Chapter 8: Water & Minerals

Brian J. Skerry/NG Image Collection

Student learning outcomes: At the end of this chapter, you should be able to:

- Describe the roles of water and minerals in health and disease
- Plan a diet to meet water and mineral recommendations

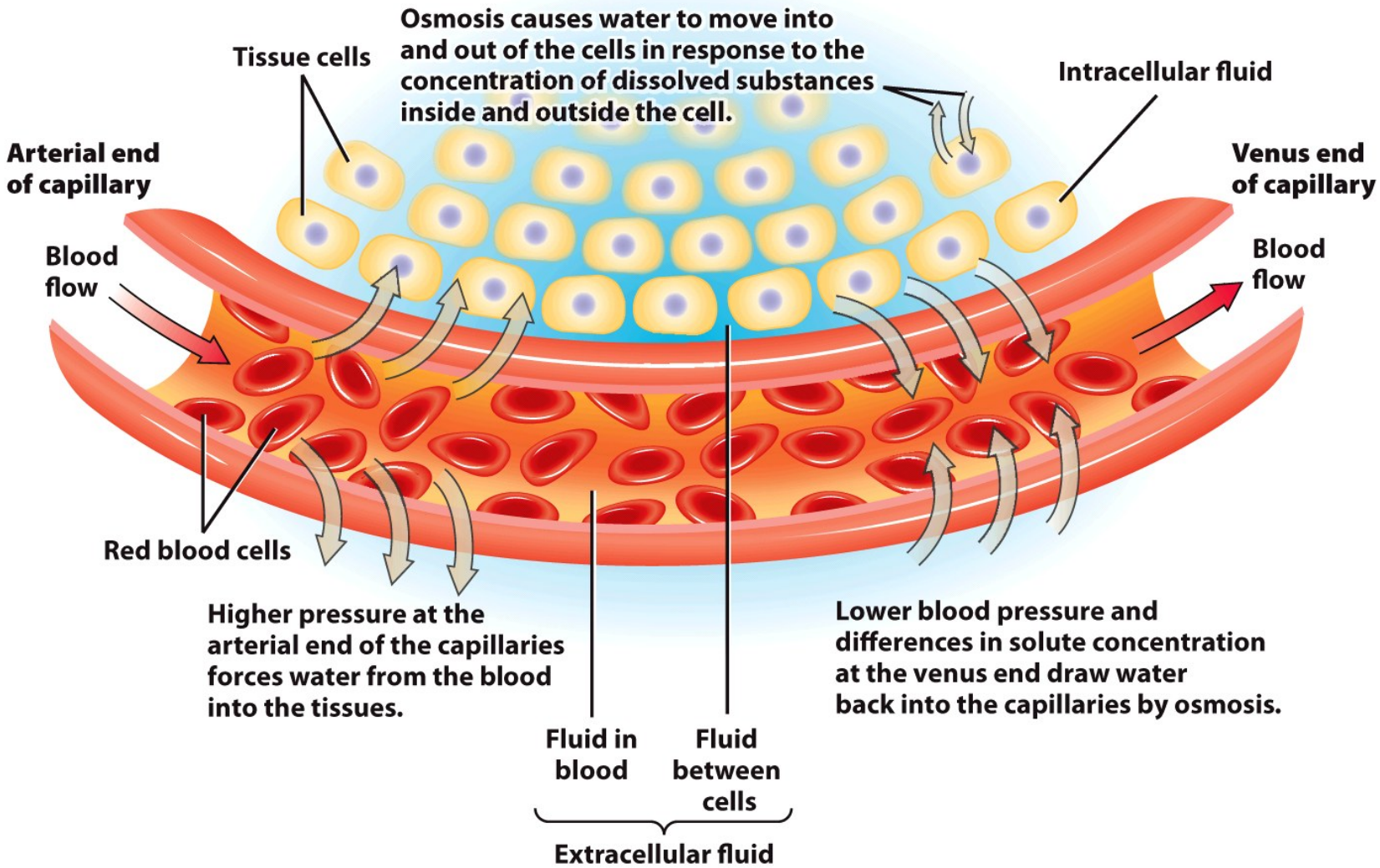
THINK about this – then share within a PAIR – then SHARE with the class

- What do you know about the supply of water?
- What do you know about the roles of water in the body?

