

# Fluid, Electrolyte, and Acid-Base Balance

Focus 7

Nursing 53A

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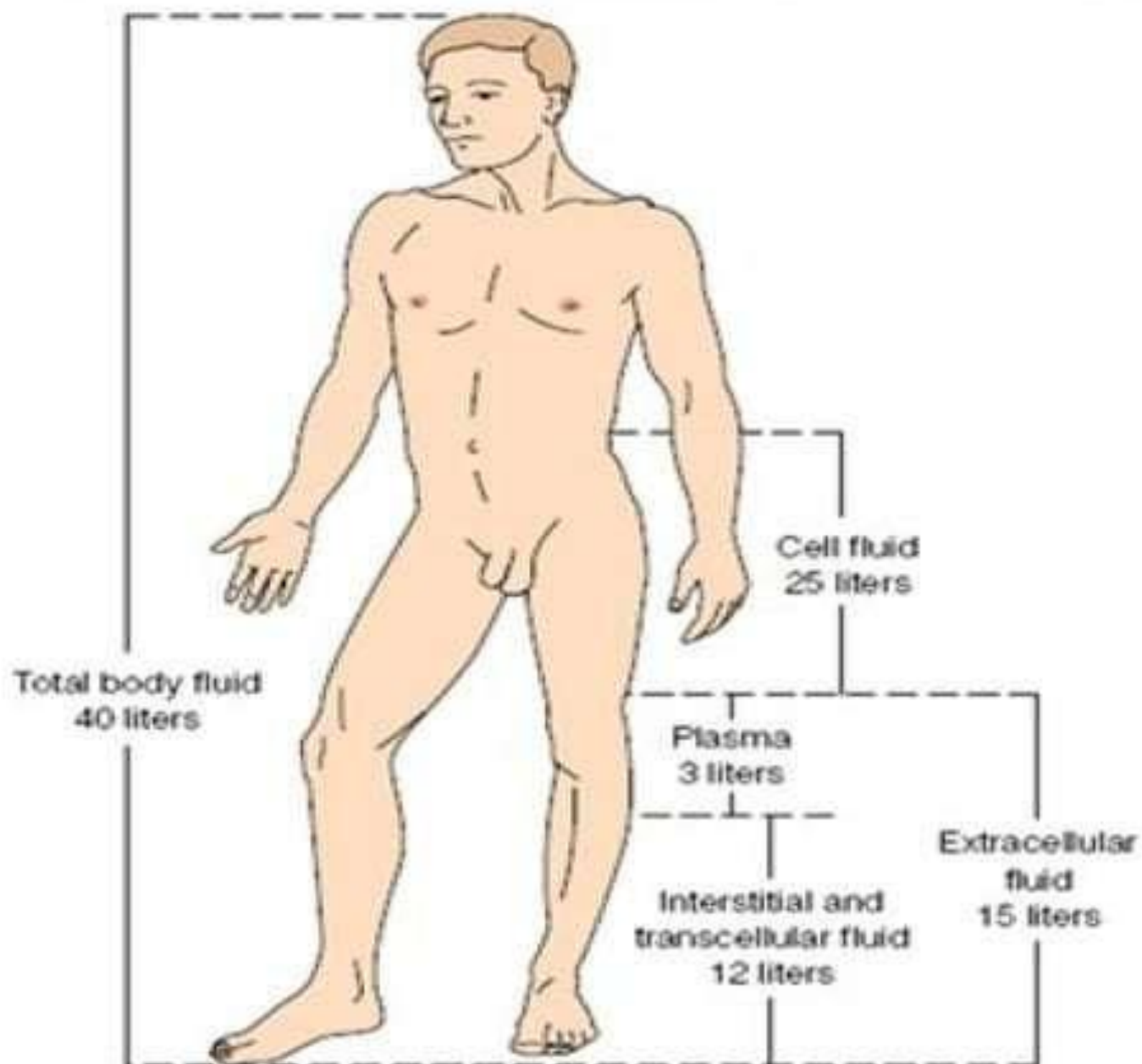
# Objectives

- Describe how fluid volume and electrolytes are regulated to maintain homeostasis.
- Describe fluid and electrolyte balance.
  - Examine fluid volume imbalance and preventative interventions.
  - Define and discuss the major electrolytes in the maintenance of homeostasis
  - Explain the proper distribution of fluid in each body fluid compartment and the effect of mal-distribution
- Define and discuss the major electrolytes essential in the maintenance of homeostasis

# Objectives

- Define populations particularly vulnerable to fluid and electrolyte imbalance.
- Discuss preventative measures to electrolyte imbalance.
- List common diagnostic tests related to fluid and electrolyte status.
- Discuss the nursing purpose responsibilities of each procedure.
- Examine altered means of fluid intake and the related nursing responsibilities/technical skills.

# Body Fluid Distribution





# Fluid and Electrolyte Balance

- Homeostasis
  - Balance of fluids, electrolytes, acids and bases
    - Physiologic processes that control intake and output
  - Body composed of 46 – 60% of adult weight
  - Every illness has potential to upset the balance

# Maintaining Fluid Balance

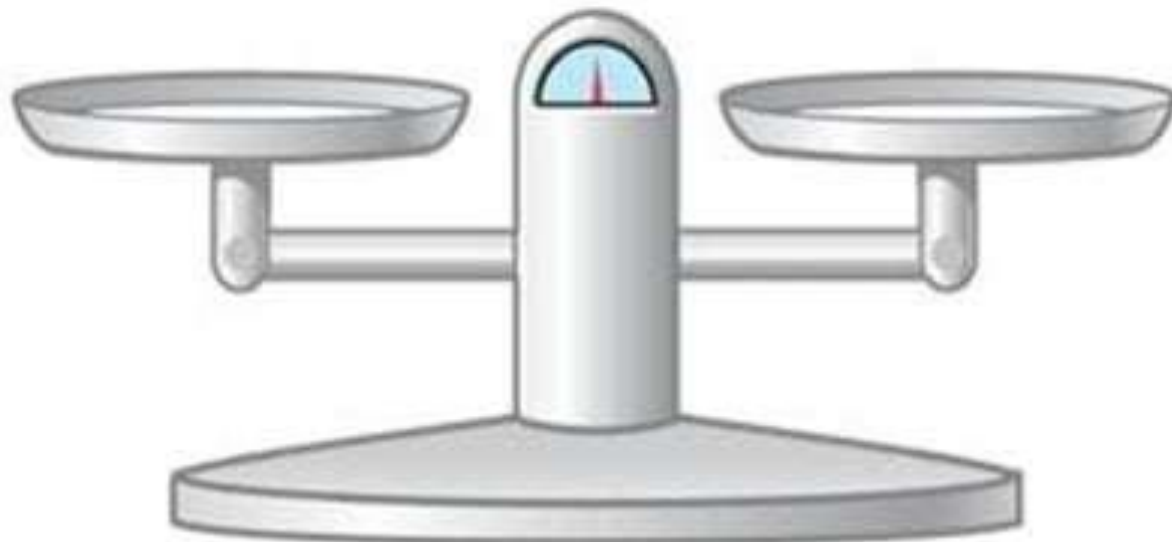
- Intake should equal fluid output
  - Intake at 2000 mL
  - Output at 1500 mL
  - Difference within 200 – 300 mL

## Fluid intake

Ingested water	1200-1500 mL
Ingested food	800-1100 mL
Metabolic oxidation	300 mL
<hr/>	
<b>TOTAL</b>	<b>2600-3000 mL</b>

## Fluid output

Kidneys	1500 mL
Insensible loss through skin	600-800 mL
Insensible loss through lungs	400-600 mL
Gastrointestinal tract	100 mL
<hr/>	
<b>TOTAL</b>	<b>2600-3000 mL</b>

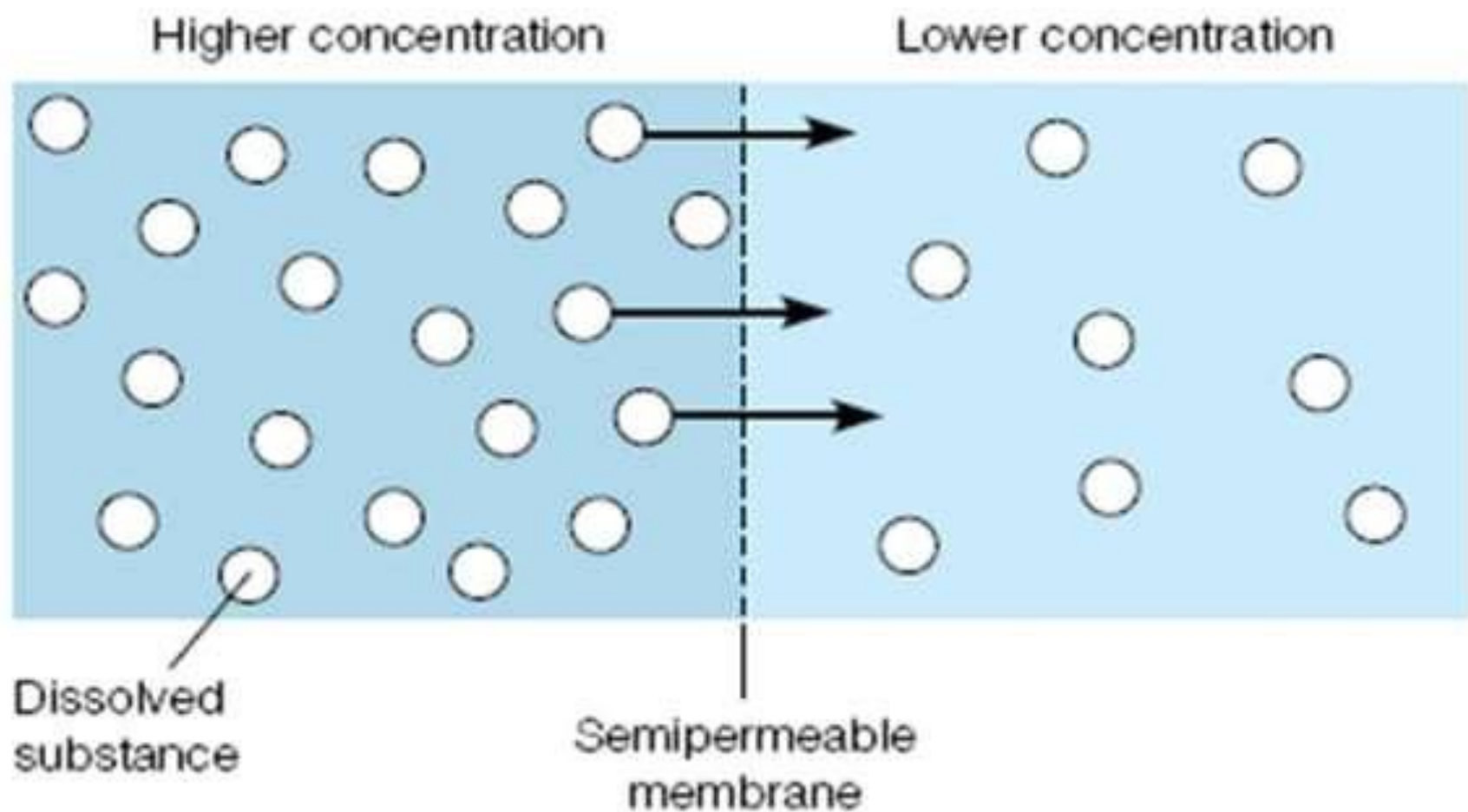


# Movement of Fluids

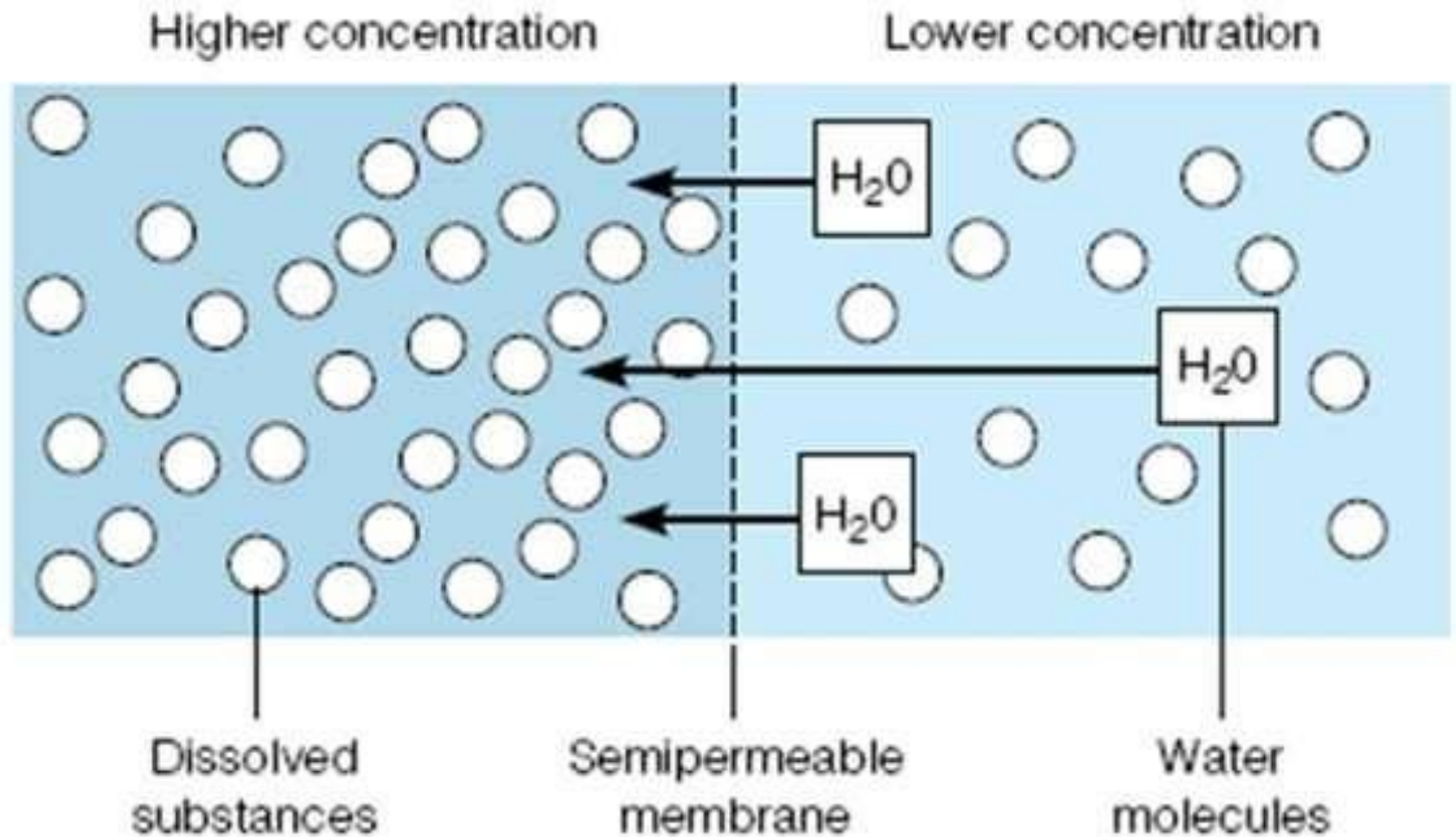
- Osmosis
- Diffusion
- Filtration
- Active transport



