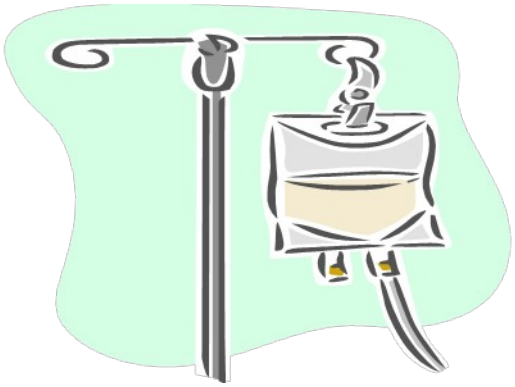
Fluid, Electrolyte, and Acid-Base Balance

Focus 7

Nursing 53A

Judy Ontiveros, RN, PHN, MSN



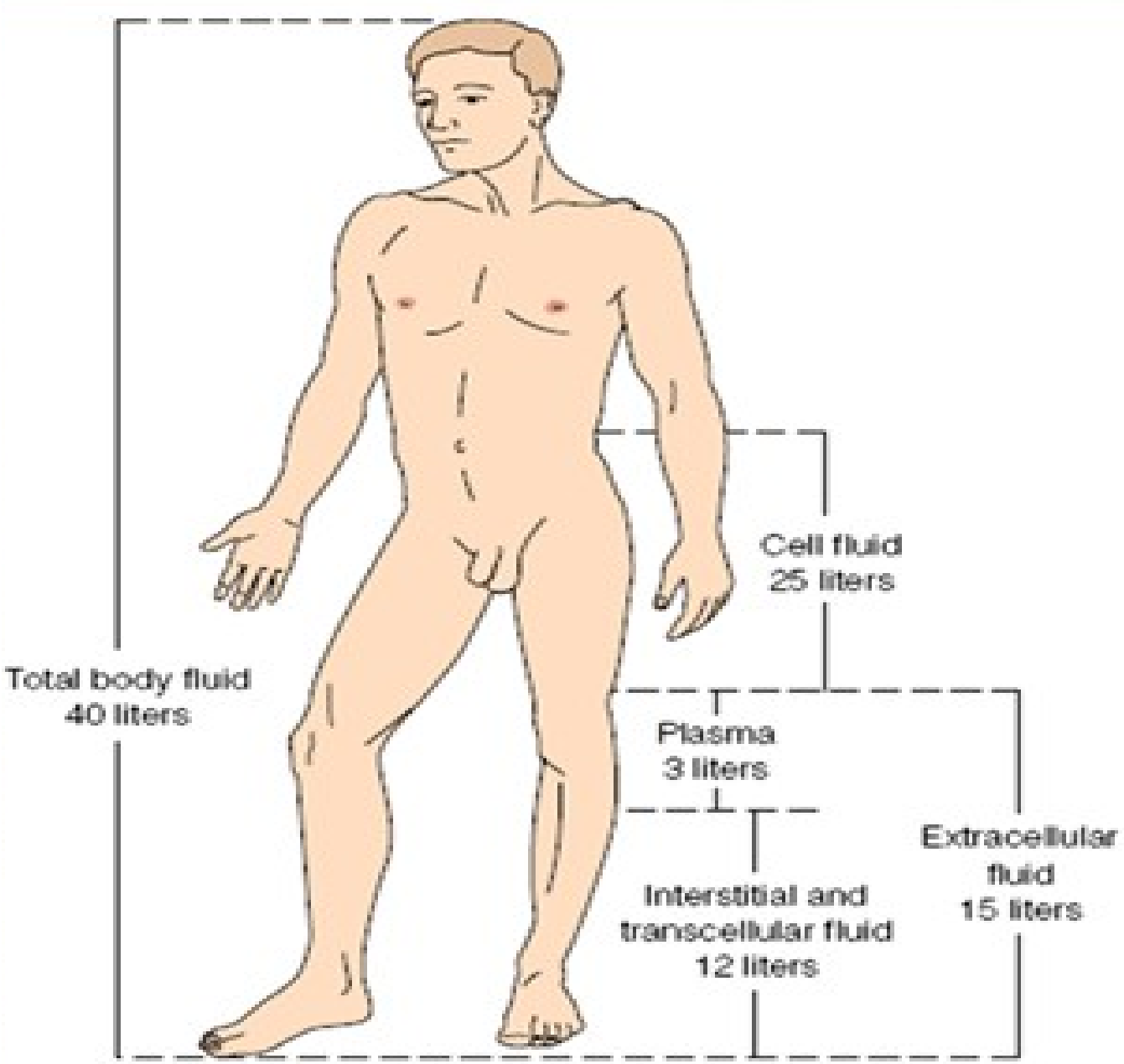
Objectives

- 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



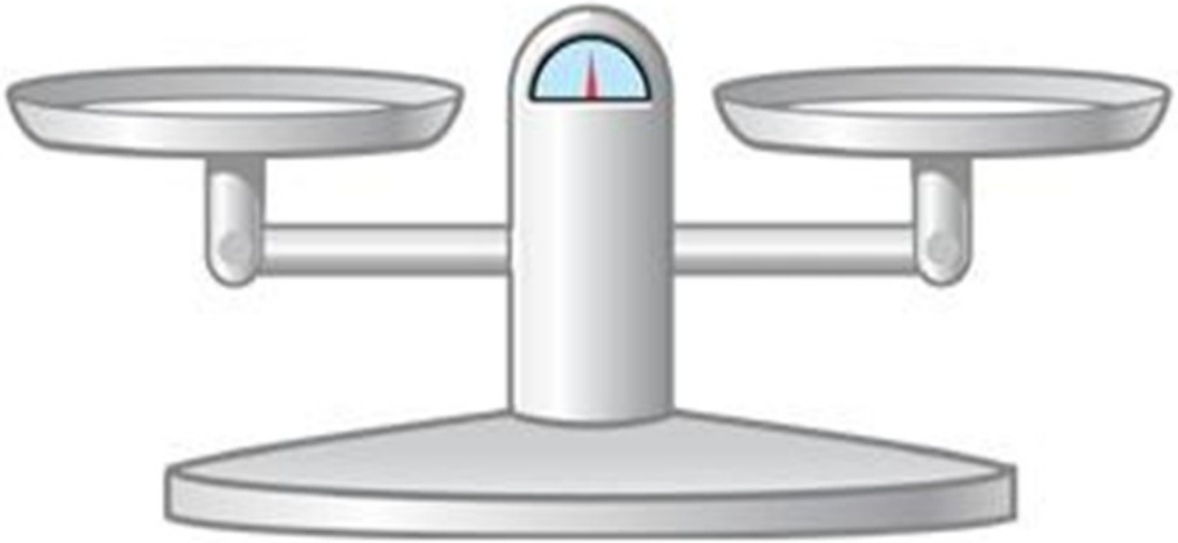
Fluid and Electrolyte Balance

- 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

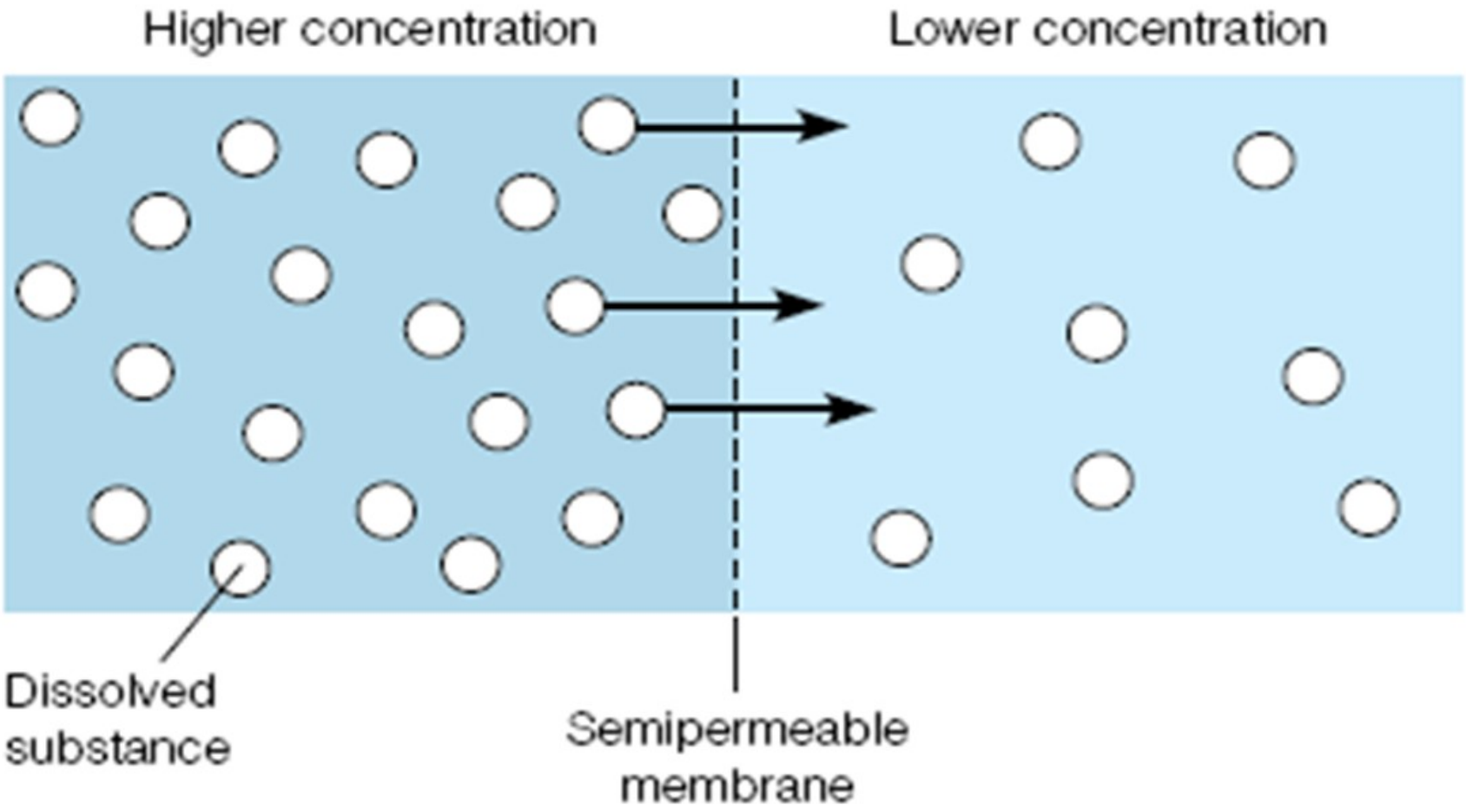
Fluid intake		Fluid output	
Ingested water	1200-1500 mL	Kidneys	1500 mL
Ingested food	800-1100 mL	Insensible loss through skin	600-800 mL
Metabolic oxidation	300 mL	Insensible loss through lungs	400-600 mL
		Gastrointestinal tract	100 mL
TOTAL	2600-3000 mL	TOTAL	2600-3000 mL



