

CHAPTER

7

Third Canadian Edition

nutrition

a functional approach

Janice Thompson
Melinda Manore
Judy Sheeshka

Nutrients Involved in Fluid and Electrolyte Balance and In Depth

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Fluids

- Substances composed of freely moving molecules
- Have the ability to conform to the shape of the container that holds them
- There are different types of fluids in our bodies

Fluids

50 – 70% of a healthy adult's body is composed of fluids

About $\frac{2}{3}$ of this fluid is within body cells and is called **intracellular fluid**

The remaining $\frac{1}{3}$ is **extracellular fluid**

Components of Body Fluid

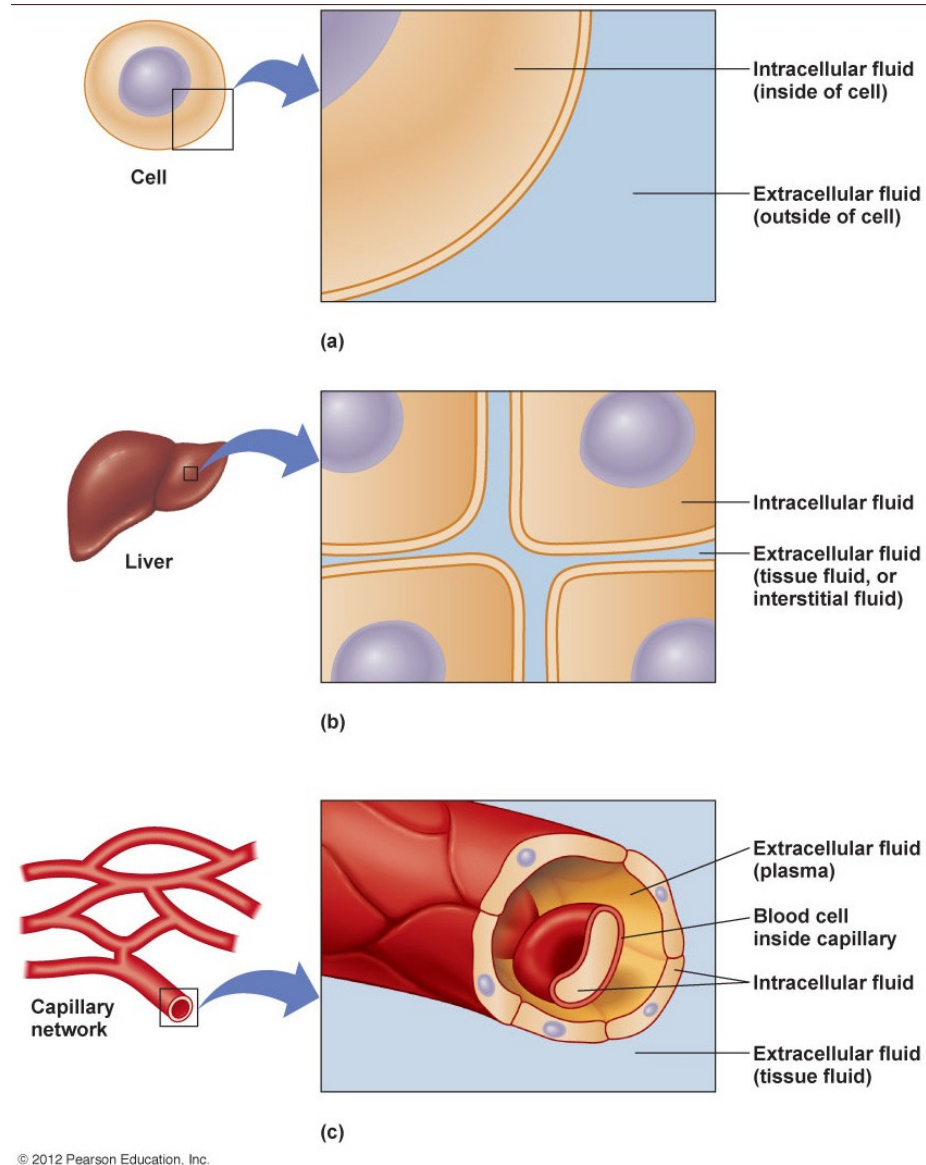


Figure 7.1

Fluids

Extracellular fluids include

- **Tissue fluid** found between the cells within tissues and organs of the body
- **Plasma**, the fluid portion of blood that carries the blood cells

Fluids

The body fluid composition of tissue varies by

- **Tissue type**—lean tissues have higher fluid content than fat tissues
- **Gender**—males have more lean tissue and therefore more body fluid
- **Age**—lean tissue is lost with age and body fluid is lost with it

Electrolytes

Body fluid is composed of

- Water
- Electrolytes: mineral salts dissolved in water, including
 - Sodium
 - Potassium
 - Chloride
 - Phosphorus

Electrolytes

Fluids have an overall **neutral charge** due to the balances between electrolytes

- In intracellular fluid, K^+ and HPO_4^{2-} are the predominant electrolytes
- In extracellular fluid, Na^+ and Cl^- predominate
- There is a slight electrical charge difference on either side of the cell membrane

Functions of Fluids

Fluids dissolve and transport substances

- Water is an excellent **solvent** because it can dissolve many different substances
- The dissolved materials, or **solutes**, include amino acids, glucose, water-soluble vitamins, minerals, and medications