Water in the body

- 60% of body weight
- 2/3 intracellular (within cells), 1/3 extracellular
- Cell membranes are permeable to water // Water crosses the membrane by osmosis to dilute dissolved solutes
- Blood pressure is generated by the heart to move water through blood vessels and into tissues

Water in the body



Think critically

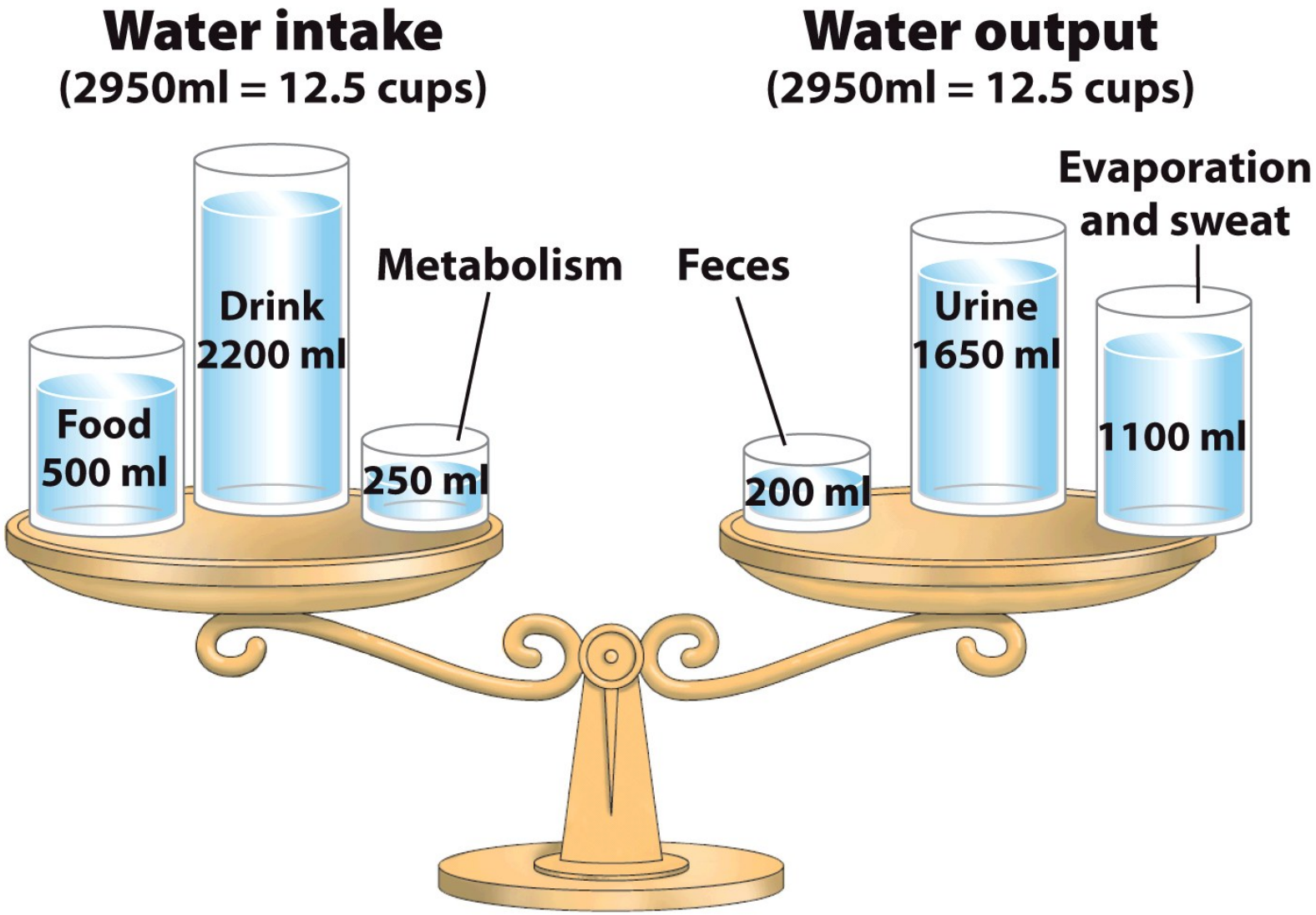
If the concentration of dissolved substances in the blood plasma was higher than in the fluid surrounding the blood vessel. What would happen to water?

