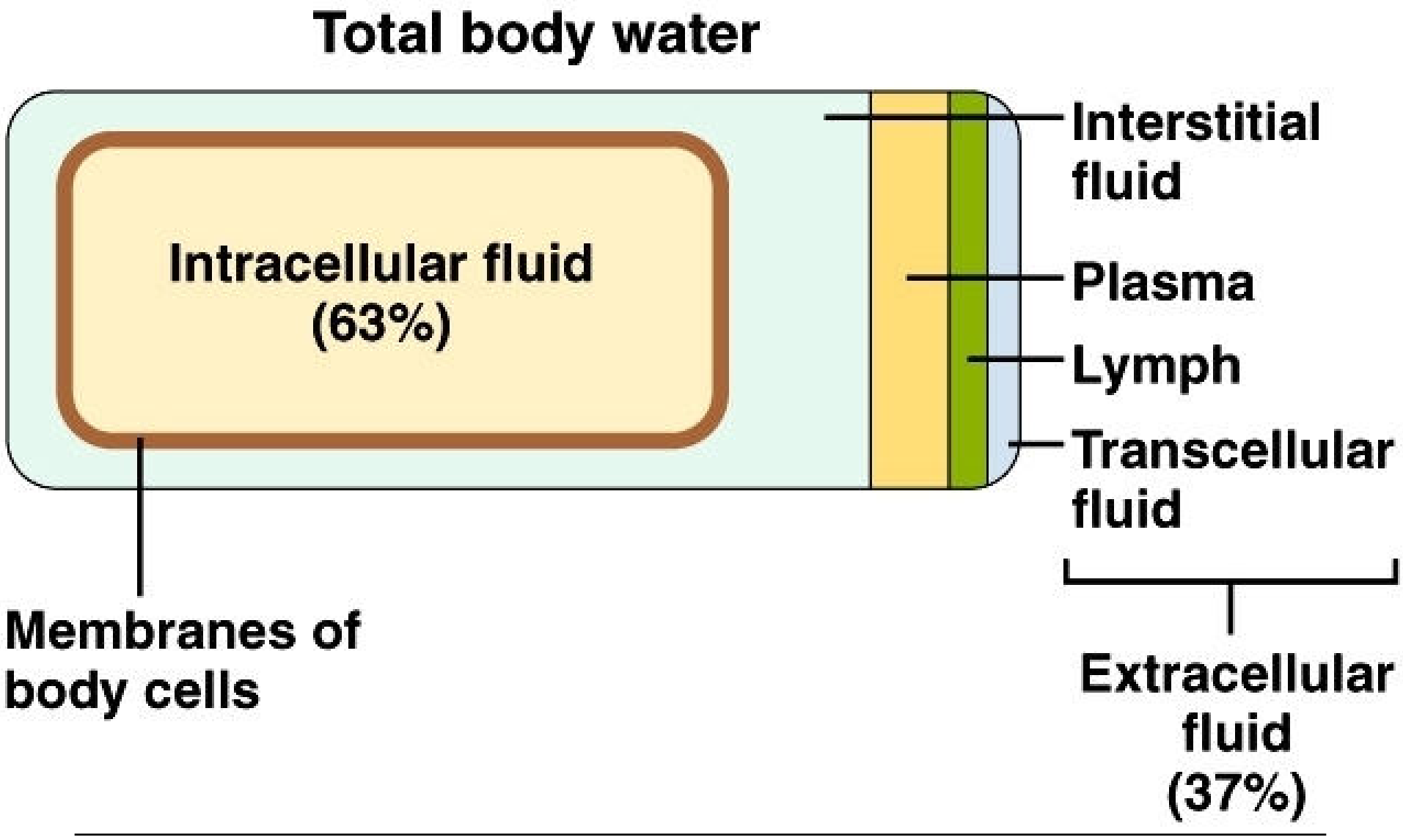
# Distribution Of Body Water

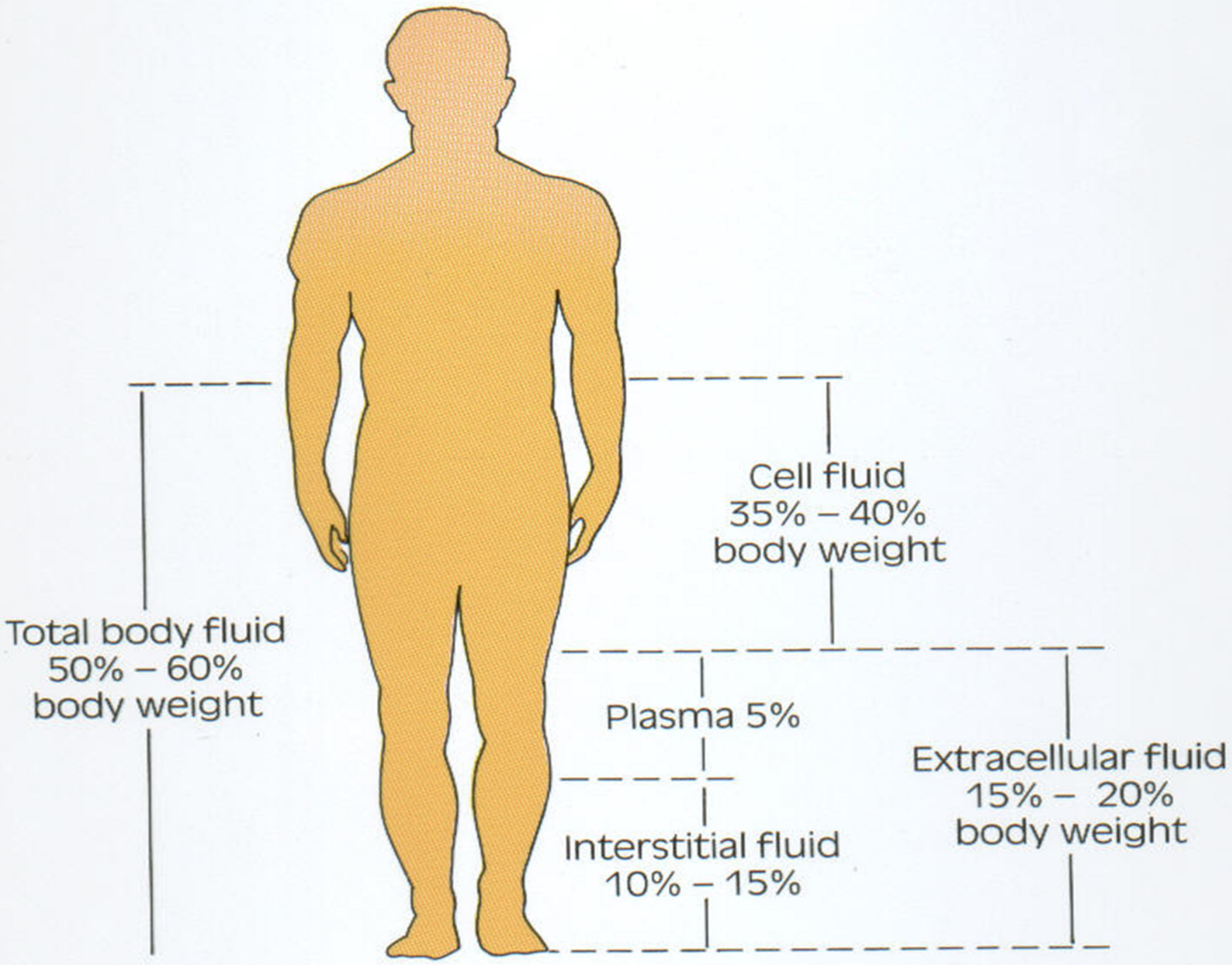


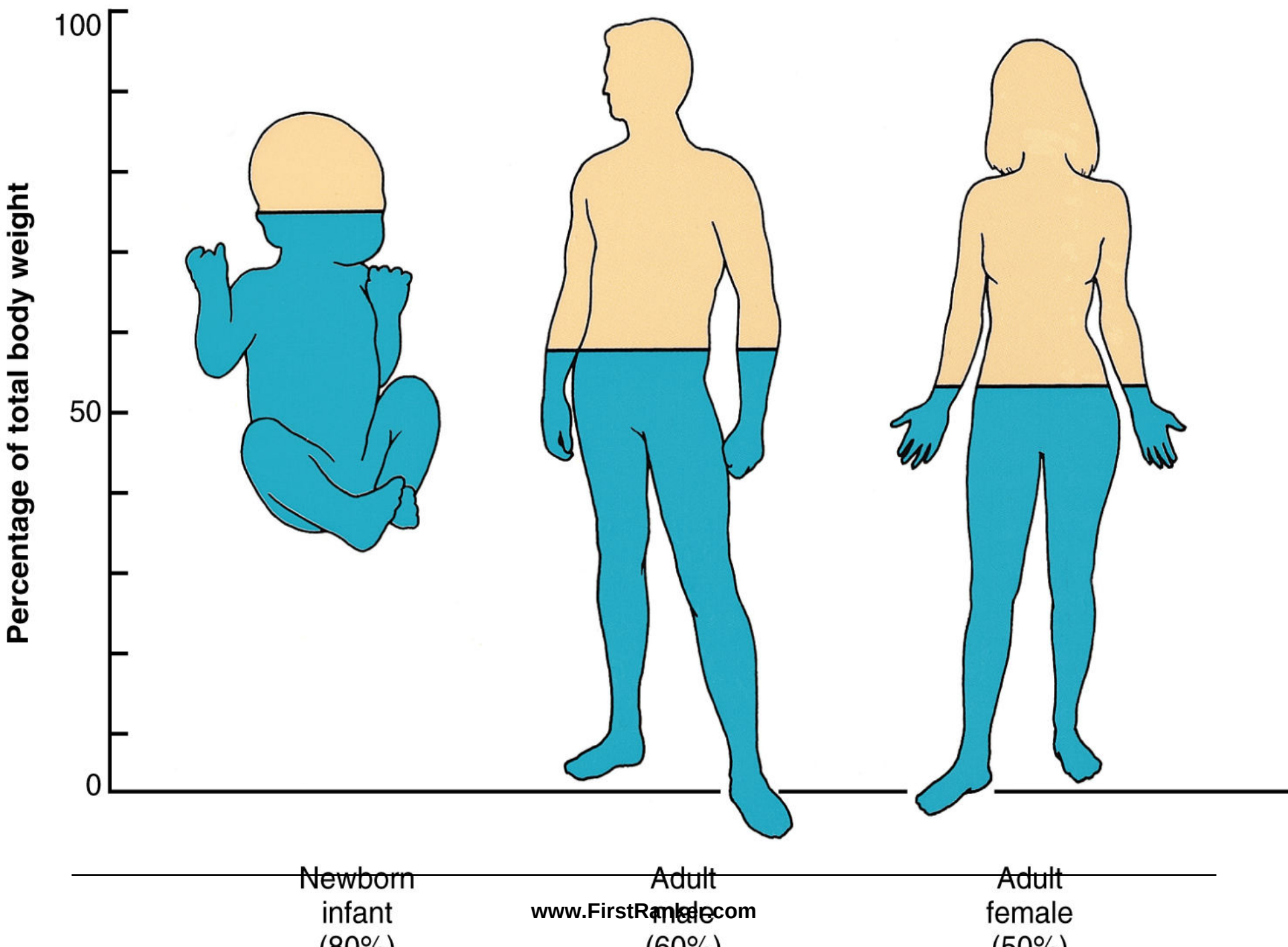
- In an adult of 70 kg body

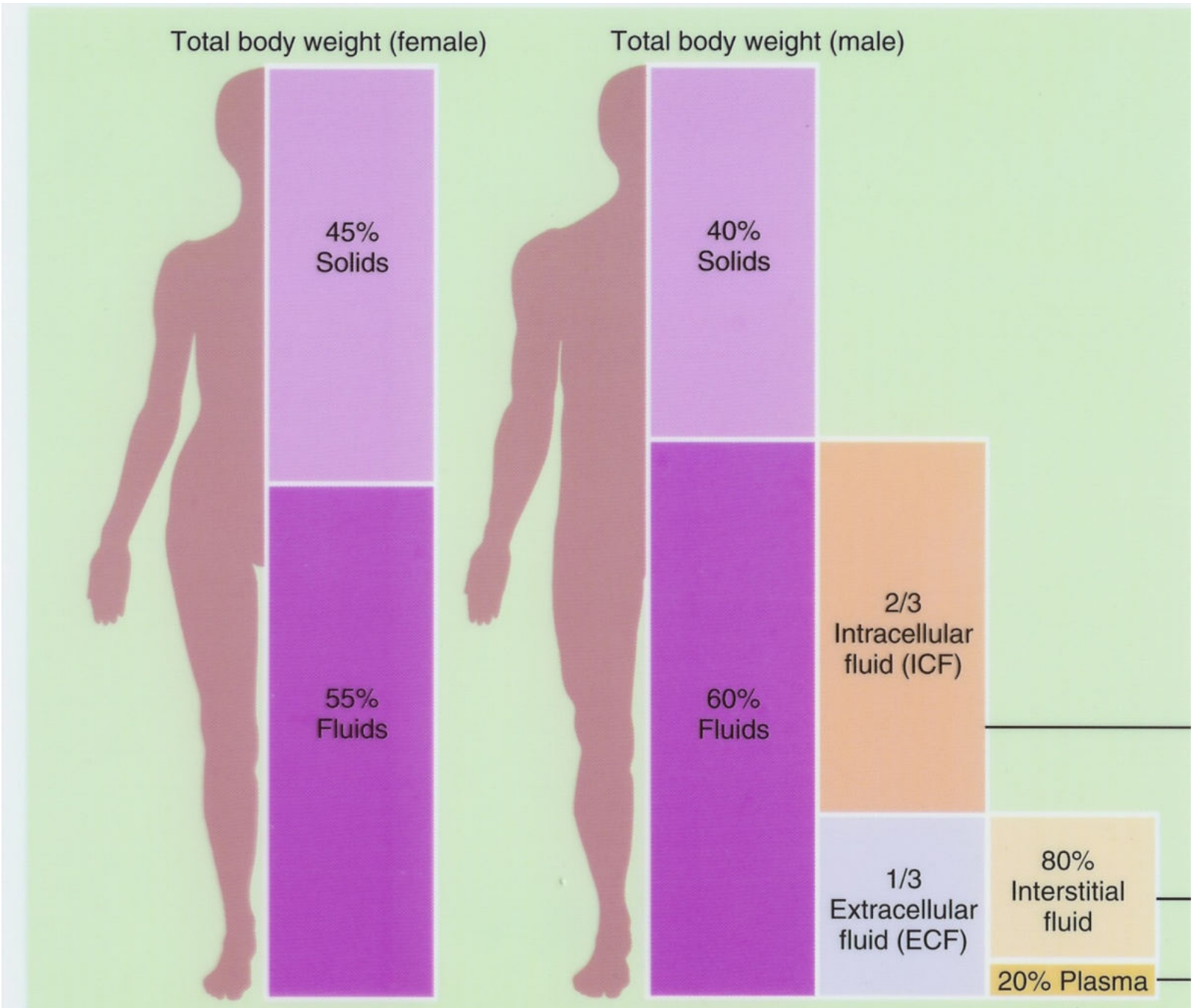
- **Total Body Water -60- 70% /36-49 Lt**
- **Intracellular Fluid -65 % - 35 L**
- **Extracellular Fluid -35% -14 L**
  - **Interstitial Tissue Fluid -25% -11L**
  - **Plasma /Intra Vascular Fluid -8% -3L**
  - **Transcellular Fluid- 2%**










- **Body water content** in percentage of a body weight is **lowest in.**

(A)Well built man

**(B) Fat woman**

(C)Well nourished child

**(D) Fat Man**

# Functions Of Body Water

- **Involved in Biochemical reactions**
  - **Water act as reactant in many hydration Hydrolytic reactions of metabolic pathways.**
- **Transporting media of body:**
  - **Transportation of nutrients and waste metabolites** through aqueous media of blood and tissue floods.
- **Regulates body temperature**

- Water transports **Hormones**, Enzymes, **blood platelets**, and **red and white blood cells**
- Water **act as a solvent** for **Electrolytes** and **Non electrolytes**
- Water Facilitates **Digestion** and promoting **Elimination of ingested food**
- Water serve as a tissue **Lubricant**

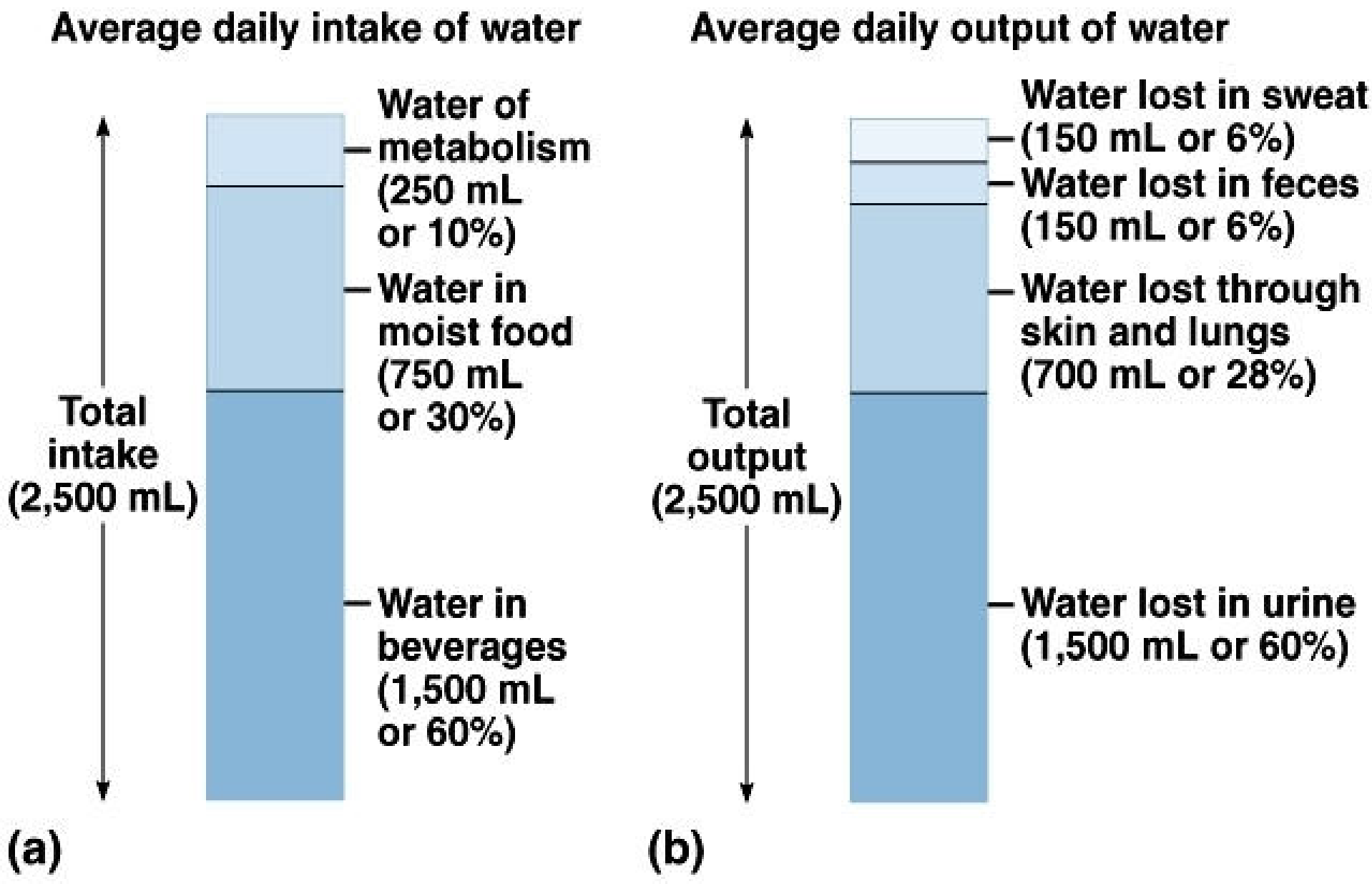
# Body Water Input and Output

# Body Water Input

- Body can gain water by
  - **Ingestion** of liquids and moist foods (**2300mL/day**)
  - **Metabolic** synthesis of water during cellular respiration **(200mL/day)**

# Body Water Output

- **Body losses water through:**
  - **Kidneys (1500mL/day)**
  - **Evaporation from Skin (600mL/day)**
  - **Exhalation from Lungs (300mL/day)**
  - **Feces (100mL/day)**