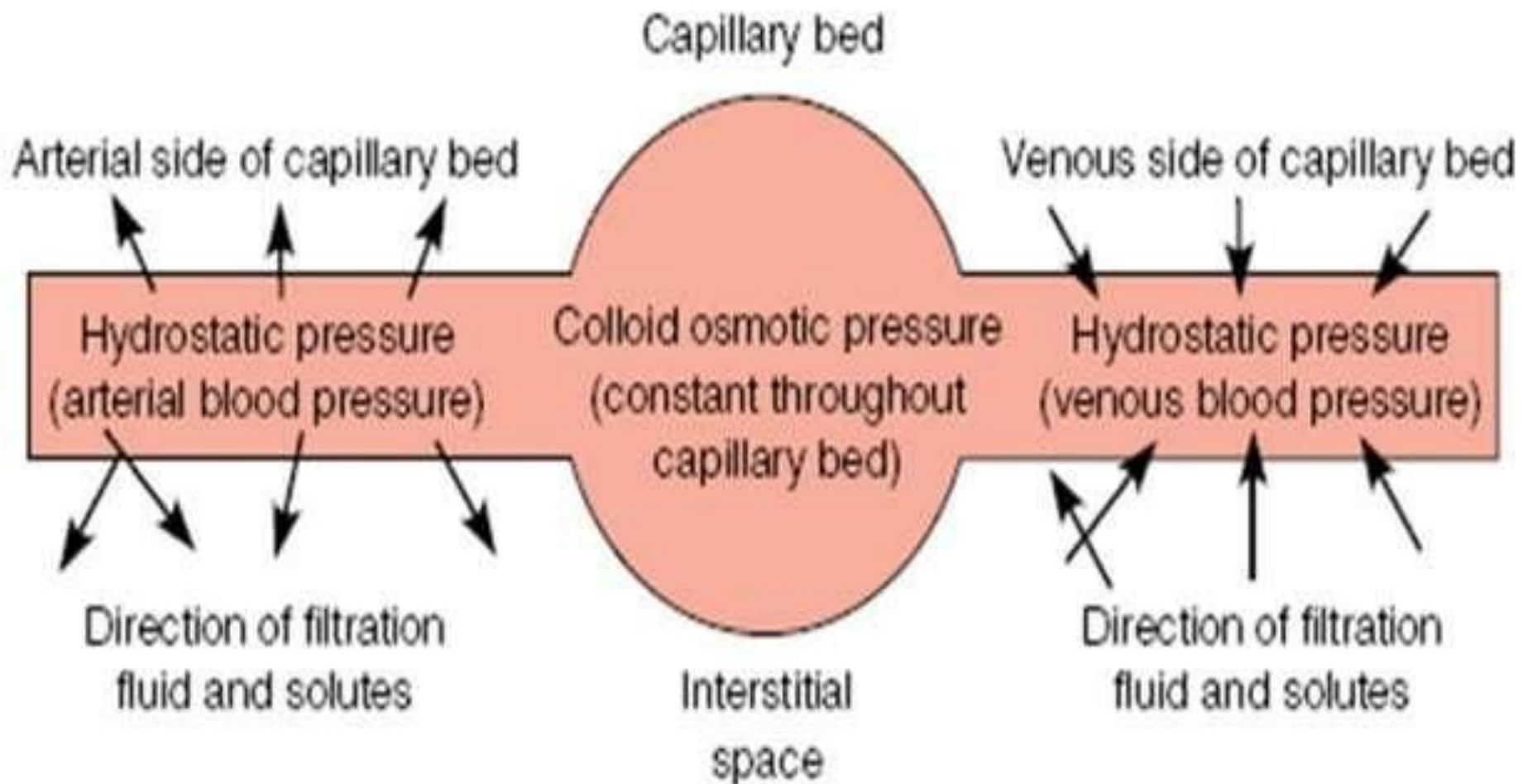
# Diffusion



# Osmosis



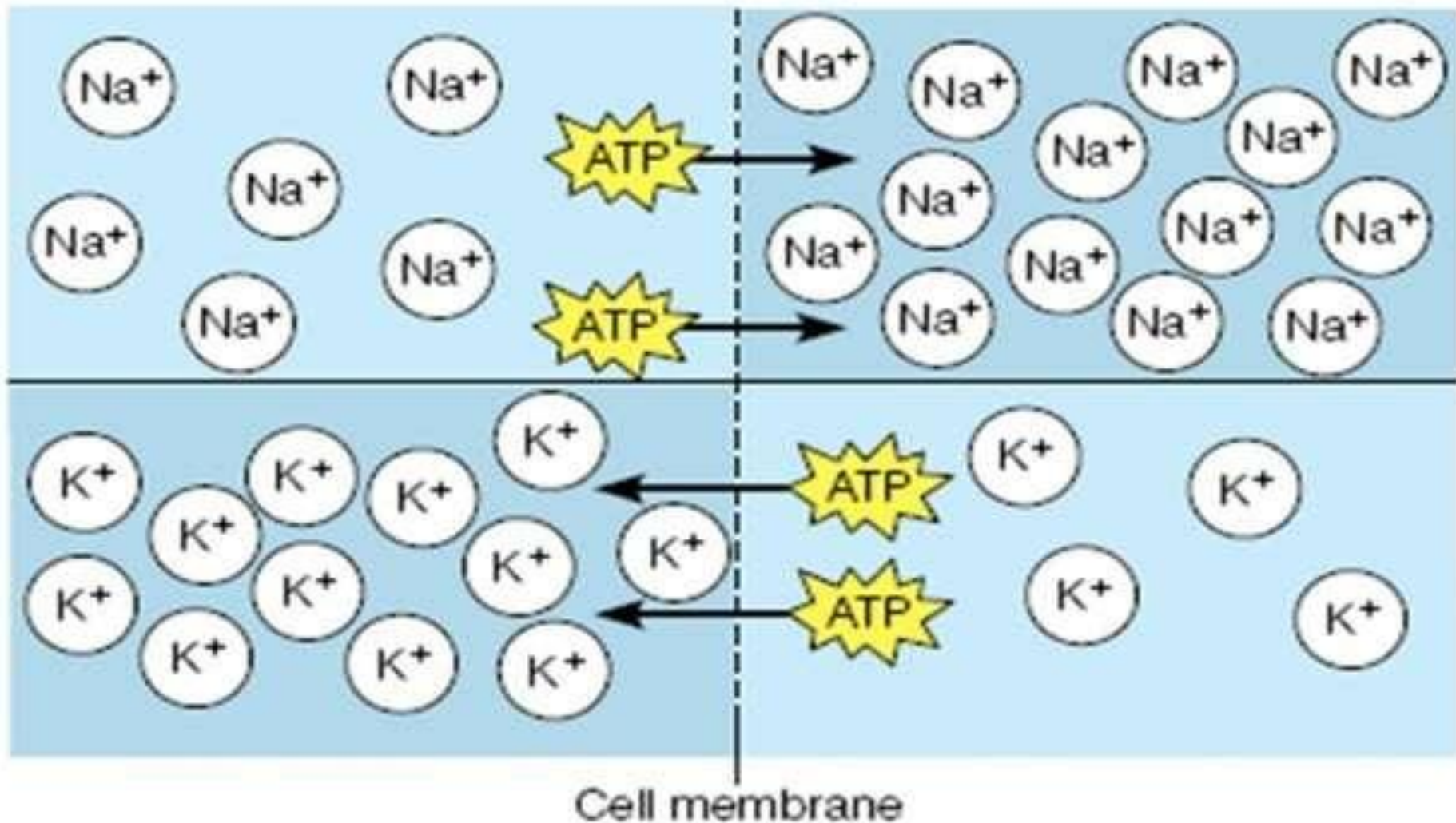
# Filtration



# Active Transport

Intracellular fluid

Extracellular fluid



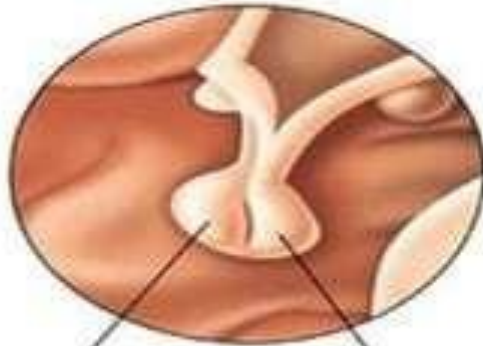


# Regulating Body Fluids

- Fluid intake
  - Thirst
- Fluid output
  - Urine
  - Insensible loss
  - Feces
- Maintaining homeostasis
  - Kidneys
  - ADH
  - Renin-angiotensin-aldosterone system
  - Atrial natriuretic system



**Pituitary gland**  
Secretes ADH into the  
bloodstream



**Anterior pituitary**  
Adrenocorticotropic  
hormone (ACTH)

**Posterior pituitary**  
Antidiuretic  
hormone (ADH)  
stored

**Hypothalamus**  
Produces antidiuretic  
hormone (ADH)

**Thyroid gland**  
T<sub>4</sub> thyroxine and  
T<sub>3</sub> triiodothyronine  
affect cardiac output

**Adrenal glands**



**Adrenal cortex**  
Mineralocorticoids:  
aldosterone  
Glucocorticoids:  
cortisol

**Adrenal medulla**  
Epinephrine  
Norepinephrine



**Atrial natriuretic  
peptides  
(ANP)**



**Kidneys**  
RAA system

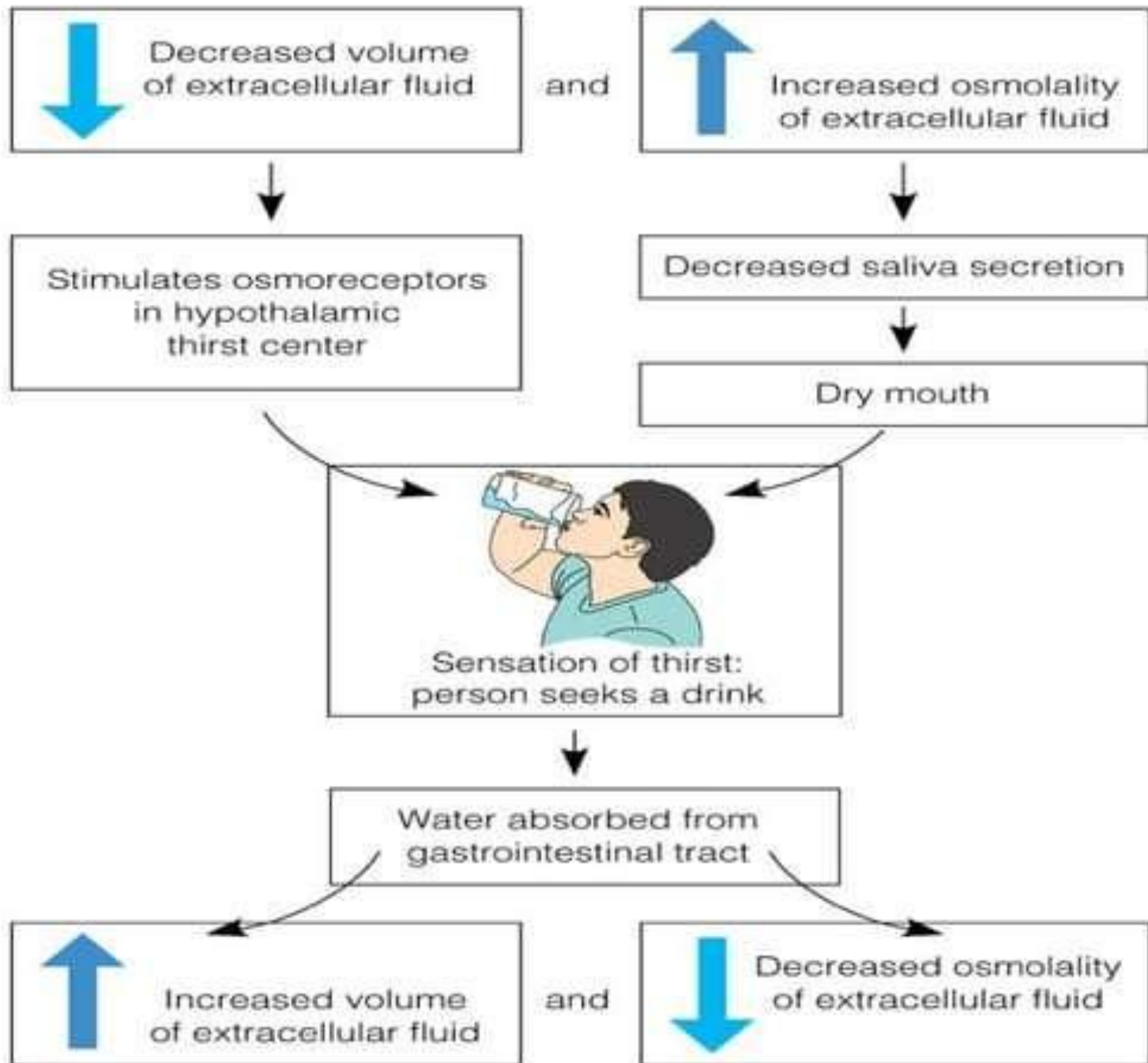
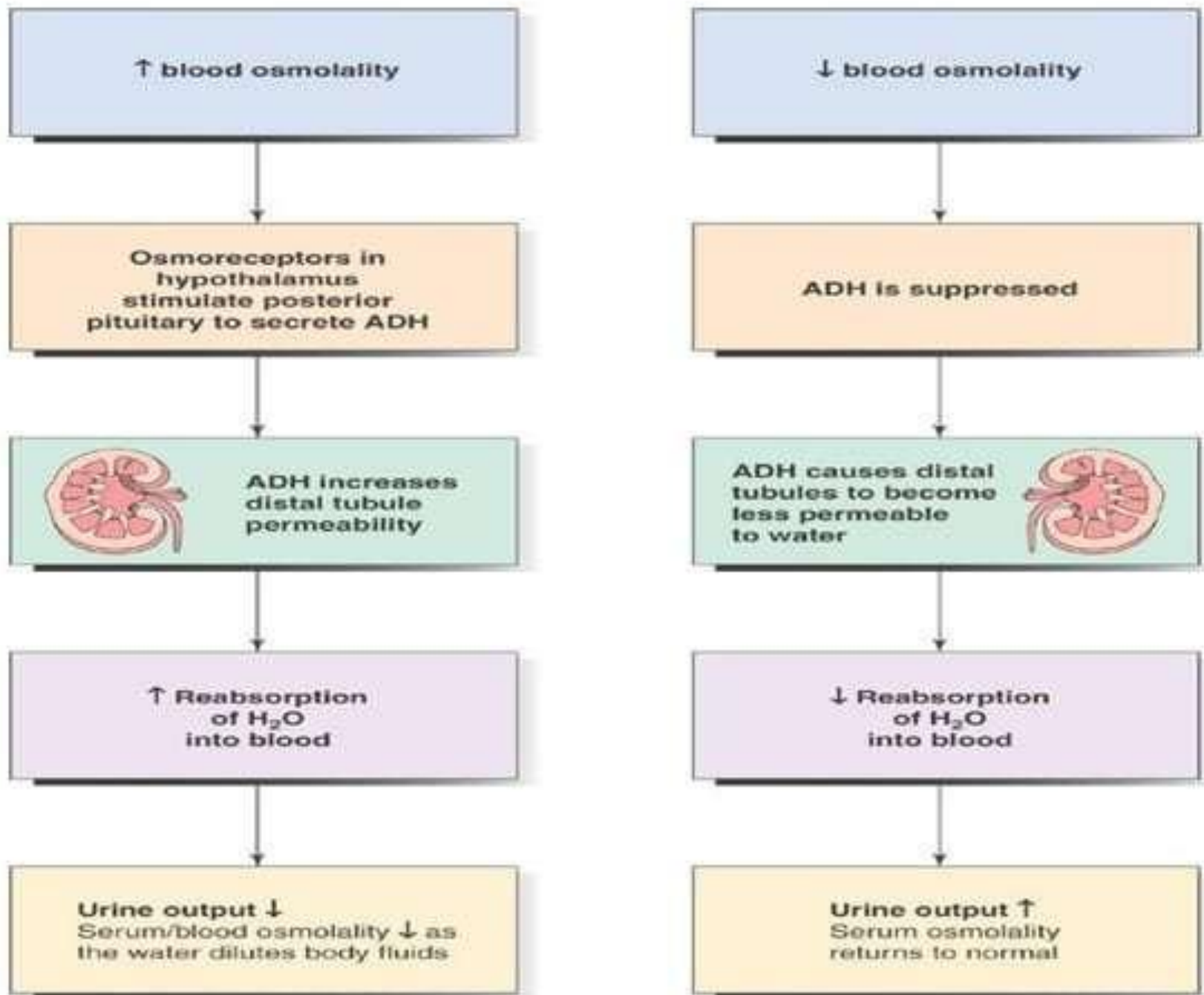


