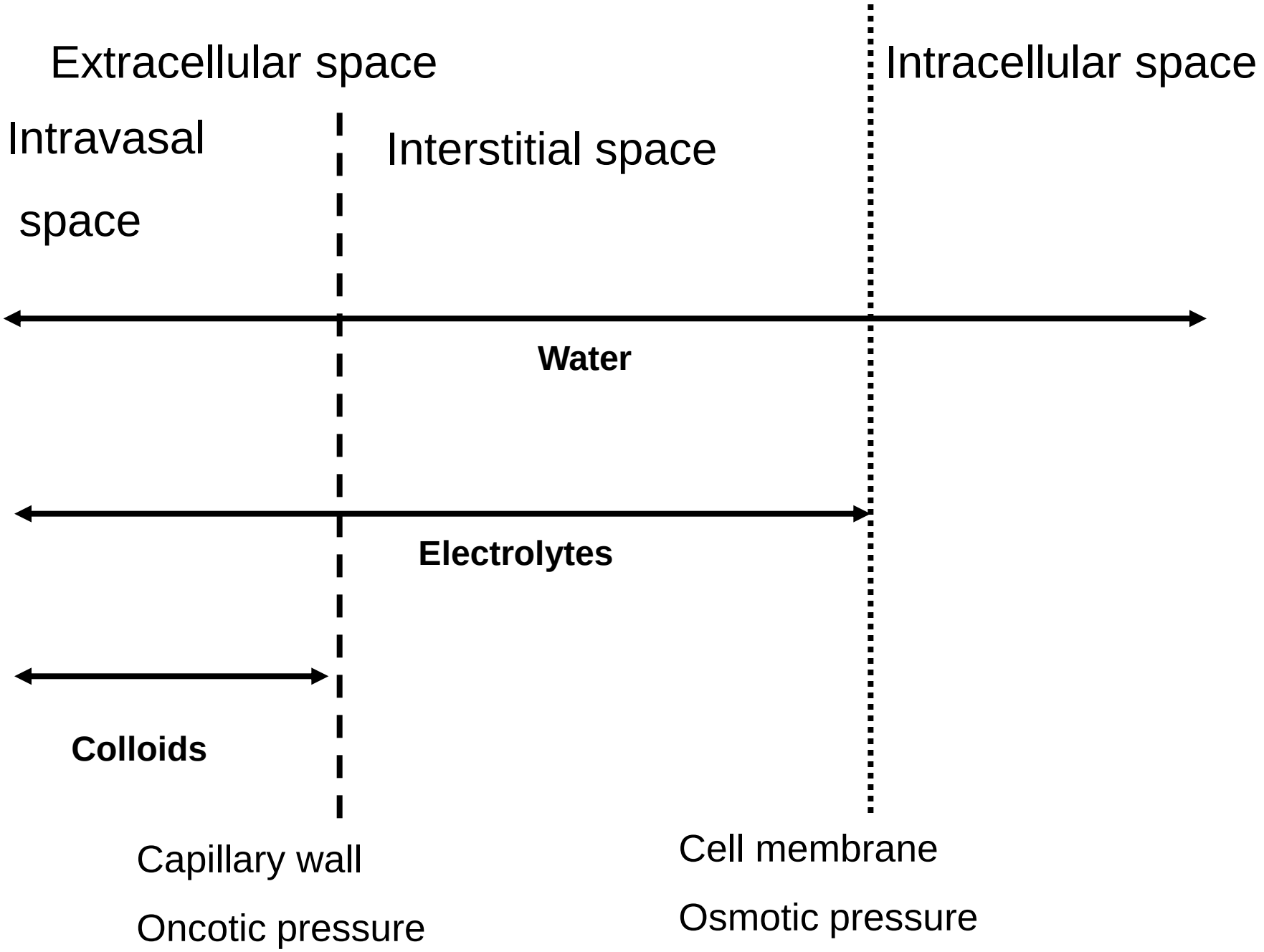
Body fluids & its balance

BPH, PU

BIJAY SUBEDI

General principles

- Osmolarity : number of osmoles per liter of solution
- Osmolality: number of osmoles per kilogram of solvent
  - Measurement: depression of freezing point
  - Calculation (plasma): 2x(Na+K)+glucose+BUN (mmol/l)
- Tonicity: effective osmolality of a solution relative to plasma
- Colloids: high molecular weight particles (> 20000 D)
- Oncotic pressure (colloid osmotic pressure): the pressure necessery to prevent diffusion of solvent molecules (water) into region in which there is a higher concentration of a colloid to which the membrane is impermeable


Extracellular space
Intracellular space
Intravasal space
Interstitial space
Water
Electrolytes
Colloids
Capillary wall
Oncotic pressure
Cell membrane
Osmotic pressure

Osmotic movement of fluids

- Cells affected by osmolality of the fluid that surrounds them.
- Isotonic-fluid with same osmolality as cell interior
- Hypotonic (hypoosmolar)-solutes are less concentrated than cells.
- hypertonic (hyperosmolar)-solutes more concentrated than cells.