Functions of Fluids

Fluids account for blood volume

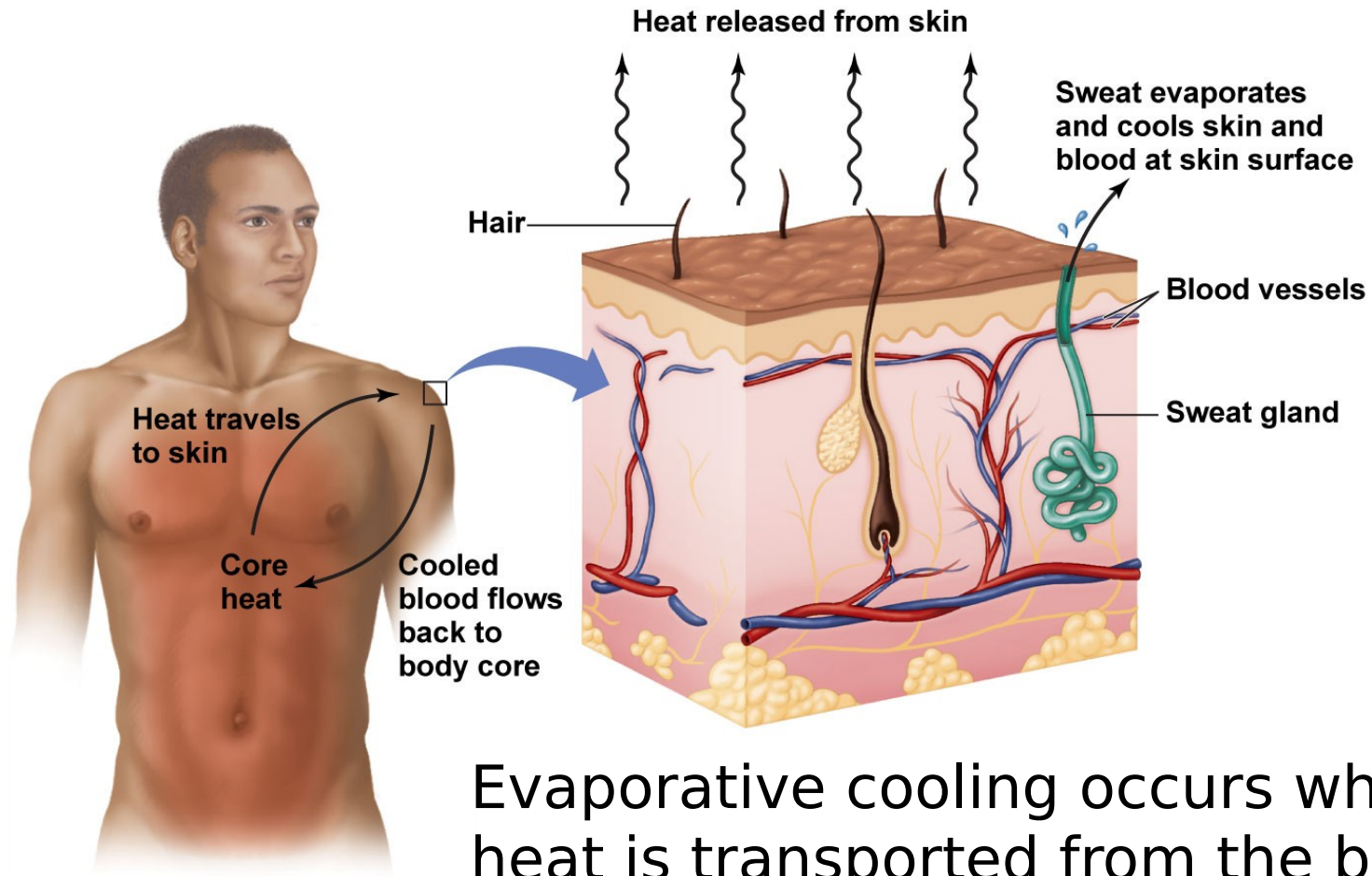
- **Blood volume** is the amount of fluid in the blood
- Increased blood volume can cause blood pressure to rise (**hypertension**)
- Decreased blood volume can cause low blood pressure (tiredness, confusion, dizziness)

Functions of Fluids

Fluids help maintain body temperature

- Because water has a high heat capacity, the temperature of our body fluids remains quite stable
- Sweating releases heat as the evaporation of water from the skin cools the skin and blood

Fluids Help Maintain Body Temperature



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Evaporative cooling occurs when heat is transported from the body core through the bloodstream to the surface of the skin.