# BODY ELECTROLYTES

# What Are Electrolytes?

- Substance when dissolved in solution **dissociates into ions**
- These ions are able to **carry an electrical current**

- **An Electrolyte** is a substance
- Which **develops an electrical charge when dissolved in water**

# Body Electrolytes

- Salts like **NaCl** and **KCl** in aqueous solutions gets dissociated to
- **Charged ions $Na^+$ and $Cl^-$ called as Electrolytes.**
- The **concentration of these Electrolytes is expressed** as **mEq/L.**

# Types Of Electrolytes

- **CATION -** Positively charged Electrolyte
- **ANION -** Negatively charged Electrolyte

- **Water molecules completely surround these dissociated ions**

- These **prevents union of Cations and Anions.**

# Distribution Of Body Electrolytes In ECF and ICF

# ELECTROLYTES IN BODY FLUID COMPARTMENTS

| INTRACELLULAR Electrolytes | EXTRACELLULAR Electrolytes |
|---|---|
| POTASSIUM | SODIUM |
| MAGNESIUM | CHLORIDE |
| PHOSPHOROUS | BICARBONATE |



## To Maintain Electrical Neutrality In Each Fluid Compartments

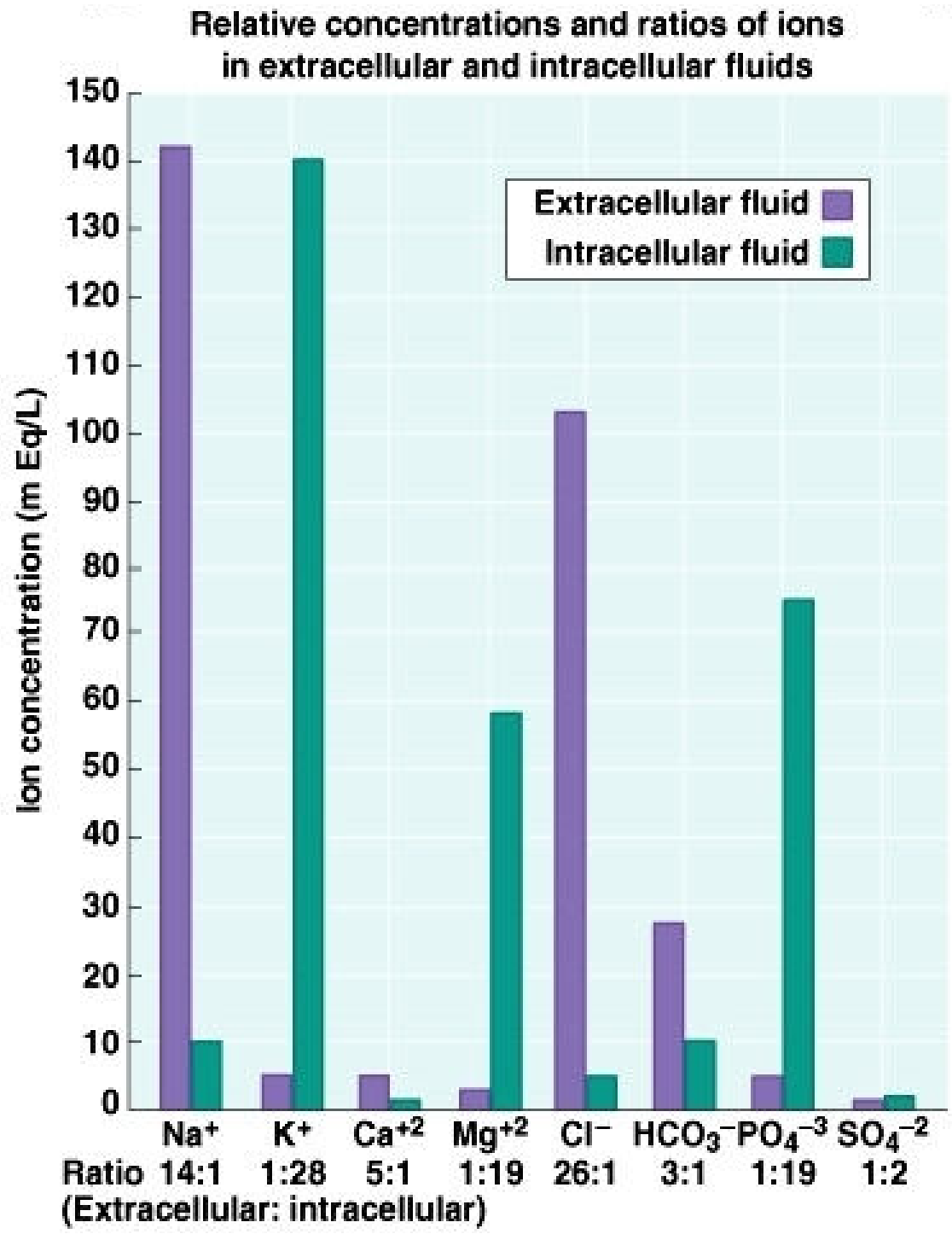
**Number Cations =Number Anions**

| ECF Cations | ECF Anions |
|---|---|
| $Na^+$ ( 140 mEq/L) | $Cl^-$ (103 mEq/L) |
| $K^+$ | $HCO3^-$ |
| $Ca^+$ | $HPO4^{--}$ |
| $Mg^+$ | $SO4^{--}$ |
| **Total Cations 155 mEq/L** | **Total Anions 155 mEq/L** |

- **Predominant Cations and Anions of ECF:**
- **$Na^+$ and $Cl^-$ respectively.**

| ICF Cations | ICF Anions |
|---|---|
| $Na^+$ | $Cl^-$ |
| $K^+$ (150 mEq/L) | $HCO3^-$ |
| $Ca^+$ | $HPO4^{--}$ (140 mEq/L) |
| $Mg^+$ | $SO4^{--}$ |
| **Total Cations 195 mEq/L** | **Total Anions 195 mEq/L** |

- Thus the predominant Cations and Anions of ICF
- **$K^+$ and $HPO4^{--}$ respectively.**