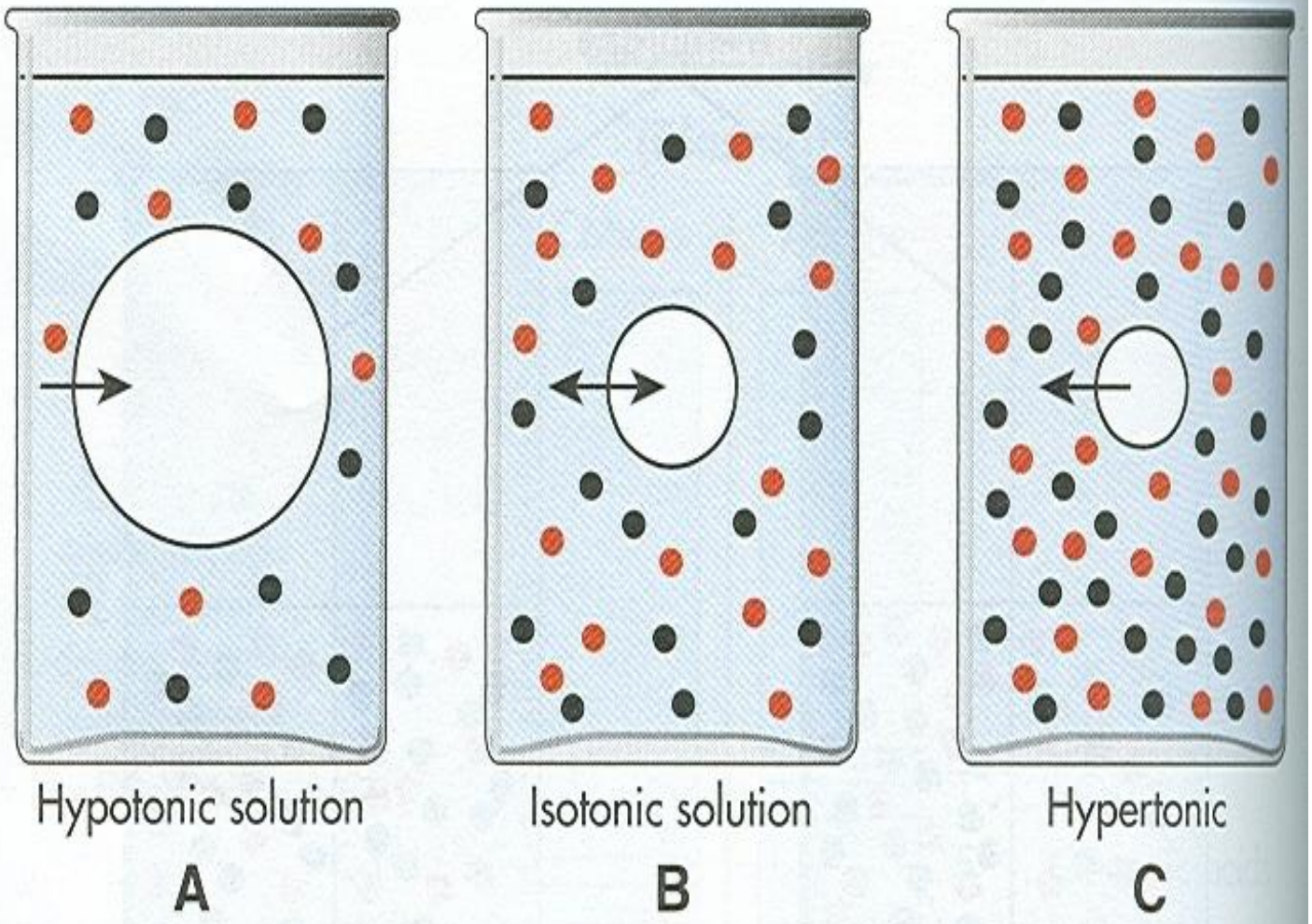


FIG. 17-7 Effects of water status on cell size. **A,** Hypotonic solution (H_2O excess) results in cellular swelling. **B,** Isotonic solution (normal H_2O balance) results in no change. **C,** Hypertonic solution (H_2O deficit) results in cellular shrinking.

Body Fluids

- **Total amount of fluid in the human body is approximately 70% of body weight**
- **Body fluid has been divided into two compartments –**
  - **Intracellular fluid (ICF)**
    - **Inside the cells**
    - **60% of total body water**
  - **Extracellular fluid**
    - **Outside the cells**
    - **40% of total body water**

Body Fluid Compartments

Extracellular fluid includes

- **Interstitial fluid**
  - Present between the cells
  - Approximately 80% of ECF
- **Plasma**
  - Present in blood
  - Approximately 20% of ECF
- **Also includes**
  - Lymph
  - synovial fluid
  - aqueous humor
  - cerebrospinal fluid

- vitreous body,
- endolymph,
- perilymph,
- pleural, pericardial and peritoneal fluids

Composition of body fluids

- Organic substances
  - Glucose
  - Amino acids
  - Fatty acids
  - Hormones
  - Enzymes
- Inorganic substances
  - Sodium
  - Potassium
  - Calcium
  - Magnesium
  - Chloride
  - Phophate
  - Sulphate

Difference

ECF

- Most abundant cation - Na+,
  - muscle contraction
  - Impulse transmission
  - fluid and electrolyte balance
- Most abundant anion - Cl-
  - Regulates osmotic pressure
  - Forms HCl in gastric acid

ICF

- Most abundant cation - K^+
  - Resting membrane potential
  - Action potentials
  - Maintains intracellular volume
  - Regulation of pH
- Anion are proteins and phosphates (HPO_4^{2-})

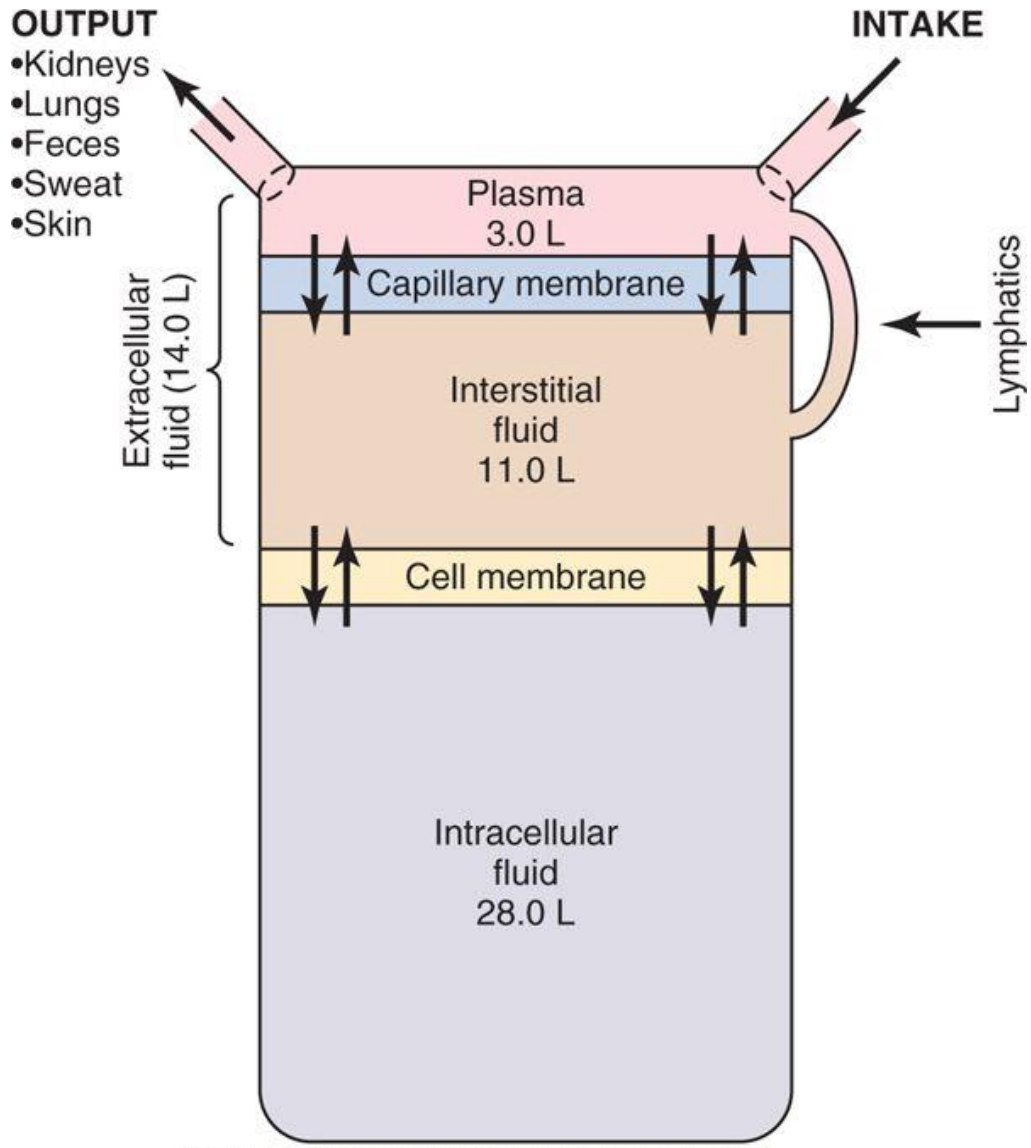
●Na+ /K+ pumps play major role in keeping K+ high inside cells and Na+ high outside cell