Figure 7.2

Functions of Fluids

Fluids protect and lubricate body tissues

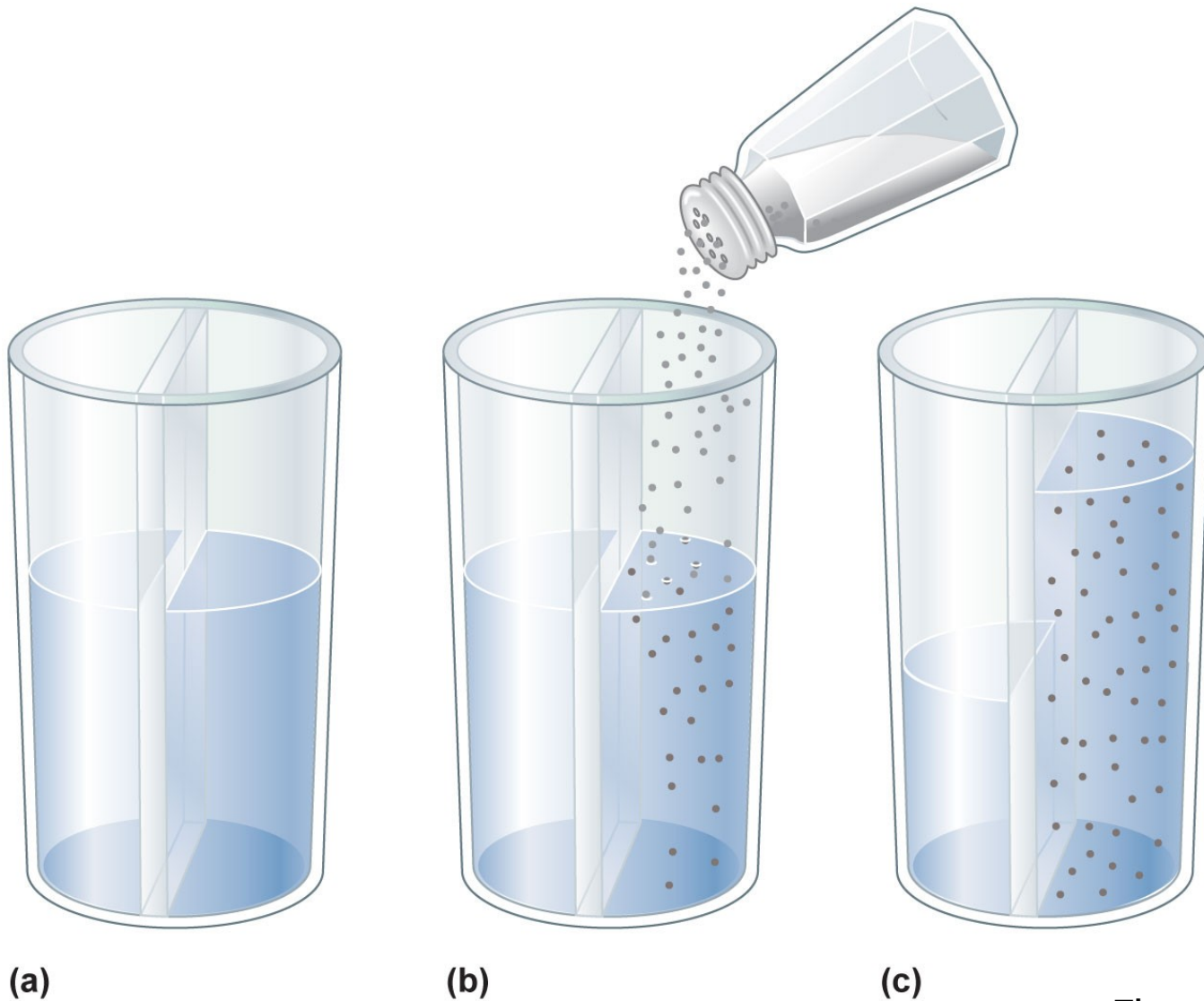
- Cerebrospinal fluid protects the brain and spinal column
- Amniotic fluid protects the fetus
- Synovial fluid is a lubricant around joints
- Digestive secretions allow for easy passage of material
- Pleural fluid covering lungs allows for expansion and contraction in chest cavity

Functions of Electrolytes

Electrolytes help regulate fluid balance

- Water follows the movement of electrolytes, moving by osmosis to areas where the concentration of electrolytes is high
- This allows for the controlled movement of fluids into and out of cells
- Some illnesses that lead to protracted vomiting and diarrhea can alter this balance