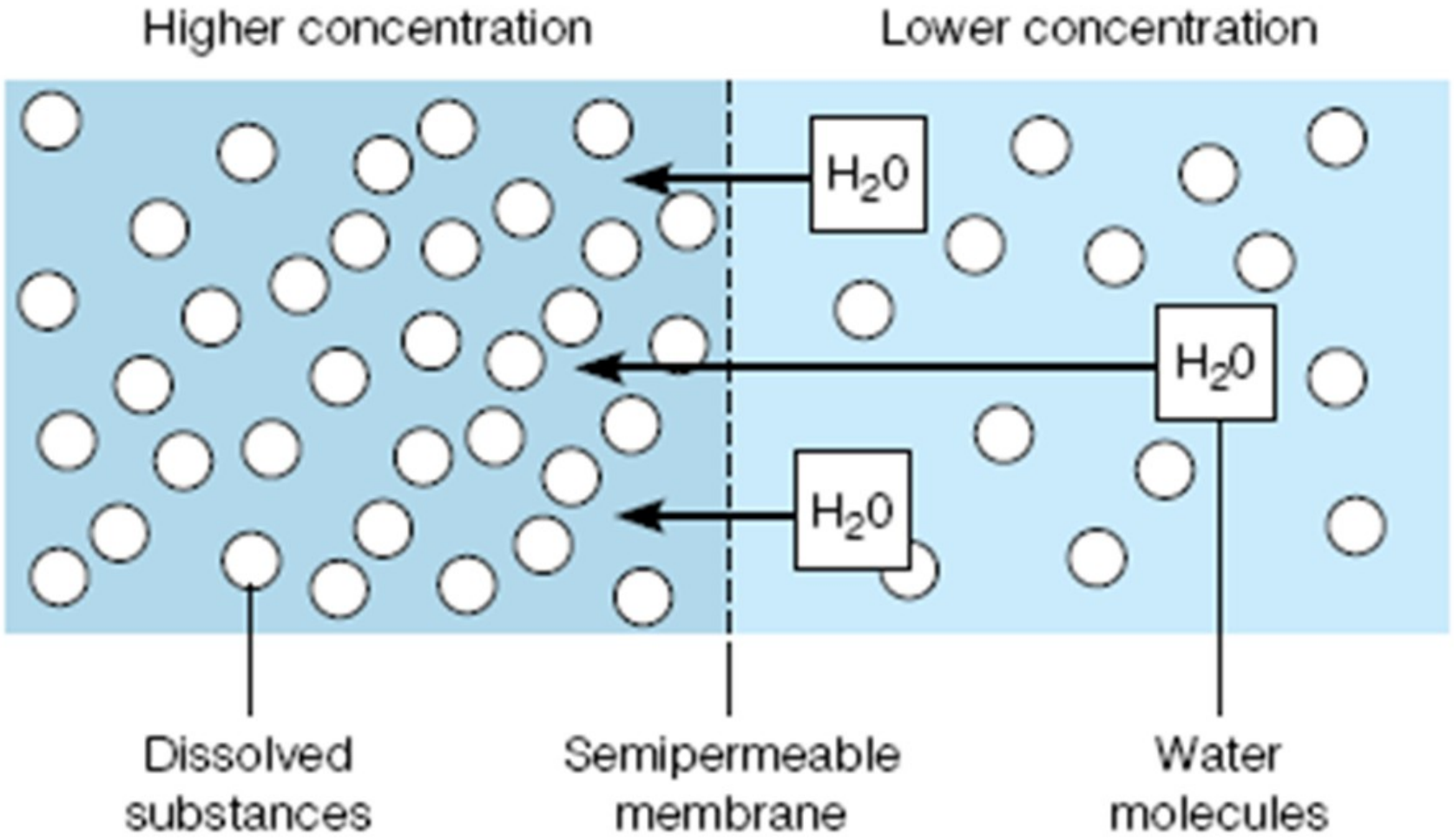
Movement of Fluids

- Osmosis
- Diffusion
- Filtration
- Active transport

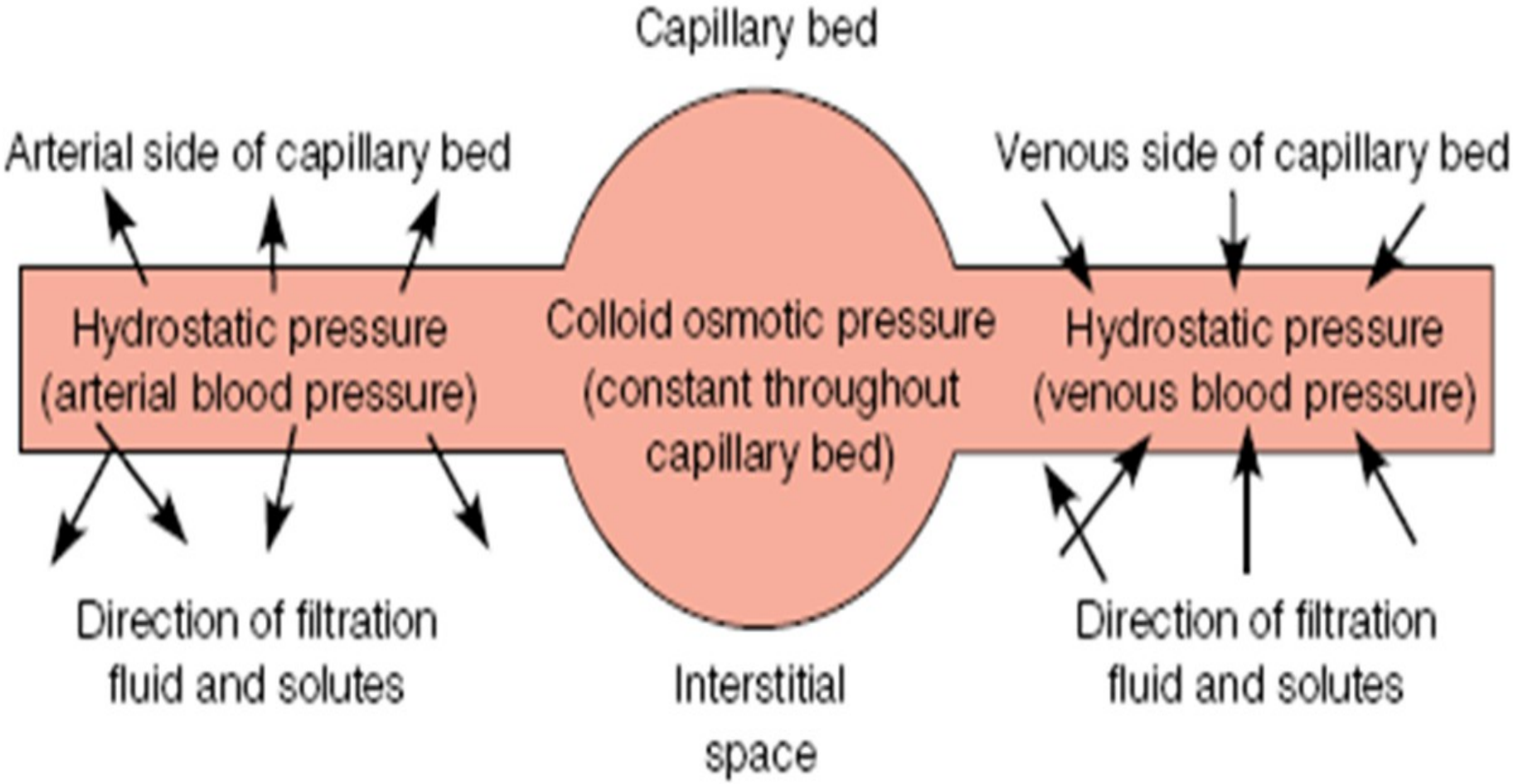
Diffusion


Higher concentration
Lower concentration
Dissolved substance
Semipermeable membrane

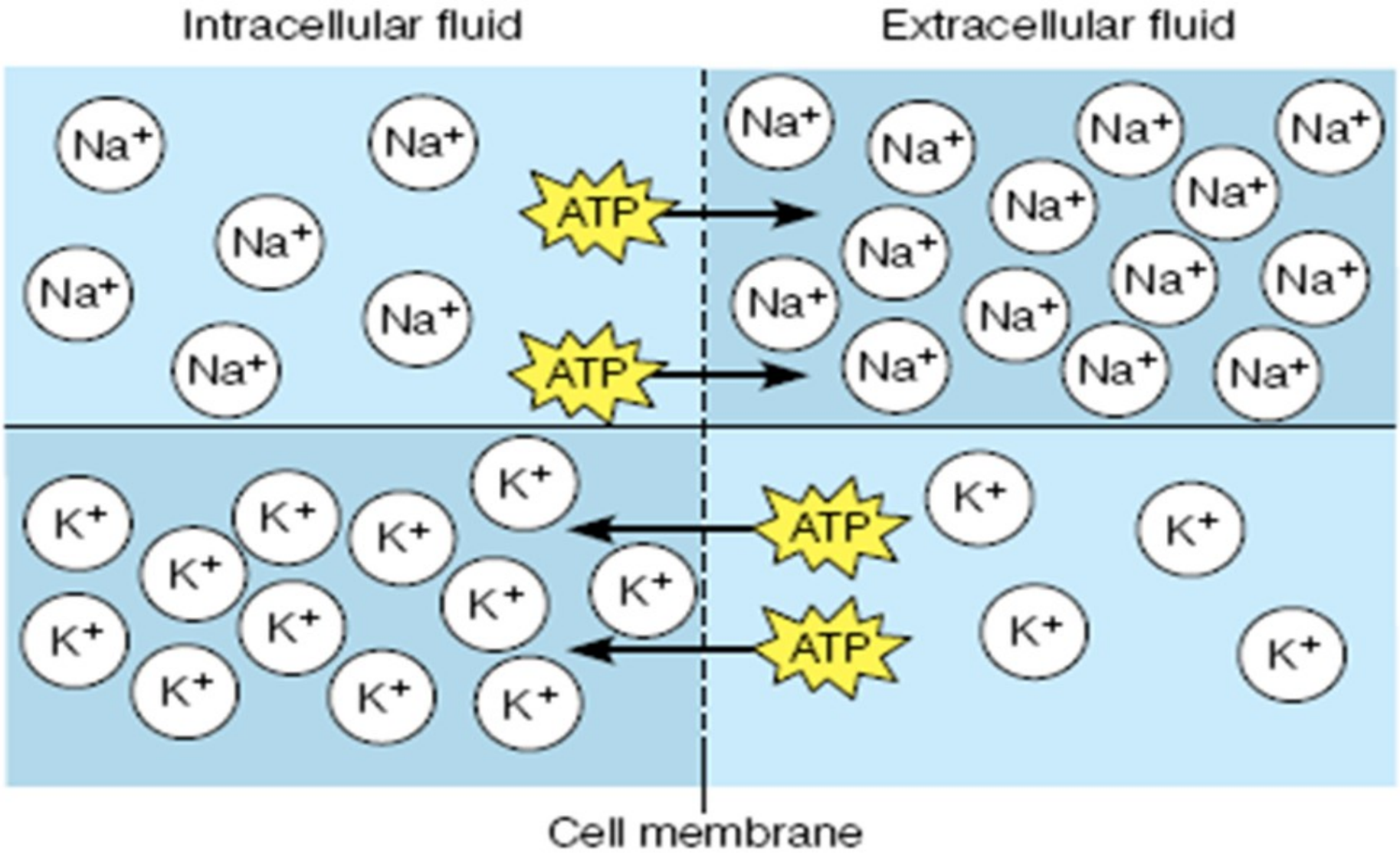
Osmosis


Higher concentration
Lower concentration
H_2O
H_2O
H_2O
Dissolved substances
Semipermeable membrane
Water molecules

Filtration

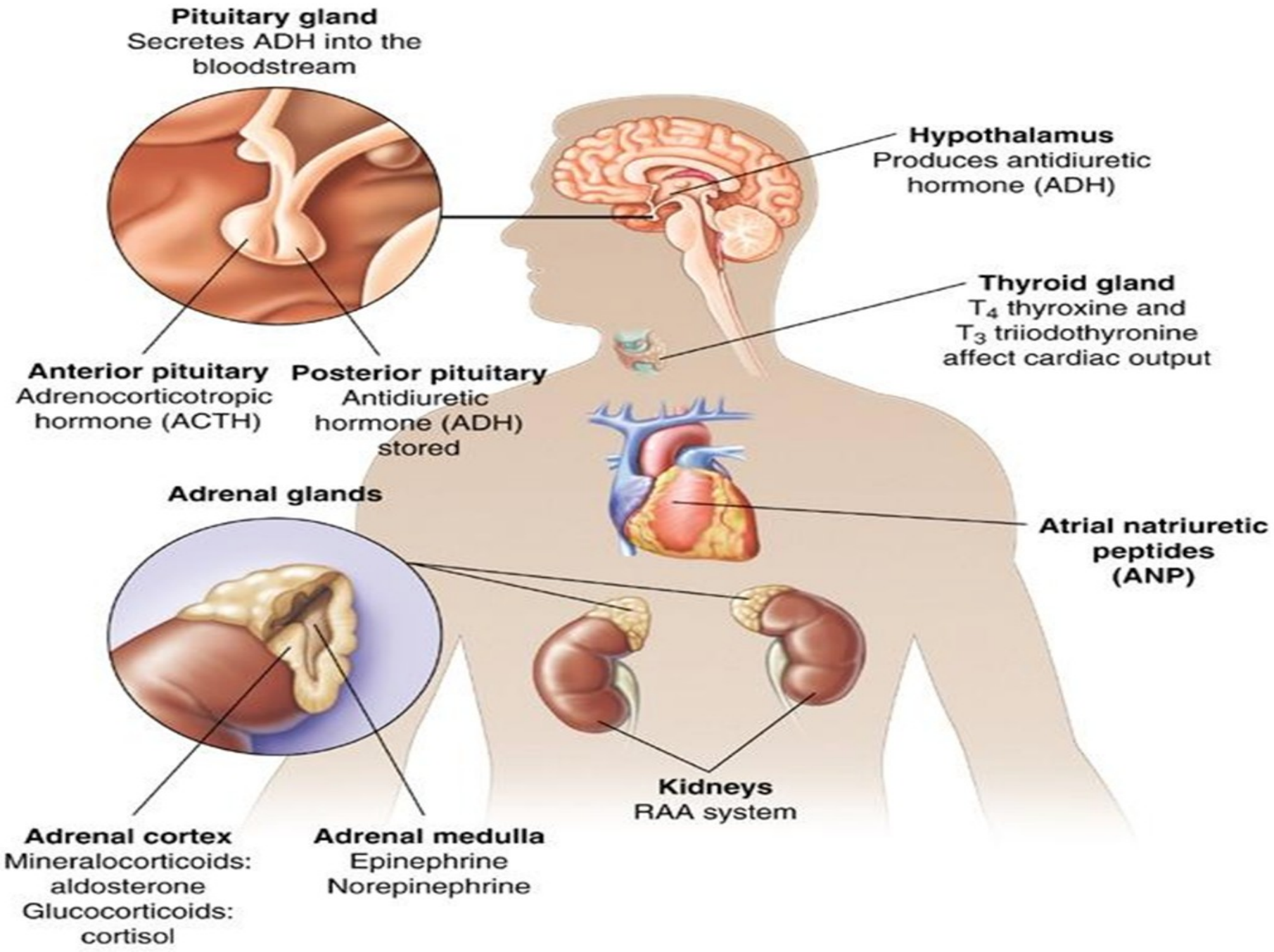

Capillary bed
Arterial side of capillary bed
Venous side of capillary bed
Hydrostatic pressure
(arterial blood pressure)
Colloid osmotic pressure
(constant throughout
capillary bed)
Hydrostatic pressure
(venous blood pressure)
Direction of filtration
fluid and solutes
Interstitial
space
Direction of filtration
fluid and solutes

Active Transport



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
Hypothalamus
Produces antidiuretic hormone (ADH)
Thyroid gland
T_4 thyroxine and T_3 triiodothyronine affect cardiac output
Anterior pituitary
Adrenocorticotropic hormone (ACTH)
Posterior pituitary
Antidiuretic hormone (ADH) stored
Adrenal glands
Atrial natriuretic peptides (ANP)
Kidneys
RAA system
Adrenal cortex
Mineralocorticoids: aldosterone
Glucocorticoids: cortisol
Adrenal medulla
Epinephrine
Norepinephrine