Body Fluids

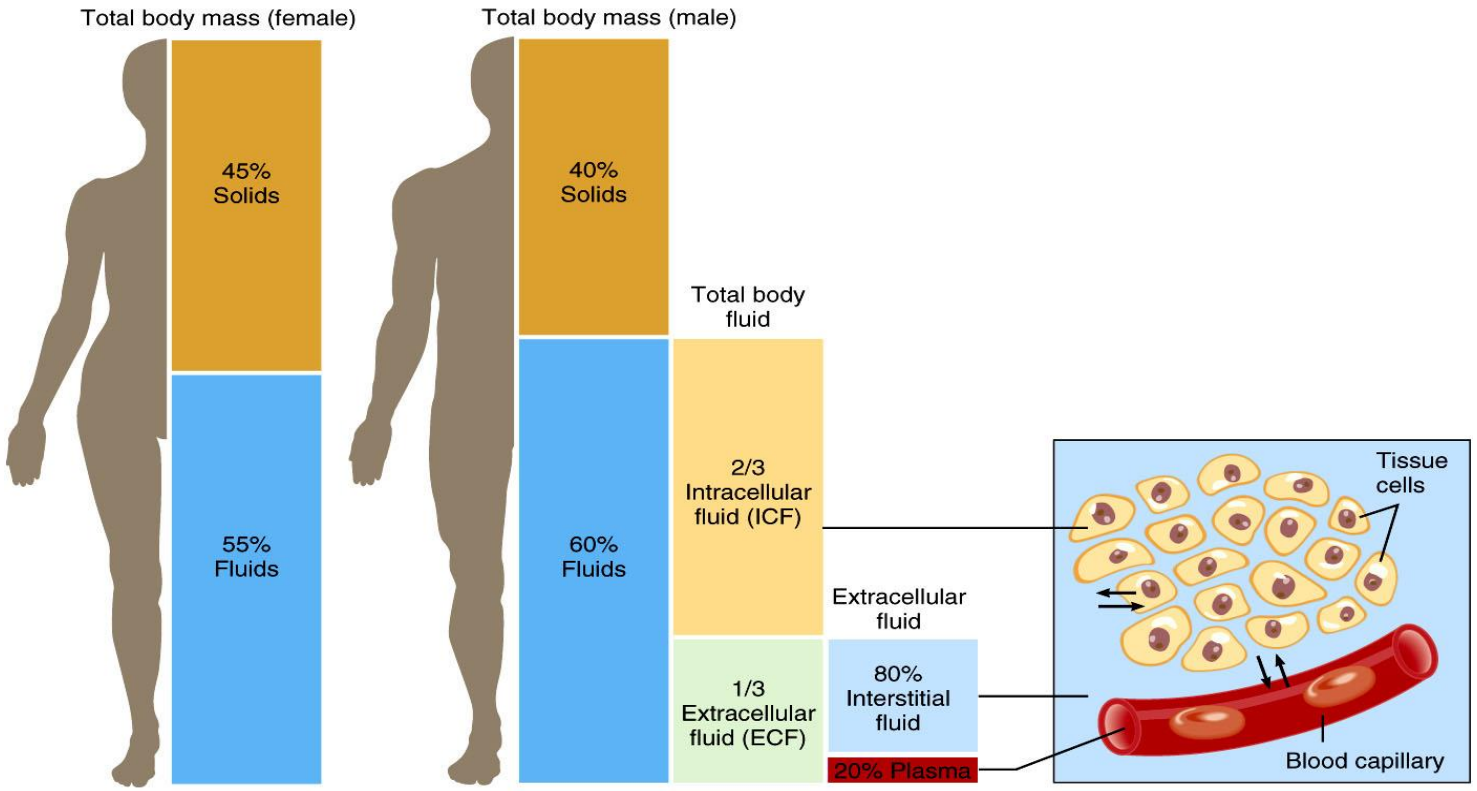
- Water= most important nutrient for life.
- Water= primary body fluid.
  Adult weight is 55-60% water.
- Loss of 10% body fluid = 8% weight loss **SERIOUS**
- Loss of 20% body fluid = 15% weight loss **FATAL**
- Fluid gained each day should = fluid lost each day
  (2 -3L/day average)
- What is the minimum output per hour necessary to maintain renal function? **30ml/hr**

Functions of Body Fluid

- Medium for transport
- Needed for cellular metabolism
- Solvent for electrolytes and other constituents
- Helps maintain body temperature
- Helps digestion and elimination
- Acts as a lubricant