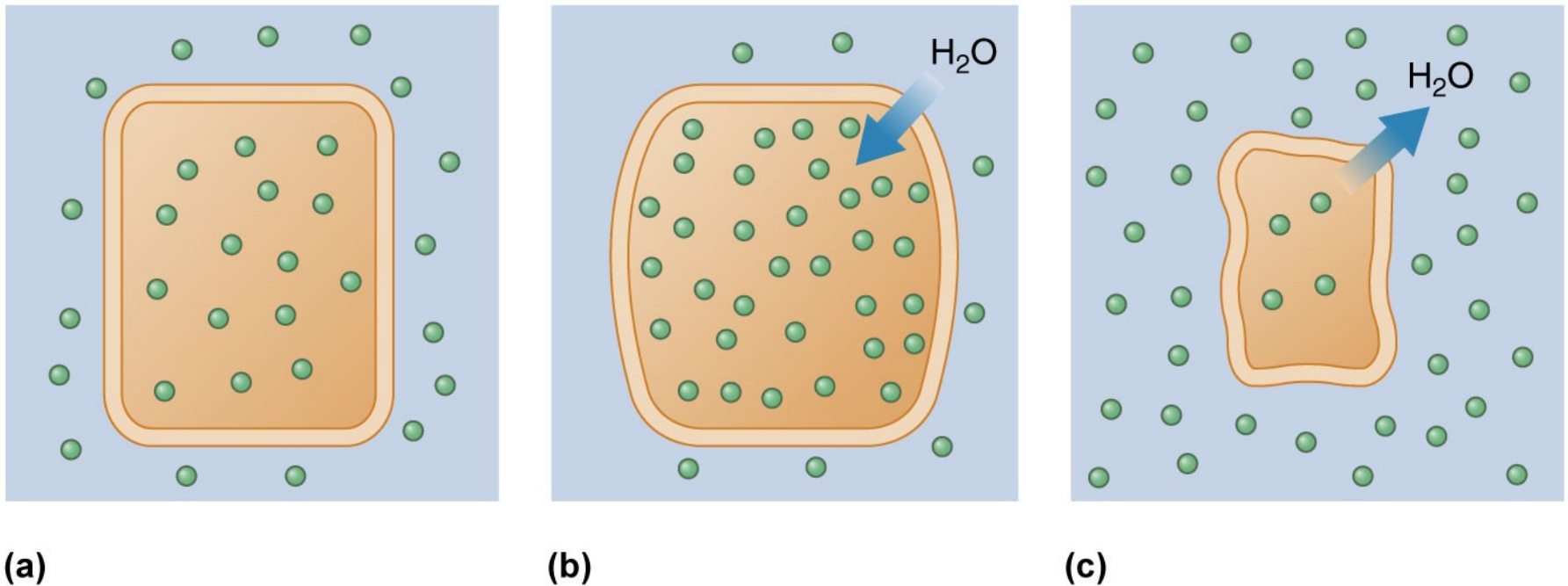
Functions of Electrolytes: Osmosis



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Figure 7.3

Fluid and Electrolyte Balance



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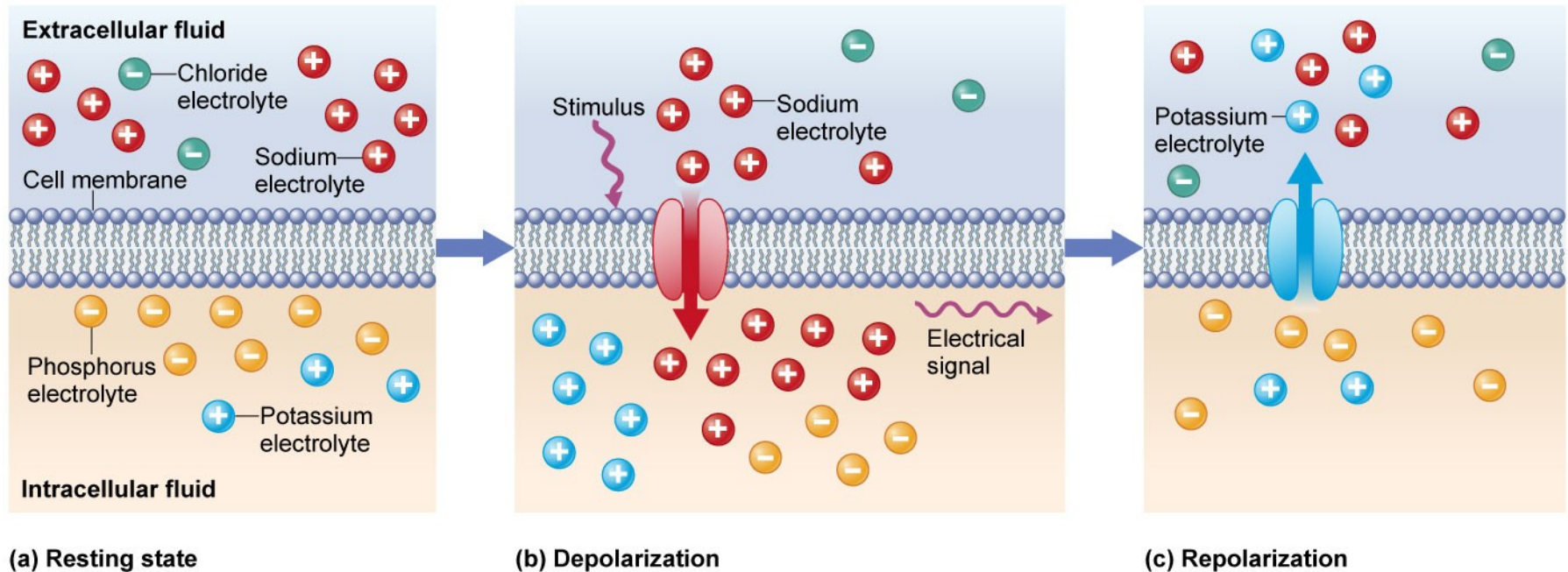
Figure 7.4

Functions of Electrolytes

Electrolytes help nerves respond to stimuli

- Movement of Na^+ and K^+ across the membranes of nerve cells changes the electrical charge across the membrane
- This change in electrical charge carries the nerve impulse along the nerve cell

Role of Electrolytes in Nerve Function



(a) Resting state

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(b) Depolarization

(c) Repolarization

Figure 7.5

Functions of Electrolytes

Electrolytes signal our muscles to contract

- The movement of calcium (Ca^{2+}) into a muscle cell stimulates the muscle to contract
- The Ca^{2+} is pumped back out of the cell after the muscle contraction

Maintaining Fluid Balance

Fluid balance is maintained by different mechanisms prompting us to drink and retain fluid

The **thirst mechanism** occurs from a cluster of nerve cells that stimulate our desire to drink

However, the thirst mechanism is not always sufficient; the amount of fluids people drink may not be enough to achieve fluid balance