Fig 52-8

Antidiuretic hormone (ADH) regulates water excretion from the kidneys



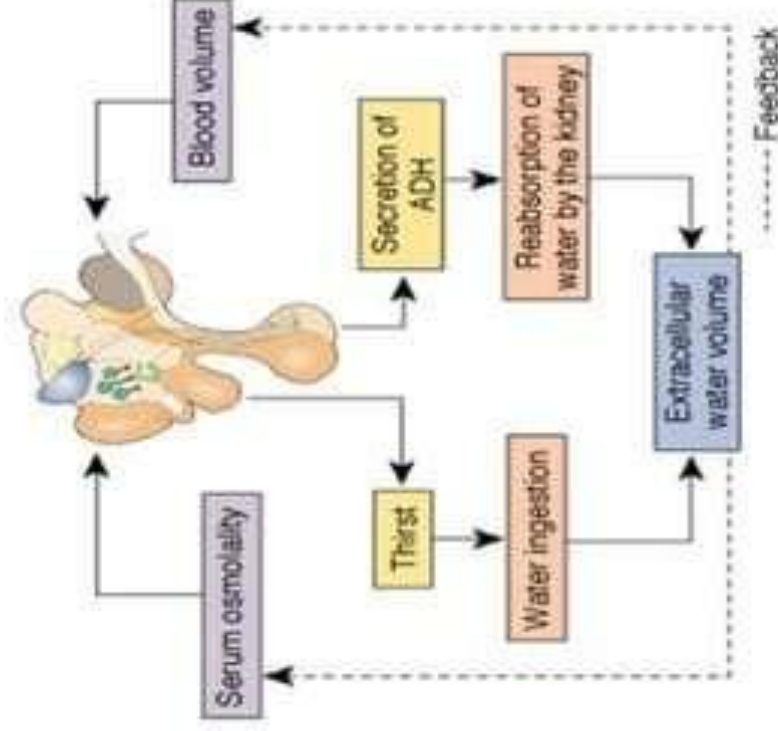
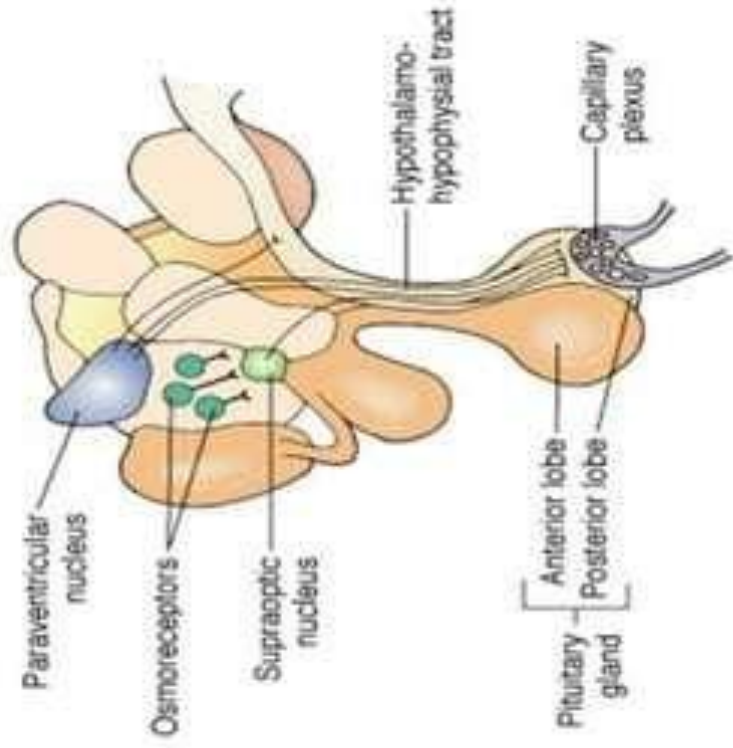


Figure 33-10 (Top) Sagittal section through the pituitary and anterior hypothalamus. Antidiuretic hormone (ADH) is formed primarily in the supraoptic nucleus and to a lesser extent in the paraventricular nucleus of the hypothalamus. It is then transported down the hypothalamohypophysial tract and stored in secretory granules in the posterior pituitary, where it can be released into the blood. (Bottom) Pathways for regulation of extracellular water volume by thirst and antidiuretic hormone.



# Fluid and Electrolyte Balance

- Volume imbalance:
  - Net volume gain
    - hypervolemia
  - Net volume loss
    - hypovolemia
  - Water intoxication
    - overhydration



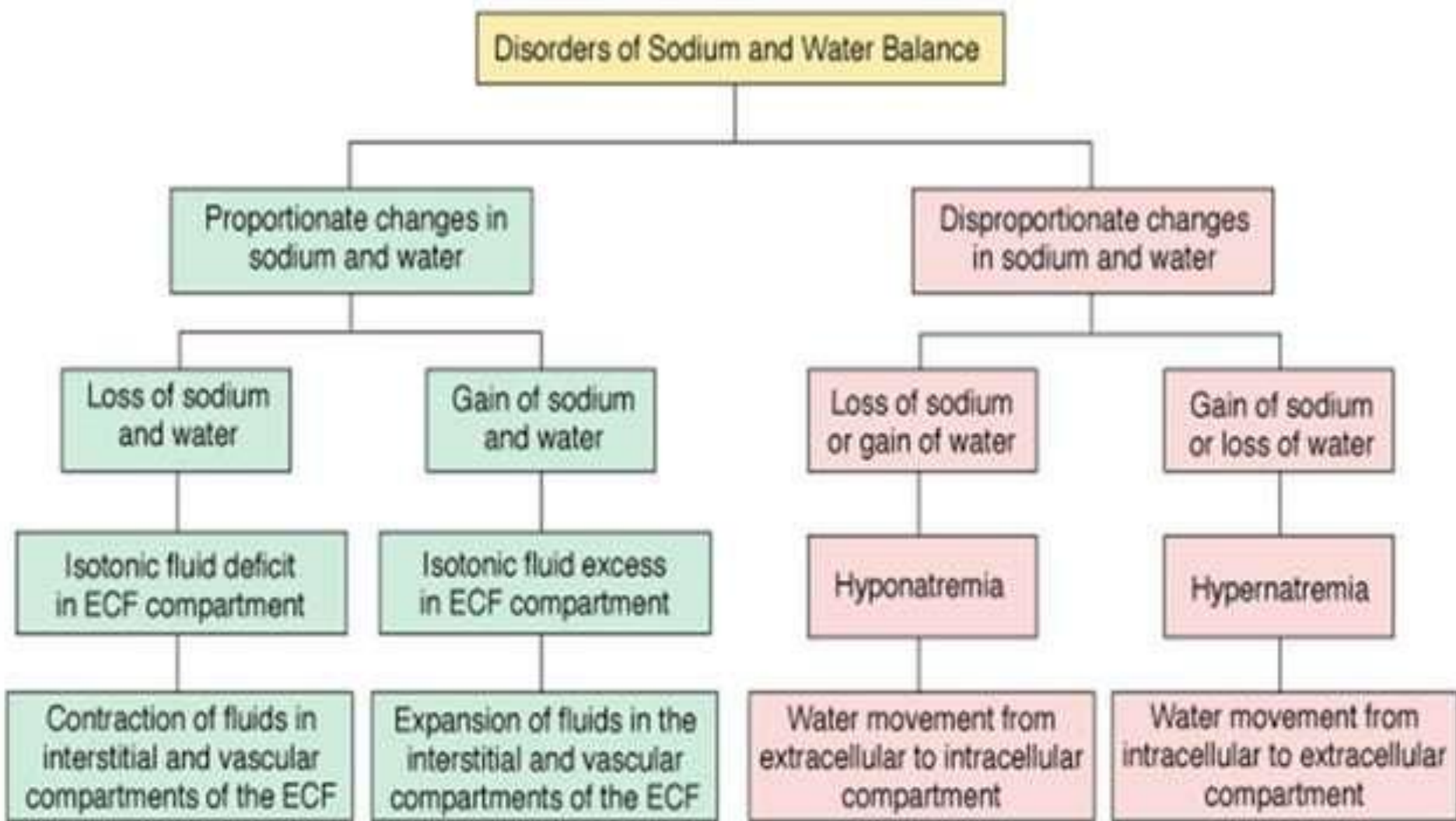


Figure 33-7 The effect of proportionate and disproportionate changes in sodium and water balance on extracellular sodium concentration.

# Fluid Volume Excess (FVE)

## Intake Exceeds Output

- Weight gain
  - Surgery
- Pitting edema
- Cough
- Dyspnea
- Cardiac palpitations
- Decreased urinary output
- Mental status changes

# Fluid Volume Deficit (FVD)

Output exceeds intake

- Diarrhea
- Diuretics
- Vomiting
- Gastric suction
- Anorexia
- Increasing fatigue and weakness
- Weight loss
- Fever
- Excess urine output
- Change in mental status
- Traumatic injury (burn)
- Blood loss