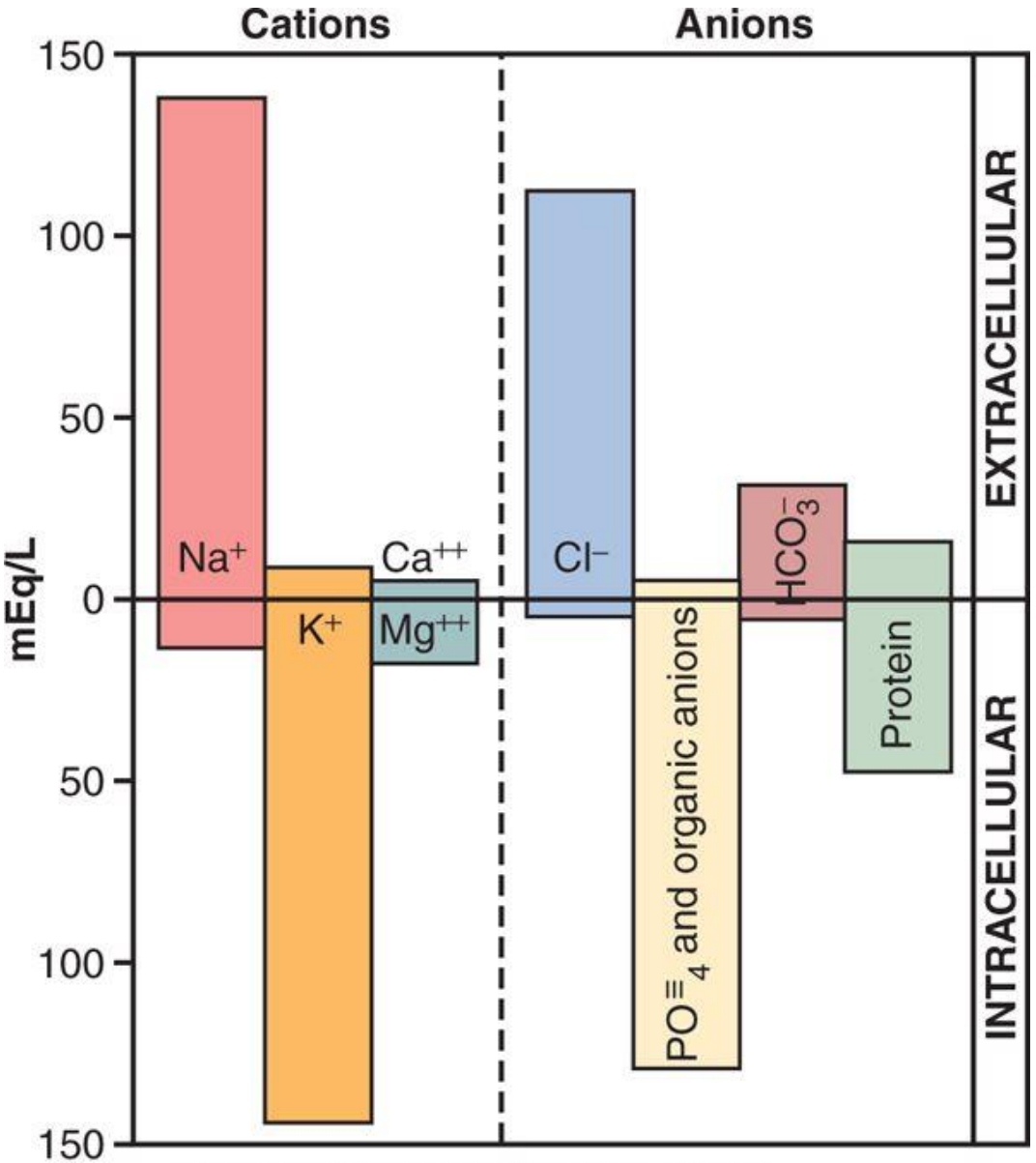


Body Fluid Compartments



(a) Distribution of body solids and fluids in an average lean, adult female and male

(b) Exchange of water among body fluid compartments



Barriers separate ICF, interstitial fluid and plasma

- Plasma membrane
  - Separates ICF from surrounding interstitial fluid
- Blood vessel wall
  - Separate interstitial fluid from plasma

Total body composition of adult males and females

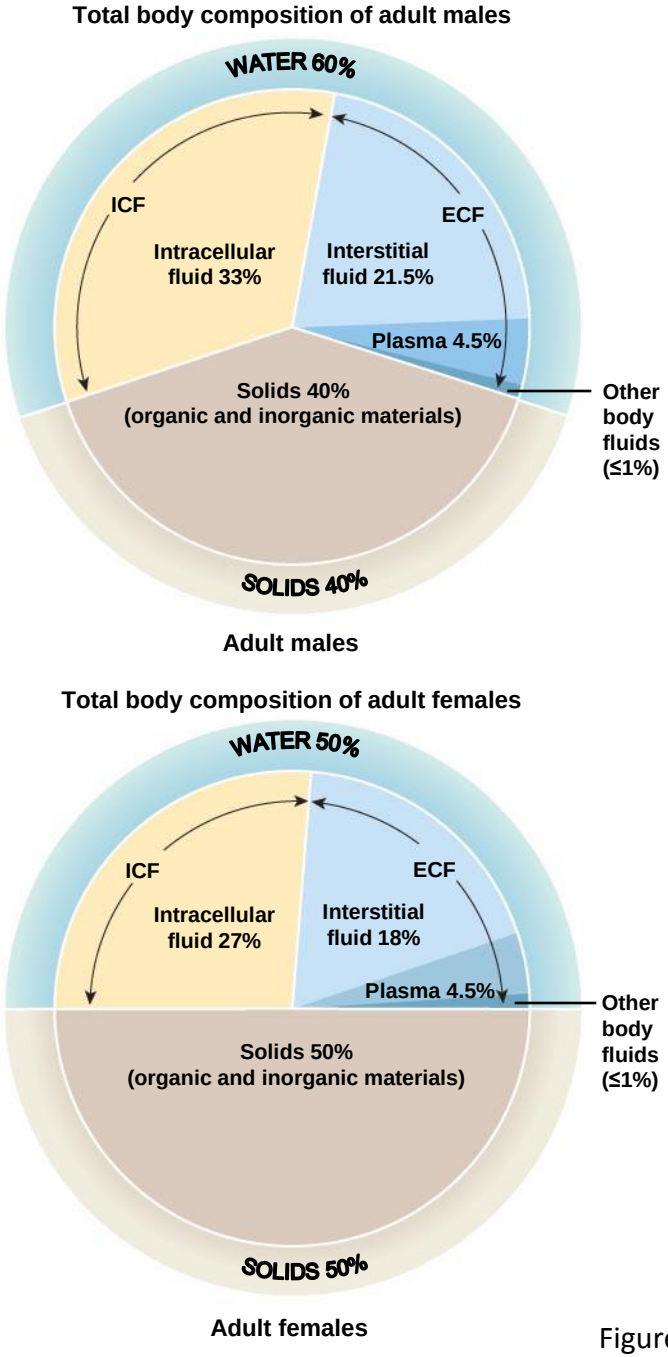


Figure 24 Section 1

The solid components of a 70-kg (154-pound) individual with a minimum of body fat