# Electrolyte and protein anion concentrations

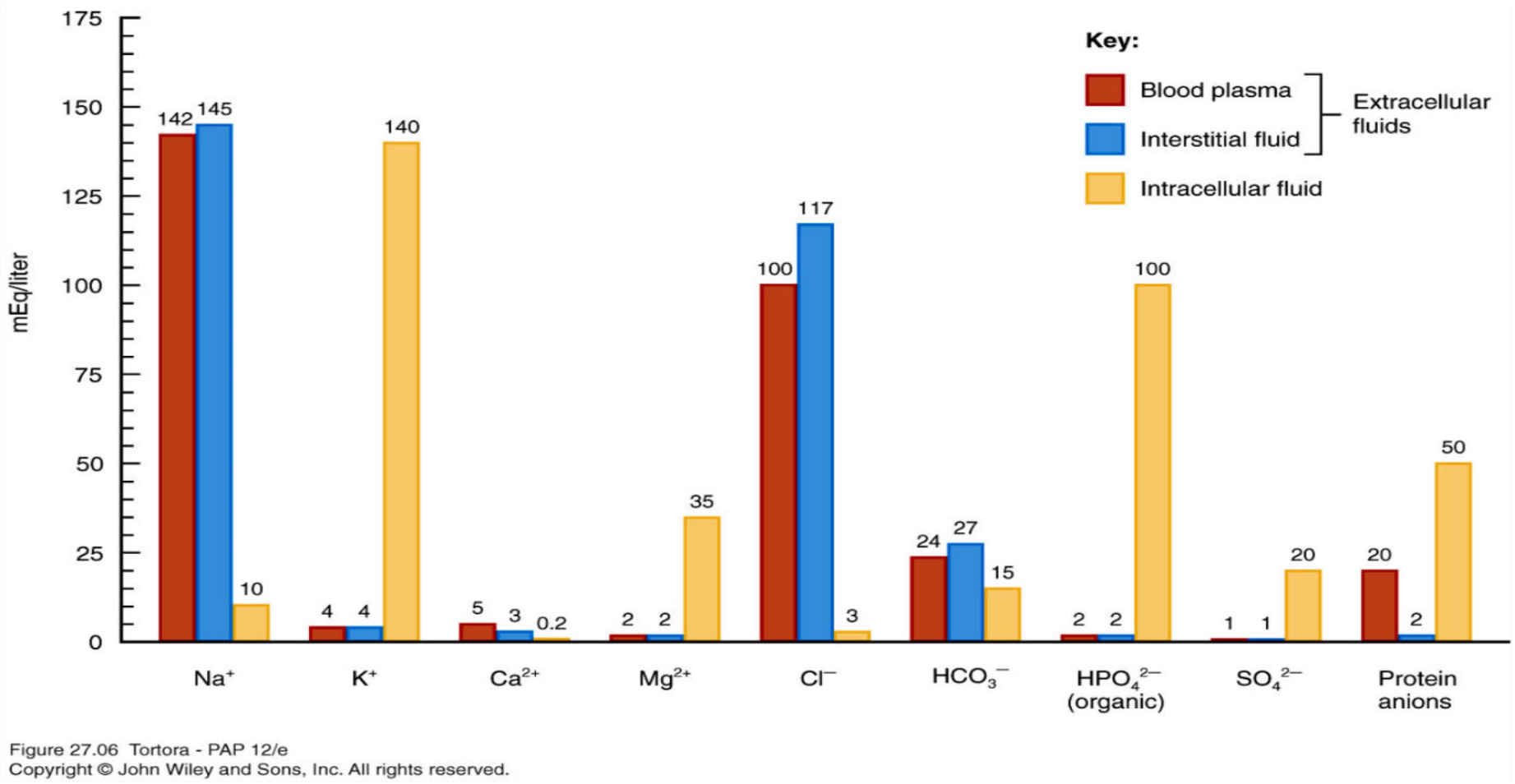



Figure 27.06 Tortora - PAP 12/e

# Functions Of Body Electrolytes

- **Electrolytes are well distributed in the body compartments**.
- Electrolytes in the medium/compartments **produce osmotic pressure**.
- This osmotic pressure **helps in maintaining water balance.**

# ELECTROLYTES

- **$Na^+$:** Most abundant electrolyte in the ECF.

- **$K^+$:** Essential for normal membrane excitability for nerve impulse

- **$Cl^-$:** Regulates osmotic pressure and assists in regulating acid-base balance

- **$Ca^{2+}$:** Promotes nerve impulse and muscle contraction/relaxation

- **$Mg^{2+}$:** Plays role in carbohydrate and protein metabolism, storage and use of intracellular energy and **neural transmission. Important in the functioning of the heart, nerves, and muscles**

- For more detail functions of Electrolytes
- **Refer Minerals Chapter.**

# Movement of Water and Electrolytes

**Diffusion** – movement of particles down a concentration gradient.

**Diffusion:** the random movement of particles in all directions through a solution

- **Osmosis:** movement of water across a membrane from a less concentrated solution to a more concentrated solution

- **Osmosis** – diffusion of water across a selectively permeable membrane

- **Osmolarity:** The number of moles **per liter of solution**

- **Osmolality:** The number of moles **per Kg of Solvent.**

- **Sodium** and its associated ions in plasma make the **largest contribution** (90%) for **plasma Osmolality**.

- **Osmolality is measured by Osmometer**

- **Plasma Osmolality = 2 x Plasma $Na^+$ mmol/L**

- **Osmolality**: concentration of a solution determined by the number of dissolved particles per kilogram of water.
- **Osmolality controls water movement and distribution in body fluid compartments**

- **Active transport:** Movement of solutes across membranes;
- **Requires transporters** and **expenditure of energy**
- Movement of particles **is up a concentration gradient**

- **Filtration:** transfer of water and solutes through a membrane
- From a **region of high pressure to a region of low pressure**

# Normal Fluid and Electrolytes Exchanges In Body

## Water And Electrolytes Movement INN and OUT of Cells.

## Remember

- Normally in a healthy body there **is osmotic equilibrium maintained in each compartment.**

- In a healthy body the **semipermeable cell membrane**

- **Allows only passage of Water but not Electrolytes through it.**

- **Disturbance in osmotic equilibrium of compartments**
- **Draws water from the compartment** with **lower osmotic pressure (Hypotonic)**
- **Into the compartment with higher osmotic pressure (Hypertonic)**
- **Until equilibrium is restored.**

- In the **concentration gradient of $K^+$ and $Cl^-$**

- **$K^+$ tends to diffuse out of the cells** and **$Cl^-$ enters into cells.**

- During difference **in electrical potential**
- For example **in relative negativity inside the cells**
- **There tend to keep $Cl^-$ out and $K^+$ inn.**

# Remember

- Cells do not allow accumulation of $Na^+$
- **Na rapidly enters in the cells**
- **By the Sodium pump, Na is effectively extrudes out from ICF**
- **By active transport of Na out of cells.**

- However in case of $Na^+$ diffusion into cells
- It is **favored by both the concentration gradient and electrical potential.**

## Remember

- **Where Sodium goes, Water follows.**

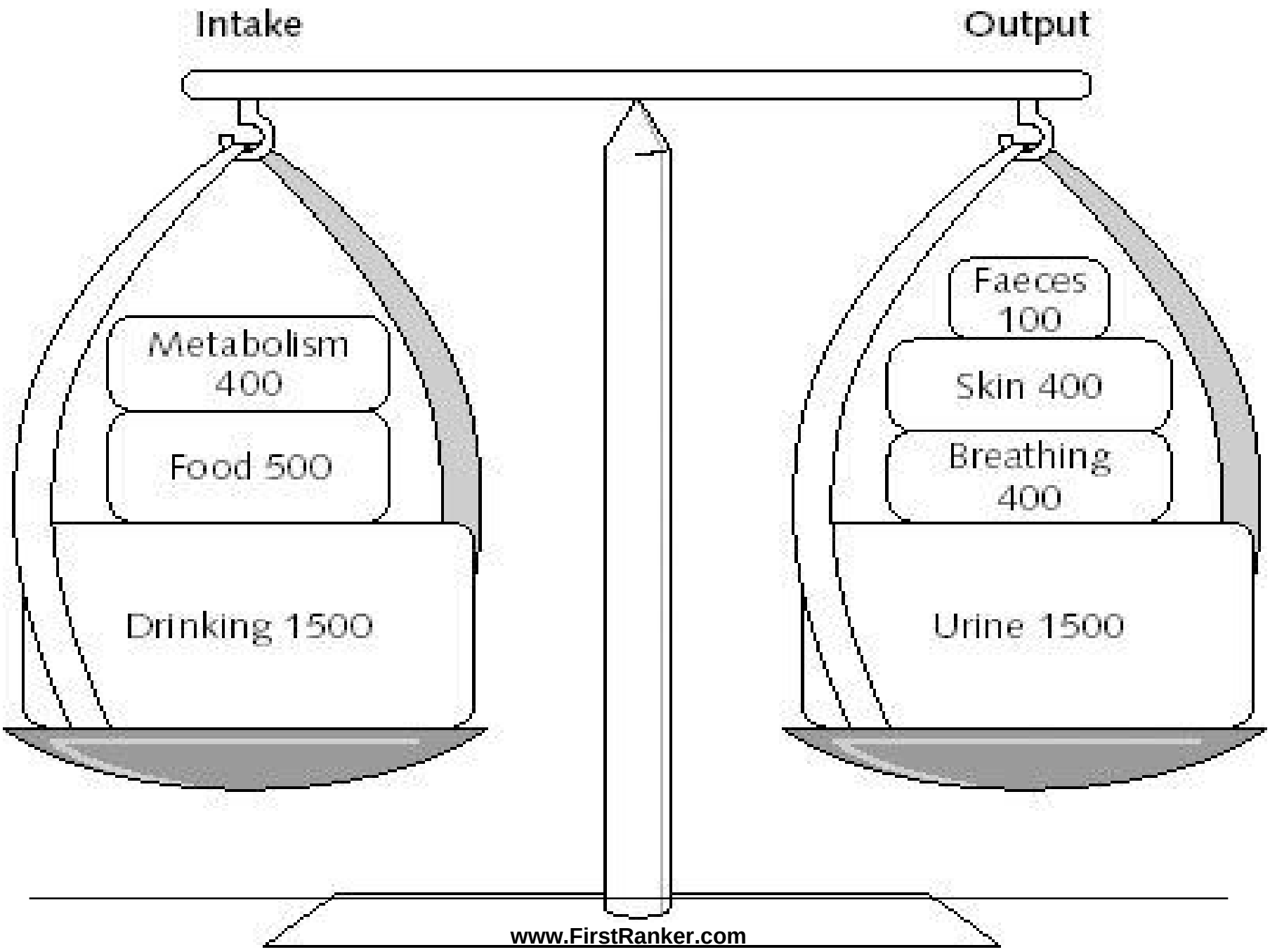
# Homeostasis Of Body Water
# OR
# Regulation Of Body Water

# Water Balance

- An **healthy adult individual always try**
- **To maintain water balance** by the homeostatic mechanisms.
- Since **Water balance is vital for human body**

- A body is said to be in **water balance In a day**
- When the amount of **water intake in the body is equal**
- **To the amount of water output by that body.**

- A healthy body tries to regulate the body water
- **Proportionately distribute the water in ICF and ECF**



| **Water Input** | = | **Water Out put** |
|---|---|---|
| **2100ml** | | **2100 ml** |
| | | **Sensible loss** |
| ▪ Drinking Water 1000 ml | | Urine 1000 ml |
| ▪ Cooked Foods 700 ml | | Feces 100 ml |
| ▪ Metabolic Water 400 ml | | |
| | | **Insensible loss** |
| | | Skin 600 ml |
| | | Lungs 400 ml |

# Electrolyte Balance

- Healthy body obeys the **law of electrical neutrality.**
- Fluid in any body compartment **contain, equal number of Cations and Anions**.