a) It would move into the blood vessels
b) It would move out of the blood vessels
c) It would move into the blood cells
d) The amount in the blood would not change

Water balance

- Water is not stored
- Water in must equal water out
  - In: consumption of water, fluids, foods and production during cellular respiration
  - Out: excretion in urine and feces, evaporation from the skin and lungs, and sweating

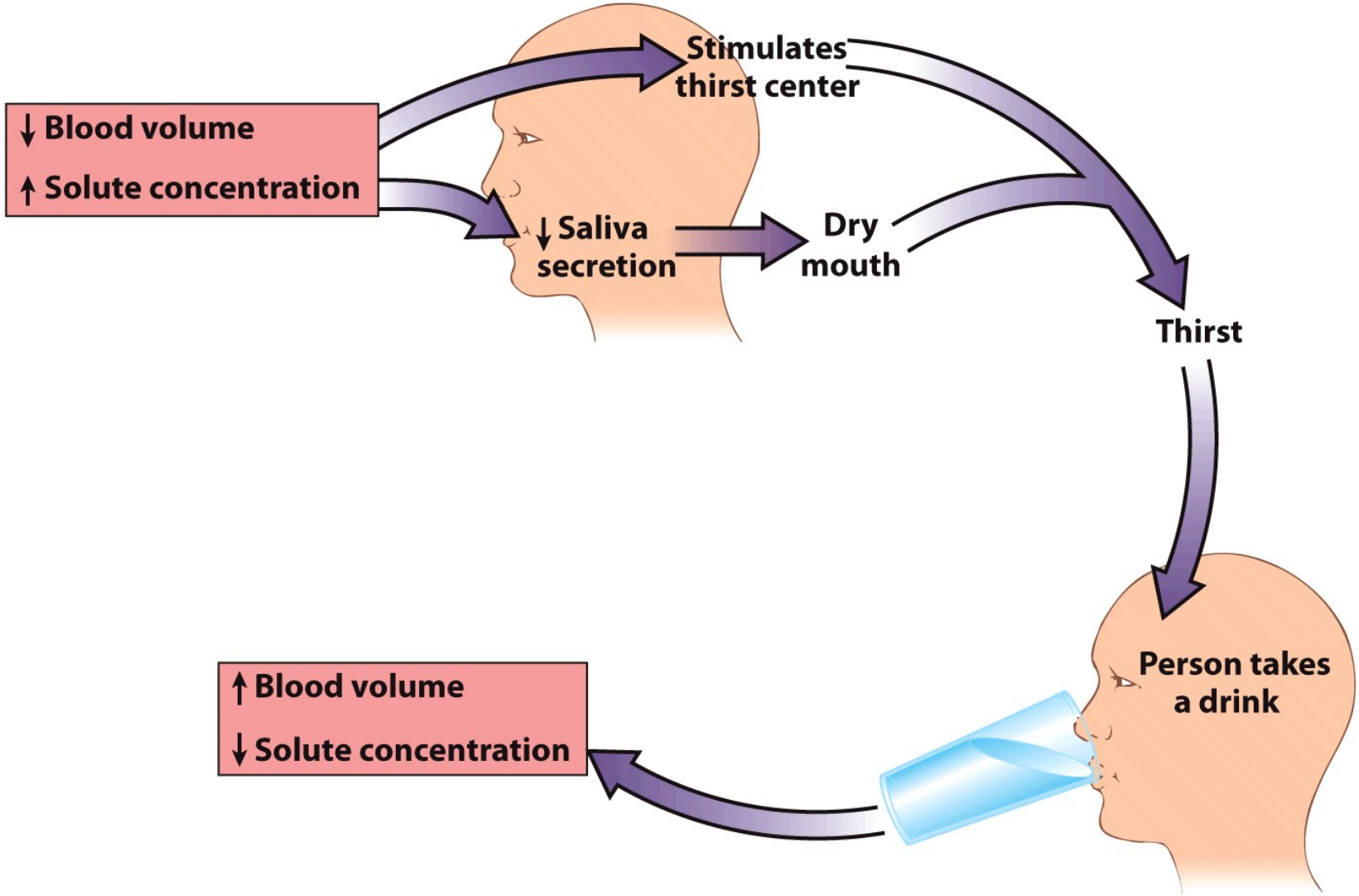
Water balance



THINK about this – then share within a PAIR – then SHARE with the class

- What causes increases in water loss?

