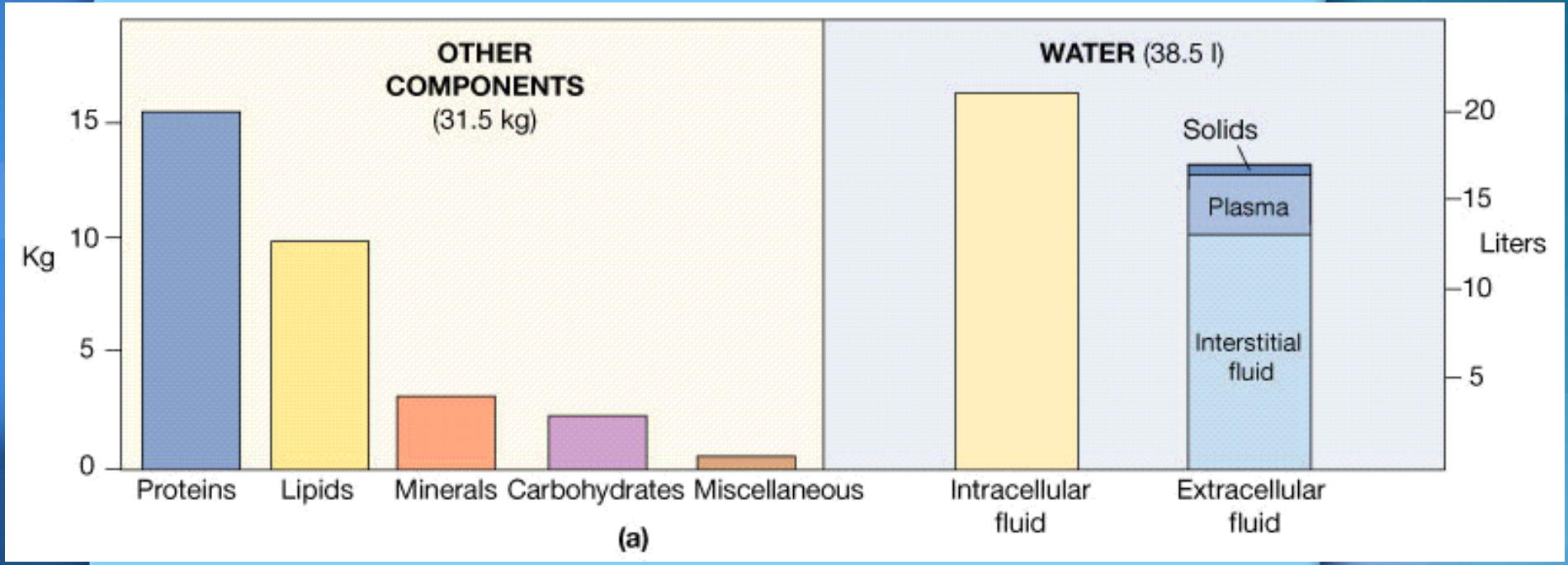
ELECTROLYTE IMBALNCES

PHARMACEUTICAL CHEMISTRY 1
UNIT III

The Composition of the Human Body



Body Fluid Compartments

- 2/3 (65%) of TBW is intracellular (ICF)
- 1/3 extracellular water
  - 25 % interstitial fluid (ISF)
  - 5- 8 % in plasma (IVF intravascular fluid)
  - 1- 2 % in transcellular fluids – CSF, intraocular fluids, serous membranes, and in GI, respiratory and urinary tracts (third space)