# Factors Affecting Distribution

- Filtration
- Hydrostatic Pressure
- Osmotic Pressure

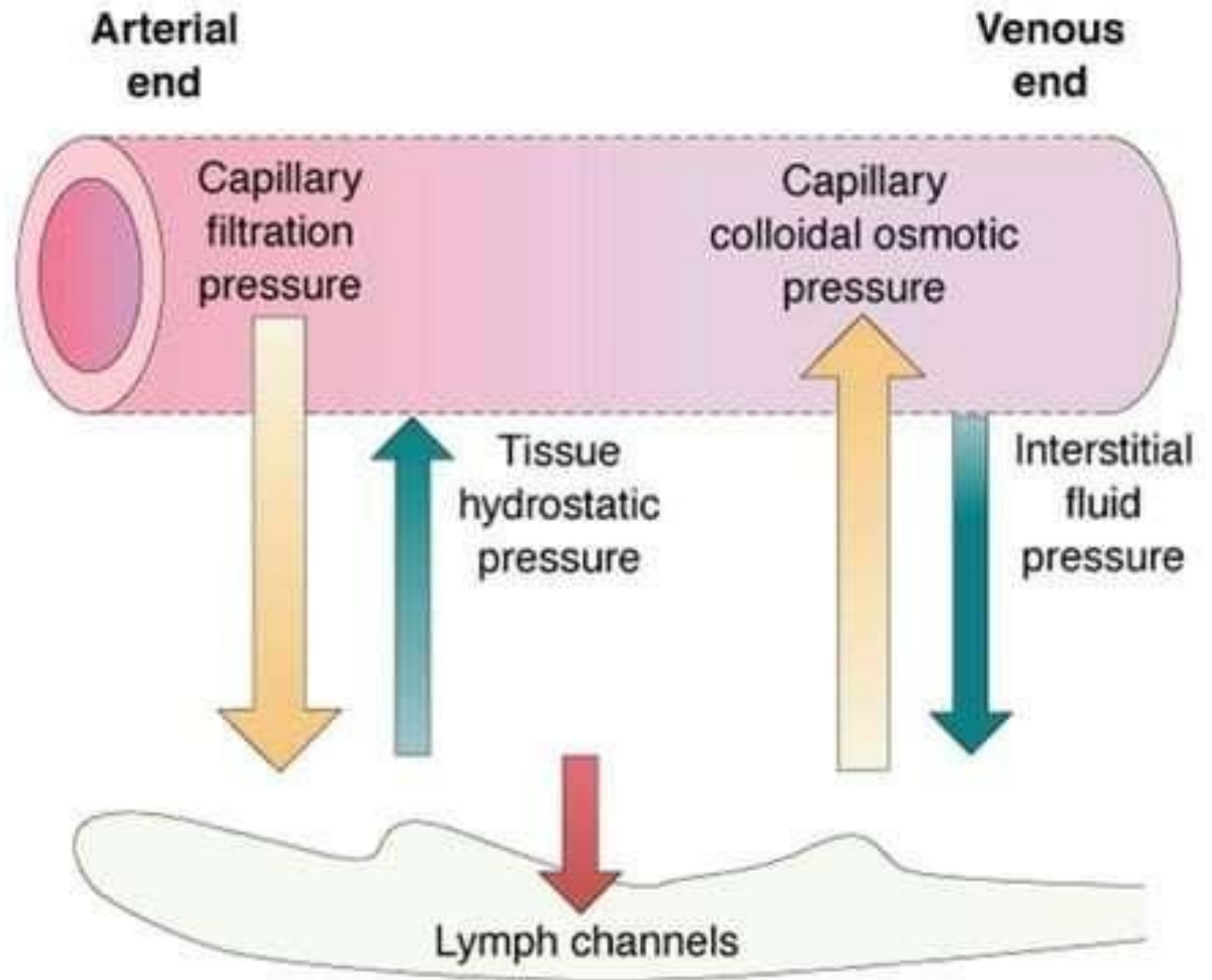


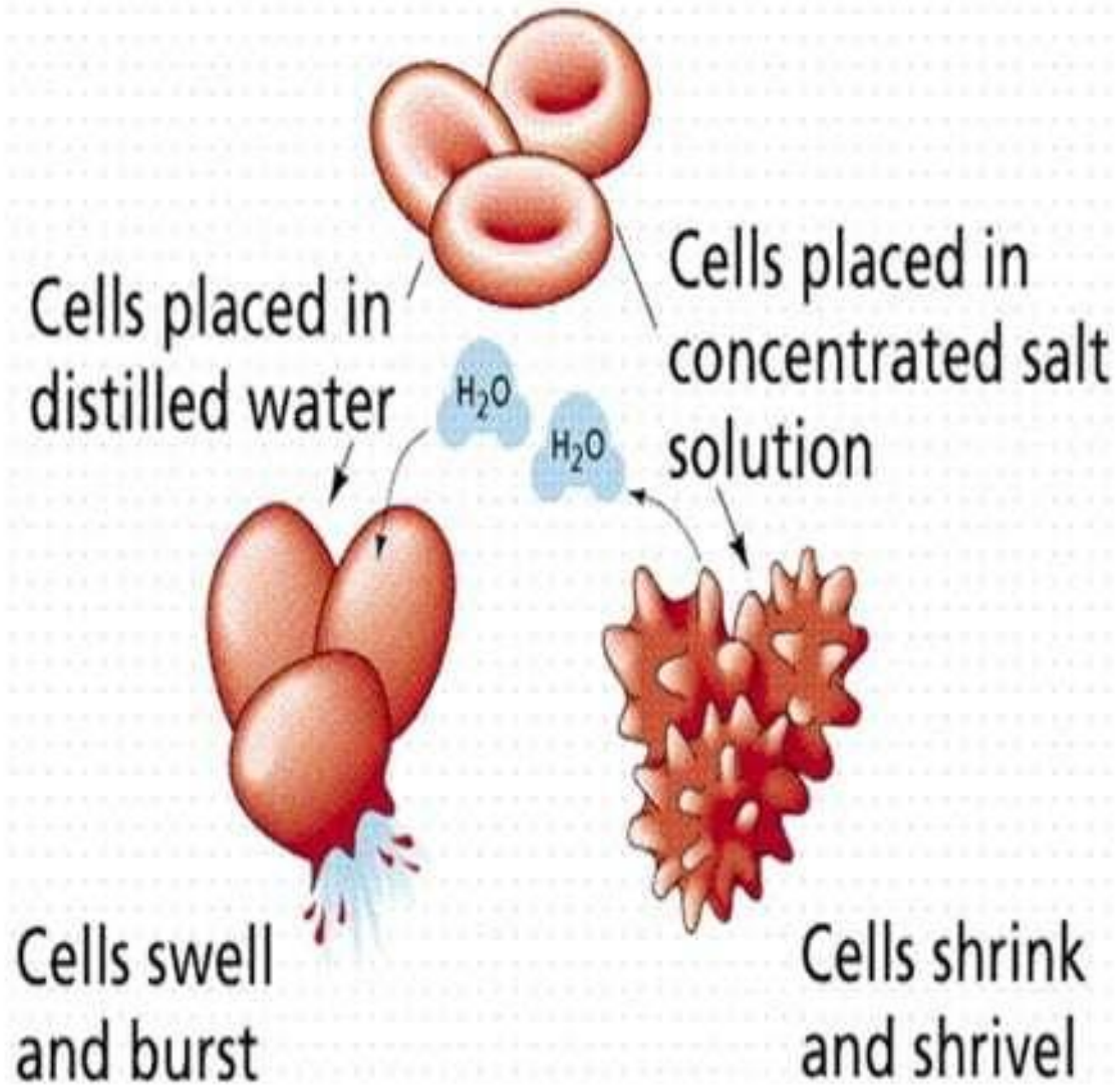
Figure 33-5 Exchange of fluid at the capillary level.



- Hypertonic

- Isotonic

- Hypotonic

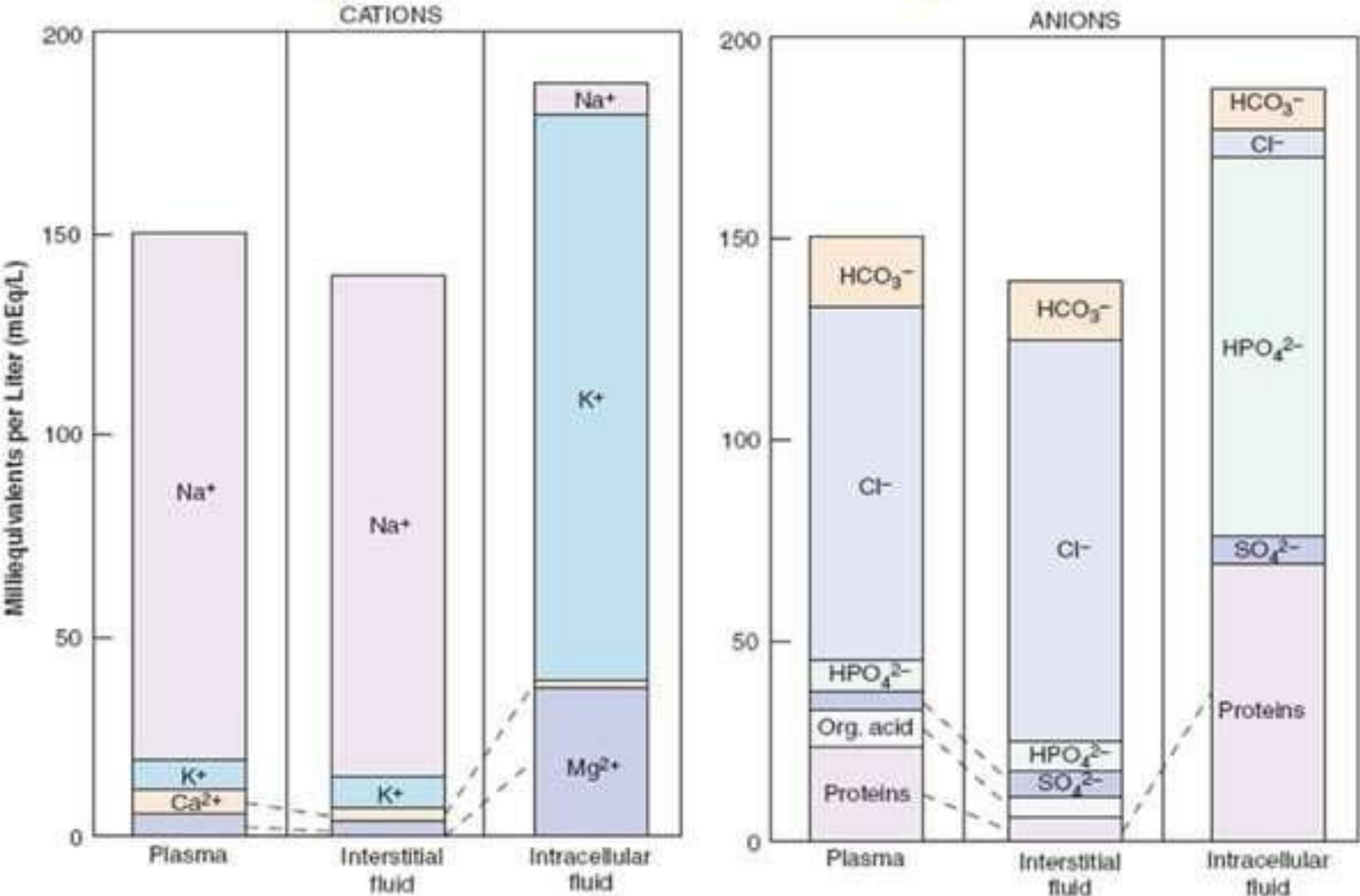




# Regulating Electrolytes

- Sodium
- Potassium
- Calcium
- Magnesium
- Chloride
- Phosphate
- Bicarbonate

# Composition of Body Fluids



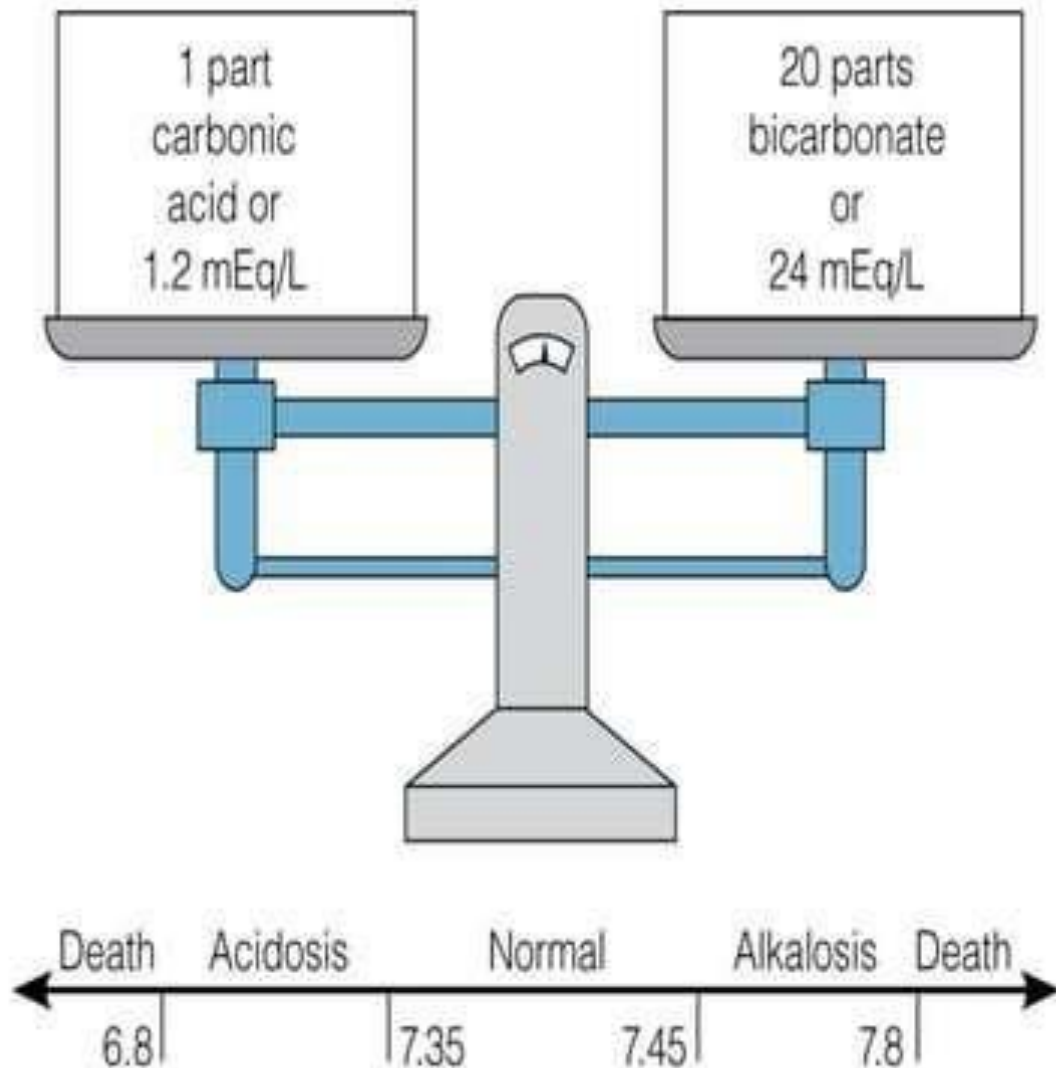


# Regulating Acid-Base Balance

- Low pH = acidic
- High pH = alkaline
- Body fluids maintained between pH of 7.35 and 7.45 by
  - Buffers
  - Respiratory system
  - Renal system



**Figure 52-10**      **Carbonic acid–bicarbonate ratio and pH.**



- Prevent excessive changes in pH
- Major buffer in ECF is  $\text{HCO}_3^-$  and  $\text{H}_2\text{CO}_3$
- Other buffers include:
  - Plasma proteins
  - Hemoglobin
  - Phosphates

# Acid-Base Imbalances

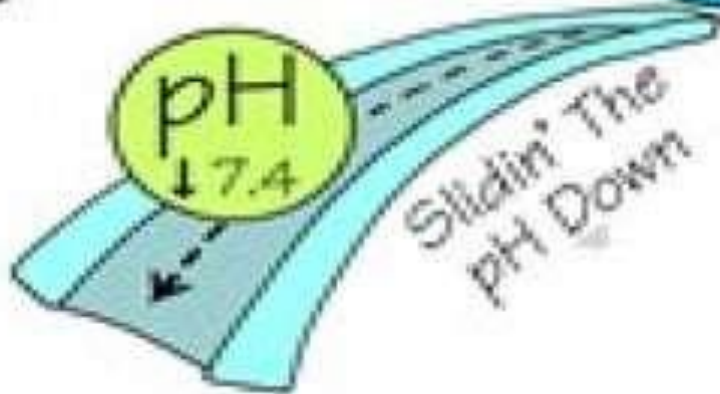
- Respiratory acidosis
- Respiratory alkalosis
- Metabolic acidosis
- Metabolic alkalosis