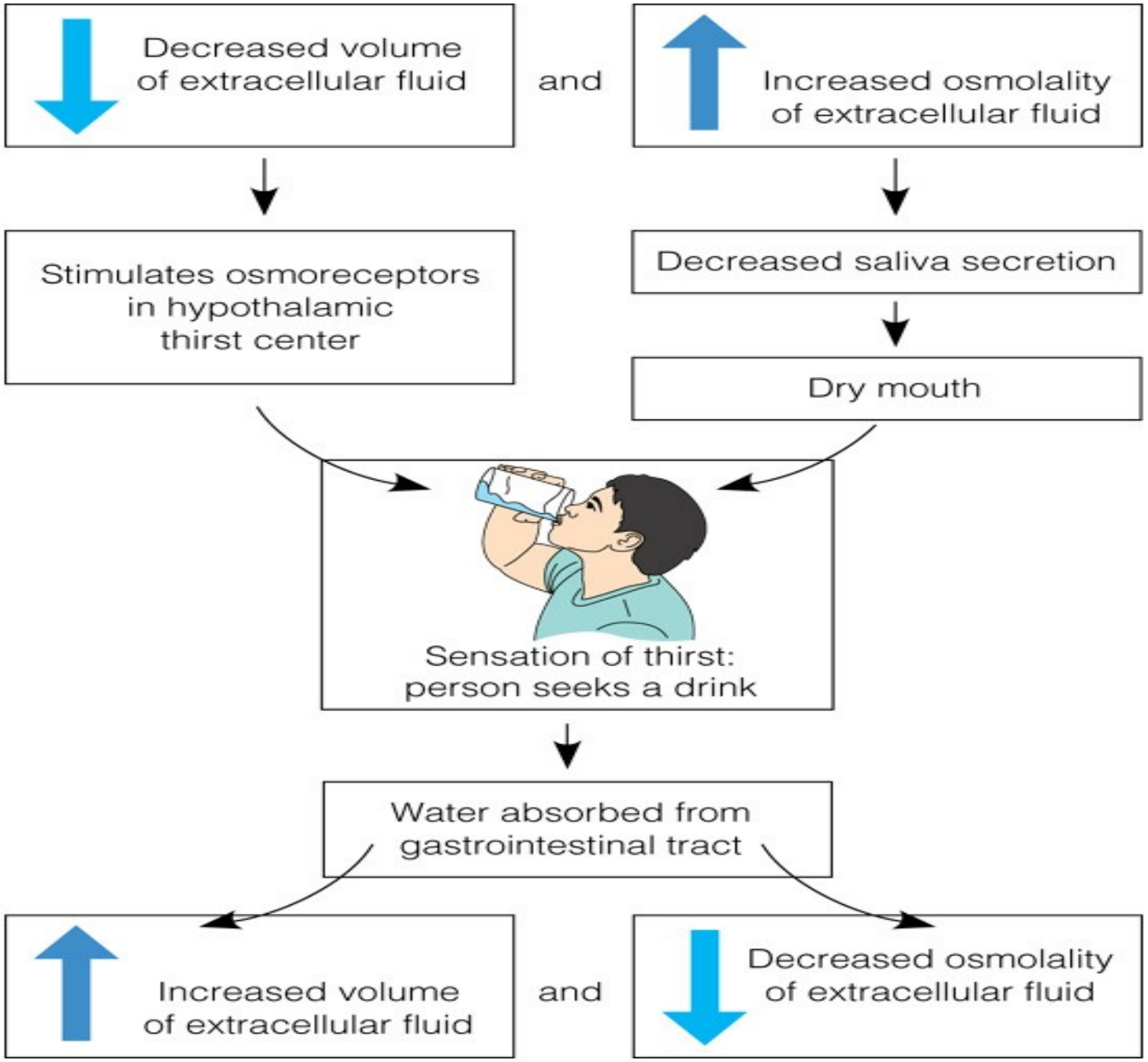
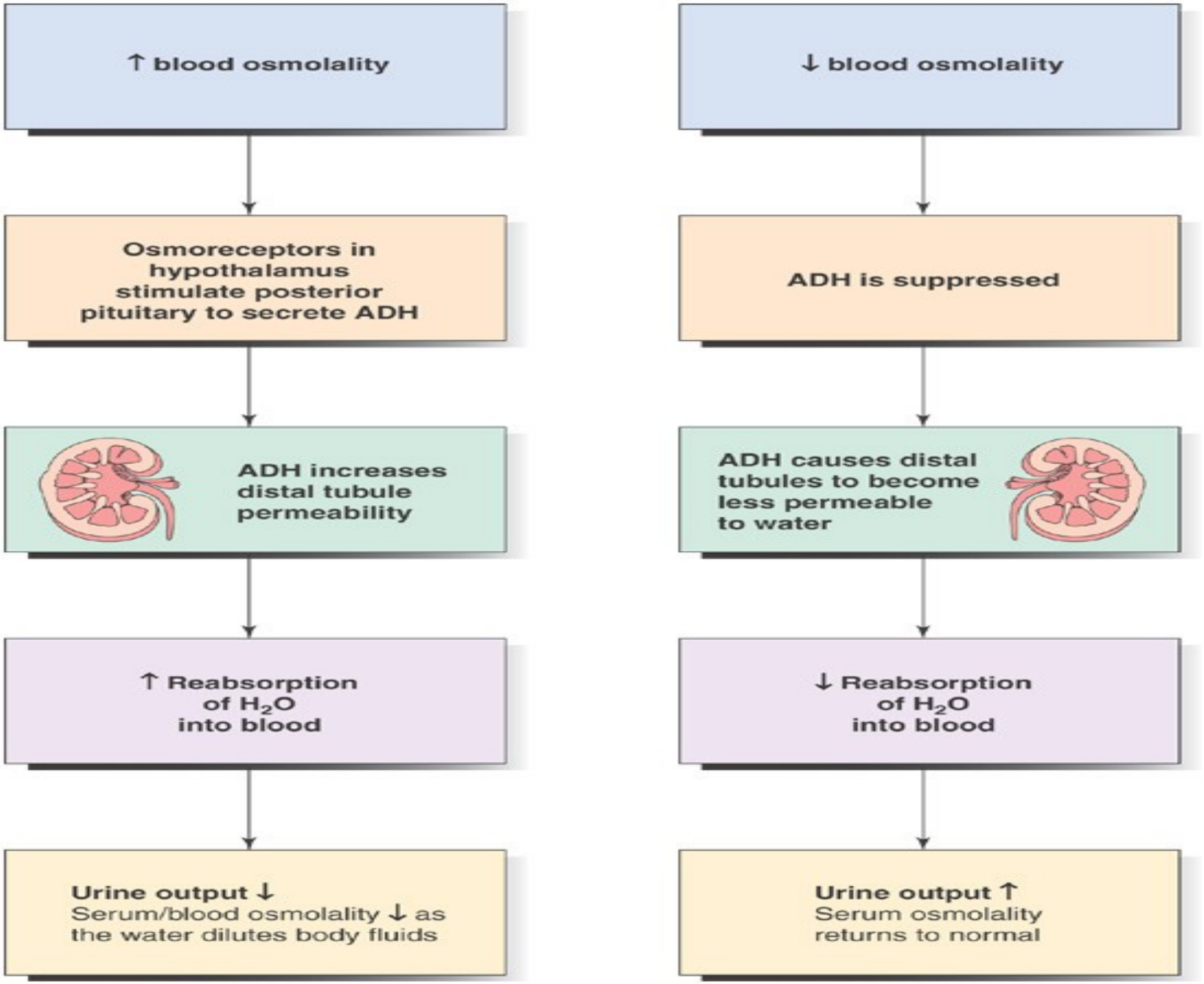

Decreased volume of extracellular fluid
and
Increased osmolality of extracellular fluid
Stimulates osmoreceptors in hypothalamic thirst center
Decreased saliva secretion
Dry mouth
Sensation of thirst: person seeks a drink
Water absorbed from gastrointestinal tract
Increased volume of extracellular fluid
and
Decreased osmolality of extracellular fluid

Fig 52-8
Antidiuretic hormone (ADH) regulates water excretion from the kidneys



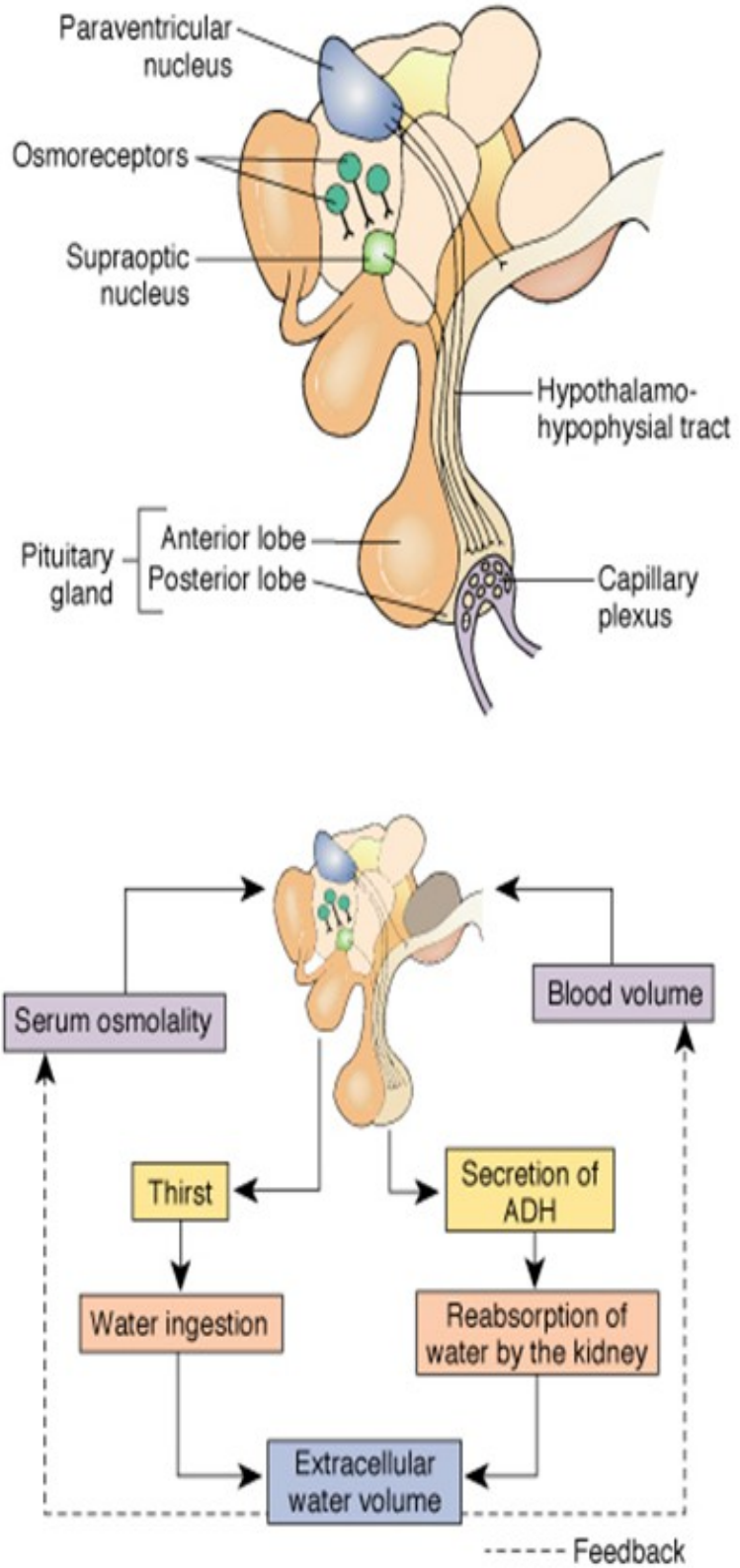


Figure 33-10 (**Top**) Sagittal section through the pituitary and anterior hypothalamus. Antidiuretic hormone (ADH) is formed primarily in the supraoptic nucleus and to a lesser extent in the paraventricular nucleus of the hypothalamus. It is then transported down the hypothalamohypophysial tract and 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

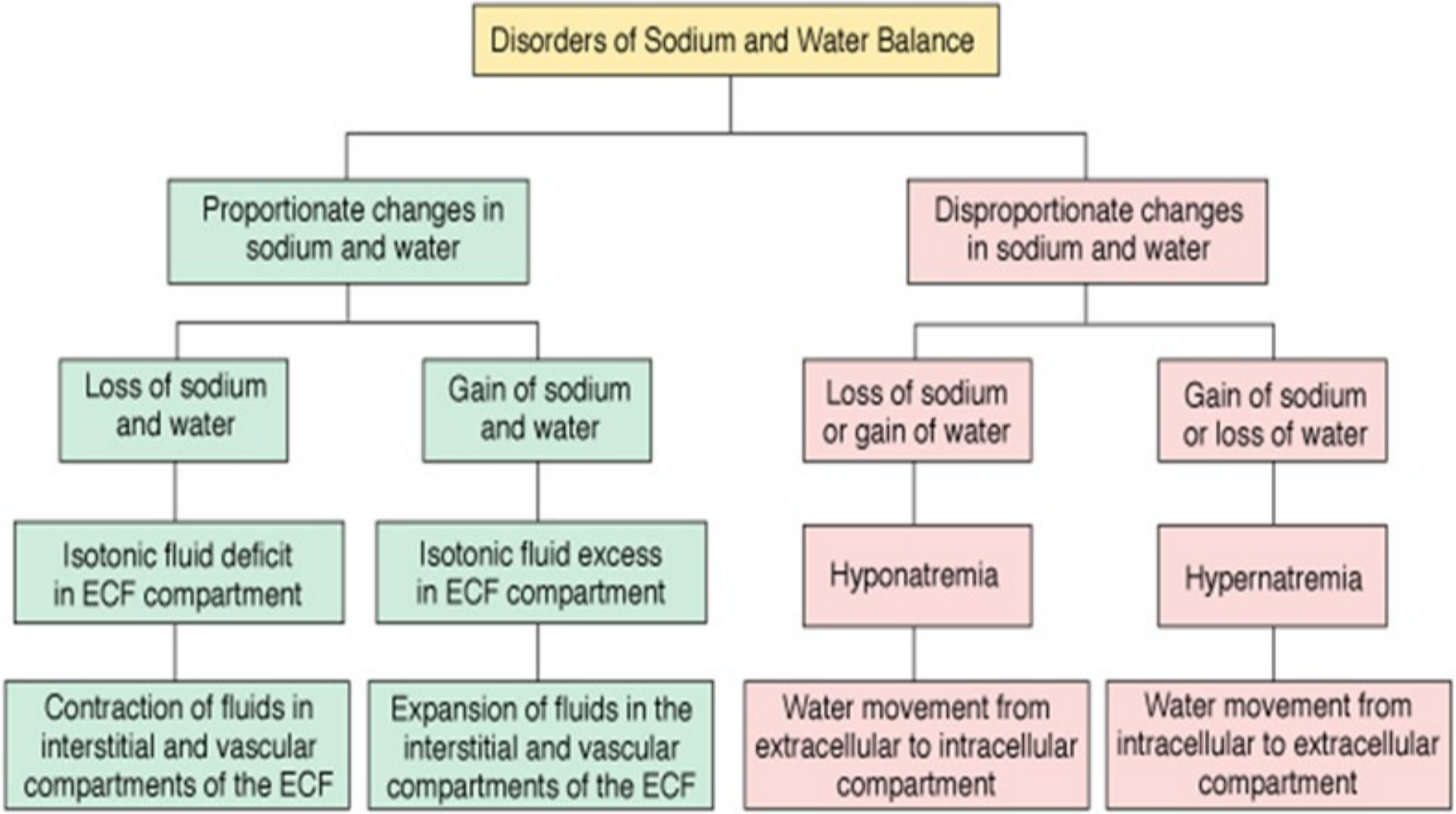


Figure 33-7 The effect of proportionate and disproportionate changes in sodium and water balance on extracellular sodium concentration.