Increased water loss stimulates thirst



Kidneys regulate body water

- Kidneys act as a filter
  - Water moves from the blood into kidney tubules
  - Blood cells and proteins are too large and remain in the blood
- Needed substances are reabsorbed back into the blood
- Un-needed substances are excreted in urine

Application

If you drink a lot of water, what would you expect to happen to:

- reabsorption?
- excretion?
- urine volume?

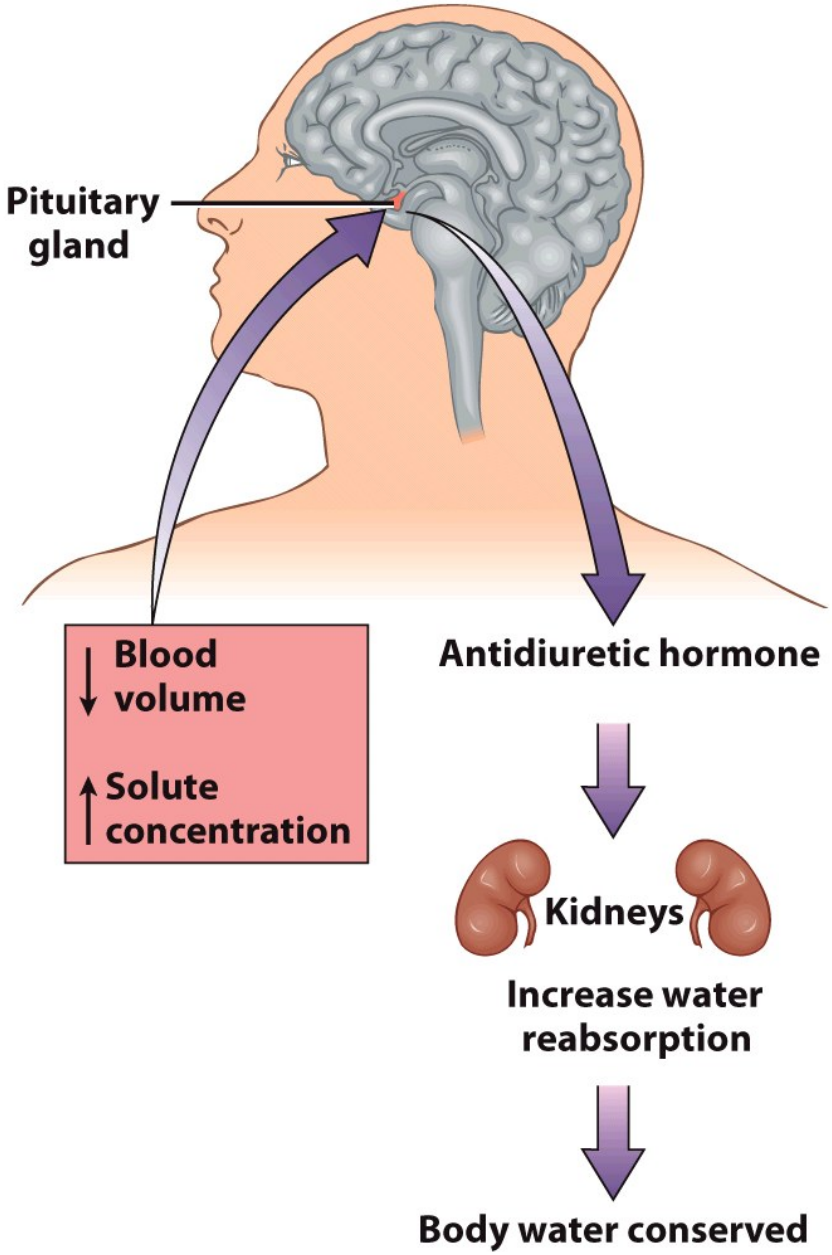
Antidiuretic hormone (ADH)

- If more water is lost than taken in, then the concentration of solutes in the blood increases
- This stimulates thirst and secretion of antidiuretic hormone (ADH) from the brain
- ADH stimulates the kidneys to reabsorb water (to keep the blood from becoming more concentrated)

Antidiuretic hormone (ADH)

Increased blood sodium → ADH secretion → Water reabsorption → Decreased blood sodium

Kidneys regulate body water



Application

Alcohol inhibits antidiuretic hormone.