# ACIDOSIS - ALKALOSIS

**ALKALOSIS**



**ACIDOSIS**



# ACID BASE MNEMONIC (ROME)

**R**

**R**espiratory

**O**pposite

**O**

pH  $\uparrow$  PCO<sub>2</sub>  $\downarrow$  Alkalosis

pH  $\downarrow$  PCO<sub>2</sub>  $\uparrow$  Acidosis

**M**

**M**etabolic

**E**qual

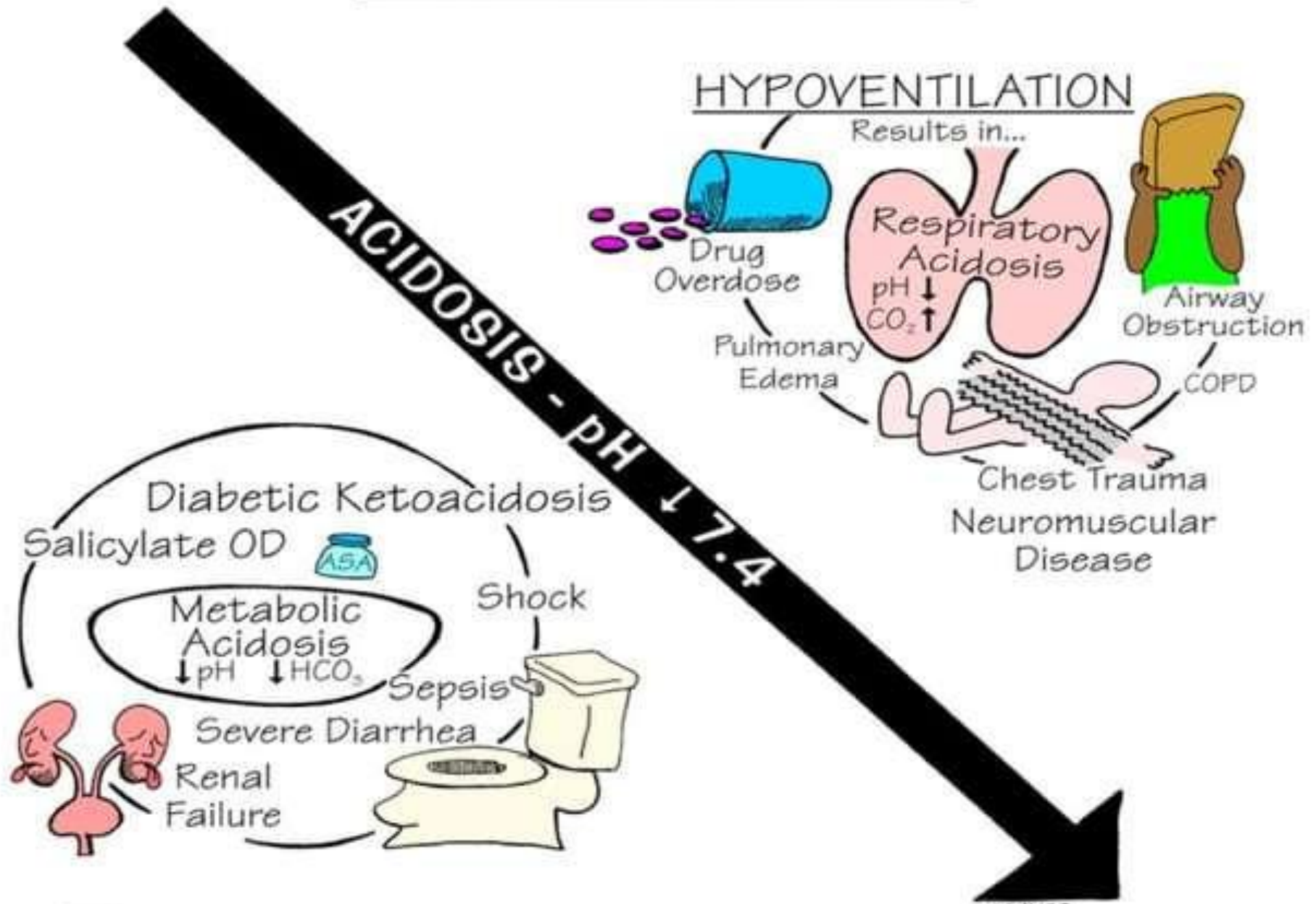
**E**

pH  $\uparrow$  HCO<sub>3</sub>  $\uparrow$  Alkalosis

pH  $\downarrow$  HCO<sub>3</sub>  $\downarrow$  Acidosis

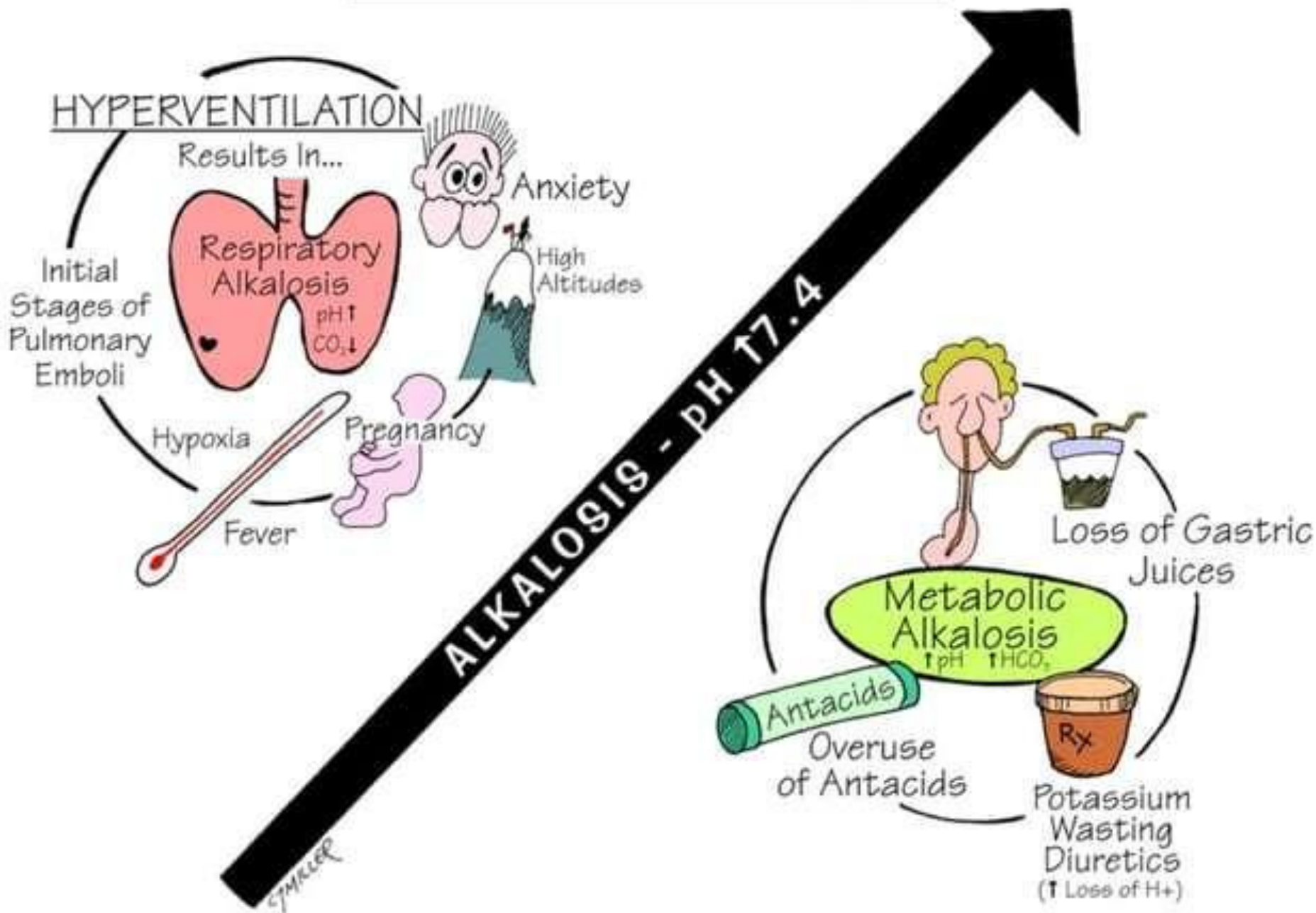


# CAUSES OF ACIDOSIS



GANER

# CAUSES OF ALKALOSIS



# Lungs

- Regulate acid-base balance by eliminating or retaining carbon dioxide
- Does this by altering rate/depth of respirations
- Faster rate/more depth = get rid of more CO<sub>2</sub> and pH rises
- Slower rate/less depth = retain CO<sub>2</sub> and pH lowers



# RESPIRATORY ACIDOSIS

- Hypoventilation → Hypoxia

- Rapid, Shallow Respirations

- ↓ BP with Vasodilation

- Dyspnea

- Headache

- Hyperkalemia

- Dysrhythmias (↑K)

I can't catch my breath.

- Drowsiness, Dizziness, Disorientation

- Muscle Weakness, Hyperreflexia

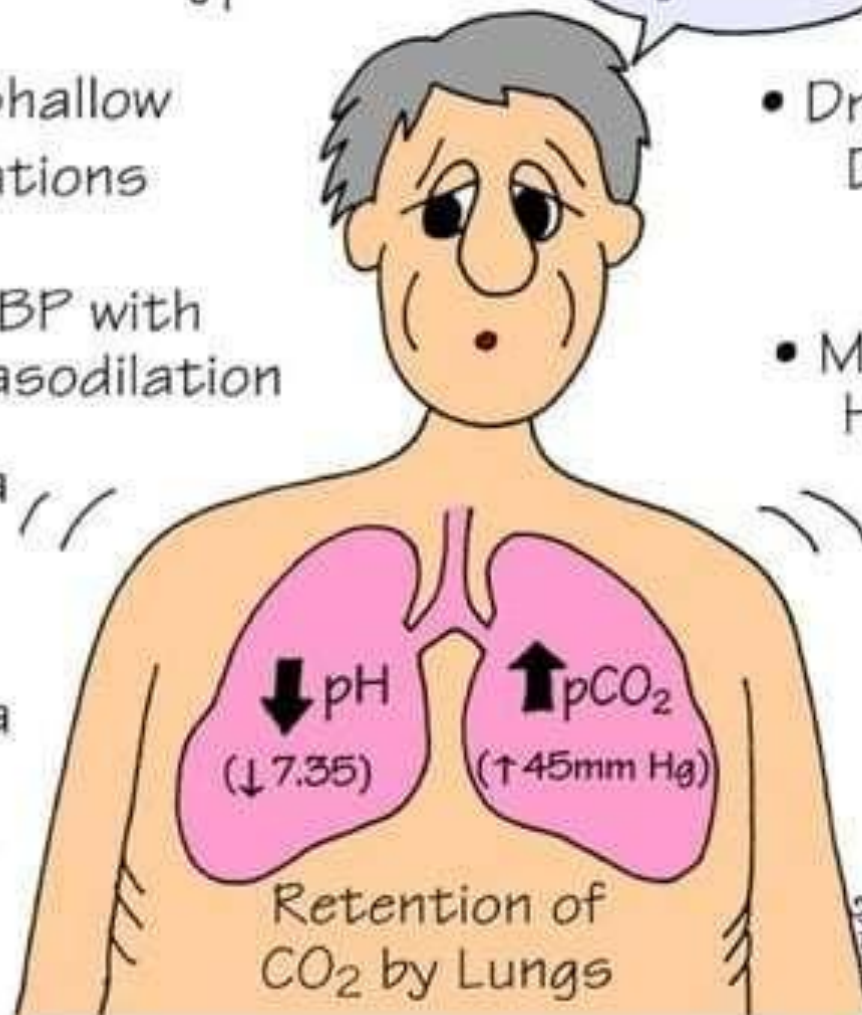
- Causes:

- ↓ Respiratory Stimuli (Anesthesia, Drug Overdose)

- COPD

- Pneumonia

- Atelectasis





# RESPIRATORY ALKALOSIS

- Seizures

- Deep, Rapid Breathing

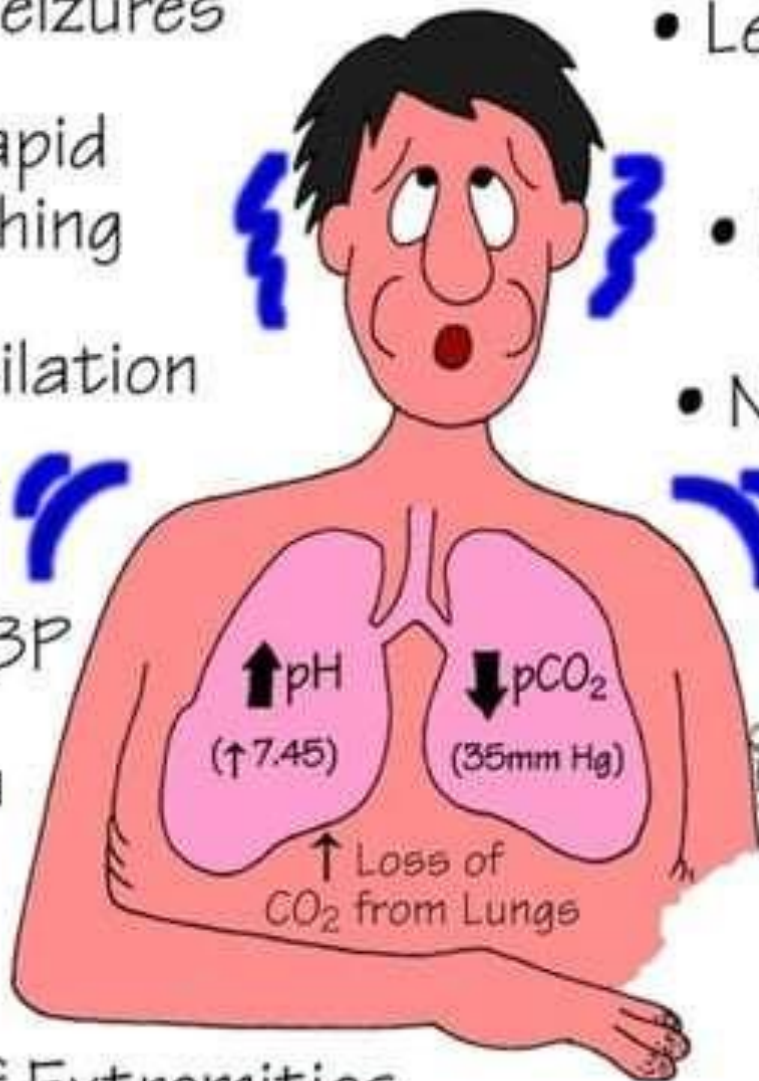
- Hyperventilation

- Tachycardia

- ↓ or Normal BP

- Hypokalemia

- Numbness & Tingling of Extremities



- Lethargy & Confusion

- Light Headedness

- Nausea, Vomiting

- Causes:

Hyperventilation

(Anxiety, PE, Fear)