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

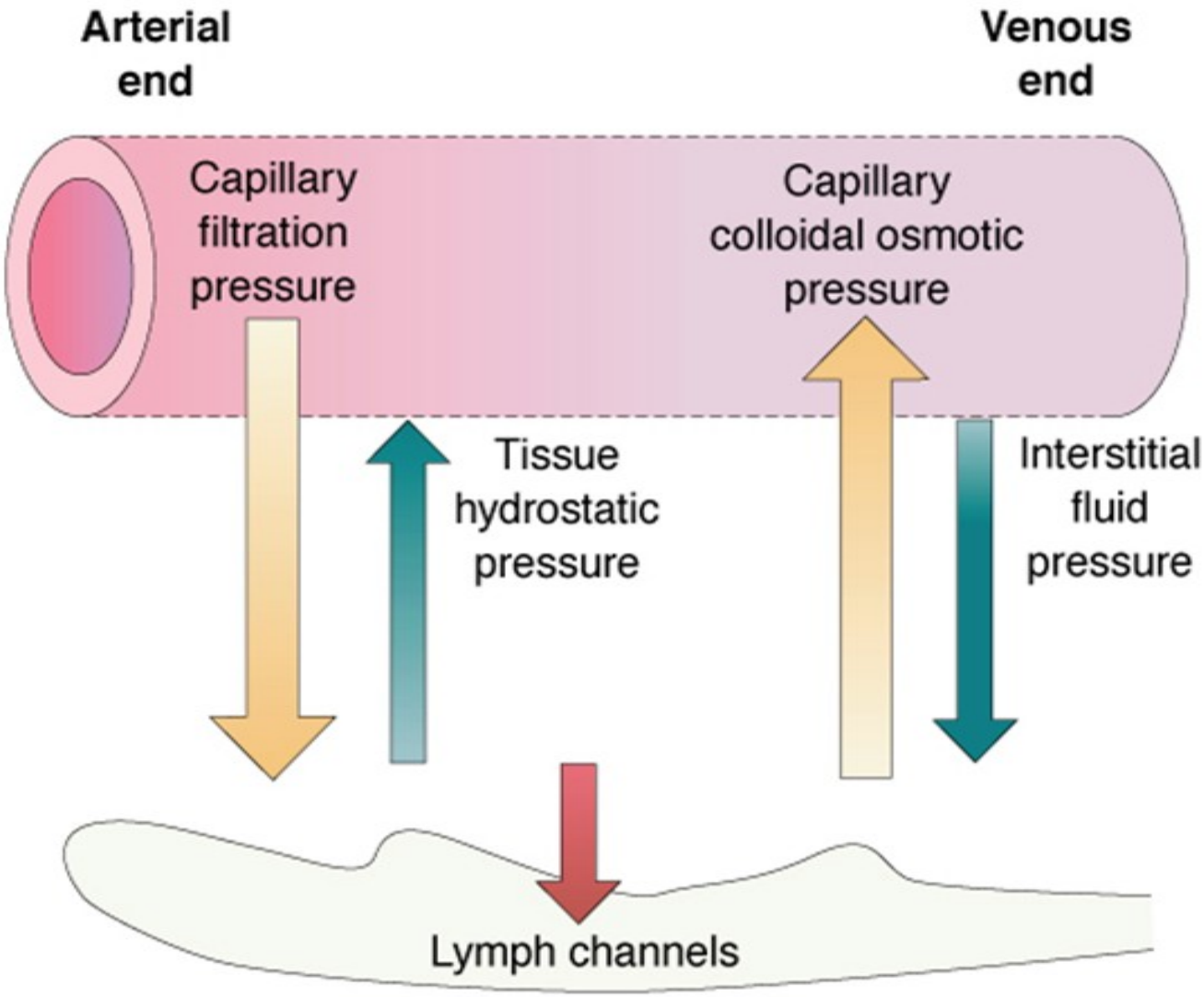
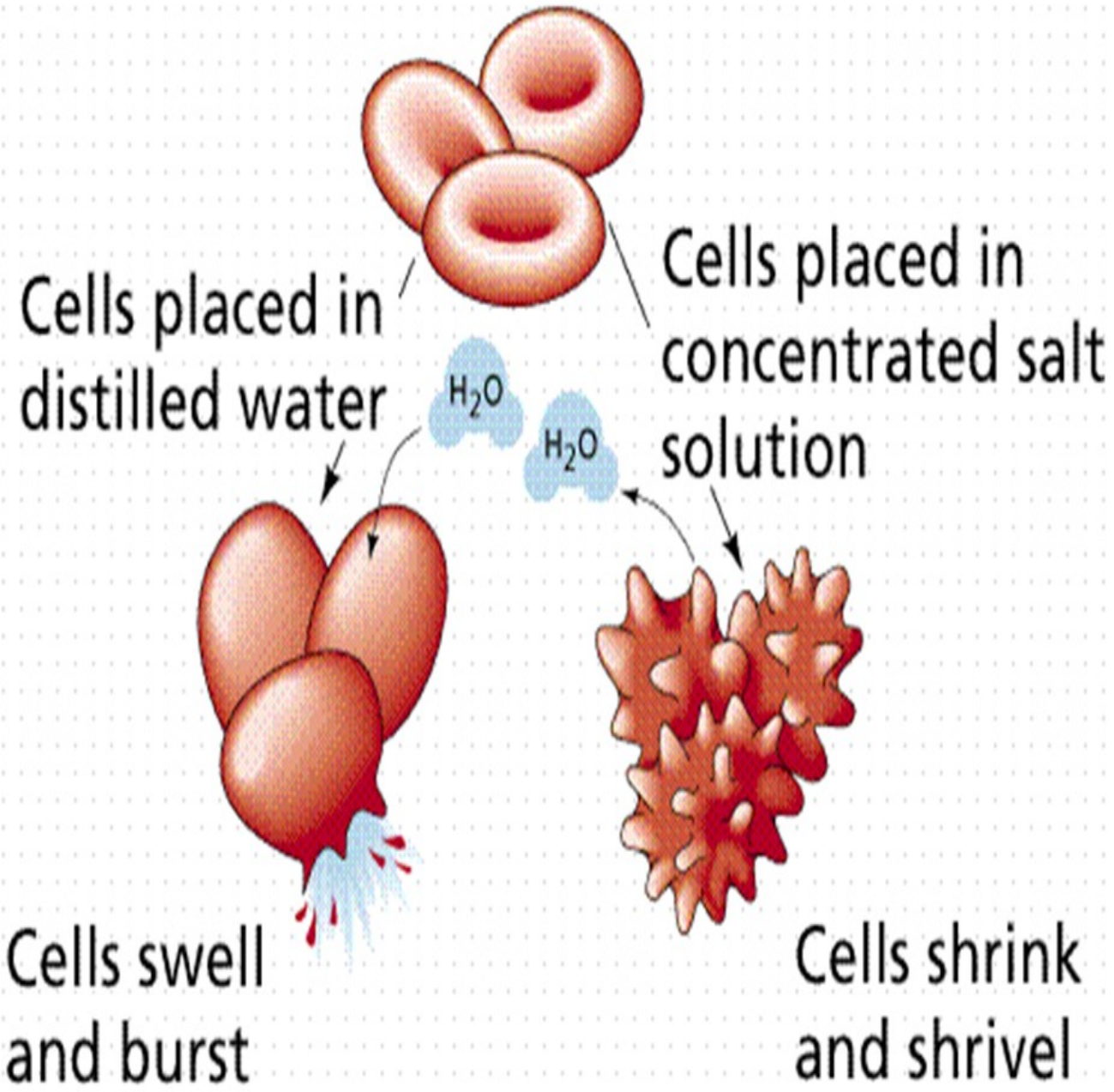


Figure 33-5 Exchange of fluid at the capillary level.