- **Specific concentrations of Electrolytes** in the body compartments are of most important
- **In distribution and retention of body water.**

- In healthy state **the Osmotic pressure due to Cations** is **equal to the osmotic pressure due to Anions.**
- Which is **predominantly due to equal concentrations of Cations and Anions in each compartment.**

# Factors Regulating Water And Electrolyte Balance

- In human body **Water and Electrolytes go togetherly**.
- That means the **osmotic equilibrium created by Electrolytes help in maintaining water balance.**
- If there is **imbalance in Electrolytes it directly affects Water balance.**

- Since the **Electrolytes and Water balance go hand in hand in human body**.
- Hence **factors regulating the water and electrolytes are same.**

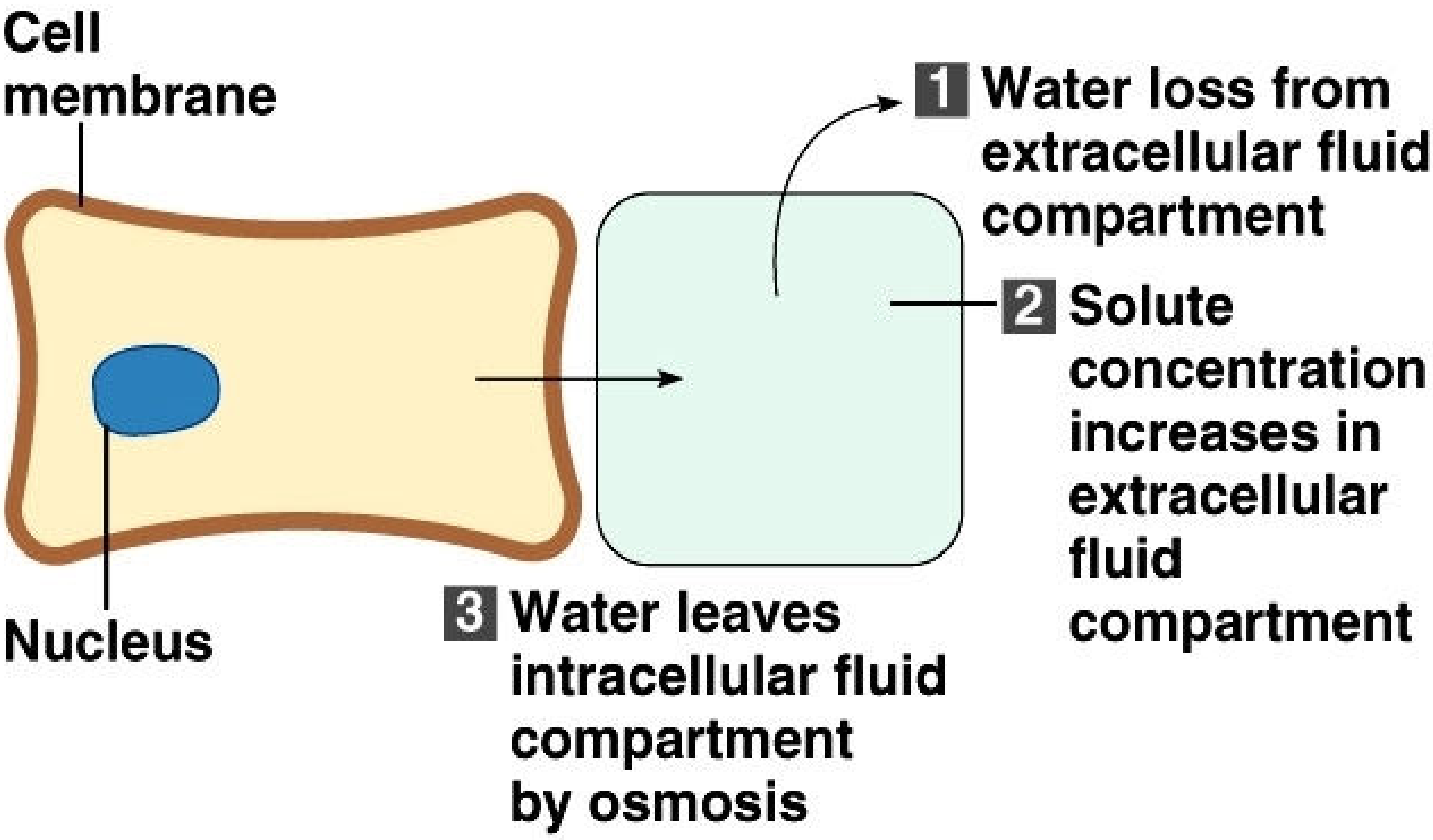
# Homeostasis of Water And Electrolytes Is Maintained By

# Solute Homeostasis Maintained by:

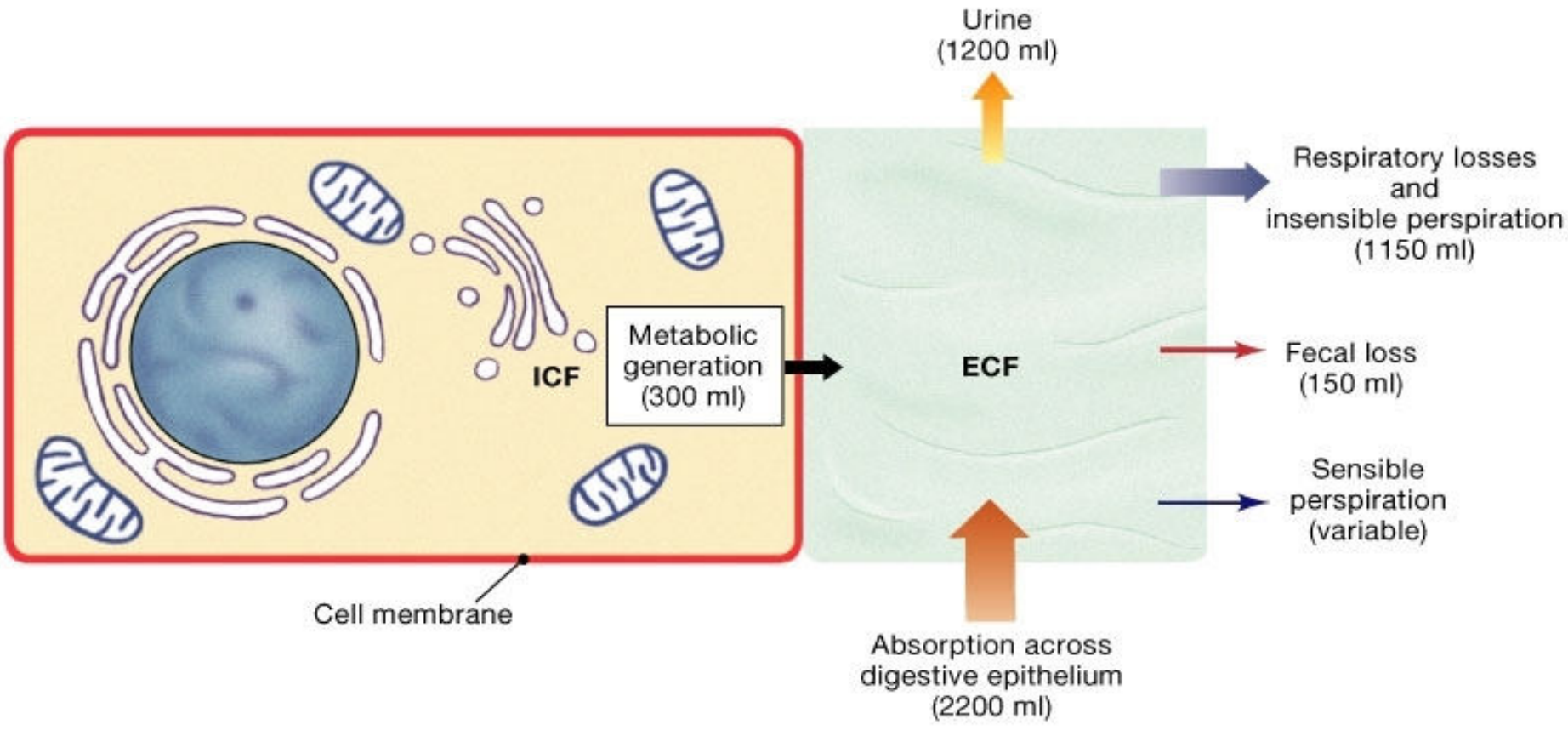
- Ion transport
- Water movement
- Kidney function

## These functions act to keep body fluids:

- **Electrically** neutral
- **Osmotically** stable



# Fluid Exchanges




- **A body consume fluids and food items variably depending upon habits and climatic condition.**

- **Intake of water and electrolytes is rarely proportional.**

- **Kidneys play a predominant role**
- In **regulating water and electrolyte balance** in the body normally.

–Kidneys play role to excrete

–**Excess water through urine (Dilute form of Urine)**

**OR**

–**Excess Electrolytes through urine (Concentrated form of Urine)**

# Biochemical Factors Regulating Water And Electrolyte Balance

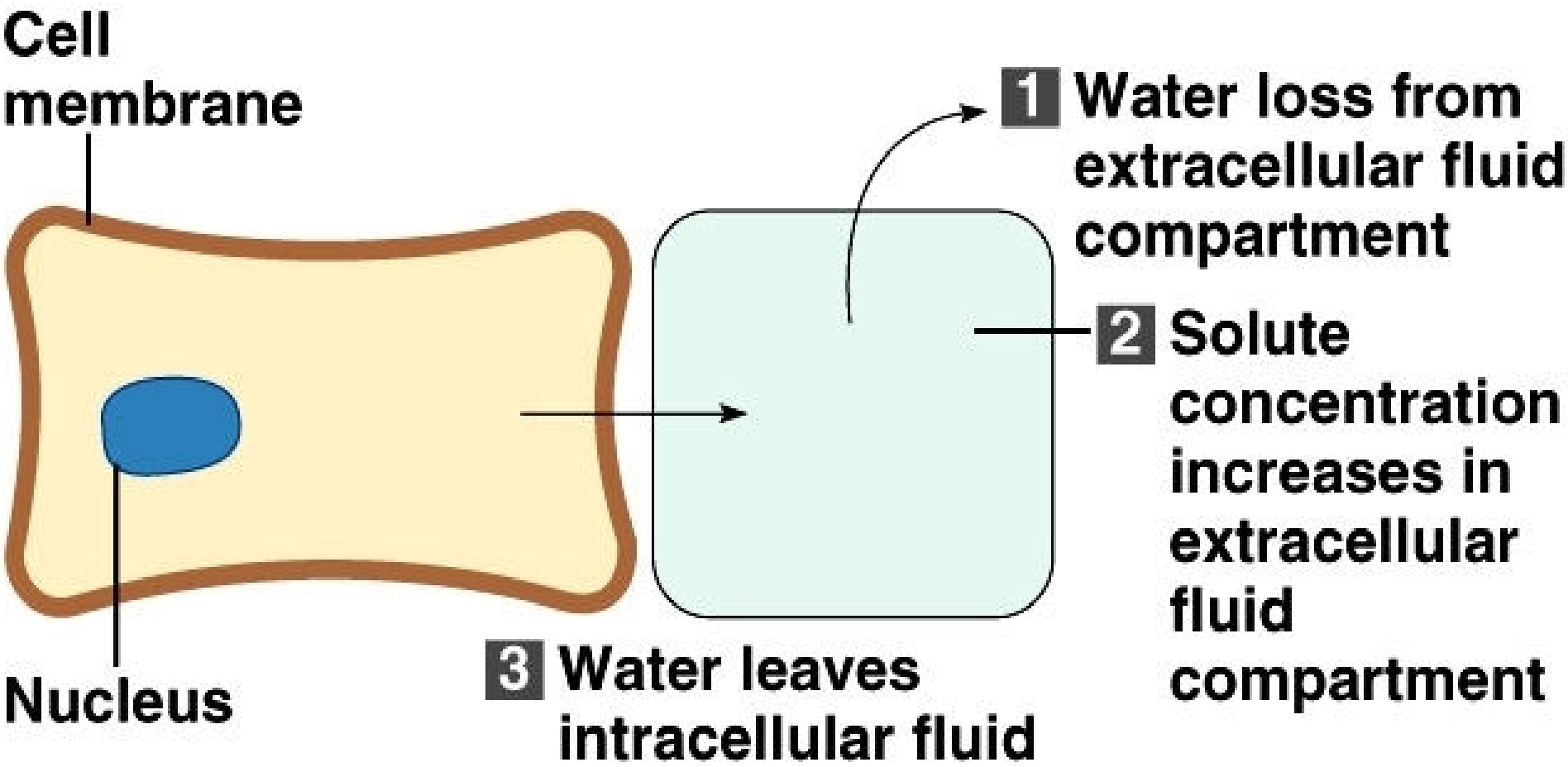
1. **Neural Mechanism-** Thirst Mechanism
2. **Antidiuretic Hormone/Vasopressin**
3. **Renin Angiotensin System**
4. **Aldosterone**
5. **Atrial Natriuretic Peptide**(ANP)
6. **Kinins** ( Increases Salt and Water excretion)

# 1.Neural Mechanism/Thirst Mechanism

# Regulate Low Body Water

- When the **body water is lowered due to:**
  - **No intake of fluids**
  - **Body fluids lost through obligatory losses (Urine and Feces).**

- This leads to **decrease in volume of body fluids with respect to solutes** and **rise in osmotic pressure.**




- The **ECF volume decreases and becomes hypertonic**.

- This **tends to draw water from ICF causing cellular dehydration**.