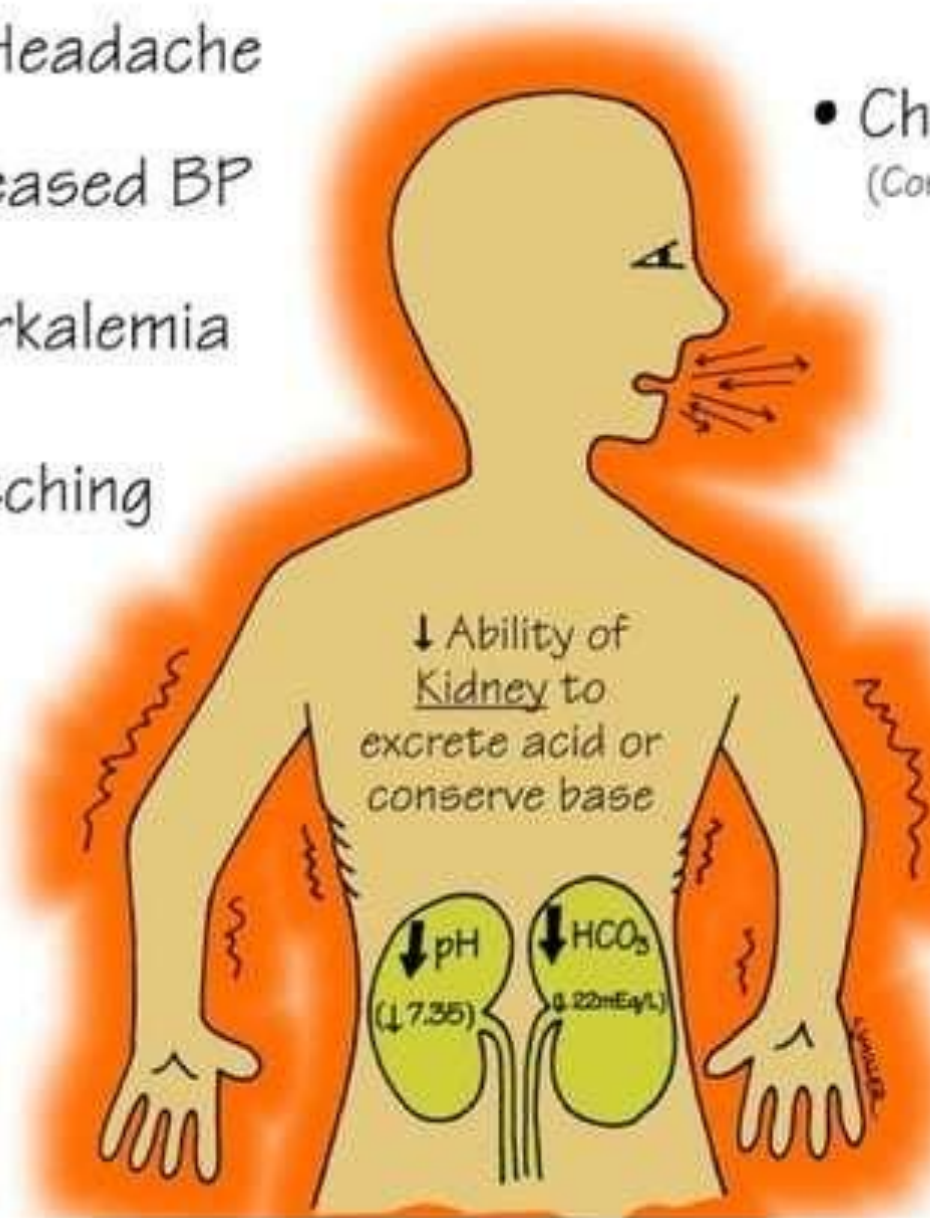
Mechanical Ventilation

# Kidneys

- Regulate by selectively excreting or conserving bicarbonate and hydrogen ions
- Slower to respond to change

# METABOLIC ACIDOSIS

- Headache
- Decreased BP
- Hyperkalemia
- Muscle Twitching
- Warm, Flushed Skin  
(Vasodilation)
- Nausea, Vomiting, Diarrhea



- Changes in LOC  
(Confusion, ↑ drowsiness)
- Kussmaul Respirations  
(Compensatory Hyperventilation)
- Causes:  
DKA  
Severe Diarrhea  
Renal Failure  
Shock

# METABOLIC ALKALOSIS

- Restlessness Followed by Lethargy

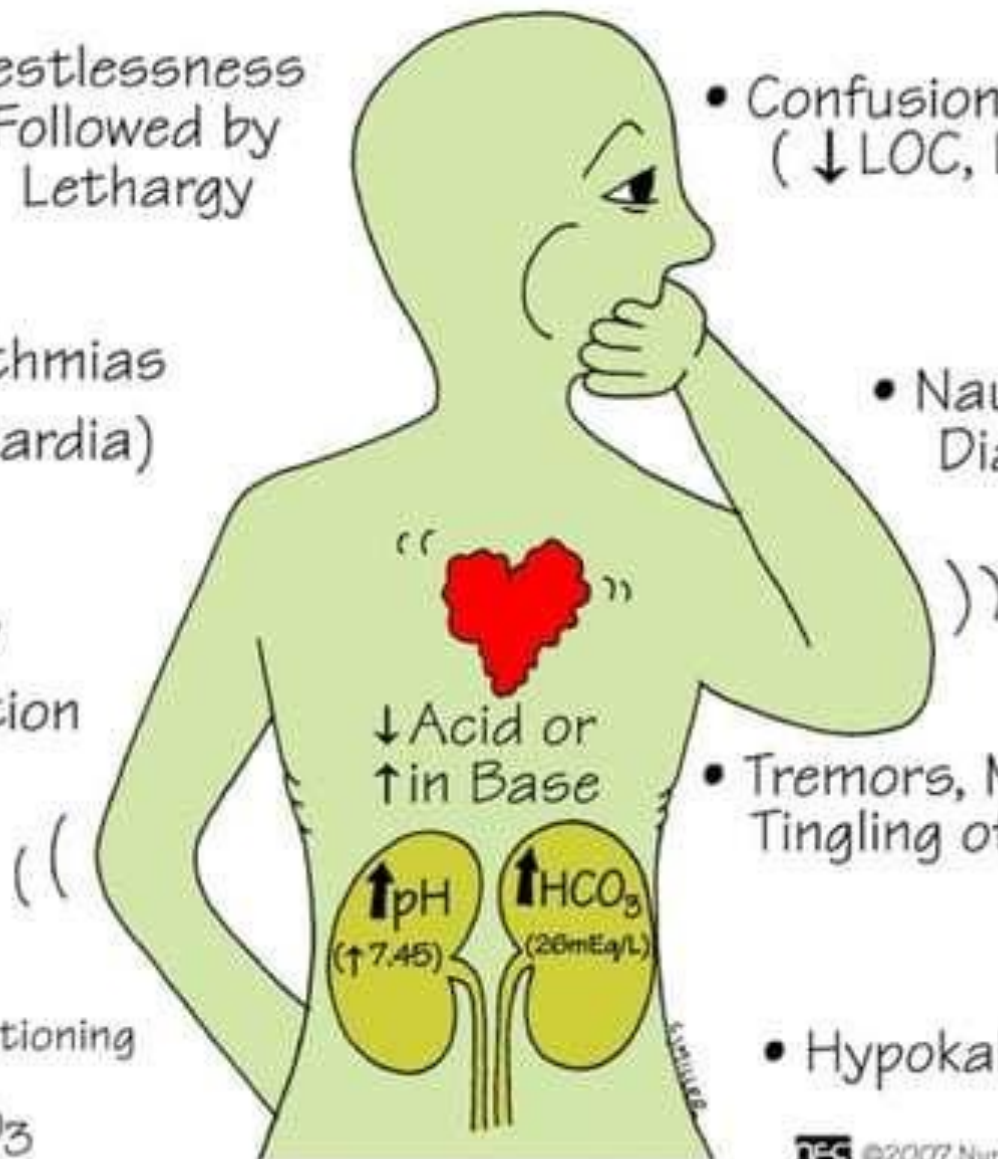
- Confusion (↓ LOC, Dizzy, Irritable)

- Dysrhythmias (Tachycardia)

- Nausea, Vomiting, Diarrhea

- Compensatory Hypoventilation

- Causes:  
Severe Vomiting  
Excessive GI Suctioning  
Diuretics  
Excessive  $\text{NaHCO}_3$

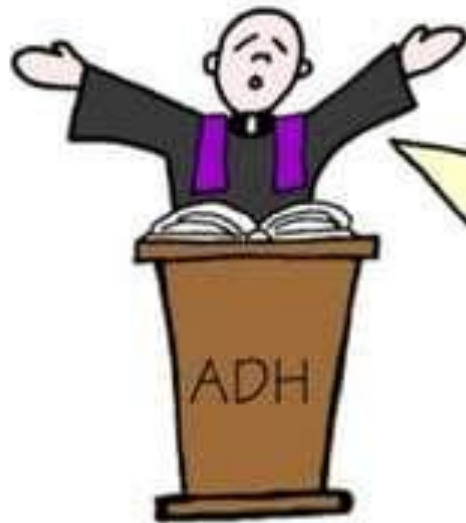


- Tremors, Muscle Cramps, Tingling of Fingers & Toes

- Hypokalemia



# RENAL COMPENSATION IN SHOCK



↑ ADH = Fluid Retention

Thou Shalt Not Pee!



Aldosterone =  
Na & Fluid  
Retention

Angio-  
Tension II

Angiotension =  
Vasoconstriction



# Arterial Blood Gas

- pH 7.35-7.45
- PaO<sub>2</sub> 80-100 mm Hg
- PaCO<sub>2</sub> 35-45 mm Hg
- HCO<sub>3</sub> 22-26 mEq/L
- Base Excess -2 - +2 mEq/L
- SaO<sub>2</sub> 95-98%

# Factors Affecting Body Fluid, Electrolyte, and Acid-Base Balance

- Age
- Gender
- Body size
- Environmental temperature
- Lifestyle

# **Risk Factors for Fluid, Electrolyte, and Acid-Base Imbalances**

- Chronic diseases
- Acute conditions
- Medications
- Treatments
- Extremes of age
- Inability to access food and fluids



# Specific Illnesses

- COPD, Asthma, Cystic Fibrosis
- CHF
- Kidney disease
- Diabetes Mellitus
- Cushing's or Addison's disease
- Cancer
- Malnutrition, anorexia nervosa, bulimia
- Ileostomy
- Gastroenteritis
- Bowel obstruction
- Head injury
- Fever, draining wounds, fistulas
- Surgery



# Medications to Monitor

- Diuretics
  - Water depletion
  - Electrolyte depletion
- Corticosteroids
  - Water retention
- NSAIDS/Opioids
  - Constipation

# Treatments that affect fluid balance

- Chemotherapy
- IV therapy or TPN
- Nasogastric suction
- Enteral Feedings
- Mechanical Ventilation

# Fluid Imbalances

- Isotonic loss of water and electrolytes (fluid volume deficit)
- Isotonic gain of water and electrolytes (fluid volume excess)
- Hyperosmolar loss of only water (dehydration)
- Hypo-osmolar gain of only water (overhydration)

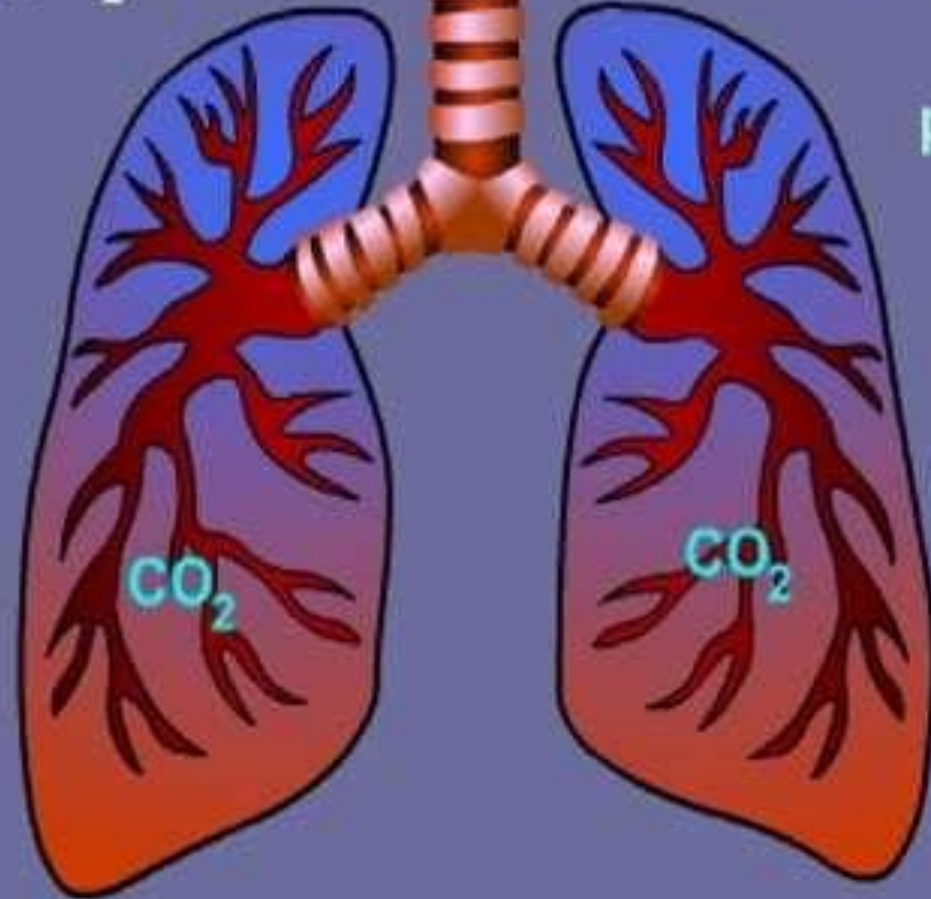
# Electrolyte Imbalances

- Hyponatremia
- Hypernatremia
- Hypokalemia
- Hyperkalemia
- Hypocalcemia
- Hypercalcemia
- Hypomagnesemia
- Hypermagnesemia
- Hypochloremia
- Hyperchloremia
- Hypophosphatemia
- Hyperphosphatemia

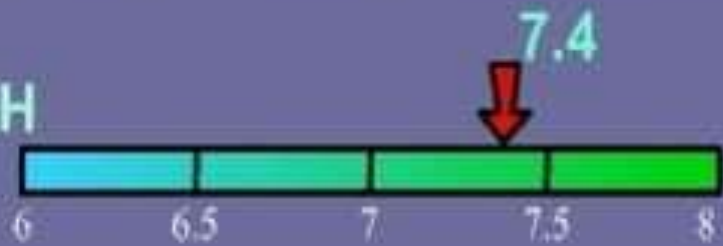


# Normal Acid - Base Balance

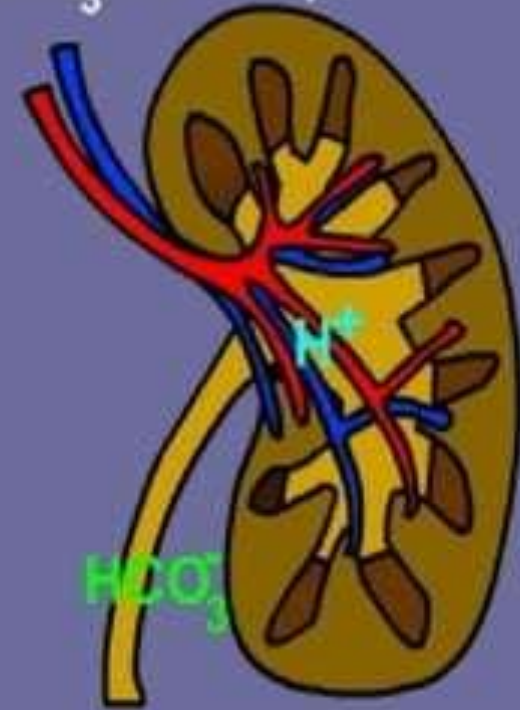
$p\text{CO}_2 \sim 40 \text{ mm Hg}$



pH



$\text{HCO}_3^- \sim 24 \text{ meq/l}$



urine pH  $\sim 6$

audio



# Hypernatremia

- Sodium

-  145 mEq/L

- Risk Factors


- water deprivation, hypertonic tube feedings, with inadequate water supplements, fever, unusually high Na<sup>+</sup> intake, profuse sweating, heatstroke, diabetes insipidus

- Defining Characteristics

- thirst, dry sticky mucus membranes, red, dry swollen tongue, dyspnea, fatigue, disorientation, convulsions

# Hyponatremia

- Sodium

–  135 mEq/L

- Risk Factors

– loss of GI fluids, adrenal insufficiency, sweating, diuretics, gain of water, hypotonic tube feedings, oral ingestion of water, excess administration of Dextrose, disease states head injury, AIDS, malignant tumors