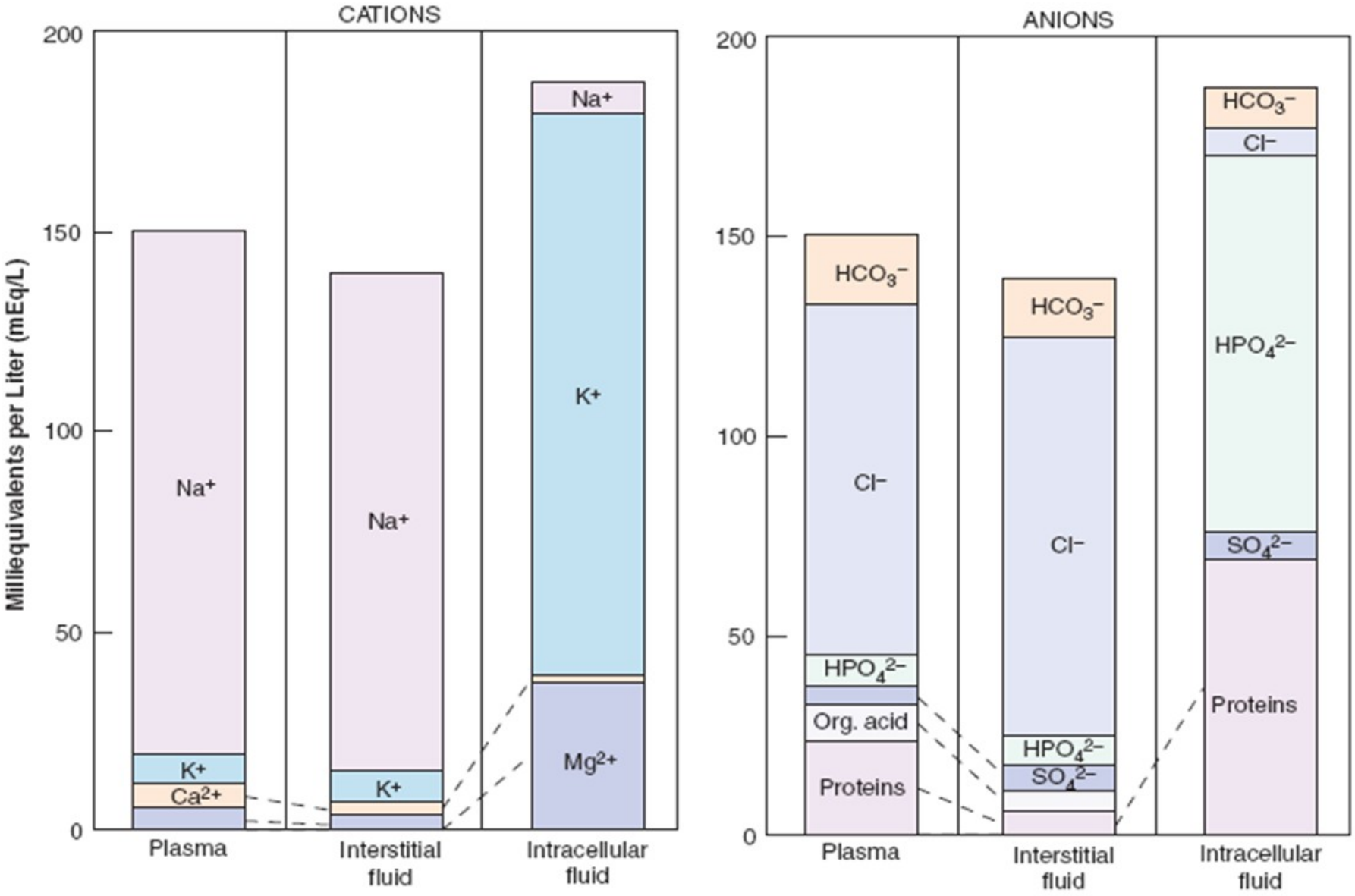
- Hypertonic
- Isotonic
- Hypotonic



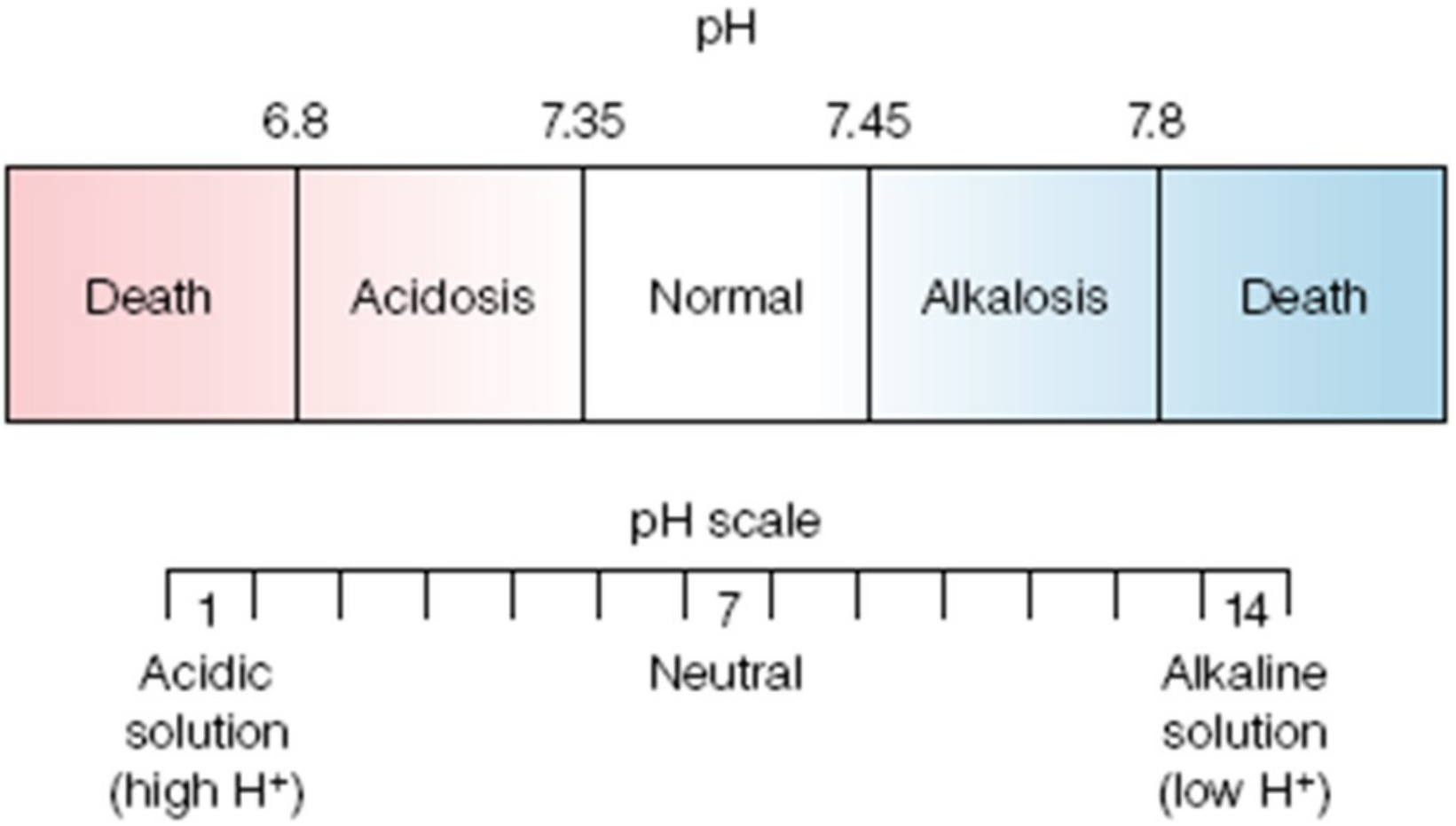
Regulating Electrolytes

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

Composition of Body Fluids



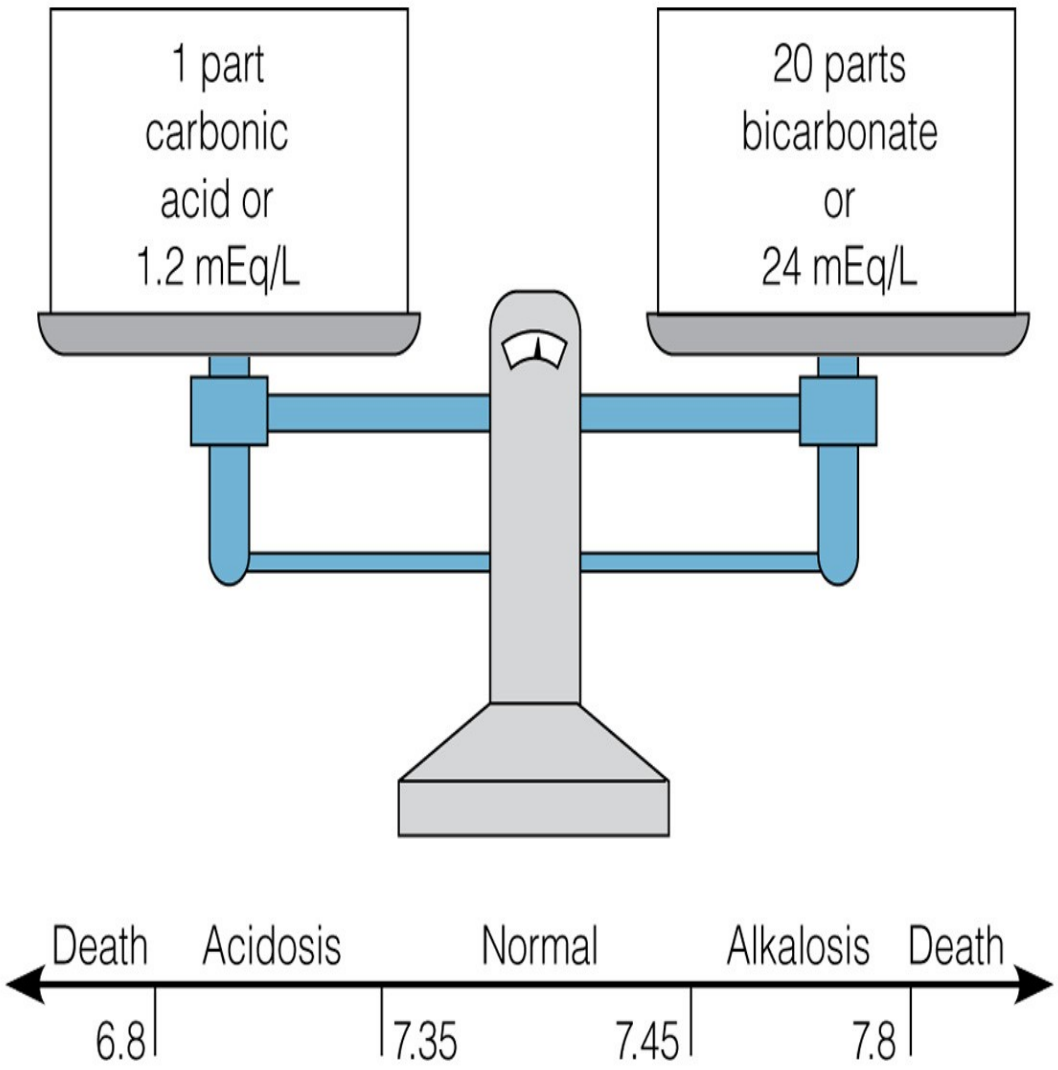
Regulating Acid-Base Balance



Regulating Acid-Base Balance

- Low pH = acidic
- High pH = alkalinic
- 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.

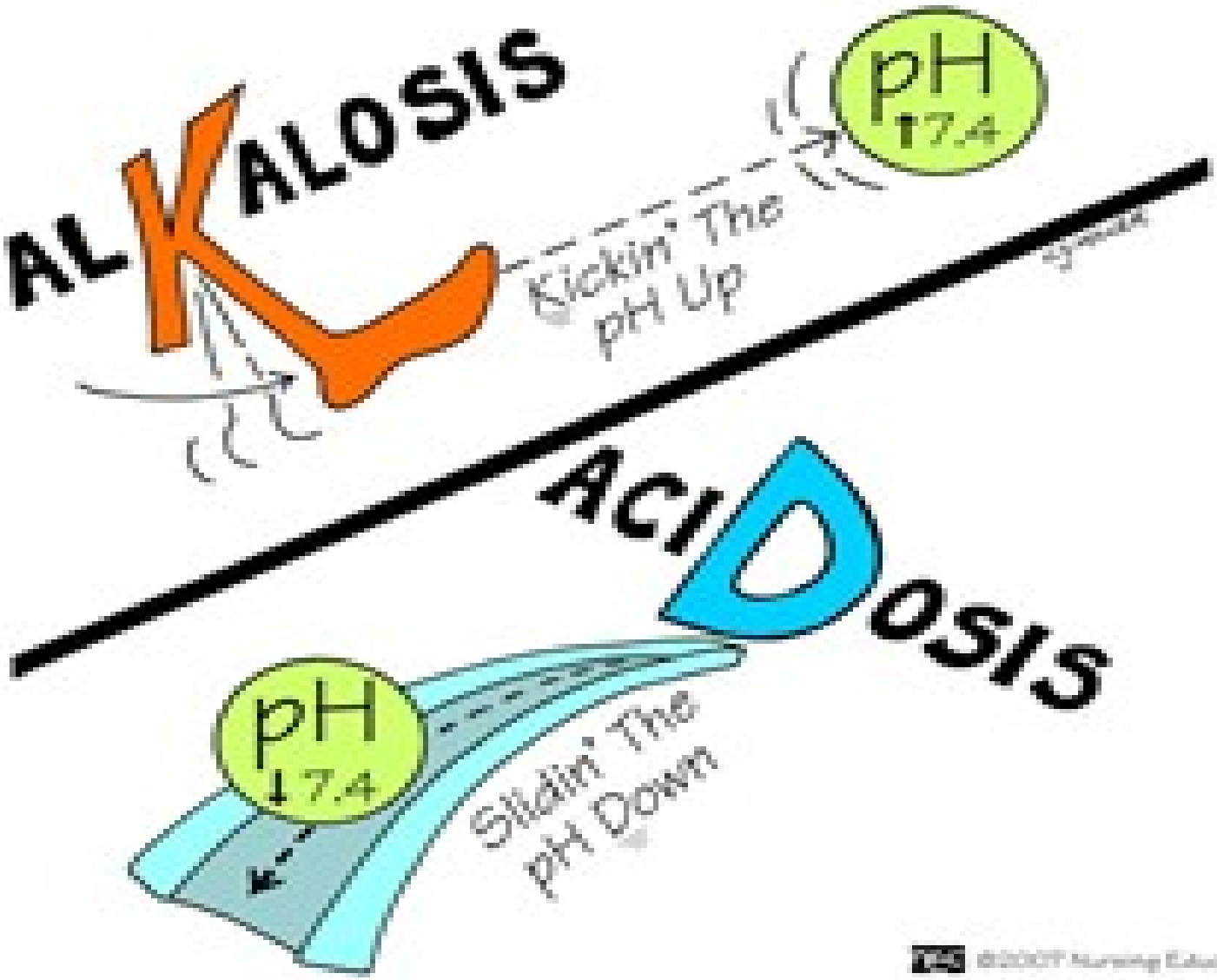


- Prevent excessive changes in pH
- Major buffer in ECF is HCO_3 and H_2CO_3
- Other buffers include:
  - Plasma proteins
  - Hemoglobin
  - Phosphates

Acid-Base Imbalances

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

ACIDOSIS - ALKALOSIS



ACID BASE MNEMONIC (ROME)