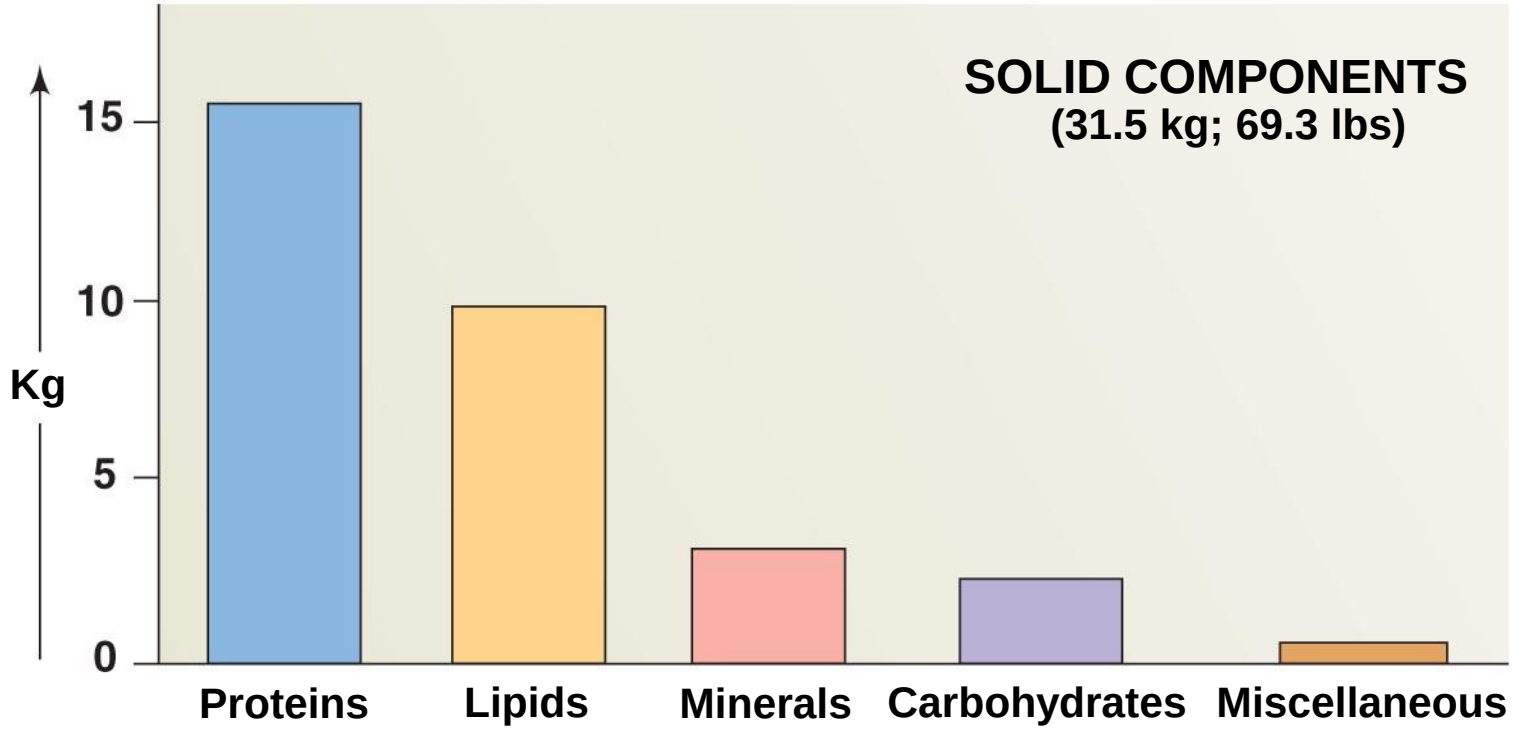


Figure 24 Section 1

Body Fluid Volumes

Compartment	*Fluid Vol. (l)*	*% Body Fluid*	*% Body Wgt.*
Total Body Fluid	42	100	60
Intracellular Fluid (ICF)	28	67	40
Extracellular Fluid (ECF)	14	33	20
Plasma	2.8	6.6 (20% ECF)	4
Interstitial Fluid	11.2	26.4 (80% ECF)	16
Lymph & Transcellular Fluid	Neg.	Neg.	Neg.

Daily Water Balance (liters)

INPUT		OUTPUT	
• FLUID INTAKE	1.5	• INSENSIBLE	0.8
• IN FOOD	0,8	• SWEAT	0,1
• METABOLIC	0.3	• FECES	0.2
• Total	2,6	• URINE	1.5
		• Total	2.6

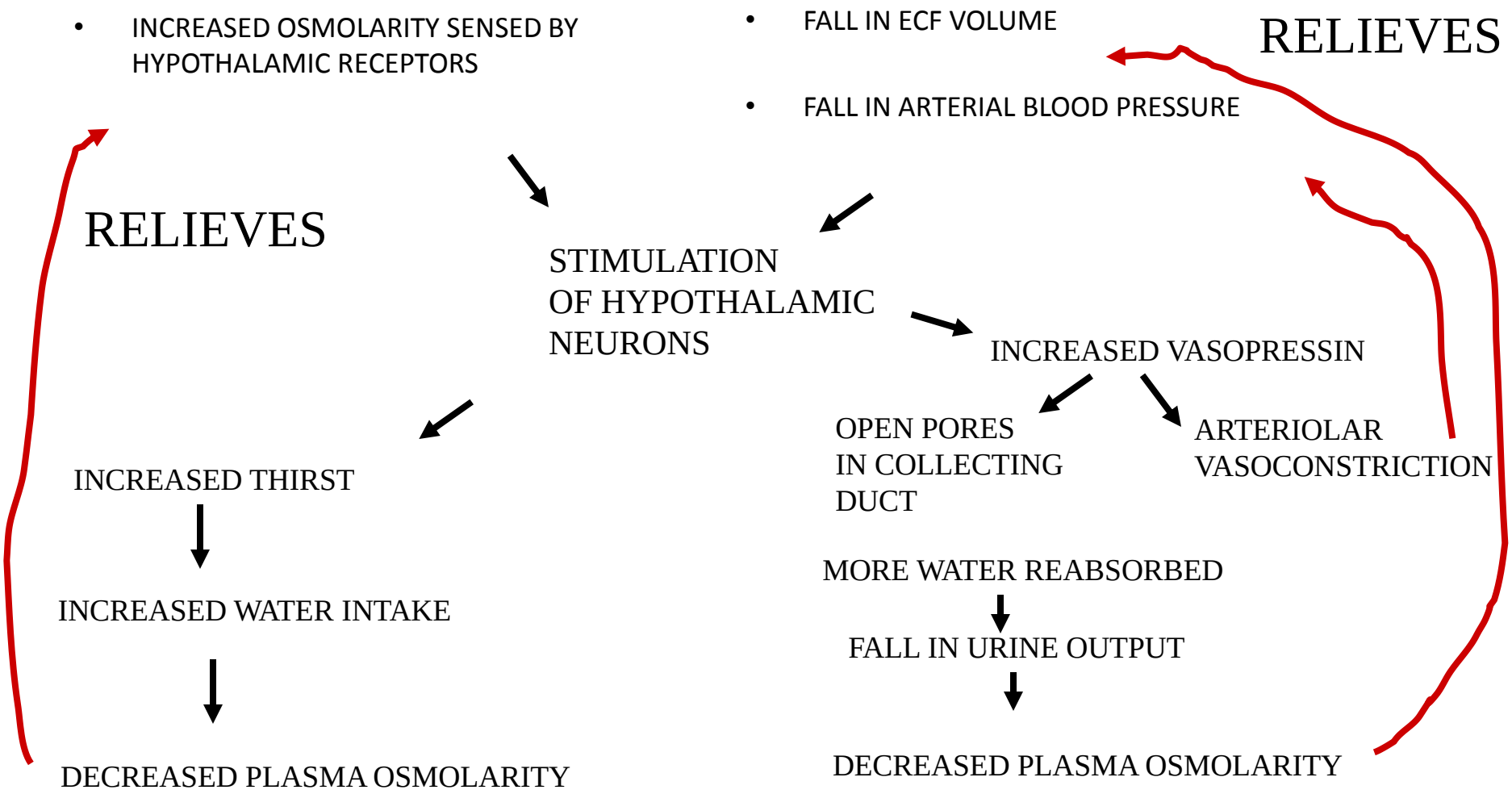
Fluid Balance

- The main way to regulate body water gain is by adjusting the volume of water intake, mainly by drinking more or less fluid. The thirst center in the hypothalamus governs the urge to drink.
- Although increased amounts of water and solutes are lost through sweating and exhalation during exercise, loss of excess water or excess solutes depends mainly on regulating excretion in the urine.
- The extent of urinary Na (and Cl) loss is the main determinant of body fluid volume, whereas the extent of urinary water loss is the main determinant of body fluid osmolarity.