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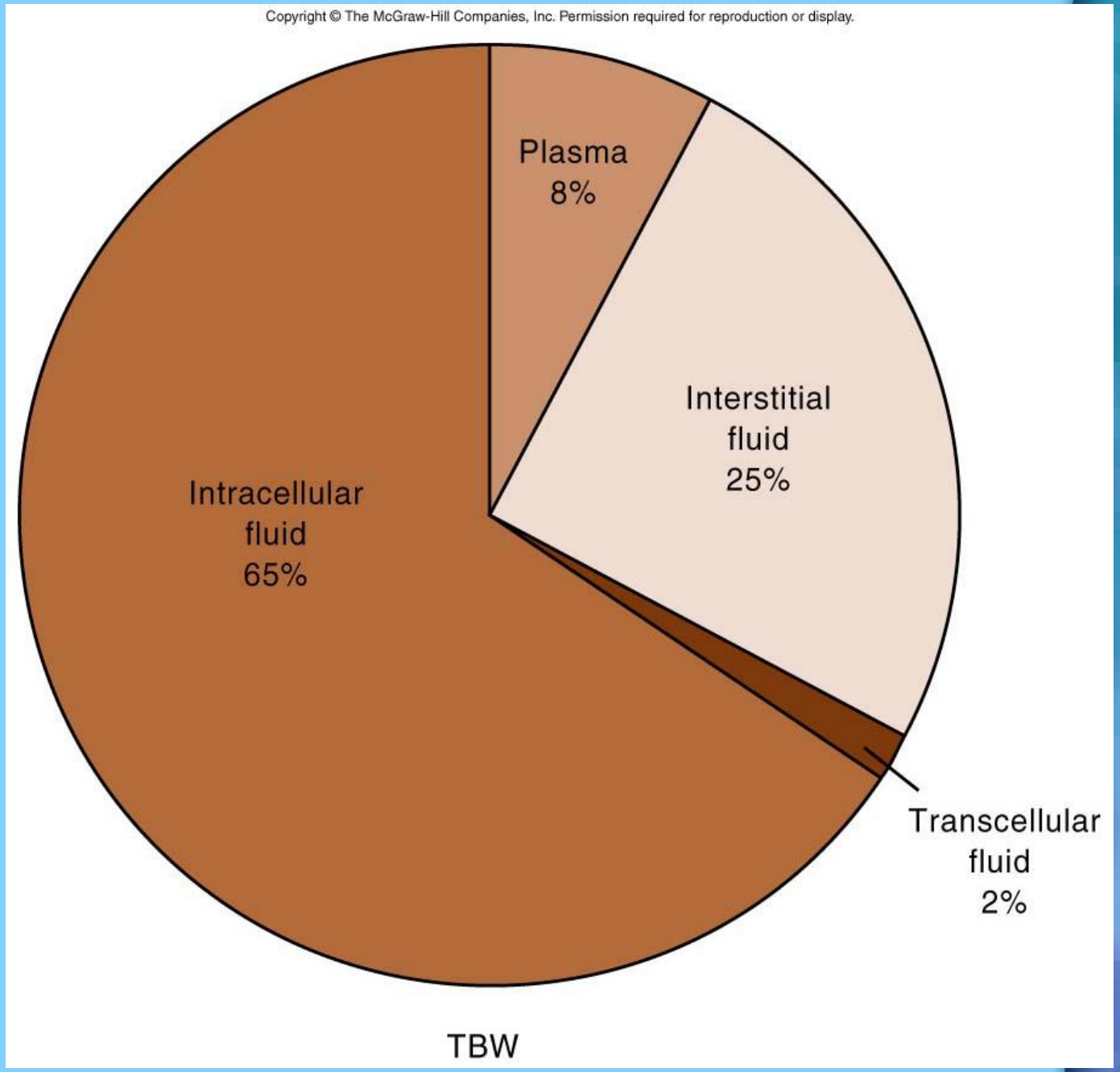