R

Respiratory

O

Opposite

pH ↑ PCO_2 ↓ Alkalosis

pH ↓ PCO_2 ↑ Acidosis

M

Metabolic

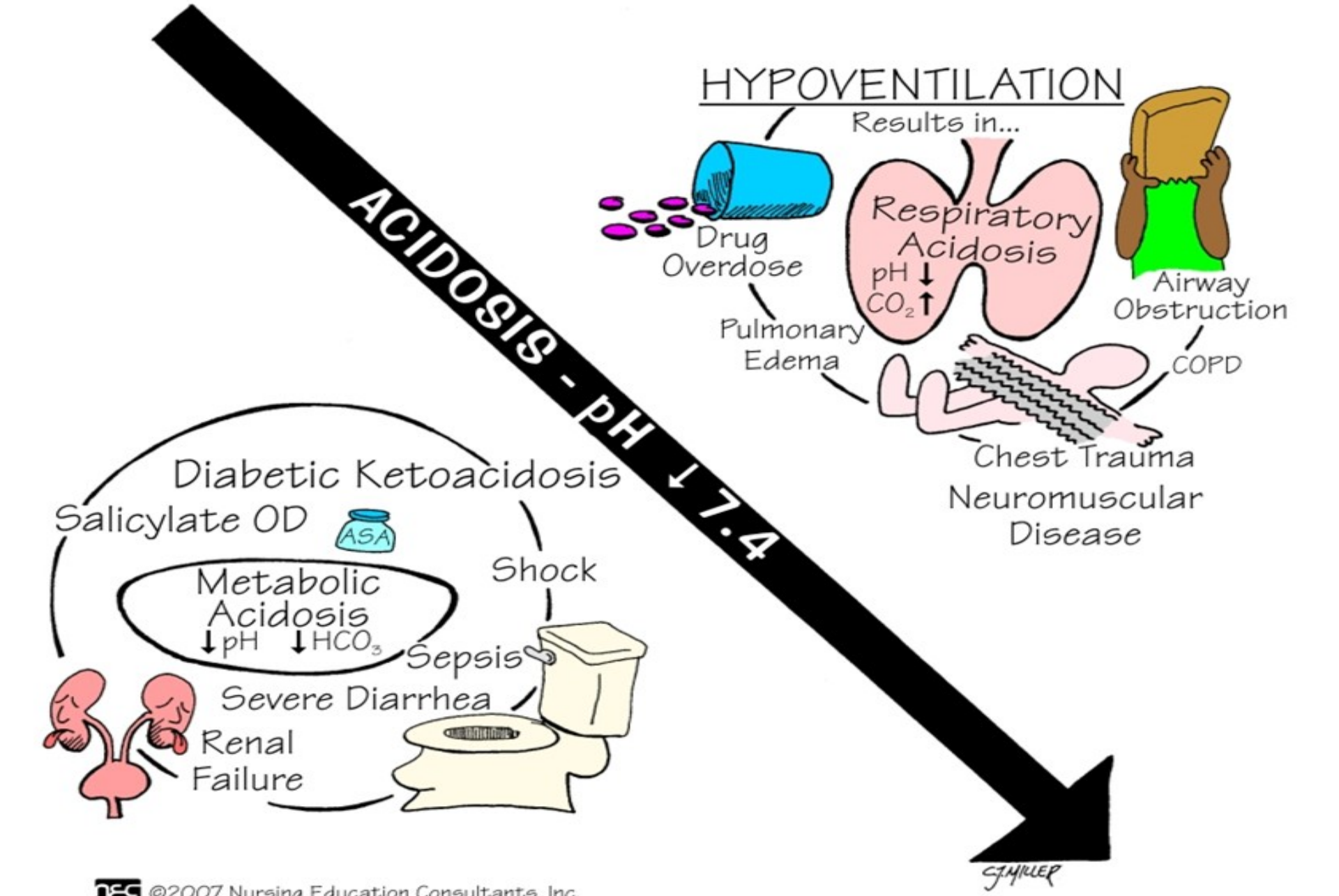
E

Equal

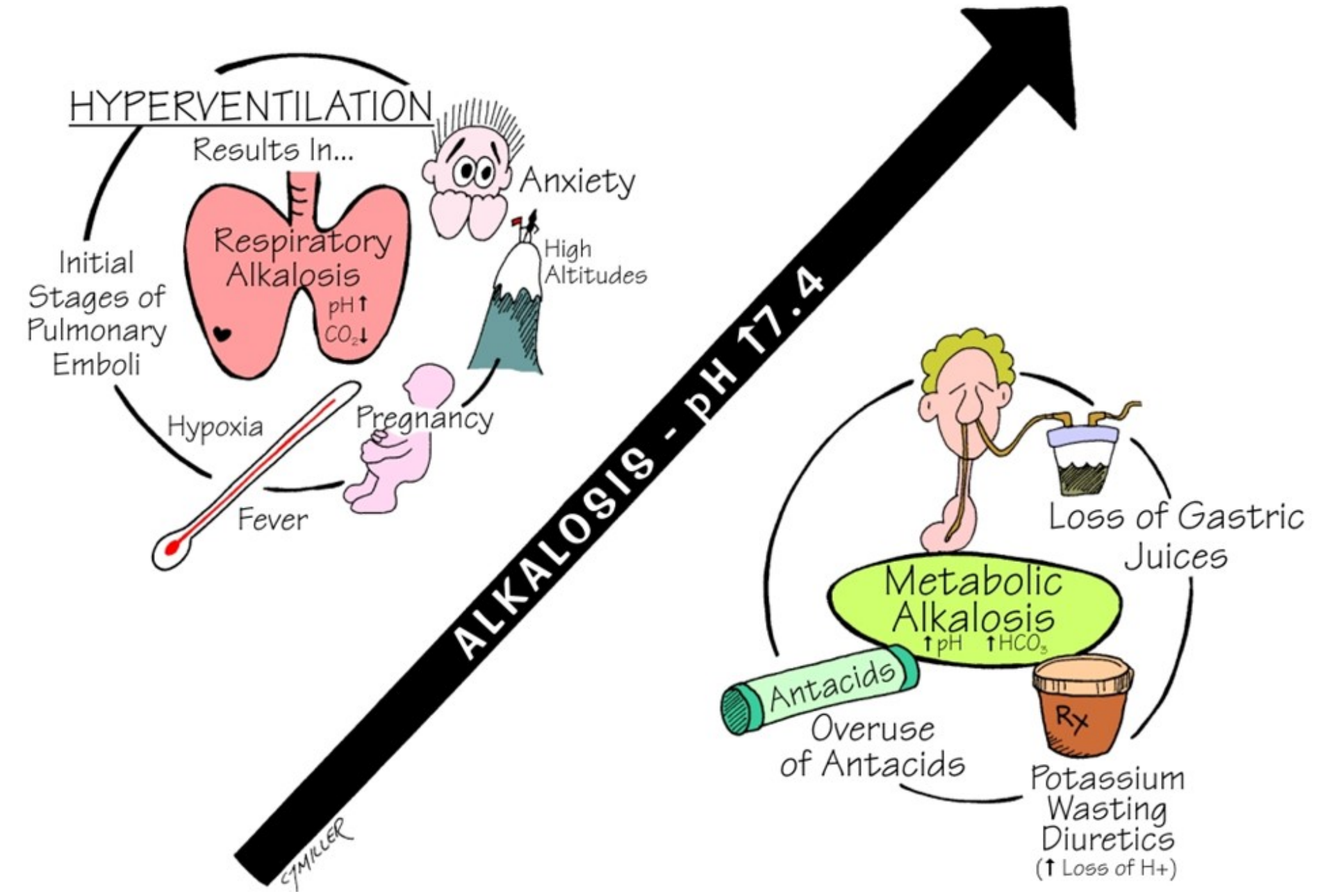
pH ↑ HCO_3 ↑ Alkalosis

pH ↓ HCO_3 ↓ Acidosis

CAUSES OF ACIDOSIS



CAUSES OF ALKALOSIS

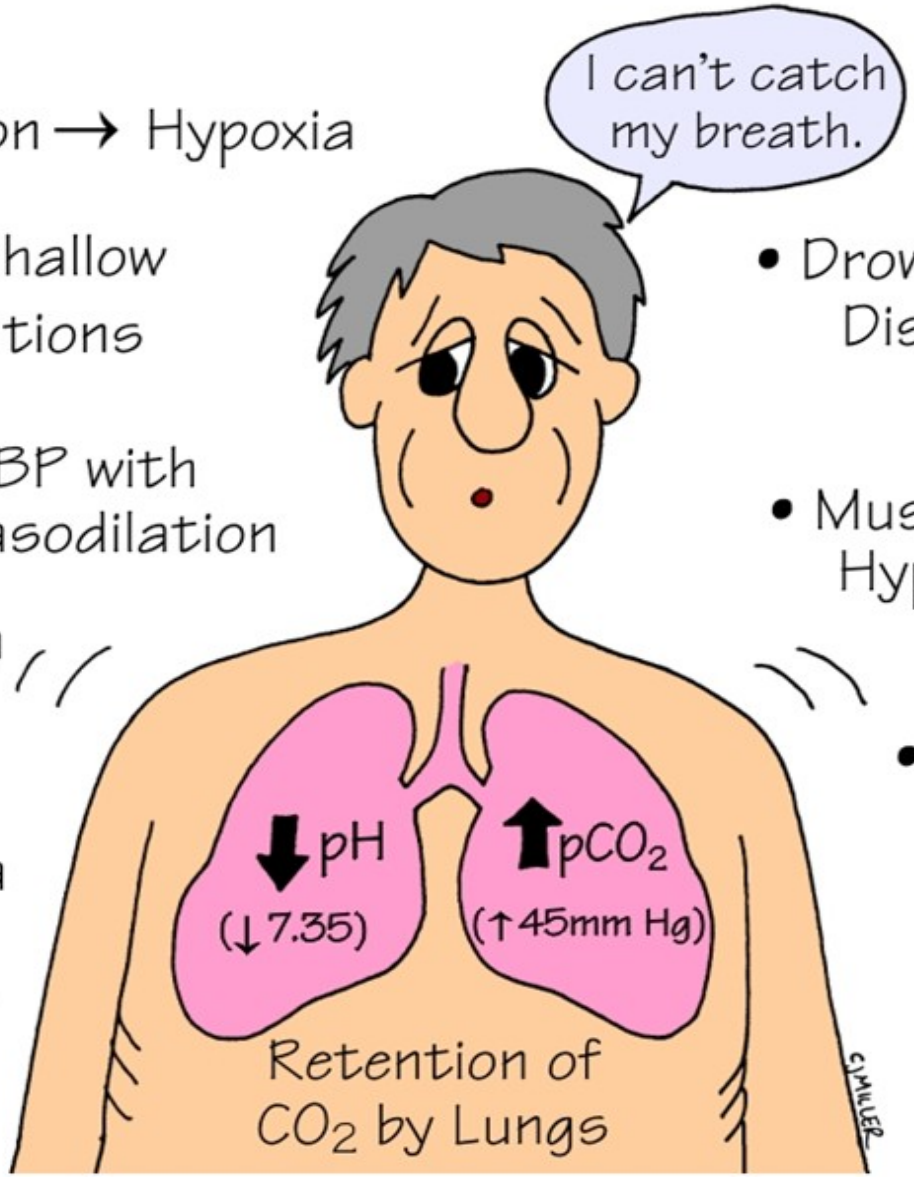


Lungs

- 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 CO2 and pH rises
- Slower rate/less depth = retain CO2 and pH lowers

RESPIRATORY ACIDOSIS

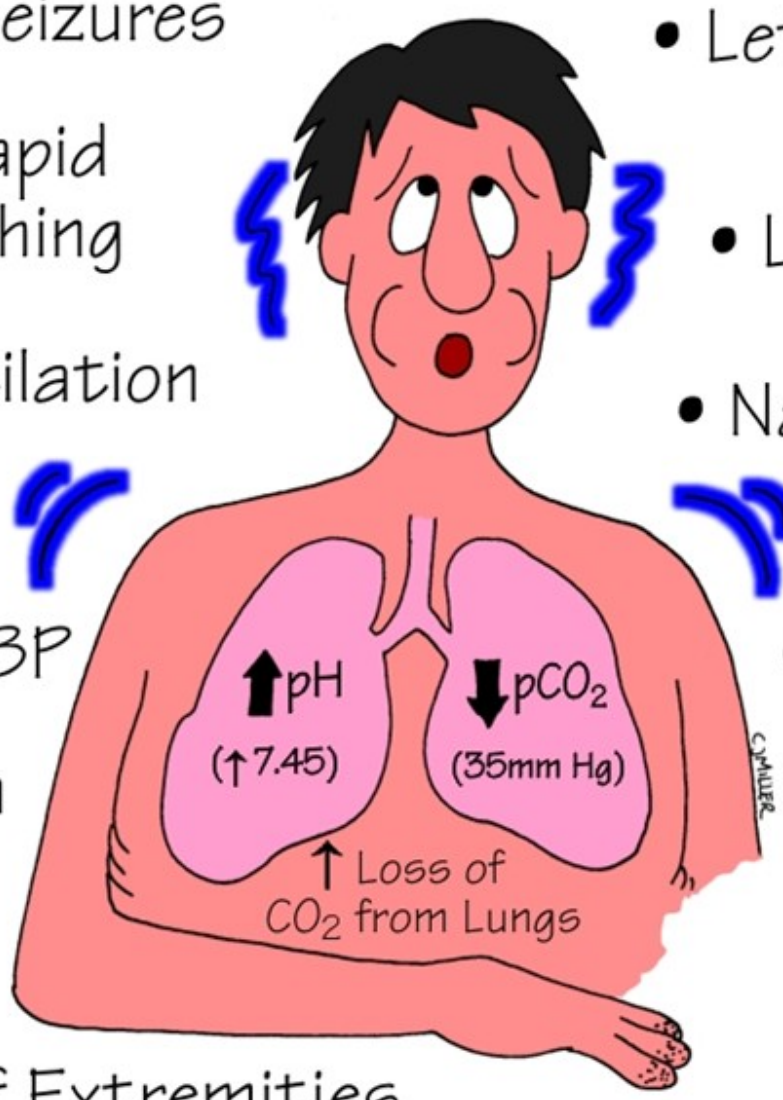
- Hypoventilation → Hypoxia
- Rapid, Shallow Respirations
- ↓ BP with Vasodilation
- Dyspnea
- Headache
- Hyperkalemia
- Dysrhythmias (↑K)



- 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



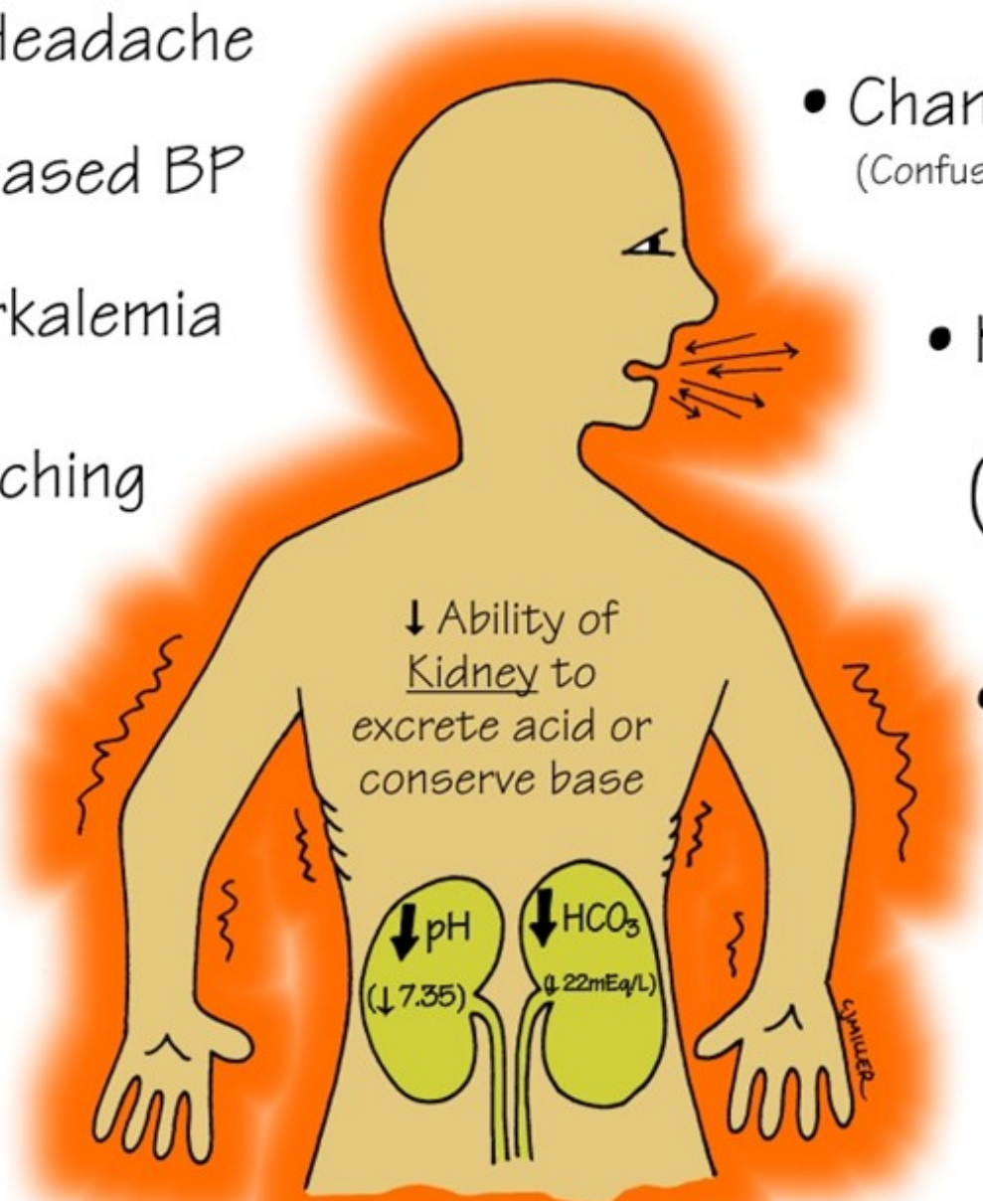
- Lethargy & Confusion
- Light Headedness
- Nausea, Vomiting
- Causes:
  Hyperventilation
  (Anxiety, PE, Fear)
  Mechanical Ventilation

Kidneys

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

METABOLIC ACIDOSIS

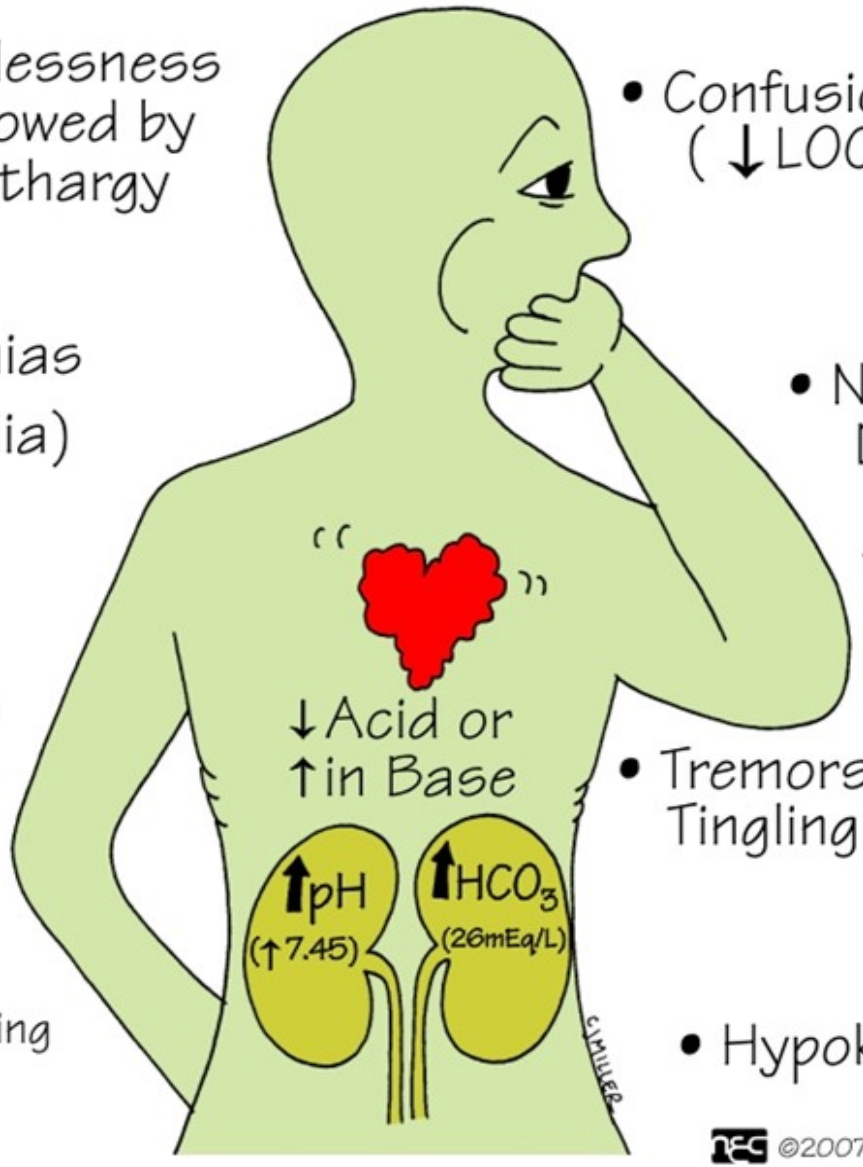
- Headache
- Decreased BP
- Hyperkalemia
- Muscle Twitching
- Warm, Flushed Skin (Vasodilation)
- Nausea, Vomiting Diarrhea