- The **cellular dehydration stimulates**
- **The thirst centre located in hypothalamus.**

- In response to the stimulus to thirst center
- **There occurs dryness of mouth and Pharynx .**
- Feeling of thirst makes drink water
- **Water ingested orally quench** the **thirst to regulate the body water.**

# 2. Antidiuretic Hormone/Vasopressin

## Antidiuretic Hormone/Vasopressin

- Anti Diuretic Hormone(ADH) is **produced in Hypothalamus**
- **Stored in posterior pituitary gland**

- The action of **Peptide Hormone ,ADH is via cyclic AMP.**

- **An increase in Osmolality** (**$Na^+$ conc**) of plasma
- **Promotes ADH secretion and vice versa.**

- **ADH** is **water conservation hormone**
- It **acts on renal collecting tubule**
- **For reabsorption of water by renal tubules.**

## Role Of Anti Diuretic Hormone (ADH)

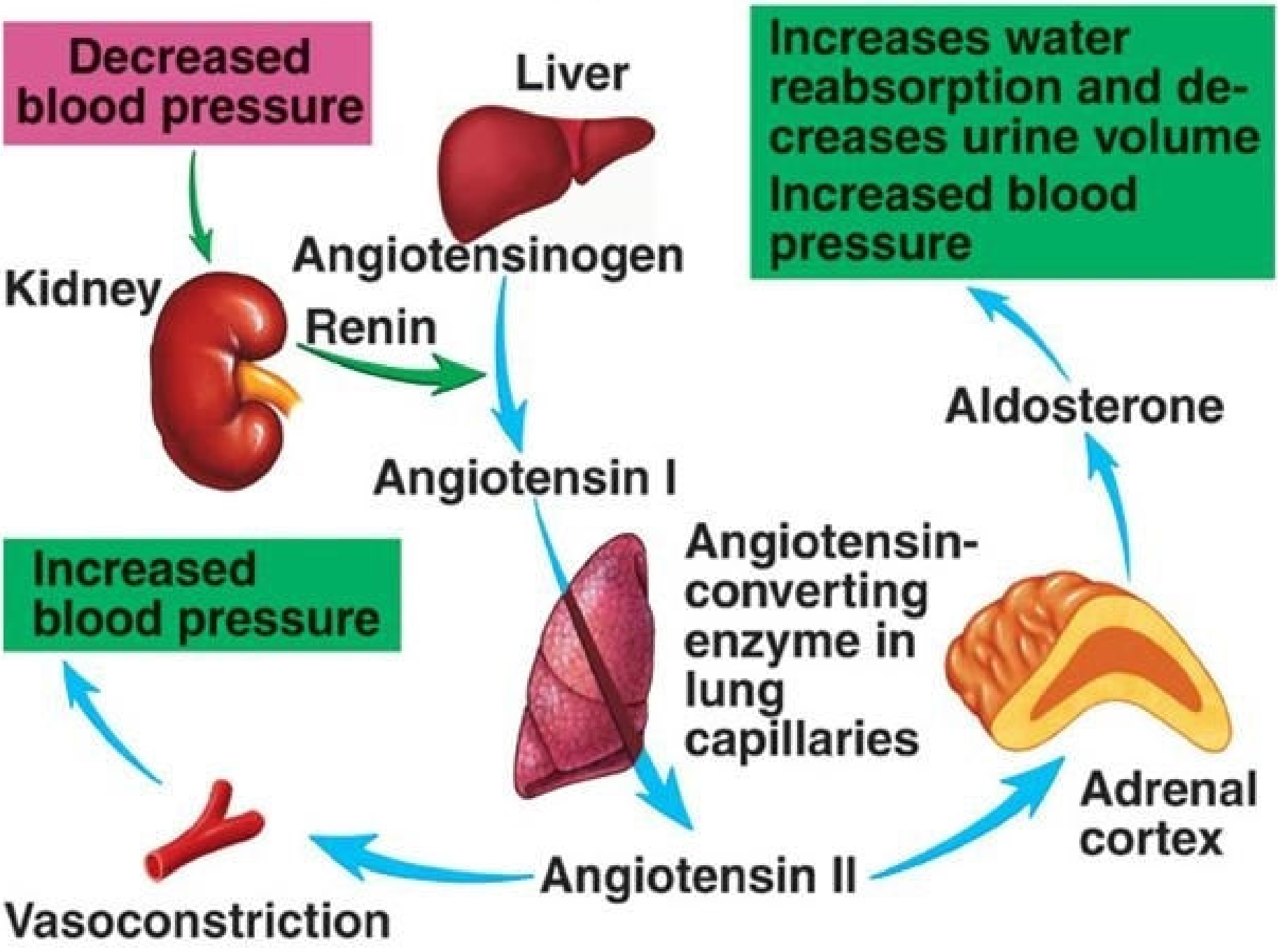
- When the **body water is depleted**
- ADH exerts **Antidiuretic effect.**

- ADH affects renal tubules
- Provides for the **facultative reabsorption of water from distal tubules.**
  - **Urine output will be lower**
  - **Urine concentration will be increased**
  - **Body water will be maintained**

# 3. RENIN ANGIOTENSIN MECHANISM

- **Renin-Angiotensin System works when the:**
  - **Blood volume is low**
  - **Blood pressure is low**

- **Kidney**, **Liver** and **Lungs** are **involved in Renin Angiotensin System**.




- **Renin is released by kidneys** in response to decreased blood volume

- **Renin causes Angiotensinogen** (plasma protein formed in Liver) **to split & produce Angiotensin I**

- **Lungs convert Angiotensin I to Angiotensin II**
- **By Angiotensin Converting Enzyme.**

- **Angiotensin II** then stimulates adrenal gland to **release Aldosterone**
- Aldosterone then **increase the peripheral vasoconstriction**

- Renin Angiotensin System **regulates Aldosterone hormone from Adrenal gland**
- During homeostatic mechanism of Water and Electrolyte Balance.

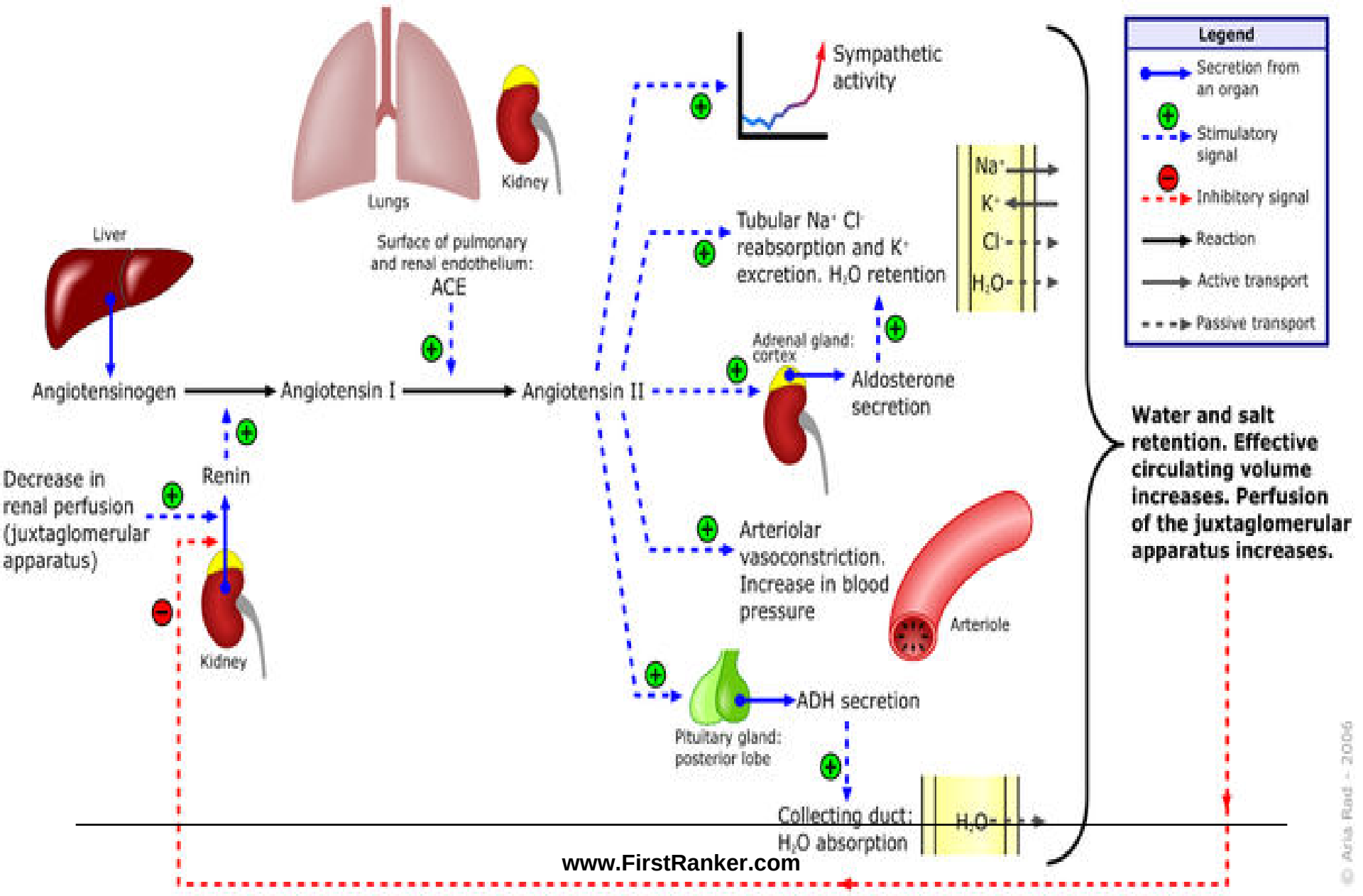
- Fall in E.C.F volume
- Decreases blood pressure
- Sensed by Juxtaglomerular apparatus of Nephrons of Kidneys to **secrete Renin**
- Renin then stimulate **Liver Angiotensinogen** to produce **Angiotensin –I**

- **Angiotensin I** is converted to **Angiotensin**

- **By Lung** produced enzyme **Angiotensin Converting Enzyme**(ACE).

- **Angiotensin II stimulates** the **release of Aldosterone from Adrenal gland.**

# Renin-angiotensin-aldosterone system



# 4. Role Of Aldosterone

## Aldosterone

- Aldosterone is a **Steroid Hormone**.
- It is a **Mineralocorticoid** produced by **Zona Glomerulus of Adrenal Cortex.**
- It has most **important effect on Mineral Metabolism**.

# ALDOSTERONE

- Aldosterone is released as part of **Renin Angiotensin mechanism**
- **Acts on renal distal convoluted tubule**

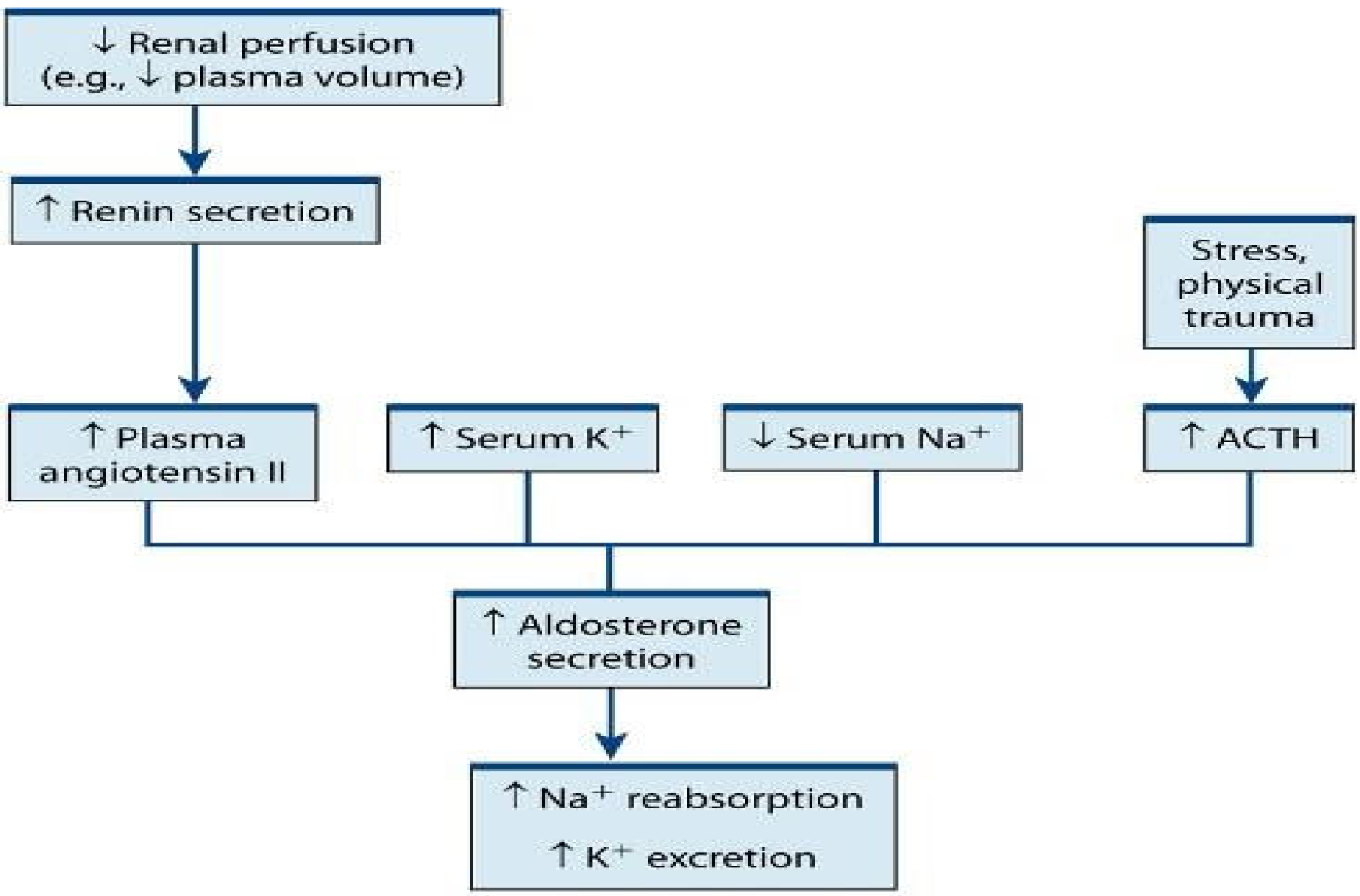
- The hormone Aldosterone by its action:
  - **Increases the rate of reabsorption of $Na^+$ (95 %) and Cl-**
  - **Increases $K^+$ loss through Urine**

# Role Of Aldosterone

- Aldosterone **increases Sodium uptake from the tubular fluid**
- Regulates water reabsorption by renal tubules and add into the blood
- **Makes excretion of Potassium**

- Thus **Aldosterone maintain Water and Electrolyte Balance** by its action on renal tubules:
  - **Reabsorbs Sodium**
  - **Retains Water**
  - **Looses Potassium**

# Factors Affecting Aldosterone Secretion






# 5. Atrial Natriuretic Peptide or Factor (ANP)/ (ANF)

# Atrial Natriuretic Peptide or Factor (ANP)/ (ANF)

- ANP is a **Cardiac hormone**
- Secreted by **right Atrium of Heart.**
- Chemically ANP is a **Polypeptide hormone**

# ANP

- **ANP is released in response to increased blood pressure** in the atria ( due to increased blood volume)
- **ANP opposes the Renin-Angiotensin-Aldosterone system**

- ANP suppresses Renin level
- Decreases the release of Aldosterone
- Decreases ADH release
- ANP stimulates excretion of Na and H2O
- Reduces vascular resistance by causing vasodilation.