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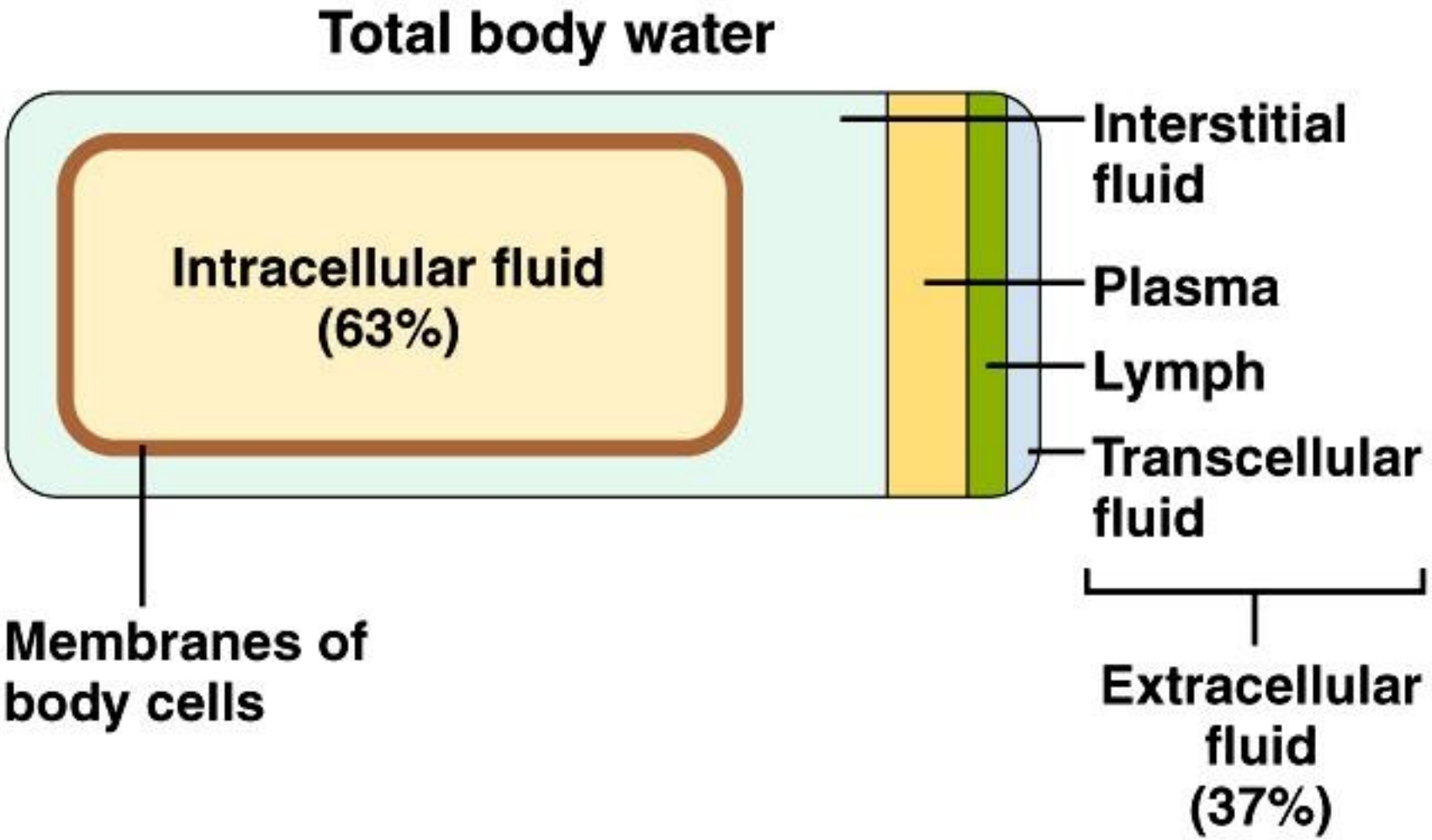

Major Compartments for Fluids

- INTRACELLULAR FLUID (ICF)
- **Inside cell**
- **Most of body fluid here - 63% weight**
- **Decreased in elderly**

- EXTRACELLULAR FLUID (ECF)
- **Outside cell**
- Intravascular fluid **- within blood vessels (5%)**
- Interstitial fluid **- between cells & blood vessels (15%)**
- Transcellular fluid - **cerebrospinal, pericardial , synovial**

ELECTROLYTES IN BODY FLUID COMPARTMENTS

INTRACELLULAR	EXTRACELLULAR
POTASSIUM	SODIUM
MAGNESIUM	CHLORIDE
PHOSPHOROUS	BICARBONATE

METHODS OF FLUID & ELECTROLYTE MOVEMENT

- Diffusion
- Osmosis
- Active Transport
- Filtration

DIFFUSION

- **Process by which a** solute in solution **moves**
- **Involves a** gas or substance
- Movement of particles **in a solution**
- **Molecules** move from an area of higher concentration to an area of lower concentration
- Evenly distributes the solute **in the solution**
- Passive **transport & requires no energy***

OSMOSIS

- Movement of the solvent or water **across a membrane**
- **Involves** solution or water
- Equalizes the concentration of ions **on each side of membrane**
- Movement of solvent molecules across a membrane to an area where there is a higher concentration of solute **that cannot pass through the membrane**

ACTIVE TRANSPORT SYSTEM

- Moves molecules or ions uphill **against concentration & osmotic pressure**
- **Hydrolysis of** adenosine triphosphate (ATP) provides energy needed
- **Requires specific "carrier" molecule as well as specific enzyme (ATPase)**
- Sodium, potassium, calcium, magnesium**, plus some sugars, & amino acids use it**

FILTRATION

- **Movement of fluid through a selectively permeable membrane** from an area of higher hydrostatic pressure to an area of lower hydrostatic pressure
- Arterial end **of capillary has** hydrostatic pressure > than osmotic pressure **so fluid & diffusible solutes move out of capillary**

ADH (Antidiuretic Hormone)

- **Made in** hypothalamus; water conservation hormone
- **Stored in** posterior pituitary gland
- **Acts on** renal collecting tubule to regulate reabsorption or elimination of water
- If blood volume decreases, then ADH is released & water is reabsorbed by kidney. Urine output will be lower but concentration will be increased.