Maintaining Fluid Balance

Water lost from the body must be replaced

Water is lost through urine, sweat, evaporation, exhalation, and feces

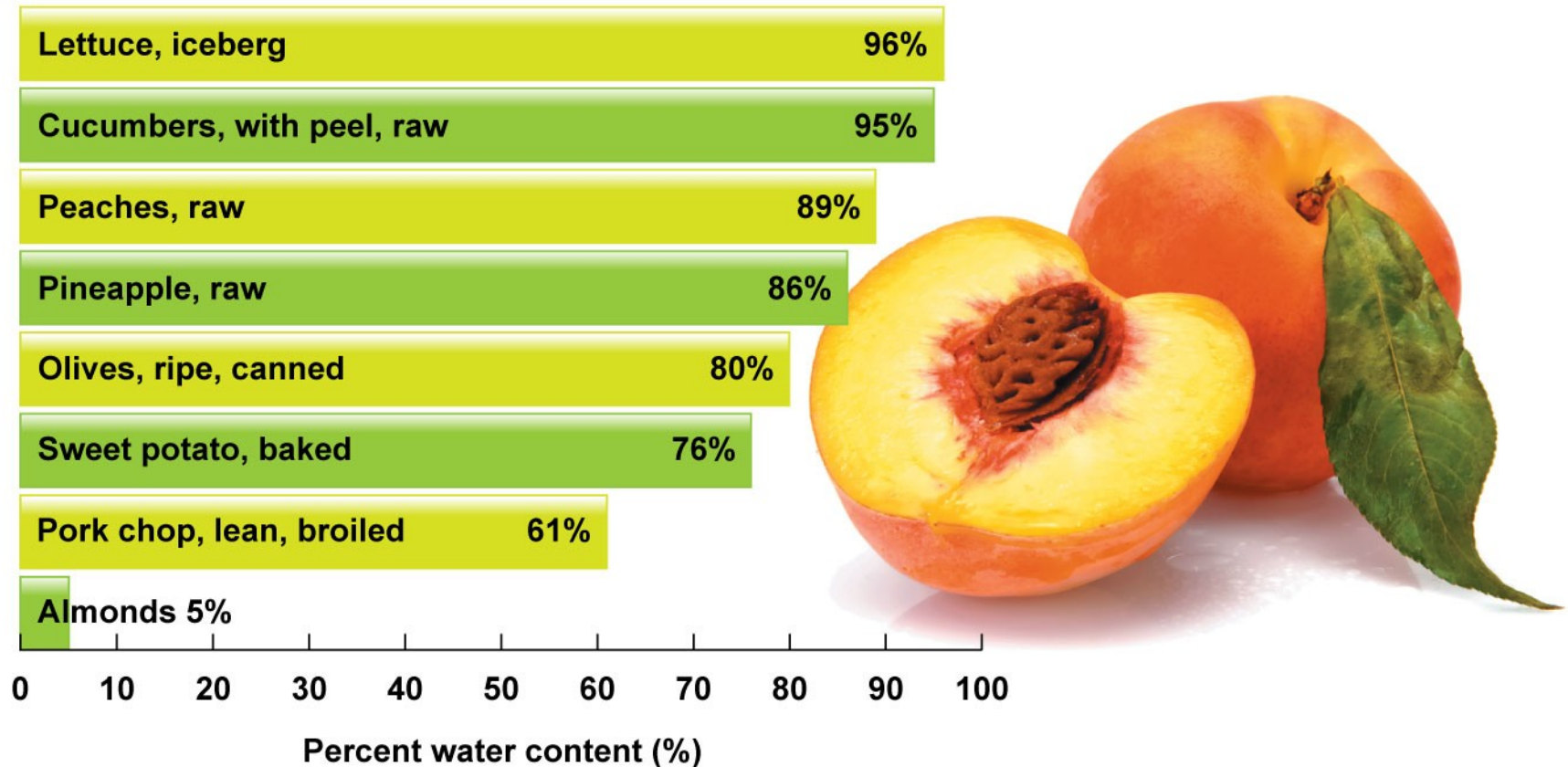
Water is gained through beverages, food, and metabolic reactions

Maintaining Fluid Balance

Loss of water

- Most water is lost through urine
- The **kidneys** control how much water is reabsorbed; excess water is processed by the kidneys and excreted as urine
- **Insensible water** is lost through the skin (sweat) or through the lungs during exhalation
- **Diuretics** increase fluid loss via the urine

Water Content of Various Foods



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Figure 7.6

Water

Functions of water

- Essential for life
- Required for fluid and electrolyte balance and many metabolic reactions

Recommended intake is very individualized

- Varies with environment, activity level
- DRI: adult men (19-50 yrs): 3.7 L
adult women (19 – 50 yrs): 2.7 L

Water

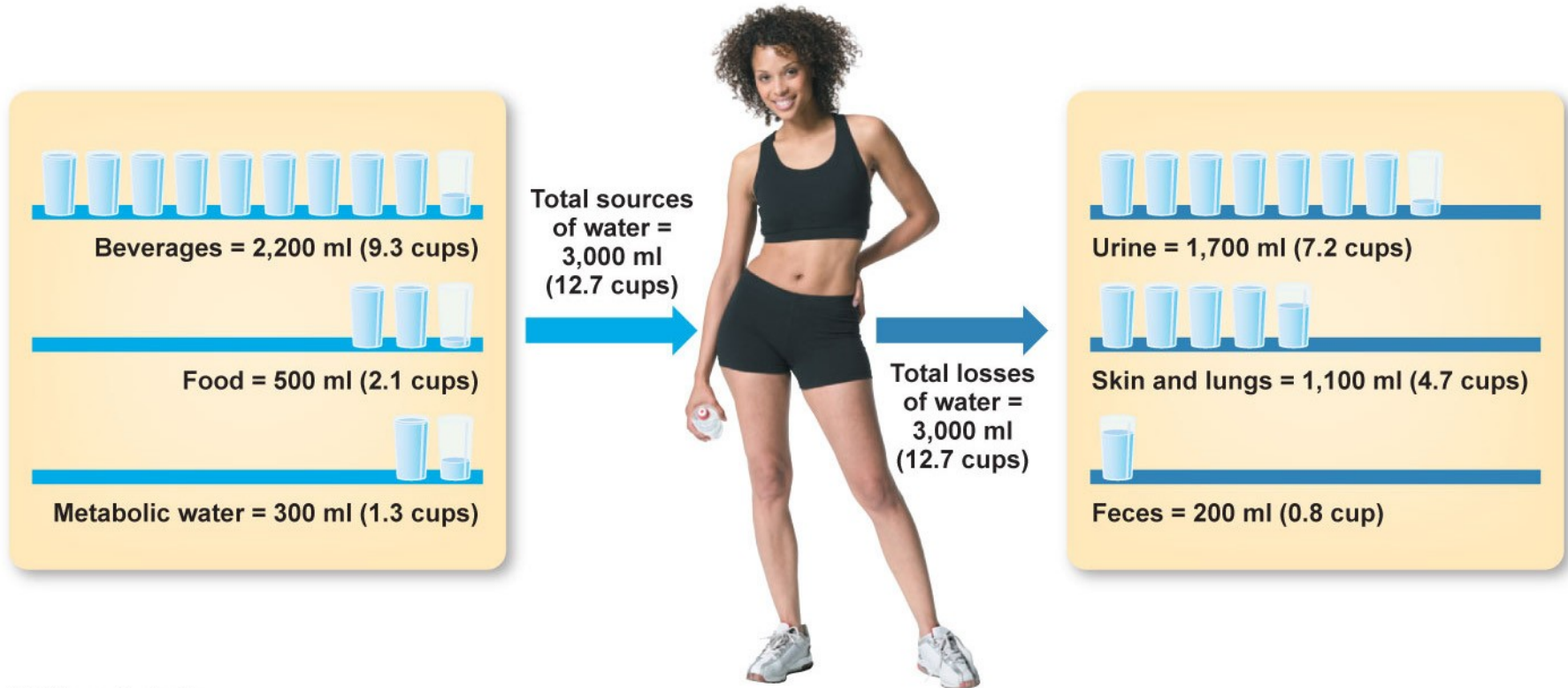
What if you drink too much water?