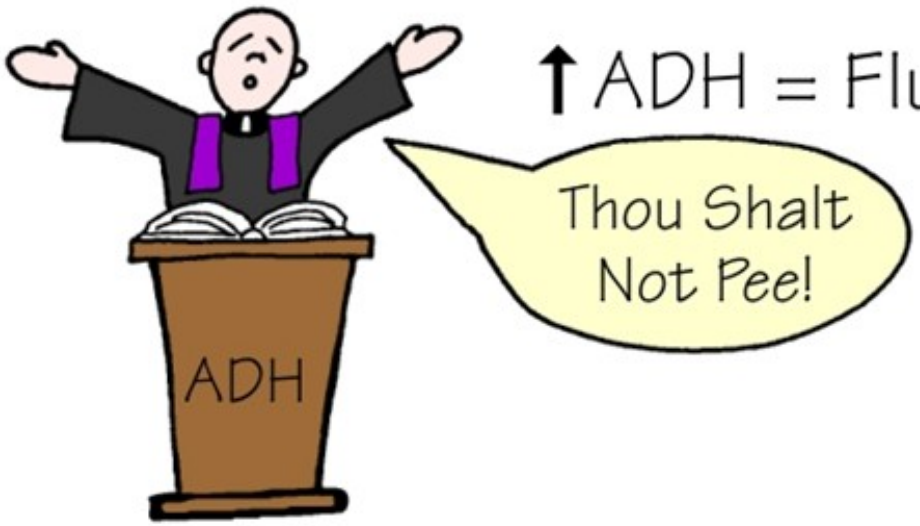
- Changes in LOC (Confusion, ↑ drowsiness)
- Kussmaul Respirations (Compensatory Hyperventilation)
- Causes:
  - DKA
  - Severe Diarrhea
  - Renal Failure
  - Shock

METABOLIC ALKALOSIS

- Restlessness Followed by Lethargy
- Confusion (↓LOC, Dizzy, Irritable)
- Dysrhythmias (Tachycardia)
- Nausea, Vomiting, Diarrhea
- Compensatory Hypoventilation
- Tremors, Muscle Cramps, Tingling of Fingers & Toes
- Causes:
  - Severe Vomiting
  - Excessive GI Suctioning
  - Diuretics
  - Excessive $NaHCO_3$
- Hypokalemia



RENAL COMPENSATION IN SHOCK



↑ ADH = Fluid Retention

Aldosterone = Na & Fluid Retention

Angiotension = Vasoconstriction

Arterial Blood Gas

- pH 7.35-7.45
- PaO2 80-100 mm Hg
- PaCO2 35-45 mm Hg
- HCO3 22-26 mEq/L
- Base Excess -2 - +2 mEq/L
- SaO2 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/Opoiods
  - Constipation

Treatments that affect fluid balance

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

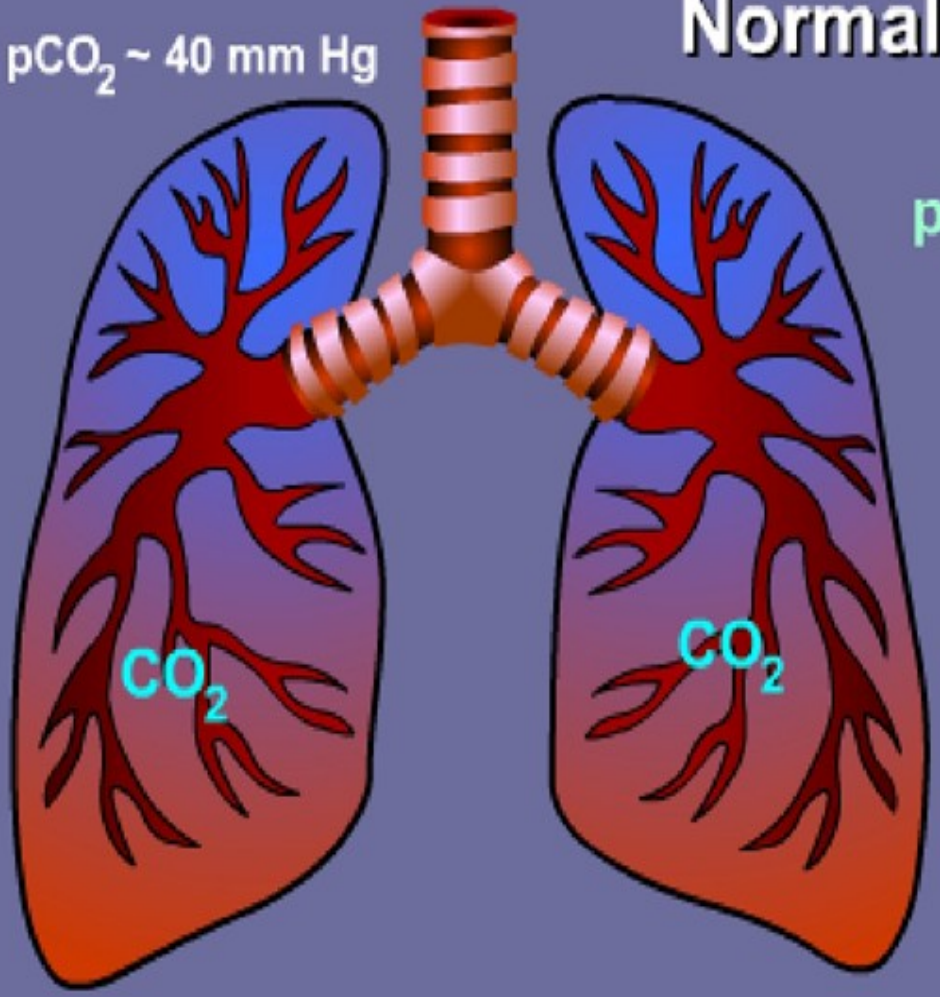
Fluid Imbalances

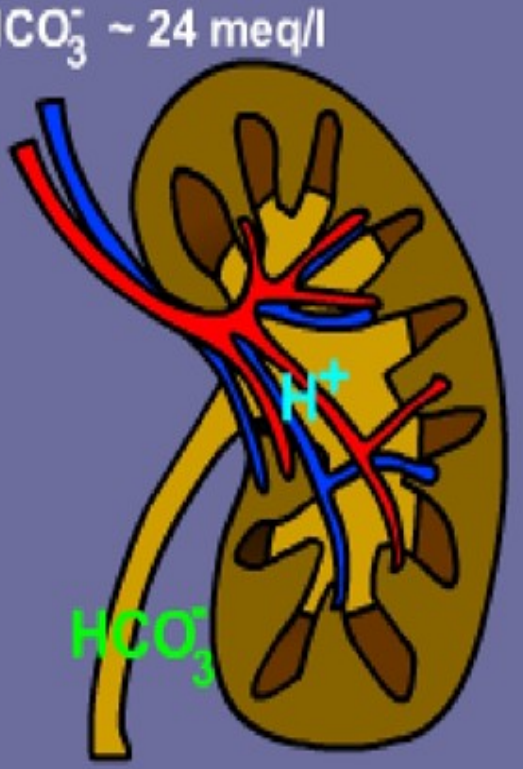
- Isotonic loss of water and electrolytes (fluid volume deficit)
- Isotonic gain of water and electrolytes (fluid volume excess)
- Hyperosmolar loss of only water (dehydration)
- Hypo-osmolar gain of only water (overhydration)

Electrolyte Imbalances

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

Normal Acid - Base Balance





CO_2

$H^+ + HCO_3^- \rightleftharpoons H_2CO_3 \rightleftharpoons CO_2 + H_2O$

urine pH ~ 6

audio

Hypernatremia

- Sodium
  -  145 mEq/L
- Risk Factors
  - water deprivation, hypertonic tube feedings, with inadequate water supplements, fever, unusually high Na+ 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+ excretion, renal failure, K+ conserving diuretics, hypoaldosteronism, High K+ intake during renal insufficiency, too rapid K+ infusion, too high dose of K+ 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+ wasting drugs like lasix and thiazide diuretics, steriod adminstration, low intake of K+ 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,

K^+ HYPERKALEMIA ↑

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

EKG Changes with K^+ Imbalance

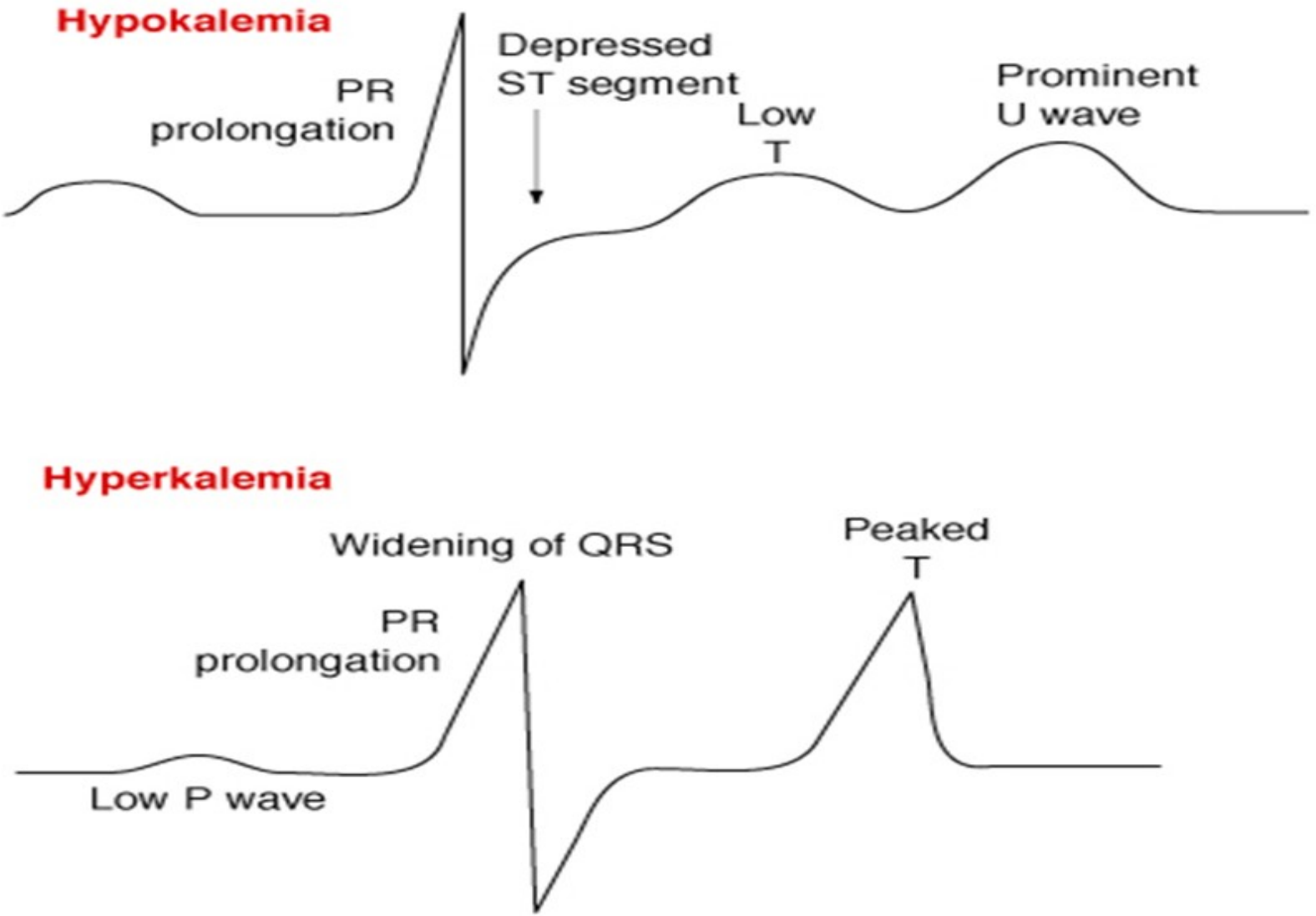
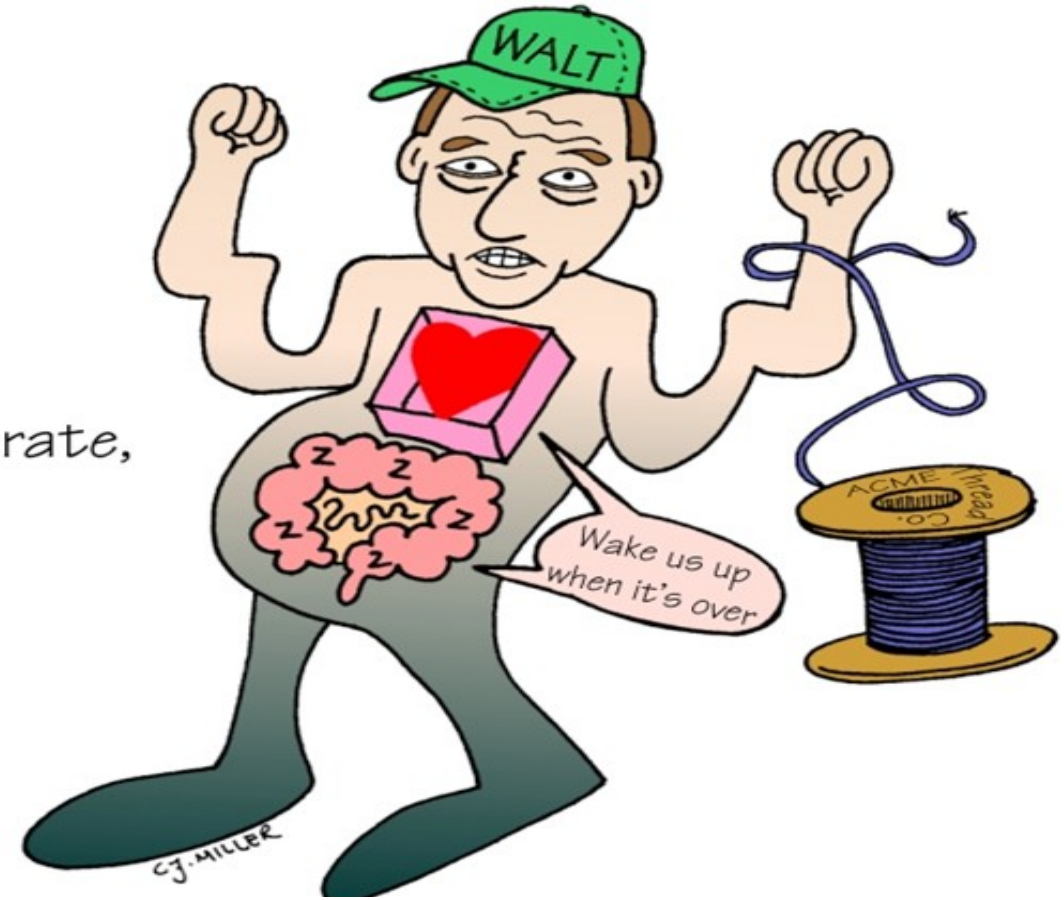


Figure 33-13 Electrocardiographic changes with hyperkalemia and hypokalemia.