## Role Of Atrial Natriuretic Peptide (ANP)

- ANP increases the urinary excretion of $Na^+$ and regulates the electrolytes balance.

# 6. Role of Kinins

- **Kinins** are proteins in the blood
- **Kinins cause inflammation** and affect blood pressure (especially **lowers the blood pressure**).
- **Kinins increases Salt and Water excretion**.

# Osmolarity of a Solutions

## Osmolarity of Solutions

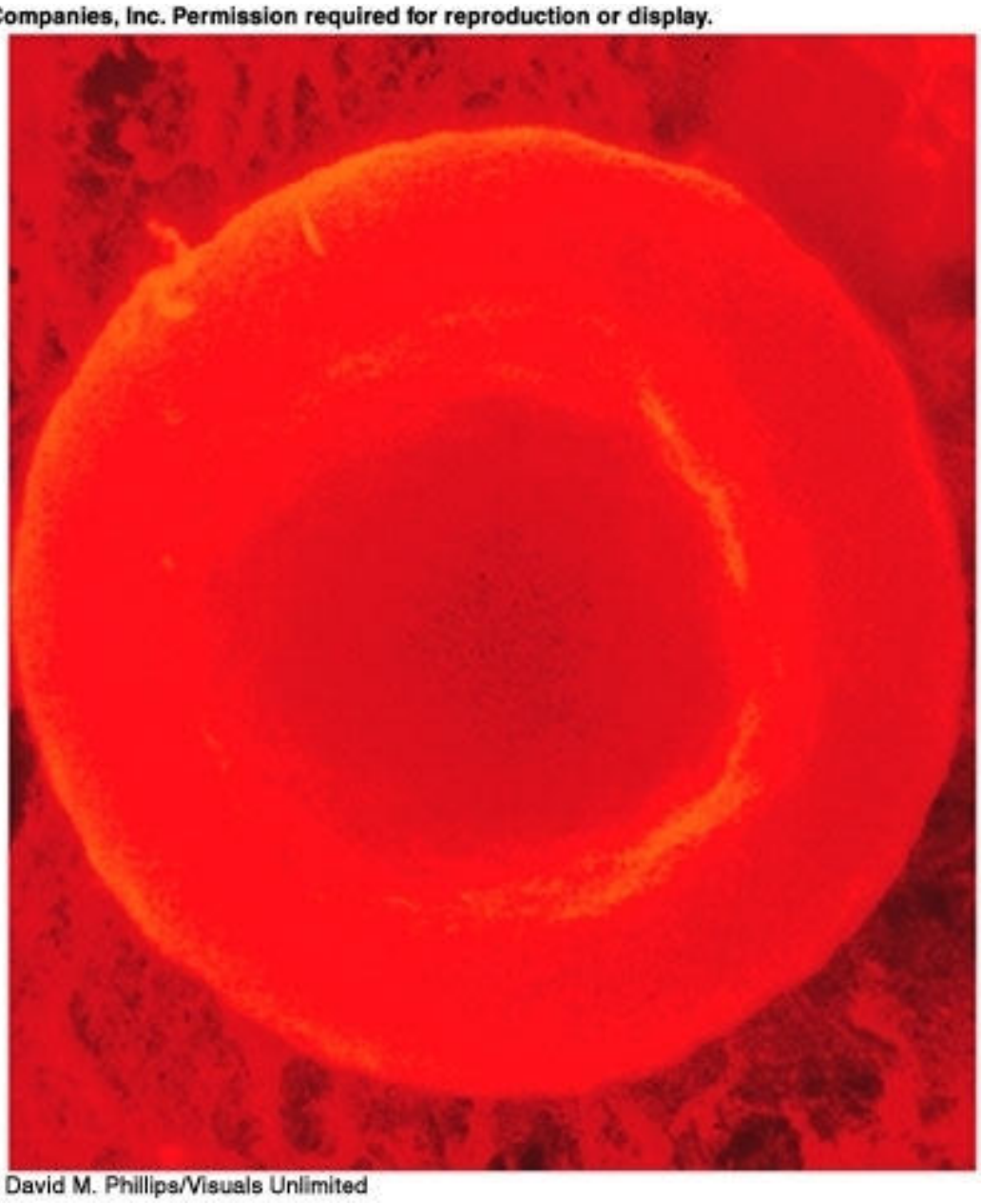
- **Isotonic Solution**— **Same** concentration of **solutes** as **plasma**
- **Hypertonic Solution**— **Greater** concentration of **solutes** than **plasma**
- **Hypotonic Solution**— **Lesser** concentration of **solutes** than **plasma**

# Example Of ISOTONIC SOLUTIONS

- **0.9% Sodium Chloride Solution / Normal Saline**
- **Ringer's Solution** typically contains
  - Sodium Chloride
  - Potassium Chloride
  - Calcium Chloride
  - Sodium Bicarbonate
- **Lactate Ringer's Solution**
  - Contains additionally Lactate

- 1 mol NaCl weighs 58.44g NaCl
- 1 mmol NaCl weighs 0.058 g NaCl
- **One mmol of NaCl contains**
  - **58.3 mg NaCl**

# Cell in Isotonic Solution







# HYPOTONIC SOLUTIONS

- 5% DEXTROSE & WATER
- 0.45% SODIUM CHLORIDE
- 0.33% SODIUM CHLORIDE

# Cell in a hypotonic solution





# HYPERTONIC SOLUTIONS

- 3% SODIUM CHLORIDE
- 5% SODIUM CHLORIDE
- WHOLE BLOOD
- ALBUMIN
- TOTAL PARENTERAL NUTRITION
- TUBE FEEDINGS
- CONCENTRATED DEXTROSE (>10%)

# Cell in a hypertonic solution







# Water And Electrolyte Imbalances

- In a human body **water distribution in compartments**

- **Is due to osmotic pressure produced by Electrolytes**

- **Since Water and Electrolytes balance in the body go together**

- **Hence imbalance in any one of it ,affects both**.

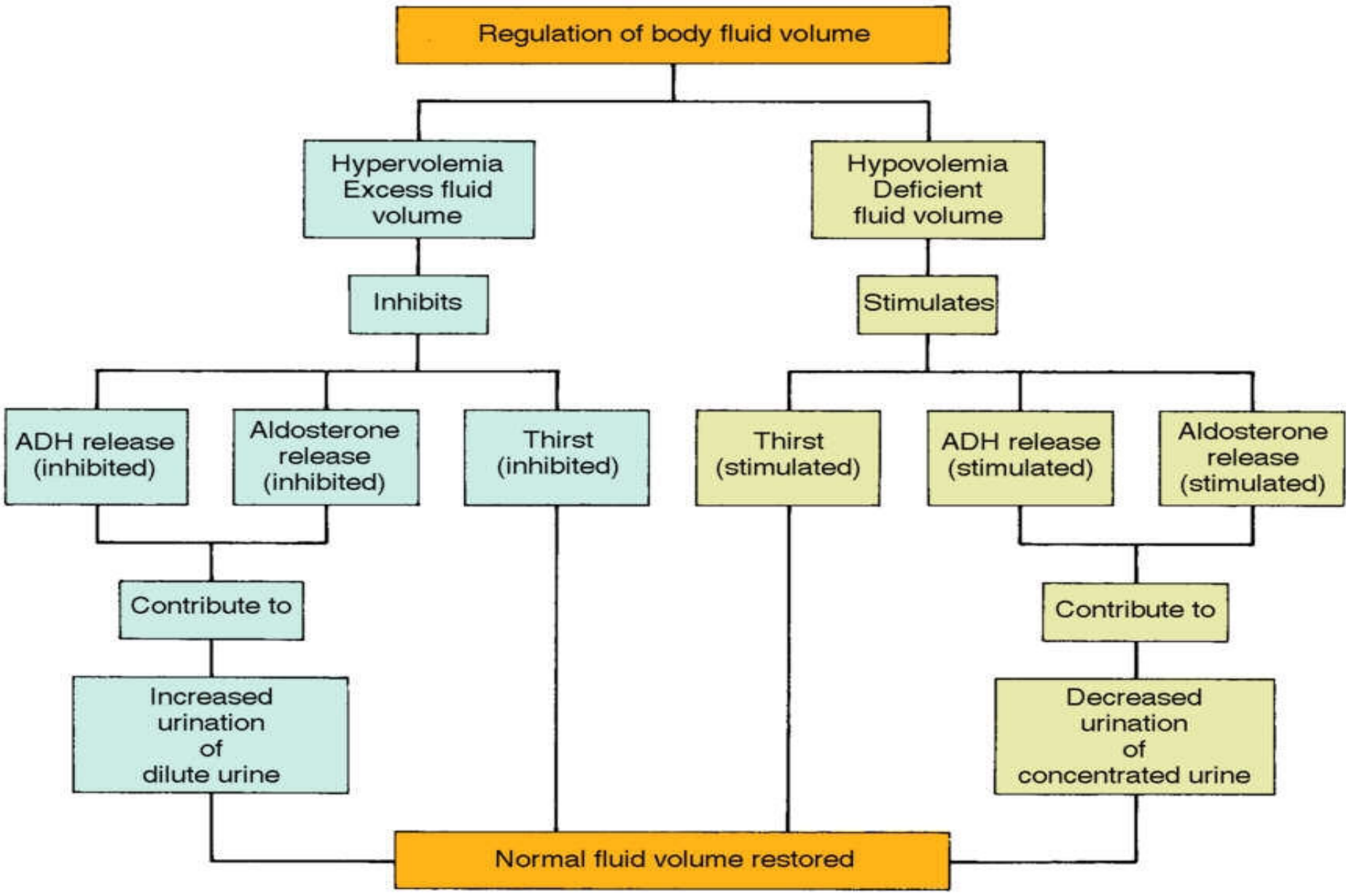
- In simple **words if there is Electrolyte imbalance, it directly affects and causes Water Imbalance.**

# What Conditions Leads To Water And Electrolyte Imbalance?

## Factors Involved In Water and Electrolyte Balance

- Water intake
- Electrolyte intake
- Organs and Mechanisms
  - Hypothalamus
  - Pituitary Gland
  - Kidneys
  - Liver
  - Lung
  - Adrenal glands
  - Cardiac tissue
  - Related Genes
  - Cholesterol
  - Amino acids

# REGULATION OF FLUID VOLUME




- Any **defect in the organs associated to factor regulating Water and Electrolyte balance**
- May lead to Water and Electrolyte imbalance.

- Anything that **alters the concentrations of Electrolytes**
- Will **alter the concentration of water, and vice versa.**

## Remember

- In condition of Water and Electrolyte imbalances
- **Care should be taken to manage both the entities simultaneously.**

# Conditions Of Water and Electrolyte Imbalances

## Water Electrolyte Imbalance Conditions

- Dehydration
- Over hydration

# Dehydration

- **Dehydration is a condition of Water imbalance.**
- Dehydration is characterized by **disturbance of Water and electrolyte balance.**
- In a **dehydrated body** the **output of water exceeds the water intake.**
- This causes **reduction of body water below the normal level.**

# Basic Cause Of Dehydration

- No Ingestion of water
- Excessive Loss of body fluids

# Features Of Dehydration

- **Water Deficiency Condition**
- **Low body water**
- **Low blood volume**
- **Disturbance in body Electrolytes.**

# Types Of Dehydration

# Types Of Dehydration

- **Primary Dehydration** /Due to pure water depletion
- **Mixed Type Dehydration** /Due to both Water and Salt depletion
- **Secondary dehydration/**Due to pure salt depletion

# Primary Dehydration
# OR
# Pure Water Depletion

## Causes Of Primary Dehydration

- **Very weak or very ill patients** unable to ingest Water.
- **Mental Patients** who refuses to drink water
- In **Coma Condition**
- Person **lost in desert or Shipwrecked**

- Defect to hypothalamus
- Patients with renal tubular disorder
- **Diabetes insipidus-ADH insufficiency.**

## Biochemical Alterations

- **Pure Water depletion** occurs almost always:
  - Because of **lack of Water intake**
  - **Rather than** because of **excess looses from the body.**

- **Body water stores get depleted** because of:
  - **Continuing obligatory losses of water through**
  - **Urine and Feces to excrete metabolic waste.**

- The **only source of water supply in this condition** is

- **Metabolic water obtained from oxidation of food stuffs**.