ALDOSTERONE

- **Produced by** adrenal cortex
- **Released as** part of RAA mechanism
- **Acts on** renal distal convoluted tubule
- **Regulates water reabsorption by** increasing sodium uptake from the tubular fluid into the blood but potassium is excreted
- **Responsible for** reabsorption of sodium & water into the vascular compartment

RENIN

- **Released by kidneys in response to decreased blood volume**
- **Causes angiotensinogen (plasma protein) to split & produce angiotensin I**
- **Lungs convert angiotensin I to angiotensinII**
- **Angiotensin II stimulates adrenal gland to** release aldosterone & causes an increase in peripheral vasoconstriction

ISOTONIC SOLUTIONS

- 0.9% Sodium Chloride Solution
- Ringer's Solution
- Lactated Ringer's Solution

HYPOTONIC SOLUTIONS

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

HYPERTONIC SOLUTIONS

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

ELECTROLYTES

- **Substance when dissolved in solution separates into ions & is able to carry an electrical current**
- CATION **- positively charged electrolyte**
- ANION **- negatively charged electrolyte**
- # Cations must = # Anions **for homeostatsis to exist in each fluid compartment**
- **Commonly measured in milliequivalents / liter (mEq/L)**

ELECTROLYTES

- **Na^+: most abundant electrolyte in the body**
- **K^+: essential for normal membrane excitability for nerve impulse**
- **Cl^-: regulates osmotic pressure and assists in regulating acid-base balance**
- **Ca^{2+}: usually combined with phosphorus to form the mineral salts of bones and teeth, 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**

SODIUM/CHLORIDE IMBALANCES

- Regulated by the kidneys
- Influenced by the hormone aldosterone
- Na is responsible for water retention and serum osmolarity level
- Chloride ion frequently appears with the sodium ion
- Normal Na = 135-145 mEq/L
- Chloride 95-108 mEq/L
- Na and CL are concentrated in ECF

Chloride

- Maintains serum osmolarity along with Na
- Helps to maintain acid/base balance
- Combines with other ions for homeostasis; sodium, hydrochloric acid, potassium, calcium
- Closely tied to Na
- Decreased level is most commonly due to GI losses

Sodium Functions

- Transmission and conduction of nerve impulses
- Responsible for osmolarity of vascular fluids
- Regulation of body fluid levels
- Sodium shifts into cells and potassium shifts out of the cells (sodium pump)
- Assists with regulation of acid-base balance by combining with Cl or HCO_3 to regulate the balance

Chloride Functions

- Found in ECF
- Changes the serum osmolarity
- Goes with Na in retention of water
- Assists with regulation of acid-base balance
- Cl combines with hydrogen to form hydrochloric acid in the stomach

Food Sources

- High Sodium
  - Bacon
  - Corned beef
  - Ham
  - Catsup
  - Potato chips
  - Pretzels with salt
  - Pickles
  - Olives
  - Soda crackers
  - Tomato juice
  - Beef cubes
  - Dill
  - Decaffeinated coffee
- Low Sodium
  - Fruit
    - Fresh
    - Frozen
    - canned
  - Unsalted grains
    - Pastas
    - Oatmeal
    - Popcorn
    - Shredded wheat
  - Fresh meats

MAJOR 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)

Hyponatremia

- Excessive sodium loss or H2O gain
- CAUSES
  - Prolonged diuretic therapy
  - Excessive diaphoresis
  - Insufficient Na intake
  - GI losses – suctioning, laxatives, vomiting
  - Administration of hypotonic fluids
  - Compulsive water drinking
  - Labor induction with oxytocin
  - Cystic fibrosis
  - alcoholism

CLINICAL MANIFESTATIONS

- Headache
- Faintness
- Confusion
- Muscle cramping/twitching
- Increased weight
- Convulsions

Hyponatremia

- **Assessment**
  - **Monitor for S/S in patients at risk**
    - **Muscle weakness**
    - **Tachycardia**
    - **Fatigue**
    - **Apathy**
    - **Dry skin, pale mucus membranes**
    - **Confusion**
    - **Headache**
    - **Nausea/Vomiting, Abdominal cramps**
    - **Orthostatic hypotension**