Fluid Balance

- Angiotensin II and aldosterone reduce urinary loss of Na^+ and Cl^- and thereby increase the volume of body fluids (baroreceptors: sinus caroticus, kidney)
- Stimulation of ANP production: elevation of atrial wall tension (Angiotensin)
- ANP promotes natriuresis, elevated excretion of Na^+ (and Cl^-), which decreases blood volume.
- The major hormone that regulates water loss and thus body fluid osmolarity is ADH (Hypothalamus)
- The regulation of the volume of body fluids superior to the regulation of osmolarity

Water Deficit



Dehydration

- Signs: increased thirst (except: advanced age, hypotonic dehydration), weakness, decreased skin turgor, dry mucous membranes, empty neck veins, decreased urine output, elevated Htk, fever, tachycardia, hypotension, decreased CVP,lethargy, stupor, coma

- Mild (loss: 4% of body weight): decresed skin turgor, sunken eyes, dry mucous membranes
- Moderate (loss: 5-8 % of body weight): + oliguria, orthostatic hypotension, tachycardia
- Severe (loss: 8-10 % of body weight): + hypotension, decreased level of consciusness, stupor

Disturbances of fluid homeostasis

- Disturbance of fluid balance (intake≠output)
  - Dehydraton, Overhydration (hyperhydration)
- Disturbance of osmolarity (electrolyte intake≠water intake)
  - Isonatremic (isotonic)
  - Hyponatremic (hypotonic)
  - Hypernatremic (hypertonic)

The functions of key minerals

Minerals and Mineral Reserves

Mineral	Functions
Bulk Minerals	
Sodium	Major cation in body fluids; essential for normal membrane function
Potassium	Major cation in cytoplasm; essential for normal membrane function
Chloride	Major anion in body fluids; functions in forming HCl
Calcium	Essential for normal muscle and neuron function and normal bone structure
Phosphorus	In high-energy compounds, nucleic acids, and bone matrix (as phosphate)
Magnesium	Cofactor of enzymes, required for normal membrane functions

Mineral	Functions
Trace Minerals	
Iron	Component of hemoglobin, myoglobin, and cytochromes
Zinc	Cofactor of enzyme systems, notably carbonic anhydrase
Copper	Required as cofactor for hemoglobin synthesis
Manganese	Cofactor for some enzymes
Cobalt	Cofactor for transaminations; mineral in vitamin B_{12} (cobalamin)

Sodium Na^+

- Most abundant ion in ECF
- 90% of extracellular cations
- Plays pivotal role in fluid and electrolyte balance as it accounts for half of the osmolarity of ECF

Chloride Cl^-

- Most prevalent anion in ECF
- Moves easily between ECF and ICF because most plasma membranes contain Cl^- leakage channels and transporters
- Can help balance levels of anions in different fluids

Potassium K^+

- Most abundant cation in ICF
- Establish resting membrane potential in neurons and muscle fibers
- Maintains normal ICF fluid volume
- Helps regulate pH of body fluids when exchanged for H^+

The body's three major buffer systems

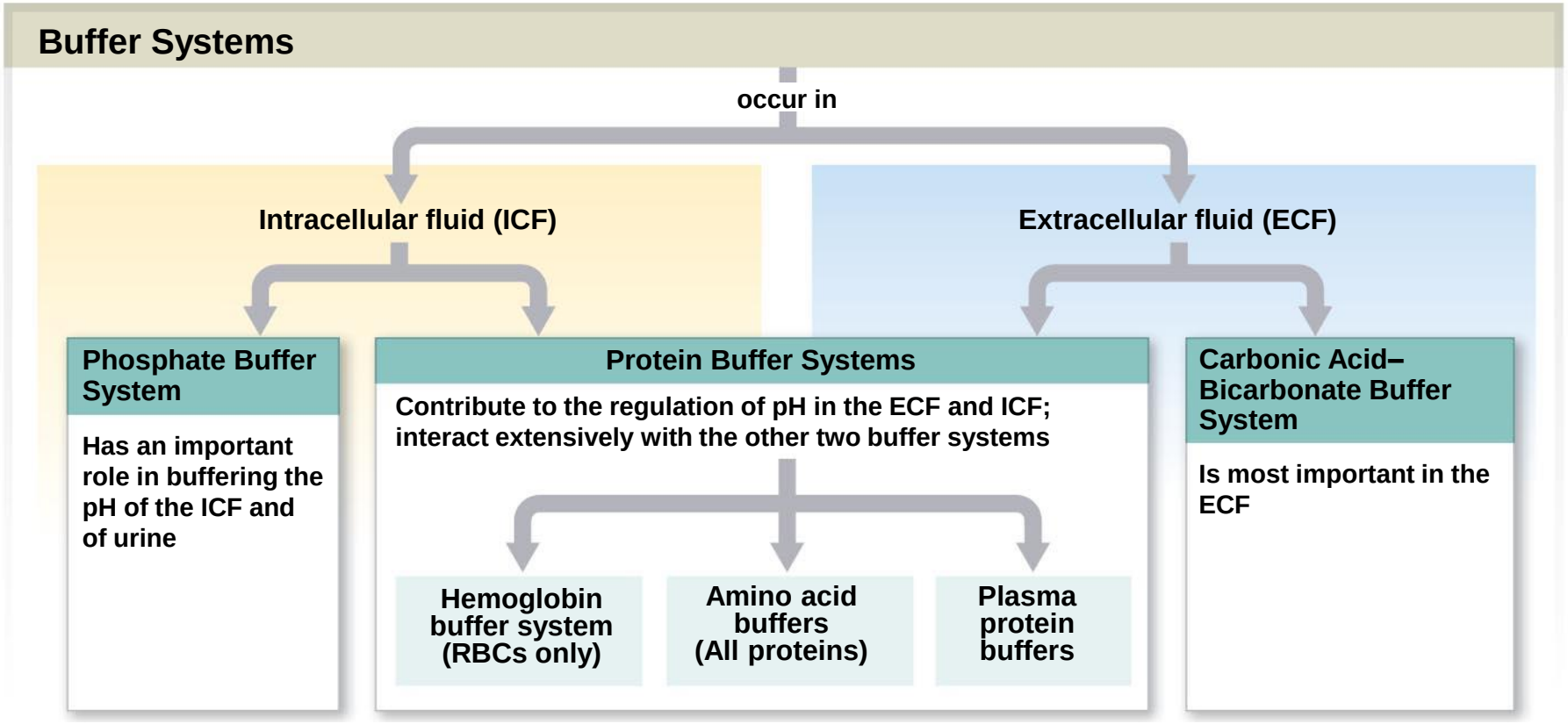


Figure 24.6

Specialized Fluids of the Body

- Lymph
- Milk
- Cerebrospinal fluid
- Amniotic fluid
- Aqueous humor
- Sweat
- Tears

Hypokalemia (<3.5mEq/L)

- Pathophysiology –
  - Decrease in K+ causes decreased excitability of cells, therefore cells are less responsive to normal stimuli

Hypokalemia (<3.5mEq/L)

- Contributing factors:
  - Diuretics
  - Shift into cells
  - Digitalis
  - Water intoxication
  - Corticosteroids
  - Diarrhea
  - Vomiting