- Defining Characteristics

– headache, muscle twitching, seizure activity, abdominal cramps, N&V, anorexia, lethargy, confusion



# Hyperkalemia

- Potassium

-  5.5 mEq/L (serum)

- Risk Factors

- decrease K<sup>+</sup> excretion, renal failure, K<sup>+</sup> conserving diuretics, hypoaldosteronism, High K<sup>+</sup> intake during renal insufficiency, too rapid K<sup>+</sup> infusion, too high dose of K<sup>+</sup> PCN or KCL dose


- Defining Characteristics

- ECG changes, vague muscle weakness, GI hyperactivity □ diarrhea, nausea, irritability, apathy, confusion, cardiac arrhythmias, arrest, absence of reflexes, flaccid muscles paralysis, numbness and paresthesias in extremities, face and tongue



# Hypokalemia

- Potassium

-  3.5 mEq/L (serum)

- Risk Factors

- vomiting, gastric suction, diarrhea, heavy diaphoresis, use of K<sup>+</sup> wasting drugs like lasix and thiazide diuretics, steroid administration, low intake of K<sup>+</sup> from ETOHism or anorexia, hyperaldosteronism, osmotic diuresis from uncontrolled DM

- Defining Characteristics

- ABGs show alkalosis, ECG changes, cardiac arrhythmias, muscle weakness, paresthesias, muscle soreness, leg cramps, fatigue, lethargy, anorexia, N&V, decrease bowel sounds and motility,

# HYPERKALEMIA $K^+$ ↑

- Muscle Twitches → Cramps → Paresthesia
- Irritability & Anxiety
- ↓ BP
- EKG Changes
- Dysrhythmias - Irregular Rhythm
- Abdominal Cramping
- Diarrhea



# EKG Changes with $K^+$ Imbalance

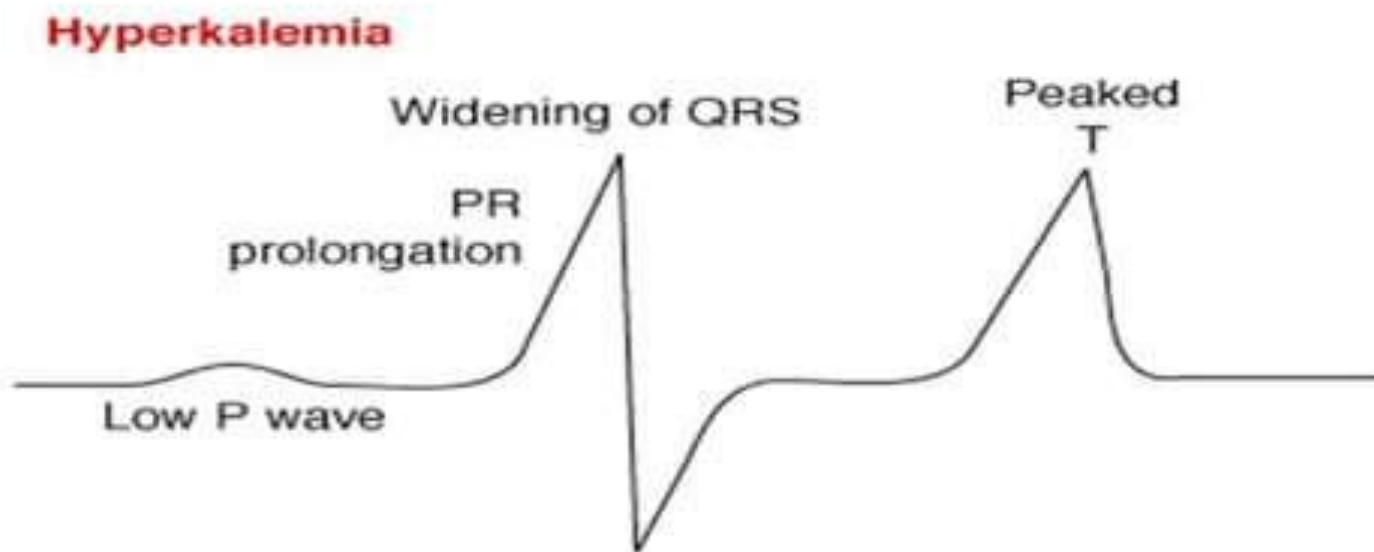
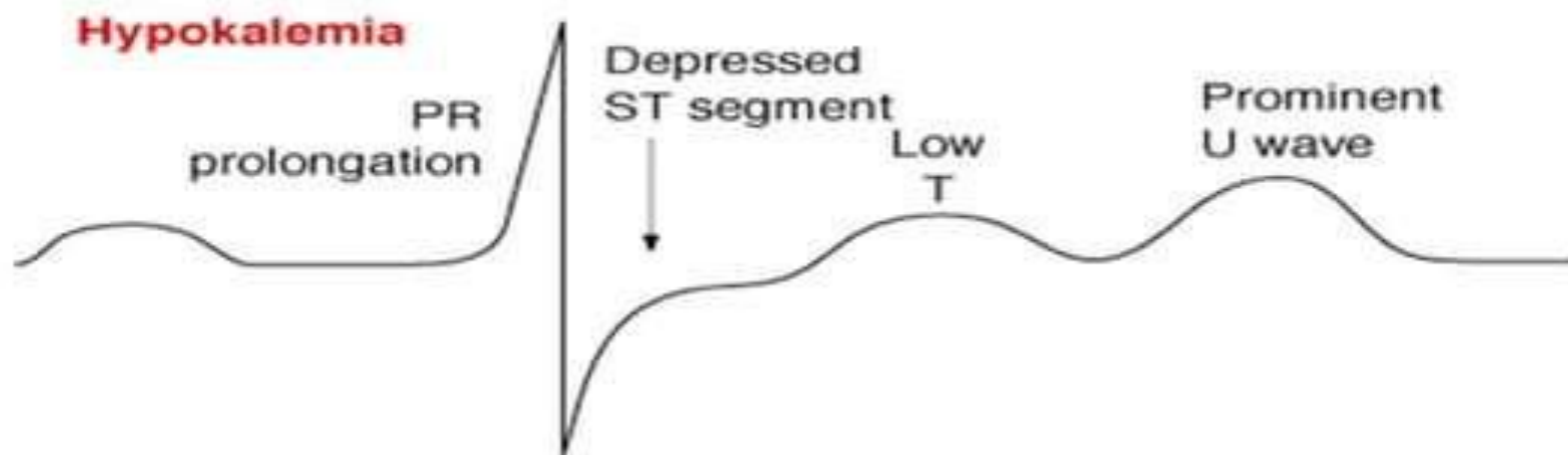
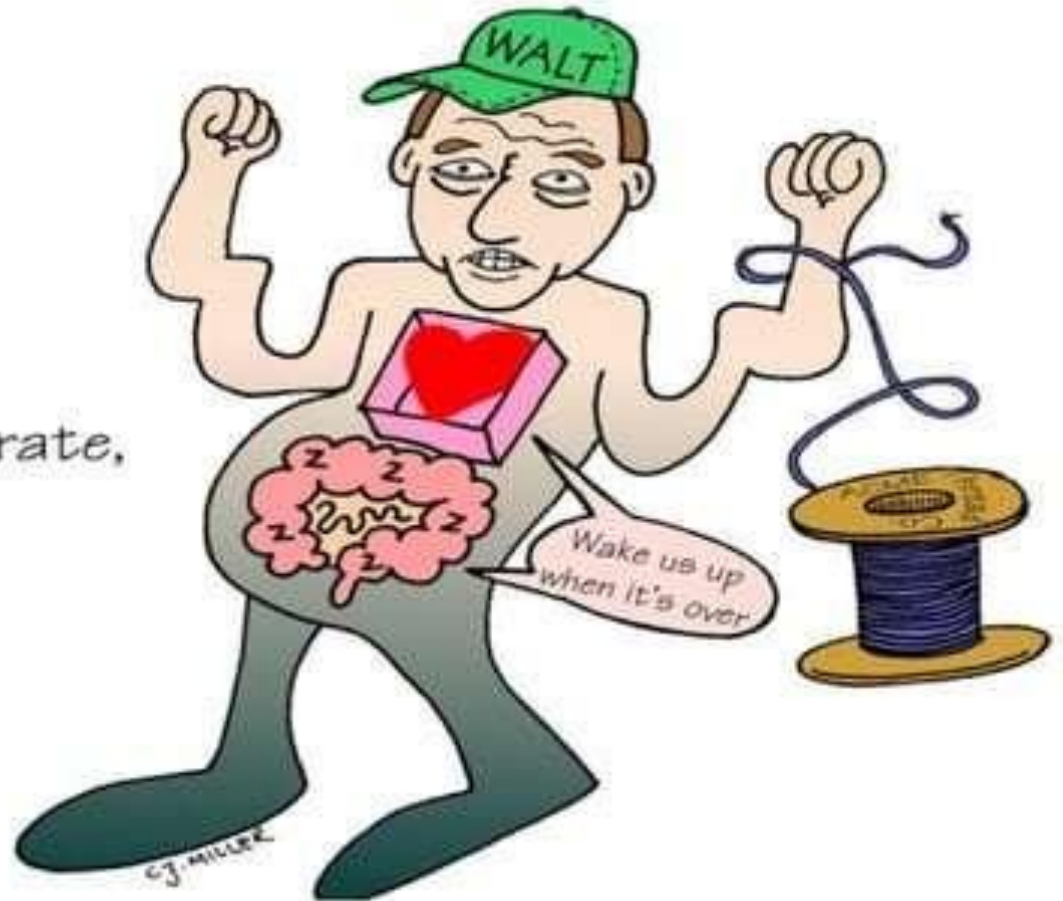


Figure 33-13 Electrocardiographic changes with hyperkalemia and hypokalemia.

# Hypokalemia

POTASSIUM  $K^+$  DEFICIT

- \* Alkalosis
- \* Shallow Respirations
- \* Irritability
- \* Confusion, Drowsiness
- \* Weakness, Fatigue
- \* Arrhythmias - Irregular rate, Tachycardia
- \* Lethargy
- \* Thready Pulse
- \* ↓ Intestinal Motility  
Nausea  
Vomiting  
Ileus






# POTASSIUM LEVELS IN ACIDOSIS



Potassium Goes Up  
In Acidosis

# Hypercalcemia

- Calcium

  -  5.5 mg/dL

- Risk Factors

  - hyperparathyroidism, prolonged immobility, megadoses of vitamin D, bone malignancy, paget's disease, thiazide diuretics, overuse of Ca<sup>+</sup> containing antacids and supplements

- Defining Characteristics

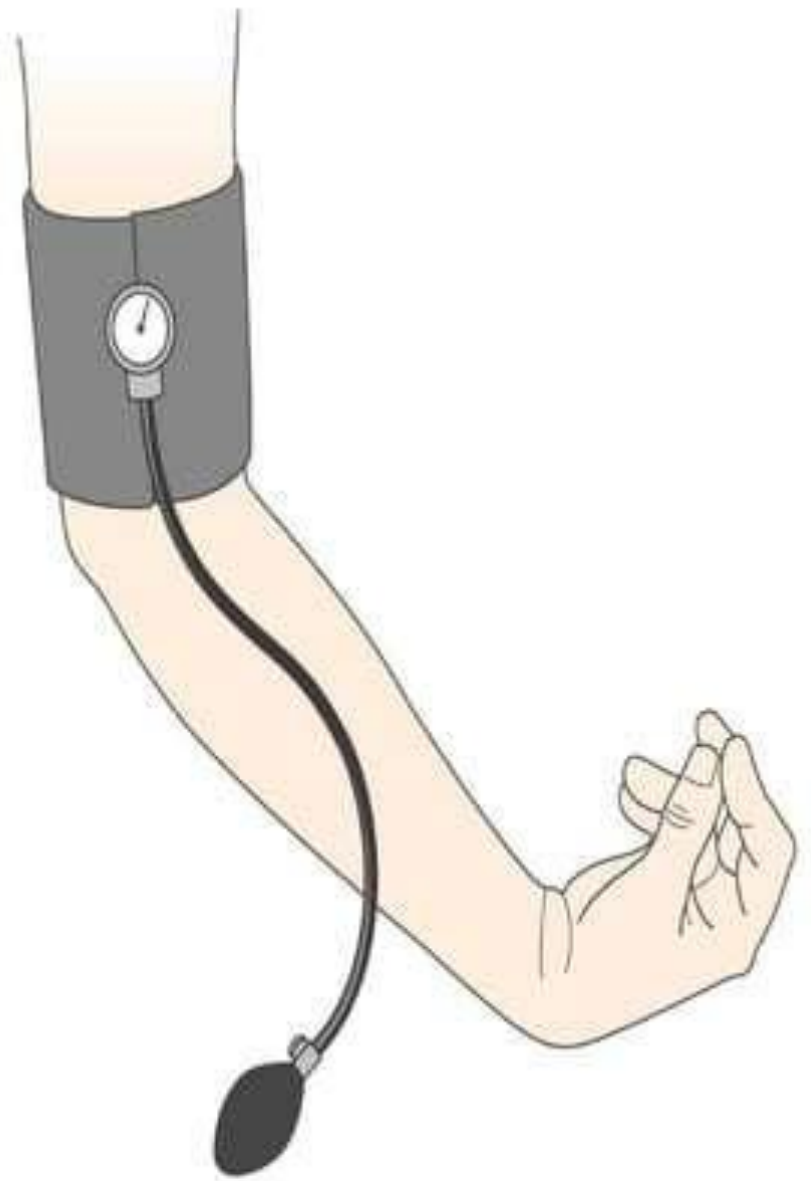
  - ECG changes, lethargy, weakness, depressed deep tendon reflexes, constipation, anorexia, N&V, polyuria, polydipsia, decreased memory and attention span, confusion, renal stones, flank pain, neuroses, psychosis reversible, cardiac arrest

# Hypocalcemia

- Calcium
- 4.5 mEq/L
-  Risk Factors
  - hypoparathyroidism, malabsorption, vitamin D deficiency, acute pancreatitis, thyroid CA, hypomagnesemia, alkalosis, sepsis, alcohol abuse
- Defining Characteristics
  - numbness, tingling, hyperactive deep tendon reflexes, muscle tremors, cramps, progressing to tetany and convulsions, cardiac arrhythmias, mental changes, Chvostek's sign, Trousseau's sign