Treatment

- Restrict fluids
- Monitor VS
- Monitor serum Na levels
- IV normal saline or Lactated Ringers
- If Na is below 115, mEq/L hypertonic saline is ordered
- May give a diuretic for increasing H2O loss
- Encourage a balanced diet
- I/O
- Safety for weakness or confusion
- Assist with ambulation if low B/P

Hypernatremia

- Occurs with excess loss of H2O or excessive retention of Na
- Can lead to death if not treated
- Causes
  - Vomiting/diarrhea
  - Diaphoresis
  - Inadequate ADH
  - Some drugs
  - Hypertonic fluids/tube feedings
  - Major burns
- S/S
  - Thirst
  - Flushed skin
  - Dry mucus membranes
  - Low UOP
  - Tachycardia
  - Seizures
  - Hyperactive deep tendon reflexes

Treatment of Hypernatremia

- Low Na diet
- May use salt substitutes if K+ OK
- Encourage H2O consumption
- Monitor fluid intake on patients with heart or renal disease
- Observe changes in B/P, and heart rate if hypovolemic
- Monitor serum Na levels
- Assess respiratory for crackles
- Weigh daily
- Assess skin and mucus membranes
- Assist with oral hygiene
- Check neurological status
- Teach patient to monitor I/O and watch for edema
- Teach patient and family signs and symptoms and when to report them
- Safety precautions

Potassium Imbalances

- Potassium is the most abundant cation in the body cells
- 97% is found in the intracellular fluid
- Also plentiful in the GI tract
- Normal extracellular K+ is 3.5-5.3
- A serum K+ level below 2.5 or above 7.0 can cause cardiac arrest
- 80-90% is excreted through the kidneys
- Functions
  - Promotes conduction and transmission of nerve impulses
  - Contraction of muscle
  - Promotes enzyme action
  - Assist in the maintenance of acid-base
- Food sources – veggies, fruits, nuts, meat
- Daily intake of K is necessary because it is poorly conserved by the body

Hypokalemia

- Causes
  - Prolonged diuretic therapy
  - Inadequate intake
  - Severe diaphoresis
  - Gastric suctioning, laxative use, vomiting
  - Excess insulin
  - Excess stress
  - Hepatic disease
  - Acute alcoholism

Signs and Symptoms

- Anorexia
- N/V
- Drowsiness, lethargy, confusion
- Leg cramps
- Muscle weakness
- Hyperreflexia
- Hypotension
- Cardiac dysrhythmias
- Polyuria

Treatment

- **IV or PO replacement**
  - **PO with 8 oz of fluid**
  - **Give K+ IV diluted in a large vein**
  - **** Never push K+ as a bolus ****
  - ***Monitor site for infiltration***
- **Monitor patients at risk**
- **Monitor I/O**
- **Monitor EKG**
- **Monitor Serum K+**
- **Watch UOP**
- **Watch patients who take Digitalis for toxicity**
- **Teach family and patient dietary changes**

Hyperkalemia

- Greater then 5.0, EKG changes, decreased pH
- Results form impaired renal function
- Metabolic acidosis
- Acts as myocardial depressant; decreased heart rate, cardiac output
- Muscle weakness
- GI hyperactivity

Etiology

- Increased dietary intake
- Excessive administration of K+
- Excessive use of salt substitutes
- Widespread cell damage, burns, trauma
- Administration of larger quantities of blood that is old
- Hyponatremia
- Renal failure

Signs and Symptoms

- Apathy
- Confusion
- Numbness/paresthesia of extremities
- Abdominal cramps
- Nausea
- Flaccid muscles
- Diarrhea
- Oliguria
- Bradycardia
- Cardiac arrest

Nursing Care

- Monitor patients at risk
- Cardiac monitoring
- Monitor pulse, rate and rhythm, and B/P
- Assess for hyperactive bowel sounds
- Assess sensory and motor function
- Monitor neurological status
- Medications
  - Calcium gluconate IV may be give as an antidote
  - D50W and regular insulin to facilitate movement into the cells
  - Administer Kayexolate (oral and rectal0
- Dialysis

Calcium

- Regulated by the parathyroid gland
- Parathyroid hormone
  - Helps with calcium retention and phosphate excretion through the kidneys
  - Promotes calcium absorption in the intestines
  - Helps mobilize calcium from the bone