- Becoming overhydrated is rare
- Can result in a dilution of sodium (hyponatremia)

What if you don't drink enough water?

- Dehydration
- Infants and the elderly are especially vulnerable

Water Intake and Output



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Amount and sources of water intake and output for a woman expending 10 500-kJ (2500-kcal)/day

Figure 7.7

Sodium

Functions of sodium

- Fluid and electrolyte balance
- Associated with blood pressure and pH balance in the body
- Required for nerve impulse transmission
- Assists in the transport of certain nutrients (e.g., glucose) into body cells

Sodium

Recommended intake

- 1.5 g (1500 mg)/day is required
- Less than 2.3 g (2300 mg)/day is recommended

Sources of sodium

- Processed foods and restaurant foods are generally high in sodium

Most Canadians consume **more** than the
UL for sodium (2011)

Sodium

What if you consume too much sodium?

- **Hypernatremia:** abnormally high blood sodium concentration
- Can occur in patients with congestive heart failure or kidney disease
- Results in high blood volume, edema, and high blood pressure
- Can cause increased urinary excretion of calcium, possibly leading to potential risk of bone loss

Sodium

What if you don't consume enough sodium?

- **Hyponatremia:** an abnormally low blood sodium level
- Can result from prolonged vomiting, diarrhea, or sweating
- Has been seen in people engaged in strenuous physical activity who consume too much water and fail to replace sodium
- If left untreated, can lead to seizures, coma and death

Potassium

Functions of potassium

- Fluid and electrolyte balance
- Very important in muscle contractions and transmission of nerve impulses
- High potassium intake helps to maintain lower blood pressure

Potassium

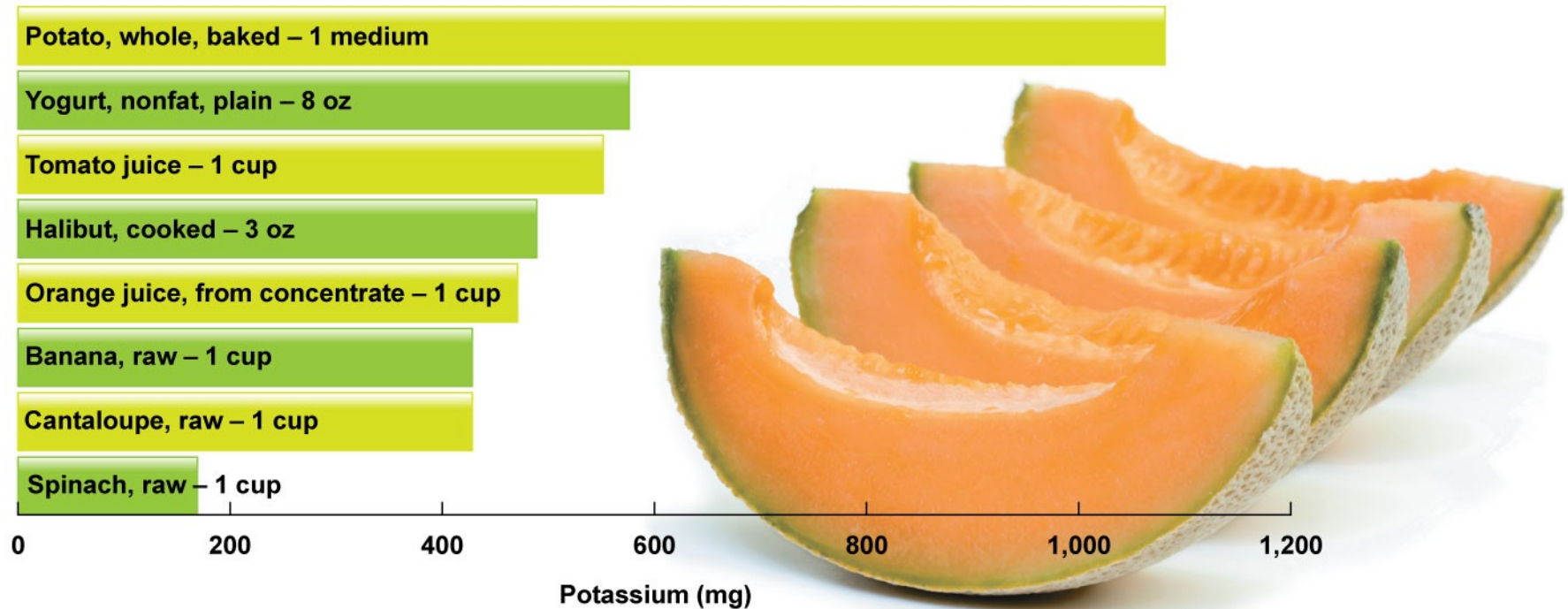
Recommended intake

- 4.7 g (4700 mg)/day
- Most Canadians do not consume the recommended amount of potassium

Sources of potassium

- Processed foods are usually low in potassium
- Fresh fruit and vegetables, legumes, dairy products, and whole grains are good sources

Common Foods Sources of Potassium



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Figure 7.8

Potassium

What if you consume too much potassium?