**A. Positive Chvostek's Sign**



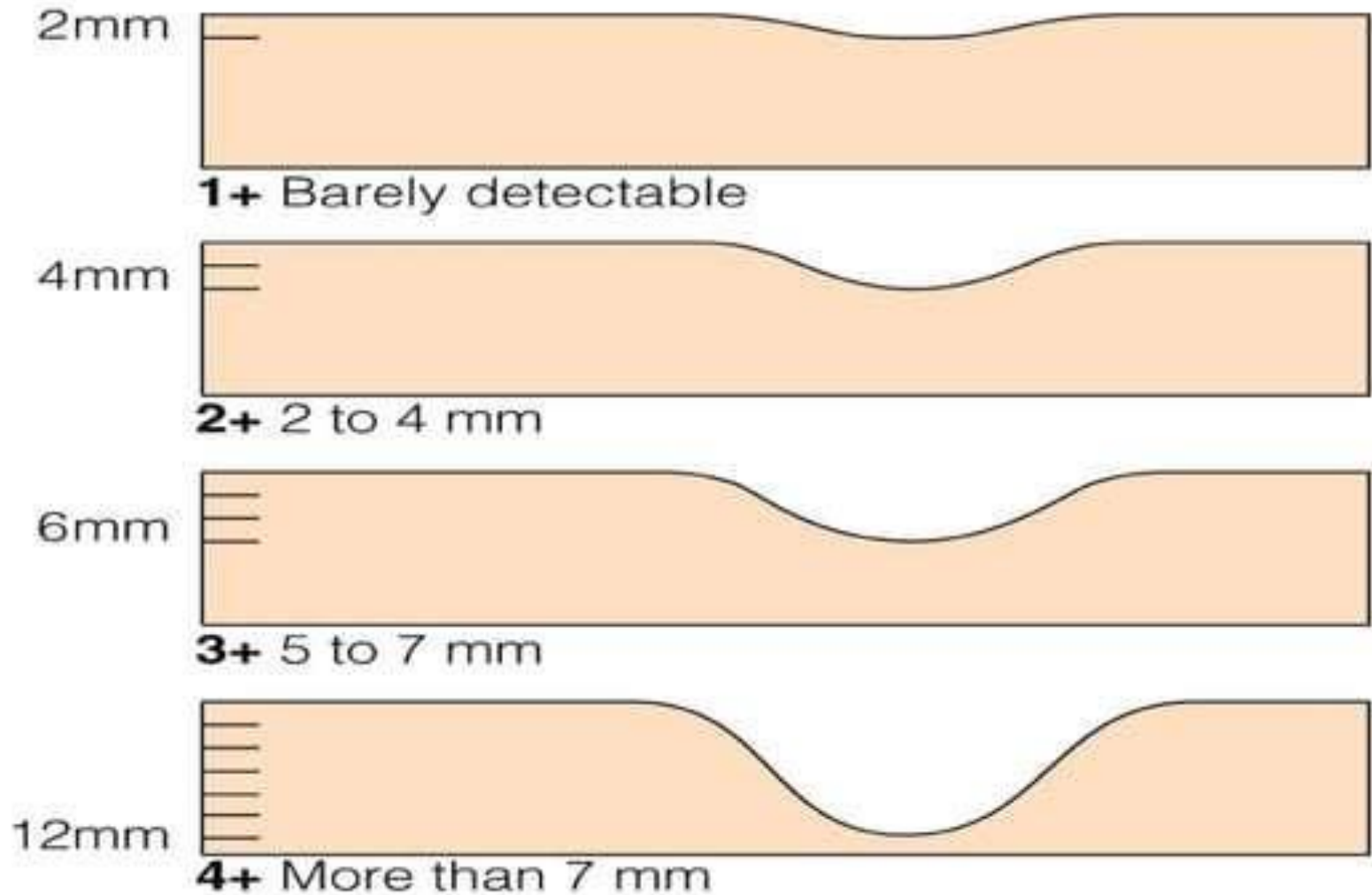
**B. Positive Trousseau's Sign**



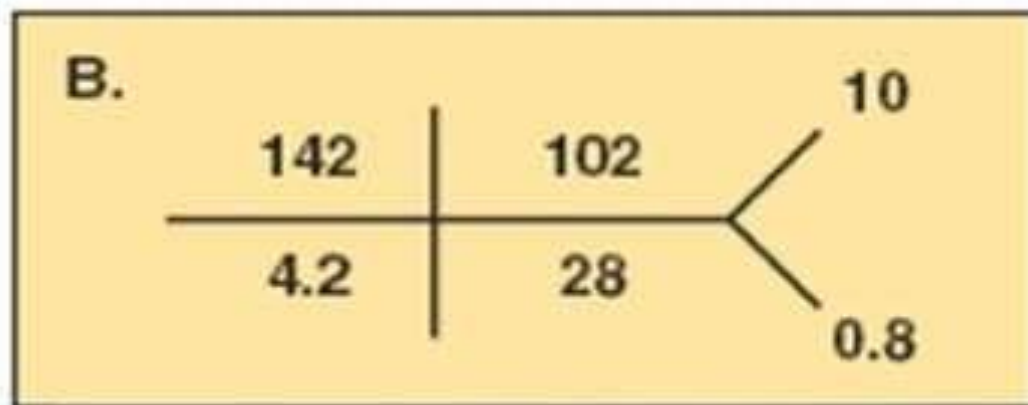
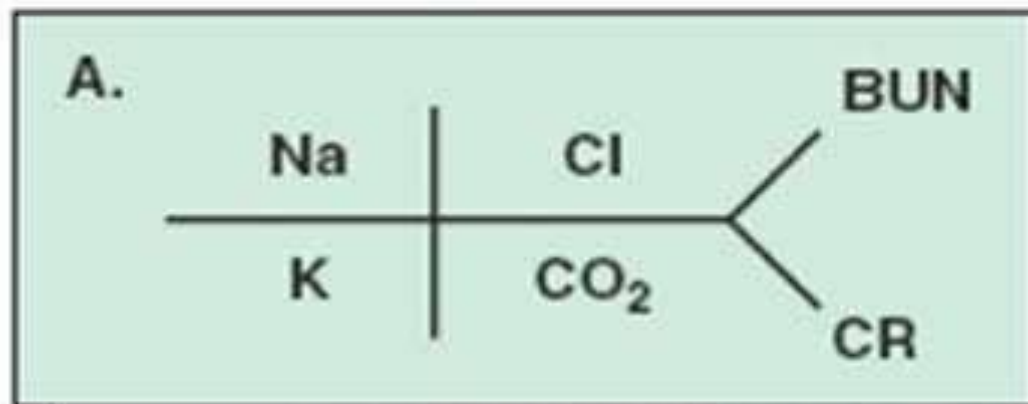
# Collecting Assessment Data

- Nursing history
- Physical assessment
- Clinical measurement
- Review of laboratory test results
- Evaluation of edema

# Figure 52-11 Evaluation of edema.



# Diagram of Serum Electrolyte Results



# Desired Outcomes

- Maintain or restore normal fluid balance
- Maintain or restore normal balance of electrolytes
- Maintain or restore pulmonary ventilation and oxygenation
- Prevent associated risks
- Tissue breakdown, decreased cardiac output, confusion, other neurologic signs



# Nursing Interventions

- Monitoring
- Fluid intake and output
- Cardiovascular and respiratory status
- Results of laboratory tests
- Assessing
- Client's weight
- Location and extent of edema, if present
- Skin turgor and skin status
- Specific gravity of urine
- Level of consciousness, and mental status

# Nursing Interventions

- Fluid intake modifications
- Dietary changes
- Parenteral fluid, electrolyte, and blood replacement
- Other appropriate measures such as:
- Administering prescribed medications and oxygen
- Providing skin care and oral hygiene
- Positioning the client appropriately
- Scheduling rest periods

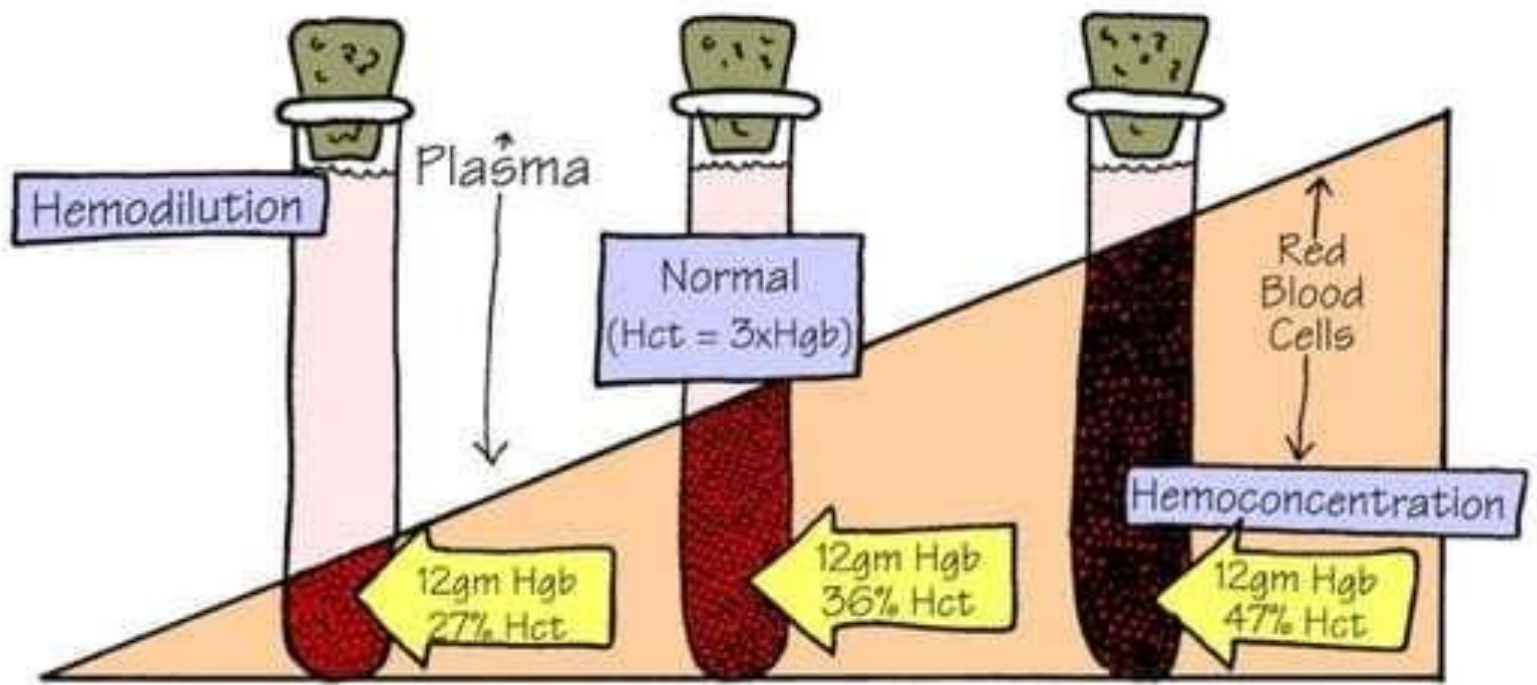
- Monitoring daily Intake and Output (I&O)
- Monitoring daily Weight -same time (am), same clothes
  - 1 Kg.(2.2 lbs) is equal to 1 Liter(1000 mL) of fluid loss or gain
- Orthostatic Blood Pressure monitoring
  - L\_\_\_\_\_ S\_\_\_\_\_ St\_\_\_\_\_

# Laboratory tests-

- Electrolytes- Metabolic Panel
  - Serum Na
  - Serum K
  - Blood Urea Nitrogen (BUN)
  - Creatinine
  - Glucose
- Urine osmolality (Sp. Gravity)
- H & H or CBC



# USING Hgb & Hct AS A GUIDE TO HYDRATION STATUS



CJMILLER

# Implementing and Documenting I & O

- Evaluating Outcomes
  - HCT ( hematocrit )
    - Range of 40 – 54% males
    - Range of 38 – 47% Females
    - Increased values = FVD
    - Decreased Values = FVE
  - Specific Gravity – 1.010-1.-25
    - High = FVD
    - Low = FVE

# Promoting Fluid and Electrolyte Balance

- Consume 6-8 glasses water daily
- Avoid foods with excess salt, sugar, caffeine
- Eat well-balanced diet
- Limit alcohol intake
- Increase fluid intake before, during, after strenuous exercise
- Replace lost electrolytes



# Promoting Fluid and Electrolyte Balance

- Maintain normal body weight
- Learn about, monitor, manage side effects of medications
- Recognize risk factors
- Seek professional health care for notable signs of fluid imbalances



# Practice Guidelines Facilitating Fluid Intake

- Explain reason for required intake and amount needed
- Establish 24 hour plan for ingesting fluids
- Set short term goals
- Identify fluids client likes and use those
- Help clients select foods that become liquid at room temperature
- Supply cups, glasses, straws
- Serve fluids at proper temperature
- Encourage participation in recording intake
- Be alert to cultural implications

# Planning and Implementation of I & O

- Assessing each patient's situation
  - Age
    - Infants and Children
      - Greater fluid turnover – high metabolic rate
      - Kidneys immature – lose more water
      - Respirations rapid –
      - Body surface area larger than adult – Increases insensible losses
      - Fluid and electrolyte losses occur very rapidly
    - Elderly
      - Thirst response diminished
      - Nephrons less functional to conserve water
      - Increase risk of dehydration
      - Risks of HD, CRF, multiple medications
        - ✦ increases risk for fluid and electrolyte imbalance

# Practice Guidelines Restricting Fluid Intake

- Explain reason and amount of restriction
- Help client establish ingestion schedule
- Identify preferences and obtain
- Set short term goals; place fluids in small containers
- Offer ice chips and mouth care
- Teach avoidance of ingesting chewy, salty, sweet foods or fluids
- Encourage participation in recording intake



# Correcting Imbalances

- Oral replacement
  - If client is not vomiting
  - If client has not experienced excessive fluid loss
  - Has intact GI tract and gag and swallow reflexes



# Correcting Imbalances

- Restricted fluids may be necessary for fluid retention
- Vary from nothing by mouth to precise amount ordered
- Dietary changes

# Oral Supplements

- Potassium
- Calcium
- Multivitamins
- Sports drink

# Correcting Imbalances



- Intravenous Fluids
  - Hypotonic
    - osmotic pressure less to that of plasma.
    - 0.45% Na CL or half normal saline
    - used for dehydration and
    - promotes waste elimination of kidneys

# Intravenous Fluids



- **Isotonic**
  - osmotic pressure equal to that of plasma
- Example #1 - *5% dextrose in H<sub>2</sub>O (D5W)*
  - supplies free water to aid in renal excretion of solutes
  - expands intracellular and extracellular volumes
- Example #2 - *Lactated Ringers,*  
*0.9% NaCl or normal saline (NS)*
  - expands vascular volume
  - contains multiple electrolytes in physiological concentrations
  - used to treat hypovolemia, burns, and diarrhea
  - used to treat mild metabolic acidosis



# Intravenous Fluids

- Hypertonic

- osmotic pressure above that of plasma

Example #1 - *5% dextrose in 0.45% NaCl*

*(D5 ½ NS)*

- treats hypovolemia
- maintains hydration
- draws fluid out of the intracellular and interstitial spaces into the vascular space
- expands volume



# Intravenous Fluids



- Hypertonic
  - Example #2 - *5% dextrose 0.9% NaCl (D5NS)*
    - replaces calories and electrolytes
    - temporary treatment of hypovolemia

# Evaluation

- Collect data as identified in the plan of care
- If desired outcomes are not achieved, explore the reasons before modifying the care plan