Hypocalcemia

- Abnormalities of the parathyroid gland or inadequate intake or excessive losses
- Can cause skeletal and neuromuscular abnormalities
- Impairs clotting mechanisms
- Affects membrane permeability
- Diagnostic findings
  - EKG changes
  - Serum Ca++levels < 8.5 mg/dL
  - Prolonged PT and PTT

Etiology

- Surgically induced hypoparathyroidism
- Renal failure
- Vitamin D deficiency
- Inadequate exposure to ultraviolet light
- Acute pancreatitis
- hyperphosphatemia

Signs and Symptoms

- Muscle cramps
- Hyperactive deep tendon reflexes
- Paresthesia of fingers, toes and face
- Tetany
- Positive Trousseau's sign/Chvostek's sign
- Laryngeal spasms
- Confusion
- Memory loss
- Cardiac dysrhythmias

Nursing Care

- Assess client's at risk; surgery/transfusions
- Seizure precautions
- Administer IV Ca++ slowly; watch for infiltration
- Keep calcium gluconate at bedside
- Assess nutritional intake of Ca++
- Watch for sensitivity if taking Digitalis, may cause lead to cardia arrest

Hypercalcemia

- Increased serum levels of Ca++
- Symptoms are directly related to degree of elevation
- Clients with metastatic cancer are especially at risk
- Cause
  - Excessive intake
  - Excessive use of antacids with phosphate-binding
  - Prolonged immobility
  - Excessive vitamin D intake
  - Thiazide diuretics
  - Cancer
  - Thyrotoxicosis

Signs and Symptoms

- Muscle weakness
- Personality changes
- Nausea and vomiting
- Extreme thirst
- Anorexia
- Constipation
- Polyuria
- Pathological fractures
- Calcifications in the skin and cornea
- Cardiac arrest

Diagnostic Findings

- Serum Ca++ > 10.5 mg/dl
- Done changes on x-ray
- EKG changes

Nursing Care

- Monitor clients at risk; immobile, cancer
- Ambulate clients early
- Drink plenty of fluids, 3-5 liters to help excrete excess Ca++
- Administer IV NS 200-500/hr if tolerated or for moderate hypercalcemia
- Administer loop diuretics
- Administer Calcitonin
- Teach client to avoid dairy products

Hypomagnesemia

- Excess Mg loss from renal or GI
- Insufficient dietary intake
- Essential for neuromuscular integration; hypomagnesemia increases muscle irritability and contractility
- Causes decreased blood pressure and cardiac dysrhythmias
- Often mistaken for hypokalemia, which can occur simultaneously

Causes

- Excessive dietary intake of Ca++ or vitamin D
- Losses from gastric suctioning
- Severe nausea, vomiting or diarrhea,
- Pancreatitis, alcoholism
- Excessive diuretic therapy
- Administration of fluids without Mg
- Starvation
- Malabsorption syndromes
- Ulcerative colitis
- Hypercalcemia. Hypoaldosteronism
- High dose steroid use
- Cancer chemotherapy

Signs and Symptoms

- Cardiac dysrhythmias; hypotension\tremor
- Tetany
- Hyperactive deep tendon reflexes
- Positive Chvostek's and Trousseau's signs
- Memory loss
- Emotional lability
- Confusion
- Hallucinations
- Seizures

Diagnostic Findings

- Serum Mg level < 1,5 mEq/liter
- Hypocalcemia
- Hypokalemia
- EKG changes

Nursing Care

- Monitor clients at risk
- Watch for digitalis toxicity
- Cardiac monitoring
- Seizure precautions
- Treat with oral, IM, IV or Mg salts
- Monitor urine output
- Teach patients about foods high in Mg
  - Green vegetables
  - Nuts
  - Beans
  - fruits

Hypermagnesemia

- Usually results from renal failure
- Excessive intake
- Produces sedative effect on neuromuscular junctions, diminishes muscle cell excitability
- Can cause hypotension or cardiac arrest

Causes

- Renal failure
- Excessive use of Mg containing antacids
- Untreated diabetic ketoacidosis
- Hypoadrenalism

Signs and Symptoms

- Lethargy and drowsiness
- Depress neuromuscular activity
- Depresses respiratons
- Sensation of warmth throughout the body
- Hypoactive deep tendon reflexes
- Hypotension
- Bradycardia
- Cardiac arrest

Diagnostic Findings

- Serum Mg > 3mEq/liter
- EKG changes

Nursing Care

- Monitor clients at risk
- Monitor VS, especially B/P
- Assess neuromuscular status
- Cardiac monitoring
- Be prepared to give Ca gluconate
- Minimize intake