- **The volume of ECF is maintained almost to normal in this condition.**
- At the expense of **I.C.F which is grossly reduced in volume**
- **Causing intracellular dehydration.**

- Neural mechanism is activated
- But if this is not responded
- By oral Water ingestion
- Causes water depletion in body.

# Clinical Manifestations

- **Dry tongue and pinched facies** (Due to intense thirst)
- **Oligouria-** ADH secreted causes reabsorption of water from kidney tubules
- Causing a gradual **diminution of Urine volume**.

# Management

- Give water to drink by mouth
- 5% Glucose by I.V (Hypotonic Soln)
- To correct intracellular dehydration.
- **Note: Never give Isotonic Saline. (0.9 % w/v NaCl solution).**

# Mixed Type Of Dehydration

## Water and Salt Depletion

- This is the **most common type of dehydration condition.**

# Causes of Mixed Type Dehydration

- **Severe Vomiting**
- **Severe Diarrhea**

## Biochemical Alterations

- Mixed dehydration has **both low volume of both water and electrolytes.**
- Here the **volume of fluids in both E.C.F and I.C.F is reduced**.
- The **patient appears dehydrated and complains of thirst.**

# Manifestations

- Feeling of thirst
- Low BP
- Increased blood Urea
- Urinary out put is diminished

# Management

- Administering **Mixture of Saline** and **5 % Glucose in 1:1 proportion.**

# Secondary Dehydration
# Pure Salt Depletion

## Pure Salt Depletion
## Secondary Dehydration

- This occurs **when fluids of high Na/Cl content are lost from the body**
- And **body is replaced by Salt deficient fluids**.

# Causes

- Excessive Sweating
- GIT loss of fluids during vomiting and diarrhea
- Continuous aspirations of G.I fluids
- In Addisons disease (Insufficiency of Adrenal Cortex)
- Vigorous use of diuretics

# Biochemical Alterations

- The loss of body water and electrolytes
- **Replaced with water without salts leads to pure salt depletion**

- In pure salt depletion **E.C.F becomes hypotonic.**
- The **lowered osmotic pressure inhibits the release of ADH**
- In this response **Kidneys excrete water** in an **attempt to maintain normal extracellular Na concentration**

- This decreases plasma and interstitial fluids .
- **The water from ECF** (hypotonic) **flows into the I.C.F** of cells (hypertonic soln).
- **This further reduces the volume of ECF.**

- In this condition **there is no cellular dehydration**.

- **No response to thirst centre**.

# Series of Events in Secondary Dehydration

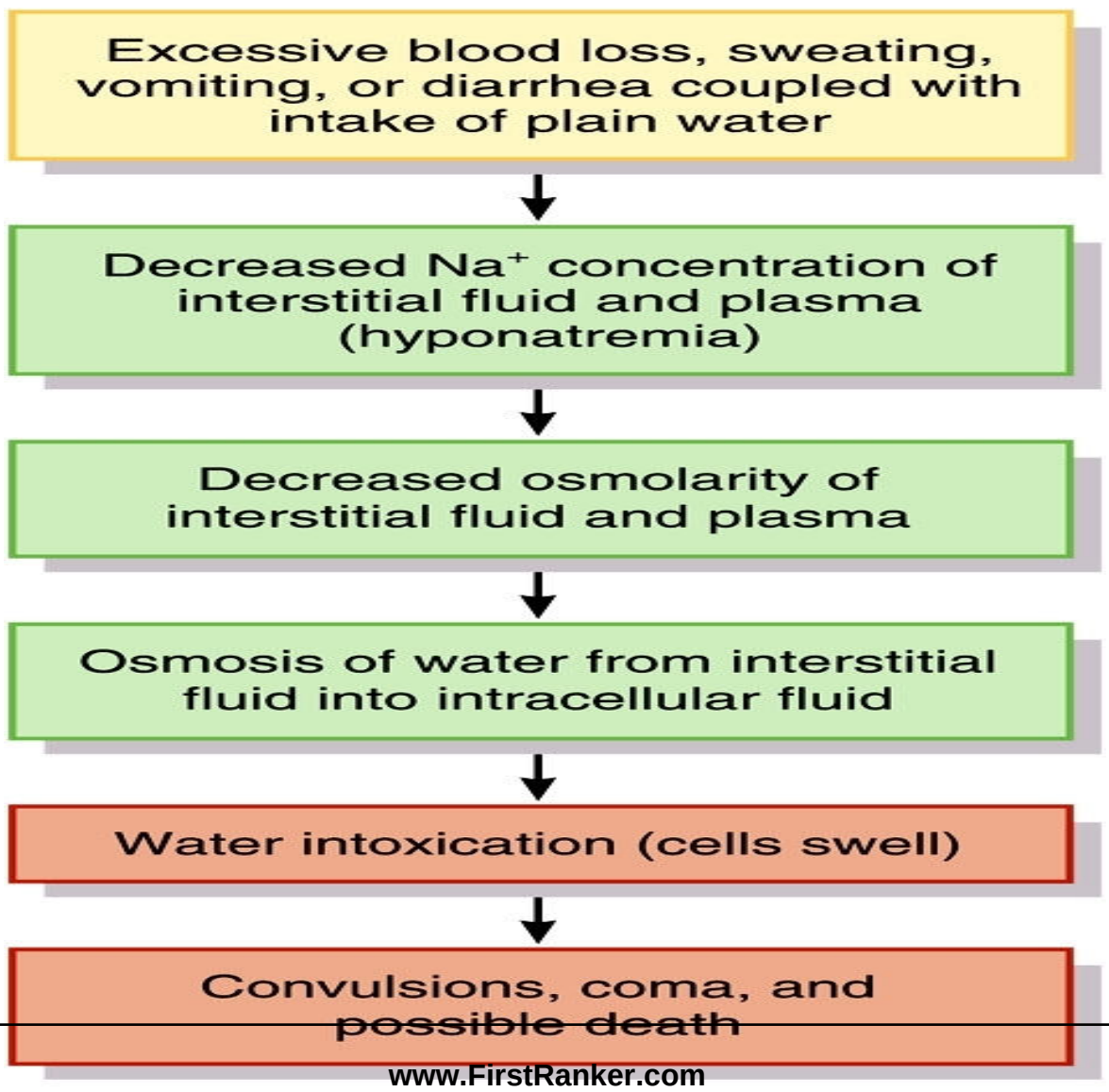





Figure 27.05 Tortora - PAP 12/e

# Manifestations Of Secondary Dehydration

- Absence of Thirst (No intracellular dehydration)
- Patient is apathetic, listless
- Hallucinations and Confusions are common
- Anorexia and Nausea
- **Cramps in thigh**, abdominal and respiratory muscles.
- Sunken eyes, inelastic skin
- Low BP, decreased  GFR and excretion

# Management of Secondary Dehydration

- By administering **Isotonic solution 0.9% NaCl.**

# Differences In Primary And Secondary Dehydration

| Primary Dehydration | Secondary Dehydration |
|---|---|
| **Caused due to pure Water Depletion** when water in take is stopped. | **Caused due to pure Salt depletion** when fluids of high salt content lost and replaced by salt deficient fluids |
| Noted in patients with dysphagia Comatose and Mental patients, Lost in deserts | Patients with excessive sweating,vomiting ,diarrhea in CCF, with no electrolytes replenished. |
| **Feels Thirst , Cramps absent ,Pulse and B.P normal.** | **Thirst absent , cramps present, rapid and thready pulse with low B.P.** |

| Primary Dehydration | Secondary Dehydration |
|---|---|
| Scanty Urine | Normal or increased Urine |
| ECF Hypertonic | ECF Hypotonic |
| Cellular Dehydration present | Cellular Edema present |
| Management by Water intake and Hypotonic soln | By infusing Isotonic solution |

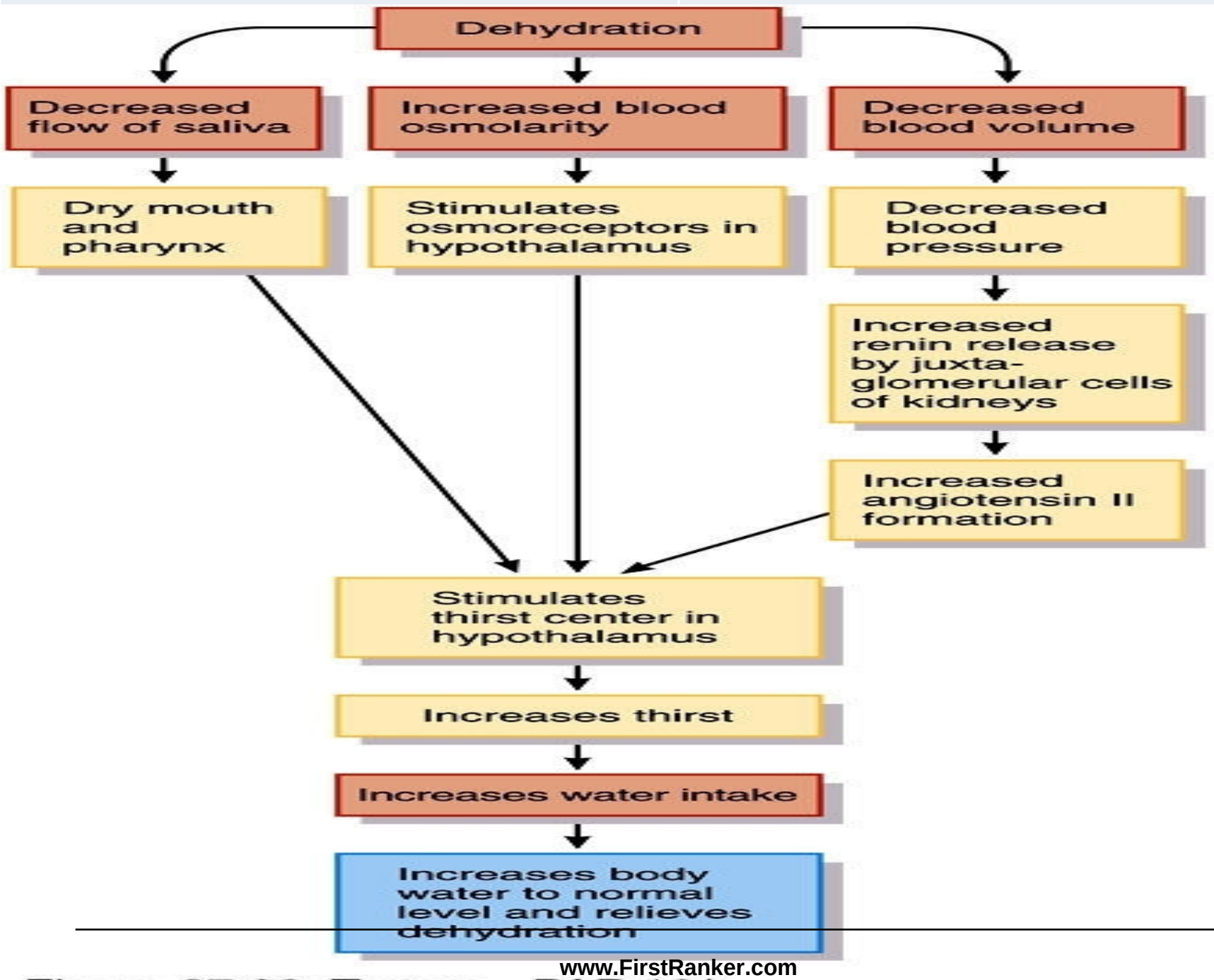
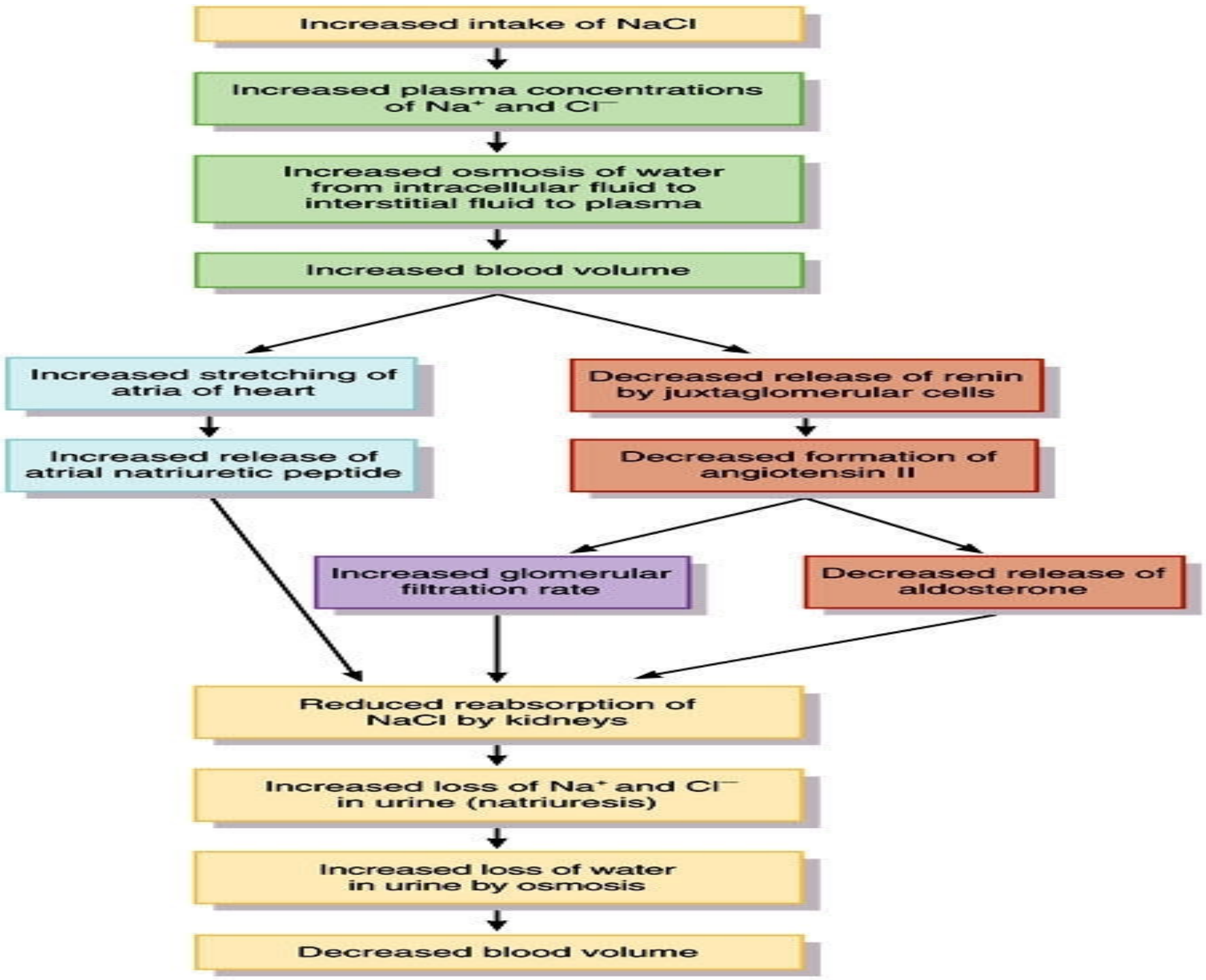