- **Hyperkalemia:** high blood potassium level
- Can occur in patients with kidney disease
- Can alter normal heart rhythm, resulting in a heart attack and death

Potassium

What if you don't consume enough potassium?

- **Hypokalemia:** low blood potassium levels
- Can be seen in patients with kidney disease or diabetic acidosis
- Can occur when taking certain diuretic medications

Chloride

Functions of chloride

- Assists with maintaining fluid balance
- Assists the immune system
- Component of HCl in the stomach
- Assists in the transmission of nerve impulses

Recommended intake

- Minimum recommendation is 2.3 g (2300 mg)/day

Chloride

What if you consume too much chloride?

- May lead to hypertension in salt-sensitive patients
- No DRI has been set

What if you don't consume enough chloride?

- This is rare, but can occur in people with eating disorders

Phosphorus

Functions of phosphorus

- The major intracellular negatively charged electrolyte
- Required for fluid balance
- Critical role in bone formation (85% of body's phosphorus is found in bone)
- Plays a key role in creating energy for the body
- Regulates biochemical pathways by activating or deactivating enzymes
- Found in ATP, DNA, RNA

Phosphorus

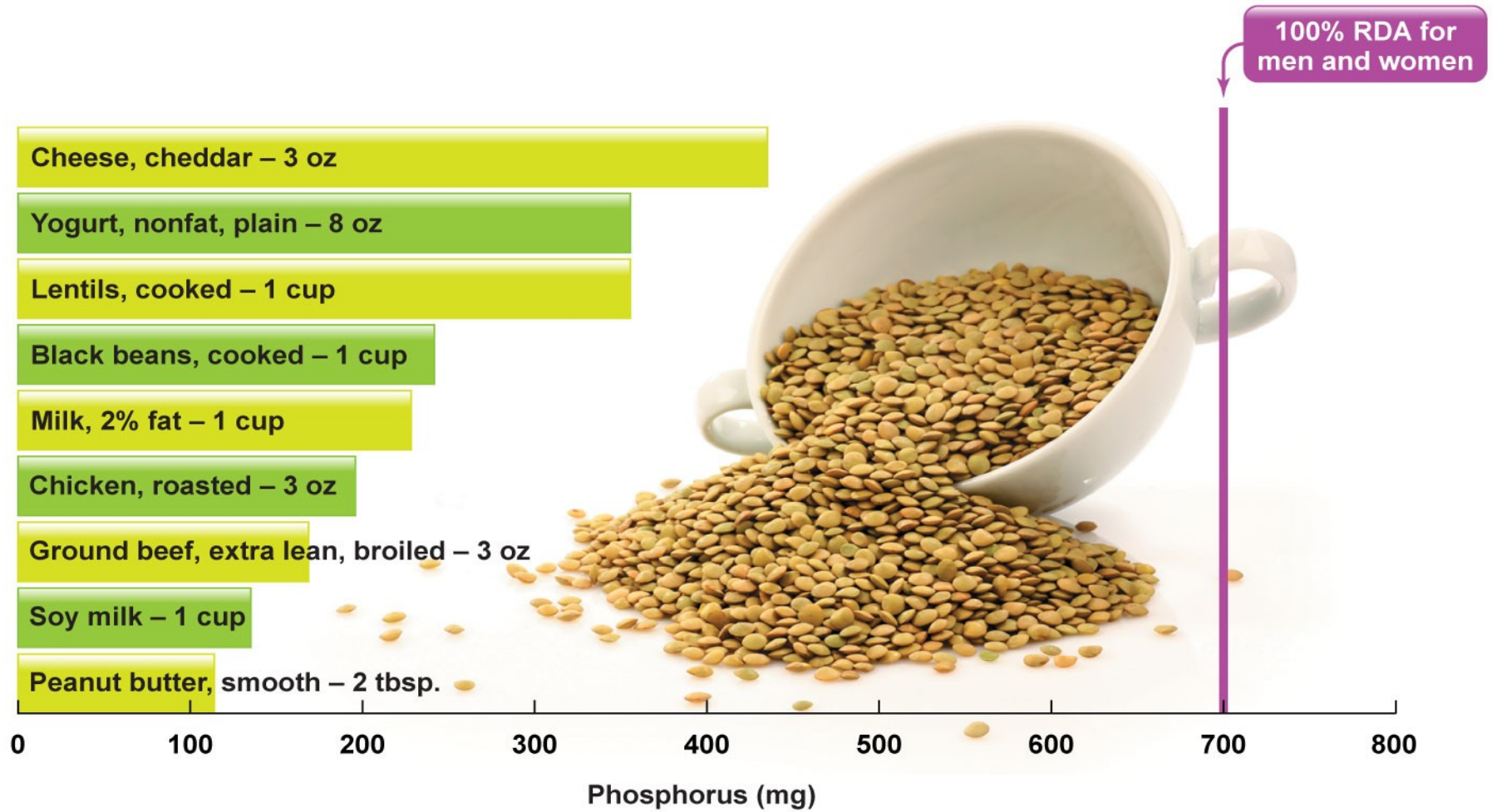
Recommended intake

- RDA is 700 mg/day

Sources of phosphorus

- Found widespread in many foods
- Found in high amounts in foods that contain protein (e.g., meat, milk, eggs)
- Absorbed more readily from animal sources than plant sources

Common Food Sources of Phosphorus



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Figure 7.9

Phosphorus

What if you consume too much phosphorus?