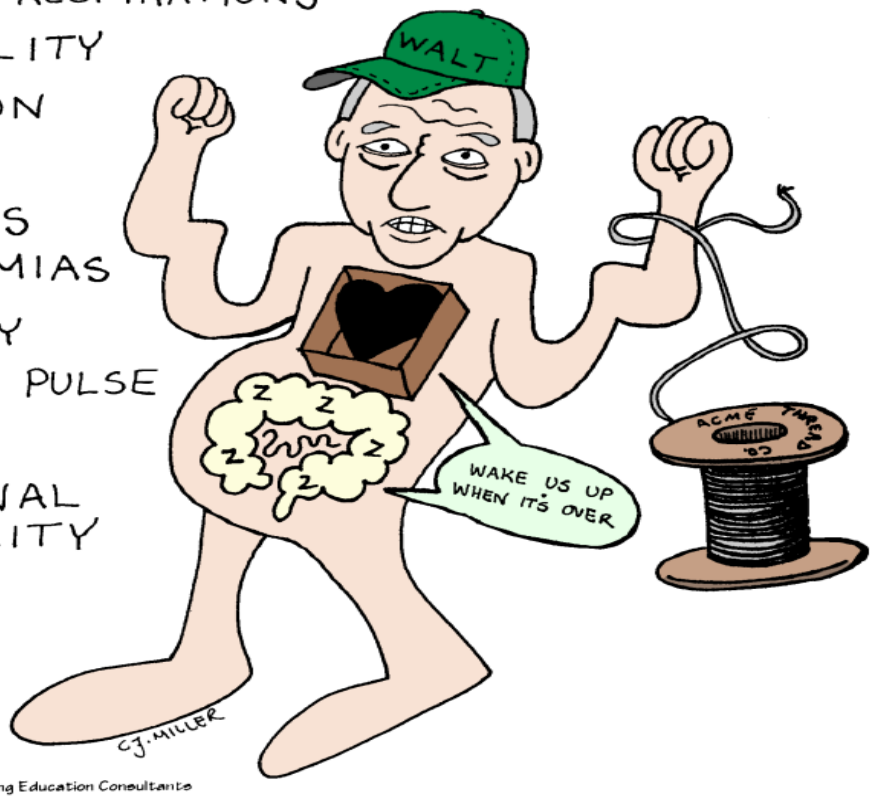
K^+ POTASSIUM DEFICIT

* ALKALOSIS

* SHALLOW RESPIRATIONS
* IRRITABILITY
* CONFUSION

* WEAKNESS
* ARRHYTHMIAS
* LETHARGY
* THREADY PULSE

* ↓ INTESTINAL MOTILITY



Hypokalemia (<3.5mEq/L)

- Interventions
  - Assess and identify those at risk
  - Encourage potassium-rich foods
  - K+ replacement (IV or PO)
  - Monitor lab values
  - D/c potassium-wasting diuretics
  - Treat underlying cause

Hyperkalemia (>5.0mEq/L)

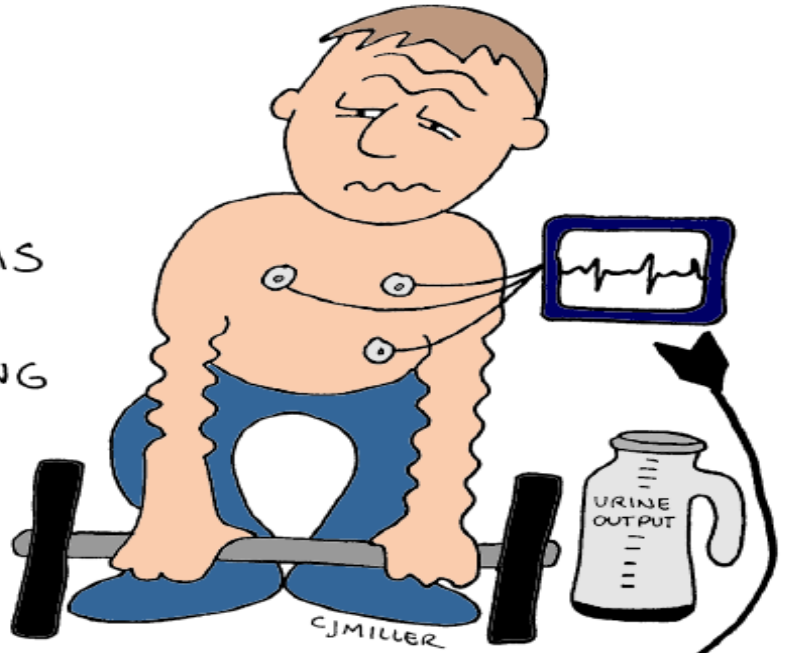
- Pathophysiology – An inc. in K+ causes increased excitability of cells.

Hyperkalemia (>5.0mEq/L)

- Contributing factors:
  - Increase in K+ intake
  - Renal failure
  - K+ sparing diuretics
  - Shift of K+ out of the cells

K^+ HYPERKALEMIA ↑

* MUSCLE CRAMPS → WEAKNESS → PARALYSIS
* DROWSINESS
* ↓ BP
* EKG CHANGES
* DYSRHYTHMIAS
* ABDOMINAL CRAMPING
* DIARRHEA
* OLIGURIA



Hyperkalemia (>5.0mEq/L)

- Interventions
  - Need to restore normal K+ balance:
  - Eliminate K+ administration
  - Inc. K+ excretion
    - Lasix
    - Kayexalate (Polystyrene sulfonate)
  - Infuse glucose and insulin
  - Cardiac Monitoring

Hypocalcemia (<9.0mg/dL)