Figure 27.03 Tortora - PAP 12/e




# Over Hydration /Water Excess

# Over hydration /Water Excess

- Here there is **excess of body water.**

# Over Hydration / Water Intoxication

- Due to excess water intake
- Due to water retention

# Causes Of Water Excess

- **Excessive administration of parenteral fluids.**
- Renal Failure (No/Less excretion of Urine)
- **Hypersecretion of ADH**
- Administration of Narcotics ,Anaesthesia **causes secretion of ADH**
- **Excess of Aldosterone** (Conn's Syndrome)

# Manifestations

- Headache
- Nausea
- Incoordination of Movements
- Delirium

## Management

- Withholding drinking of fluids.
- Administration of 3-5% **Hypertonic Saline** intravenously.

# ELECTROLYTE IMBALANCES

# ELECTROLYTE IMBALANCES

- Hyponatremia (sodium deficit < 130mEq/L)
- Hypernatremia (sodium excess >145mEq/L)
- Hypokalemia (Potassium deficit <3.5mEq/L)
- Hyperkalemia (Potassium excess >5.1mEq/L)
- Chloride imbalance (<98mEq/L or >107mEq/L)
- Magnesium imbalance (<1.5mEq/L or >2.5mEq/L)

# Common Conditions And Disorders Associated With Water And Electrolyte Imbalances

# Edema

## Edema/Swelling

- Condition in which excess fluid accumulates in the **interstitial compartment.**
- **It is a response to inflammation and injury**

Edema (swelling) of the ankles and feet

# Common Conditions Of Edema

- **Inflammation**
- **Infections**
- **Pregnancy**
- **Medications**

# Causes Of Edema

- **Increased Hydrostatic Pressure**
- **Small blood vessels become leaky and releases fluid into nearby tissues.**
  - Venous obstruction, Lymphedema, CHF, Renal failure
- **Lowered Plasma Osmotic pressure (Protein loss)**
  - Liver failure, Malnutrition, Burns
- **Increased capillary membrane permeability**
  - Inflammation, Sepsis

# Types Of Edema

- **Generalized Edema**
- **Organ specific Edema**

  [cerebral, ascites , pleural)
- **Cutaneous Pitting Edema**
- **Non Pitting Edema**

# Consequences Of Edema

- **Imbalance in Water and Electrolyte distribution.**
- **Impaired blood flow**
- Slow healing
- Increased risk of infections
- Pressure sores over bony prominences
- **Impaired organ function**
  **(Brain, Liver, Gut, Kidney)**

# Treatment Of Edema

- **Treat the underlying cause of Edema**.
- Defect in heart/Lungs/Liver /Kidney should be treated
- **Reducing amount of salt**

# Diabetes insipidus

Diabetes insipidus

- **Endocrine Disorder**
- ADH insufficiency
- **Affecting Water and Electrolyte imbalance of the body.**

# Diabetes insipidus

- **Diabetes insipidus** (**DI**) is a **condition** characterized by:
  - –Excretion of large amounts of **severely dilute urine**
  - –With **excessive thirst**

# Incidence Of DI

- 3 in 100,000 individuals of general population.

# Causes And Types of DI

## Central Diabetes Insipidus

- Central Diabetes insipidus (CDI)
- Involves a **deficiency** of **Vasopressin / Antidiuretic hormone**

# Nephrogenic Diabetes insipidus

- The second common type of DI is **Nephrogenic Diabetes insipidus** (NDI),
- Is **due to kidney or nephron dysfunction**
- Caused by an **insensitivity of the Kidneys or nephrons to ADH.**

# Manifestations Of DI

- Polyuria with dilute urine.
- Due to osmotic diuresis
- Excessive thirst(Polydypsia)
- Dehydration
- Electrolyte imbalance

# Diagnosis

- Urine Osmolarity
- Urine Specific gravity
- Electrolyte concentrations in serum and urine
- Fluid Deprivation test

# Treatment

- Central DI respond to **Desmopressin** which is given as intranasal or oral tablets

# Addisons Disease

## Hypoadrenocorticism

## Addisons Disease

- **Thomas Addison** first discoverer (1849)
- Autoimmune disease
- Endocrine disorder

# Cause

- Defect in Adrenal glands
- Adrenal gland insufficiency
- Deficient Aldosterone and Cortisol

# Incidence Of DI

- 1 in 100,000

# Biochemical Alterations

- Hypoglycemia (reduced level of blood glucose)
- Hyponatremia (low sodium level in the blood)
- Hyperkalemia (elevated potassium level in the blood)
- Hypercalcemia (elevated calcium level in the blood)

# Manifestations

- Low blood pressure
- Syncope (loss of consciousness and inability to stand)
- Confusion, Psychosis, slurred speech
- Severe Lethargy
- Convulsions

# Diagnosis

- Blood Electrolytes (Na and K)
- Blood Glucose
- Blood Calcium

- Blood Cortisol levels
- ACTH Stimulation Test
- Uses synthetic pituitary ACTH hormone Tetracosactide used for diagnosis

# Management

- Standard therapy involves intravenous injections of Glucocorticoids
- of **Hydrocortisone** tablets, **Prednisone** tablets
- Large volumes of intravenous saline solution with **Dextrose**/**Glucose**.
- Oral doses of **Fludrocortisone Acetate**

# Cushings Syndrome

# Hyperadrenocorticism

# Cause

- Over activity of Adrenal glands
- Excess of Aldosterone and Cortisol

# Incidence

- 1 in 100,000

# Biochemical Alterations

- Hyperglycemia (Increased level of blood glucose)
- Hypernatremia (High Sodium level in the blood)
- Hypokalemia (Low potassium level in the blood)
- Hypocalcemia (Low Calcium level in the blood)

# Manifestations

- High blood pressure
- Weight gain ,Central obesity. Buffalo Hump and Moon Face
- Insomnia
- Excessive Sweating
- Depression
- Anxiety

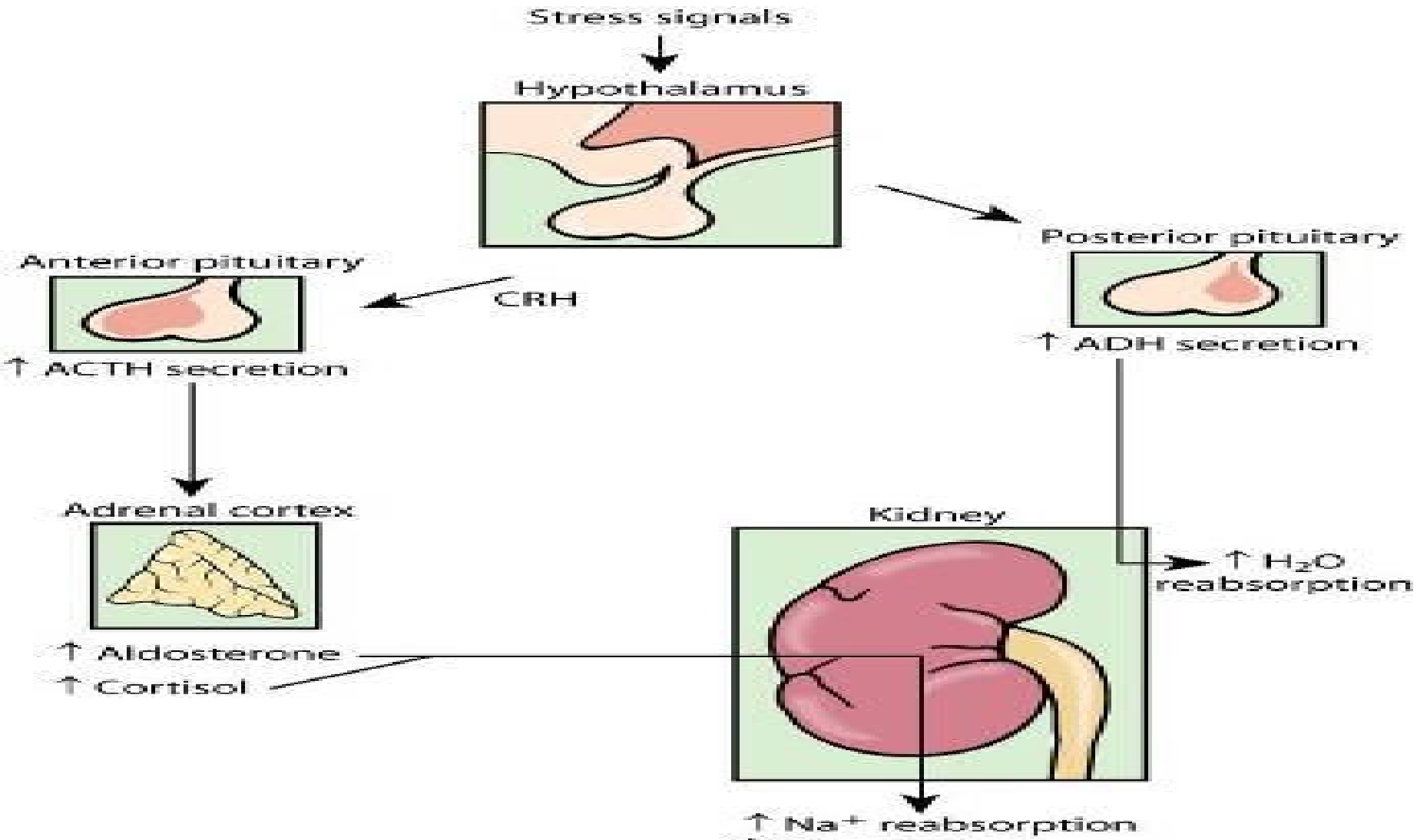
# Diagnosis

- Blood Electrolytes ($Na^+$ and $K^+$)
- Blood Glucose
- Blood Calcium
- Blood Cortisol levels

# Management

- In adrenal Adenomas surgical removal.
- Ketoconazole, Metyrapone inhibit Cortisol biosynthesis.
- Mifepristone is a powerful Glucocorticoid type II receptor antagonist

# Effects of Stress on Water And Electrolyte Balance




- **The Hypothalamus and Pituitary gland**
- **Integrate communication between nervous and endocrine systems**
- **Stress severely affect this coordination and affect Water and Electrolyte balance**

# Diagnostic Tests
# To Check for Fluid and Electrolytes Balance And Imbalance

## Blood Investigations

- Serum Electrolytes
- Serum Creatinine = 0.6 – 1.5 mg/dl
- Blood Urea and BUN = 8-20 mg/dL
- Serum Osmolality
- Serum Albumin – 3.5-5.5 g/dL
- Serum Hematocrit = 40-54%/men, 38-47% for women (Decreased in Dehydration)

# Urine Investigations

- Urine pH
- Urine specific gravity
- Urine Osmolarity
- Urine Creatinine Clearance
- Urine Sodium
- Urine Potassium

# Questions

- Distribution & functions of Water in human body.

- What are Electrolytes? Give its distribution & functions related to human body.

- What is water electrolyte balance? Explain the factors involved in water electrolyte balance.
- What are disorders of Water and Electrolyte imbalances?

- Dehydration- types, causes & management.
- Differentiate between Primary and Secondary Dehydration
- Over hydration/Water Toxicity/Water Intoxication.
- Edema
- Diabetes Insipidus.
- Addison's & Cushing Syndrome.

# Thank You