- High blood levels of phosphorus can occur with kidney disease or when taking too many vitamin D supplements
- Causes muscle spasms, convulsions

What if you don't consume enough phosphorus?

- Deficiencies of phosphorus are rare
- Those at risk are premature infants, elderly people consuming poor diets, or people who abuse alcohol

In Depth: Fluid Imbalance

Serious health problems that can occur when fluid excretion exceeds intake include

- Dehydration
- Heat illnesses

Dehydration

Dehydration occurs when water loss exceeds water intake

- Commonly due to heavy exercise or high environmental temperatures
- Infants and the elderly are more at risk

Dehydration

Other common causes of dehydration include

- Diarrhea
- Vomiting
- Fever
- Burns
- Poorly controlled diabetes
- Abuse of diuretics or laxatives

Dehydration

Dehydration is classified in terms of **percentage of weight loss** that is exclusively due to the loss of fluid

Dehydration

TABLE 1 Percentages of Body Fluid Loss Correlated with Weight Loss and Symptoms

Body Water Loss (%)	Weight Lost If You Weigh 75 kg (165 lb.)	Weight Lost If You Weigh 60 kg (132 lb.)	Symptoms
1–2	0.75–1.5 kg	0.6–1.2 kg	Strong thirst, loss of appetite, feeling uncomfortable
3–5	2.25–3.75 kg	1.8–3 kg	Dry mouth, reduced urine output, greater difficulty working and concentrating, flushed skin, tingling extremities, impatience, sleepiness, nausea, emotional instability
6–8	4.5–6 kg	3.6–4.8 kg	Increased body temperature that does not decrease, increased heart rate and breathing rate, dizziness, difficulty breathing, slurred speech, mental confusion, muscle weakness, blue lips
9–11	6.75–8.25 kg	5.4–6.6 kg	Muscle spasms, delirium, swollen tongue, poor balance and circulation, kidney failure, decreased blood volume and blood pressure

Data from Nutrition and Aerobic Exercise, edited by D. K. Layman. © 1986 American Chemical Society. (Converted to metric.)

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Table 1 In Depth

Using Urine Colour to Gauge Hydration

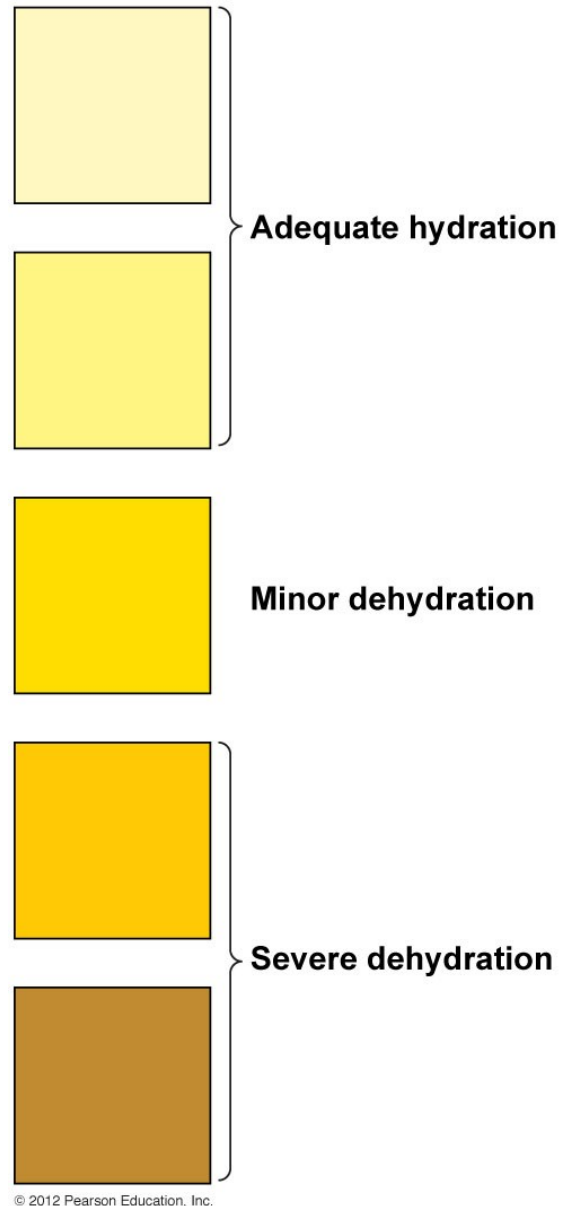


Figure 1 In Depth

Heat Illnesses

3 common types of heat illnesses closely linked to dehydration are

- Heat cramps
- Heat exhaustion
- Heat stroke

Heat Cramps

Painful muscle cramps, usually in the abdomen, arms, or legs

Develop during vigorous activity sessions in the heat

Spasms can last seconds or minutes

Important to stop activity immediately, cool down, and rest; cramps may signal a more serious problem

Heat Exhaustion

Typically occurs from vigorous activity in heat

May develop after several days in high heat when fluids are inadequate

Symptoms include cramps, weakness, vomiting, dizziness, and elevated blood pressure and pulse

Must be treated promptly and aggressively to prevent heat stroke from developing

Heat stroke

Heat stroke occurs if the body's temperature regulation mechanisms fail

- Occurs in hot, humid environments
- Symptoms include rapid pulse, hyperventilation, hot and dry skin, high body temperature, and weakness, etc.
- Has been fatal for athletes during exercise in extreme heat
- If it occurs, provide immediate cooling and rest, and contact emergency medical help quickly