Hypokalemia

POTASSIUM DEFICIT

* **A**lkalosis
* **S**hallow Respirations
* **I**rritability
* **C**onfusion, Drowsiness
* **W**eakness, Fatigue
* **A**rrhythmias - Irregular rate, Tachycardia
* **L**ethargy
* **T**hready Pulse
* ↓ Intestinal Motility
  Nausea
  Vomiting
  Ileus



POTASSIUM LEVELS IN ACIDOSIS

Potassium Goes Up
In Acidosis

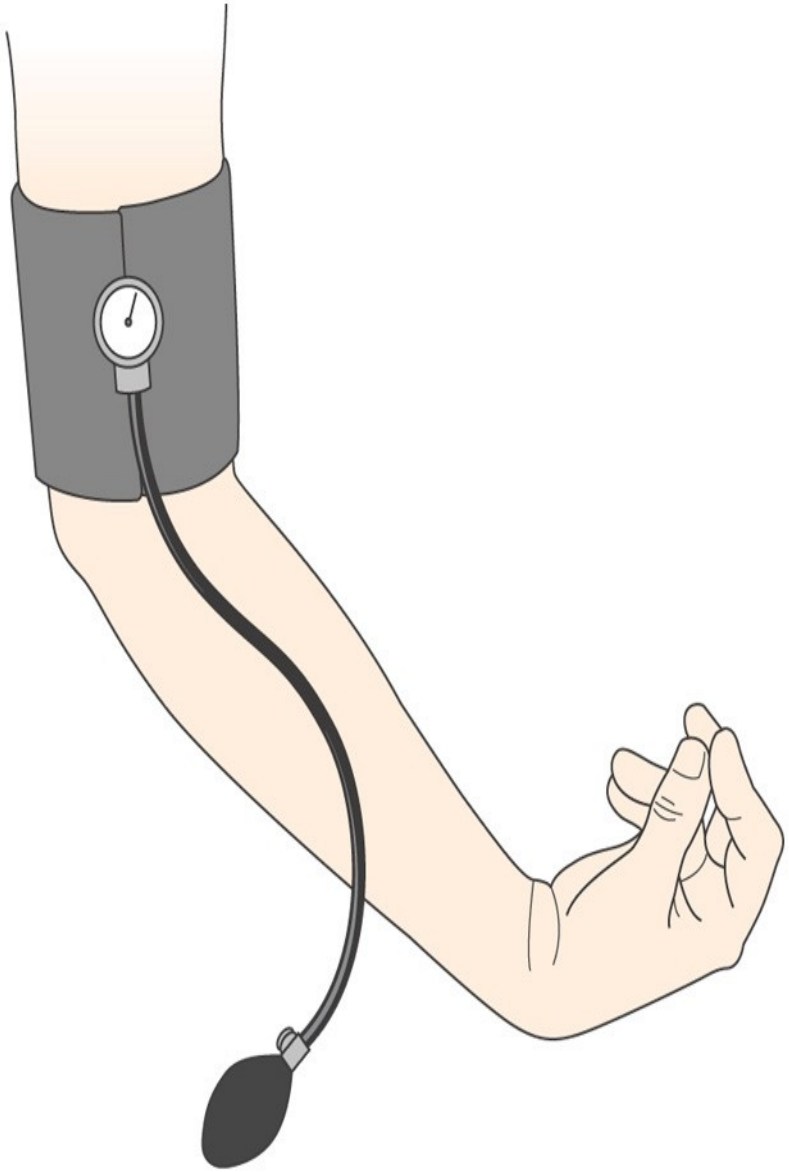
Hypercalcemia

- Calcium
  - ↑ 5.5 mg/dL
- Risk Factors
  - hyperparathyroidism, prolonged immobility, megadoses of vitamin D, bone malignancy, paget's disease, thiazide diuretics, overuse of Ca+ 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.

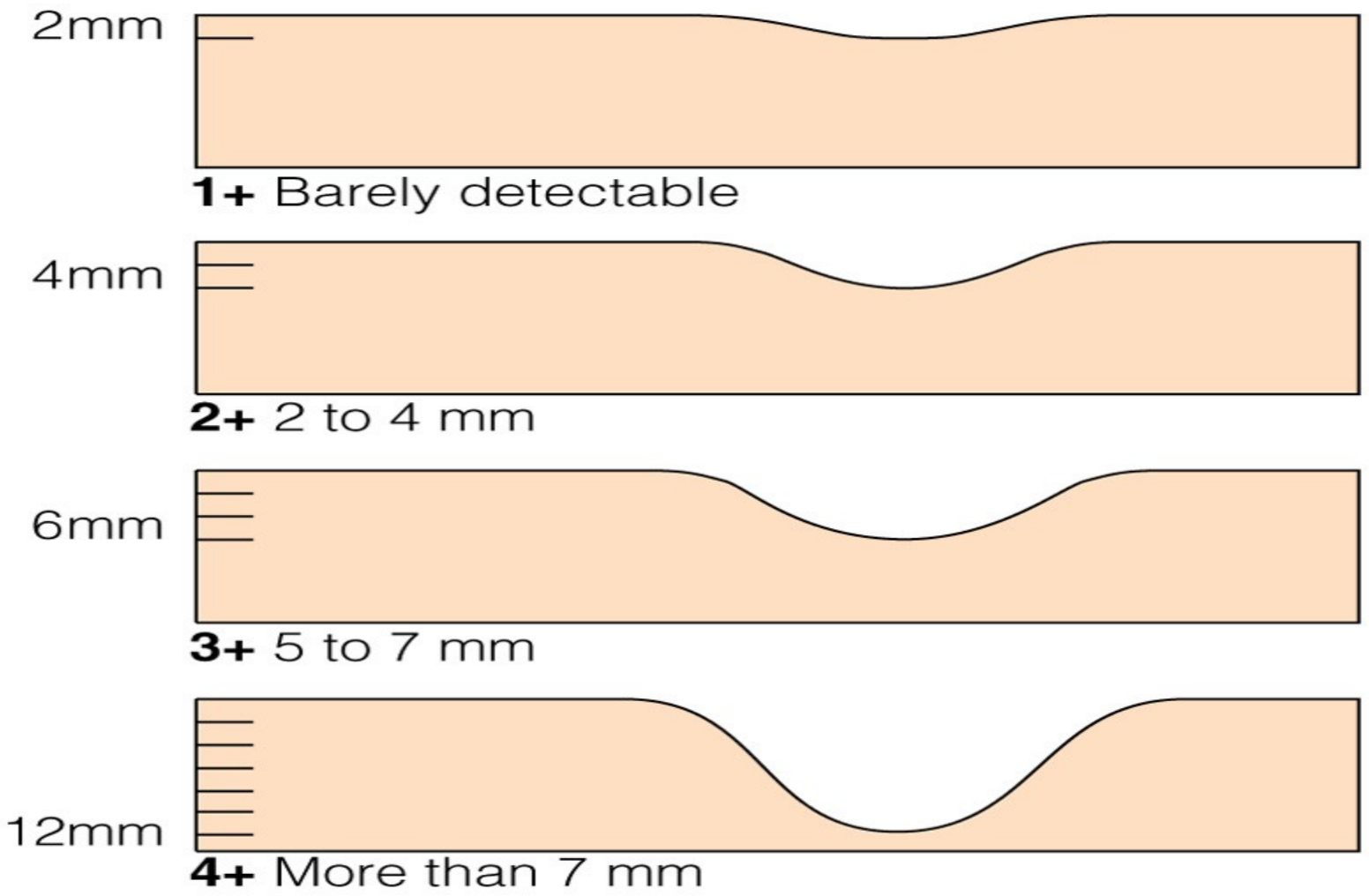
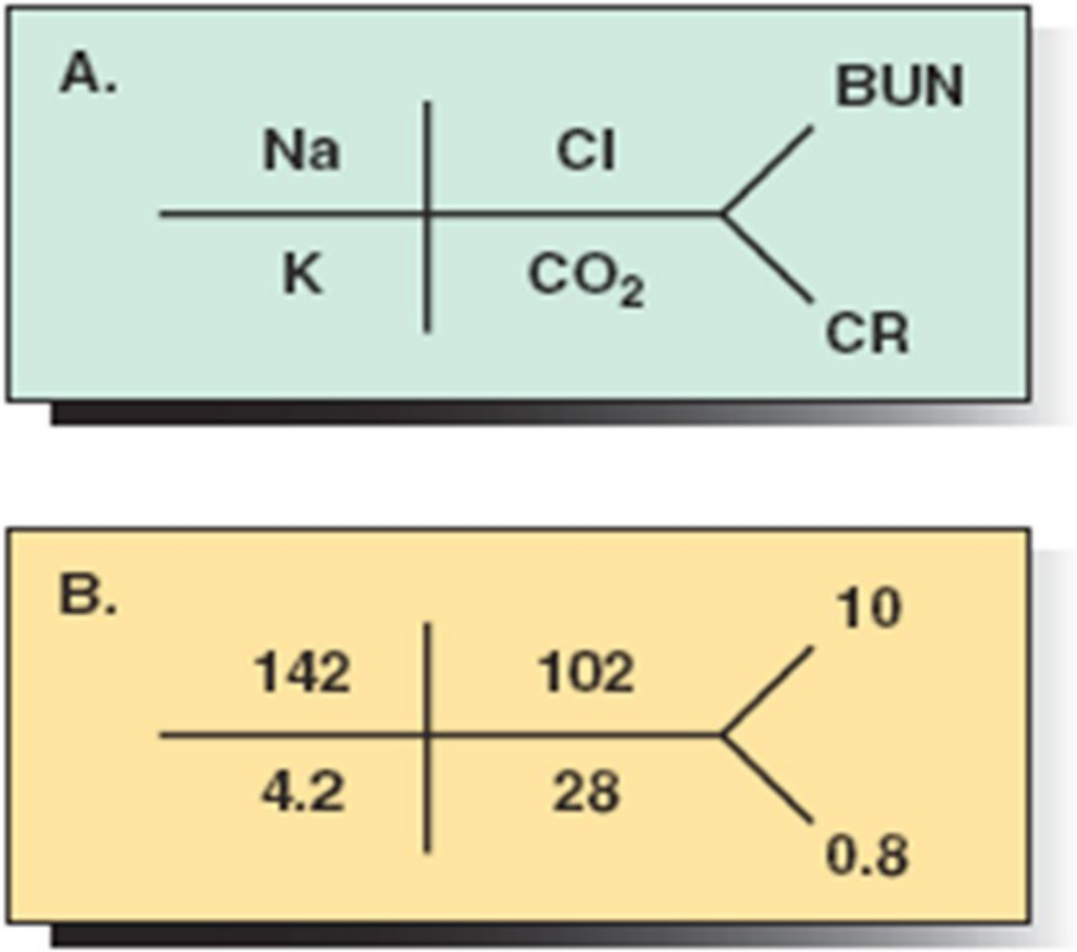


Diagram of Serum Electrolyte Results



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

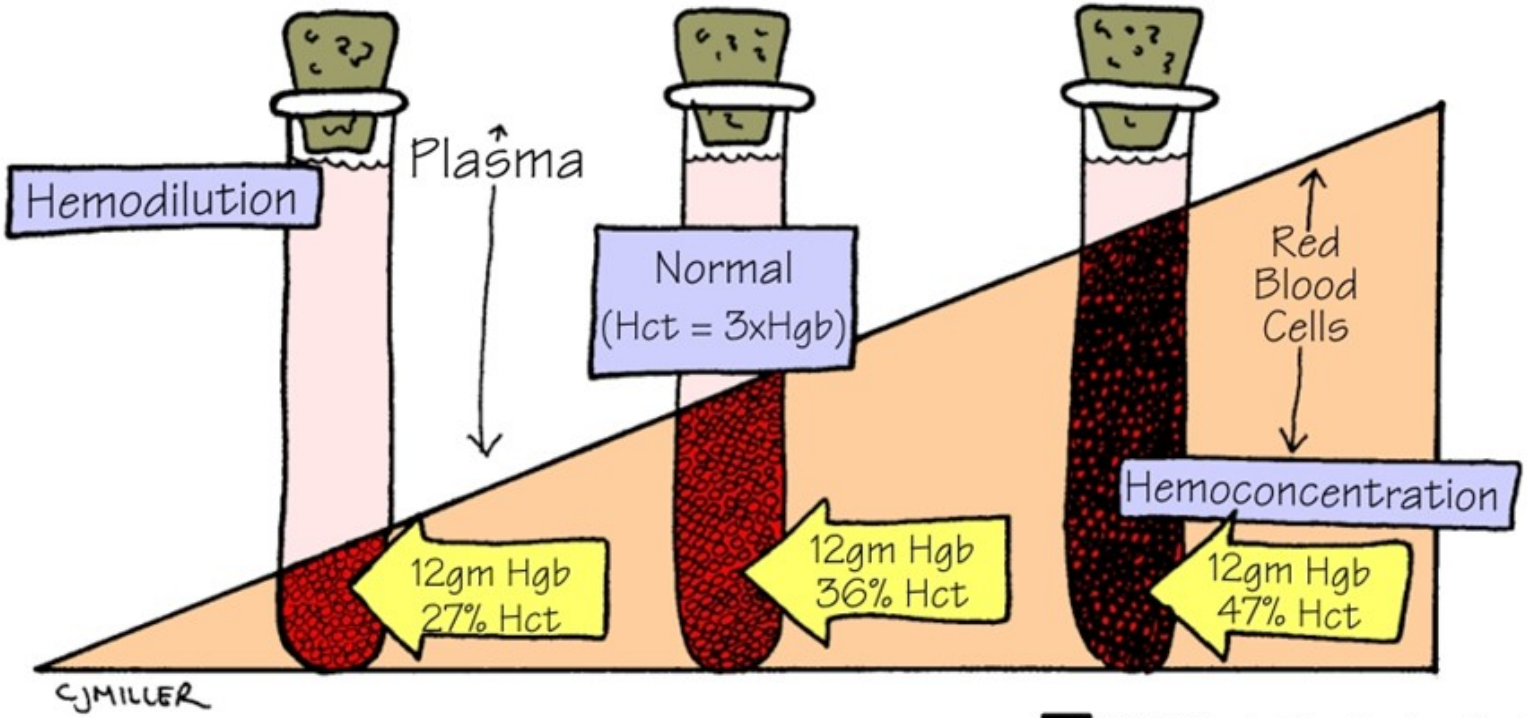
- Fluid intake modifications
- Dietary changes
- Parenteral fluid, electrolyte, and blood replacement
- Other appropriate measures such as:
- Administering prescribed medications and oxygen
- Providing skin care and oral hygiene
- Positioning the client appropriately
- Scheduling rest periods

- 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



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 H2O (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