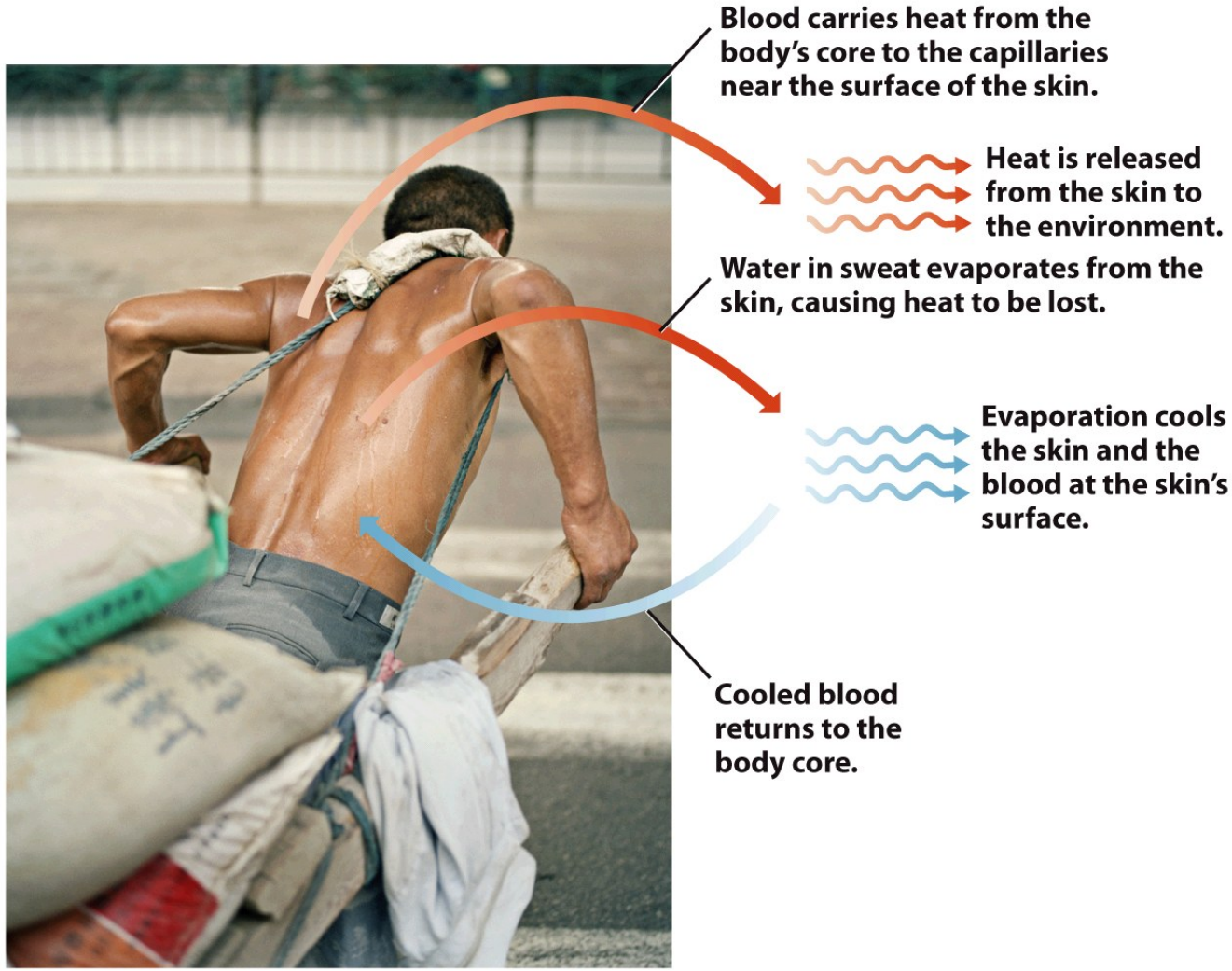
What would you expect to happen?