- **Contributing factors (cont'd):**

  Acute pancreatitis

  Hyperphosphatemia

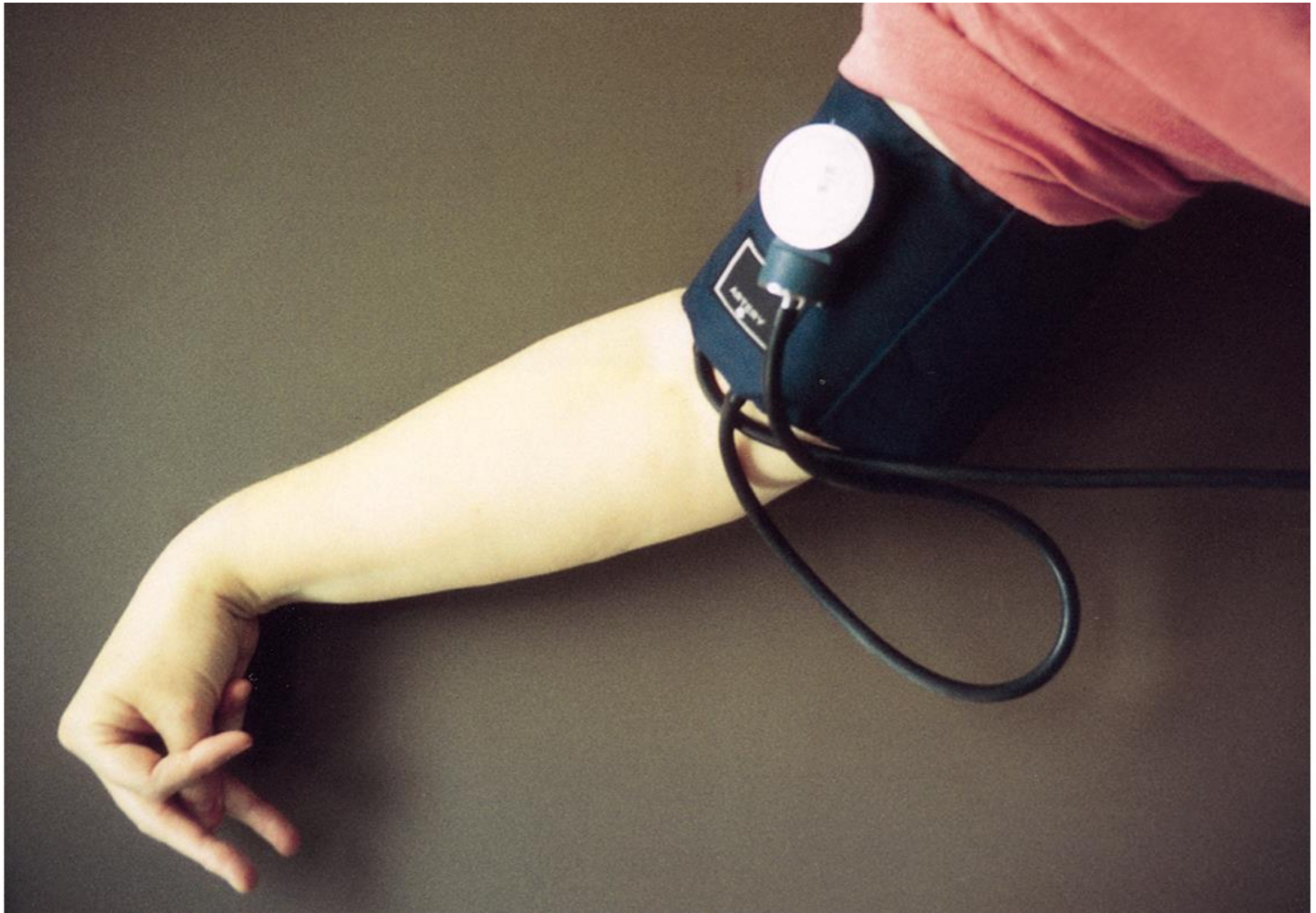
  Immobility

  Removal or destruction of parathyroid gland

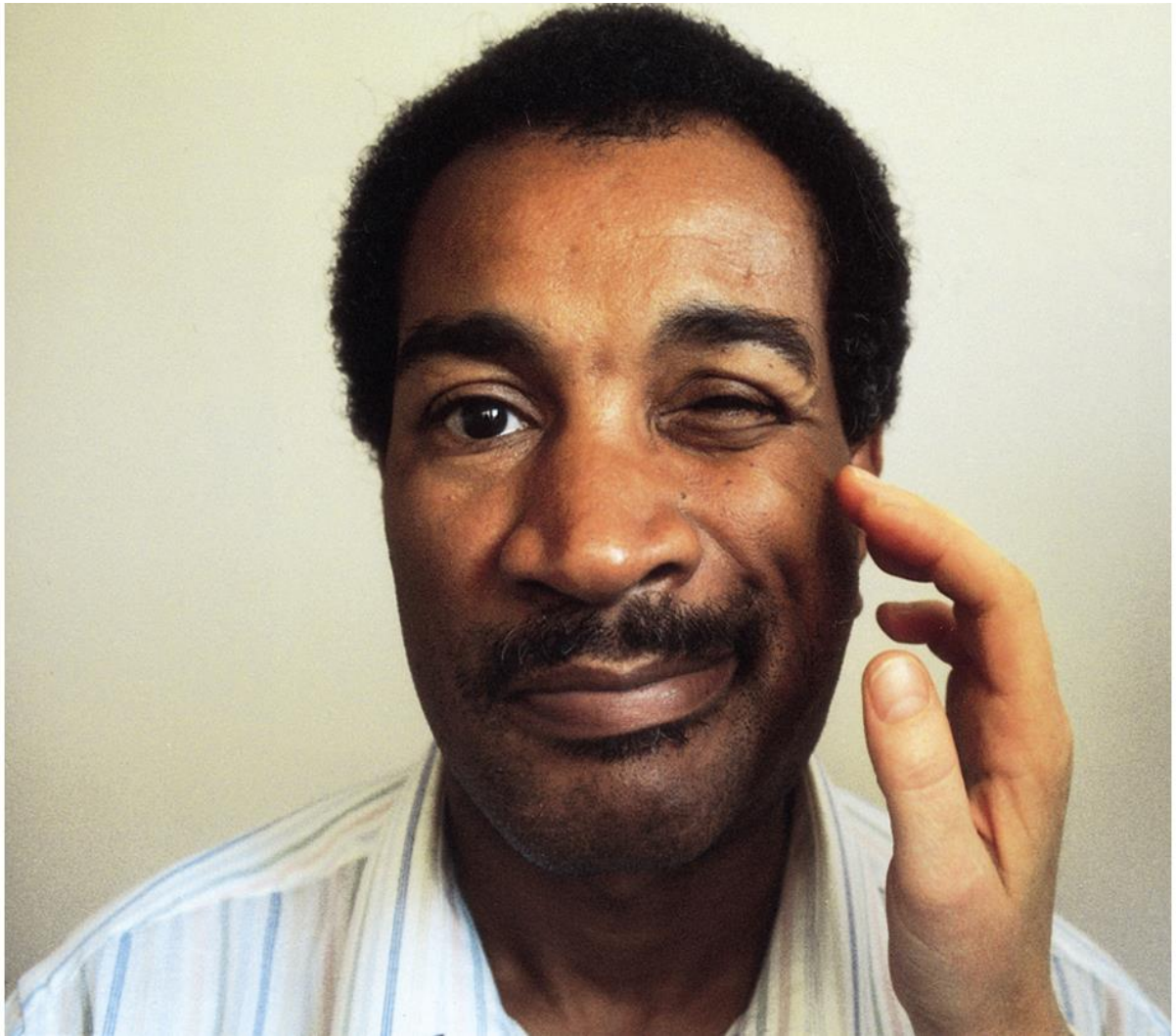
Hypocalcemia (<9.0mg/dL)

- **Assessment findings:**
  - Neuro –Irritable muscle twitches.
    - Positive Trousseau's sign.
    - Positive Chvostek's sign.
  - Resp. – Resp. failure d/t muscle tetany.
  - CV – Dec. HR., dec. BP, diminished peripheral pulses
  - GI – Inc. motility. Inc. BS. Diarrhea

Positive Trousseau's Sign



Positive Chvostek's Sign



Hypocalcemia (<9.0mg/dL)

- **Interventions/Treatment**
  - Drug Therapy
    - Calcium supplements
    - Vitamin D
  - Diet Therapy
    - High calcium diet
  - Prevention of Injury
    - Seizure precautions