a) Increased reabsorption and excretion
b) Decreased reabsorption and excretion
c) Increased reabsorption and decreased excretion
d) Decreased reabsorption and increased excretion

Water functions

- Acts as a solvent: solutes (for example: glucose, proteins, minerals) dissolve in water
- Participates in chemical reactions
- Transports nutrients, oxygen, waste materials, hormones, etc. as the main component of blood
- Protects and cushions body structures
- Regulates pH and temperature

Water functions



Justin Guariglia/NG Image Collection

Dehydration

- Water loss is greater than water intake
- Reduces blood volume which reduces blood pressure

Application

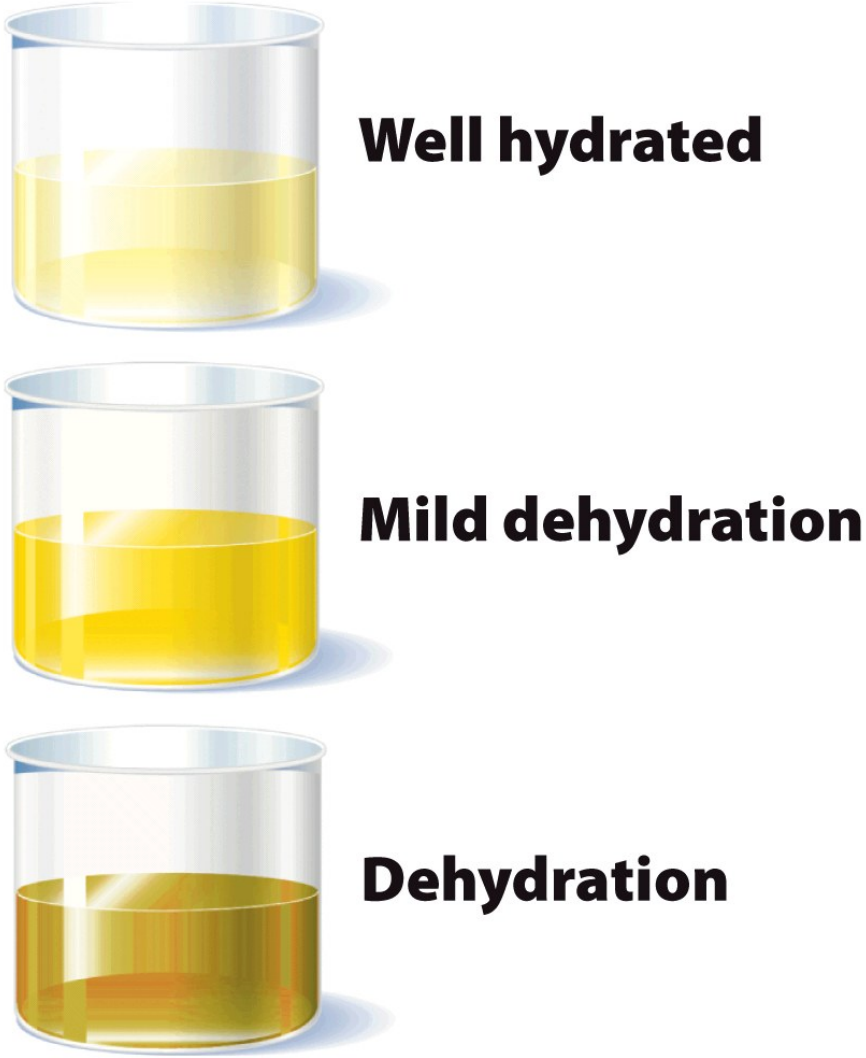
In a person with severe dehydration, what would you expect to happen to:

- delivery of nutrients and oxygen?
- secretion of antidiruetic hormone?
- reabsorption and excretion of water?

Why does alcohol consumption result in dehydration?

Dehydration

James P. Blair/NG Image Collection



Water intoxication (over hydration)

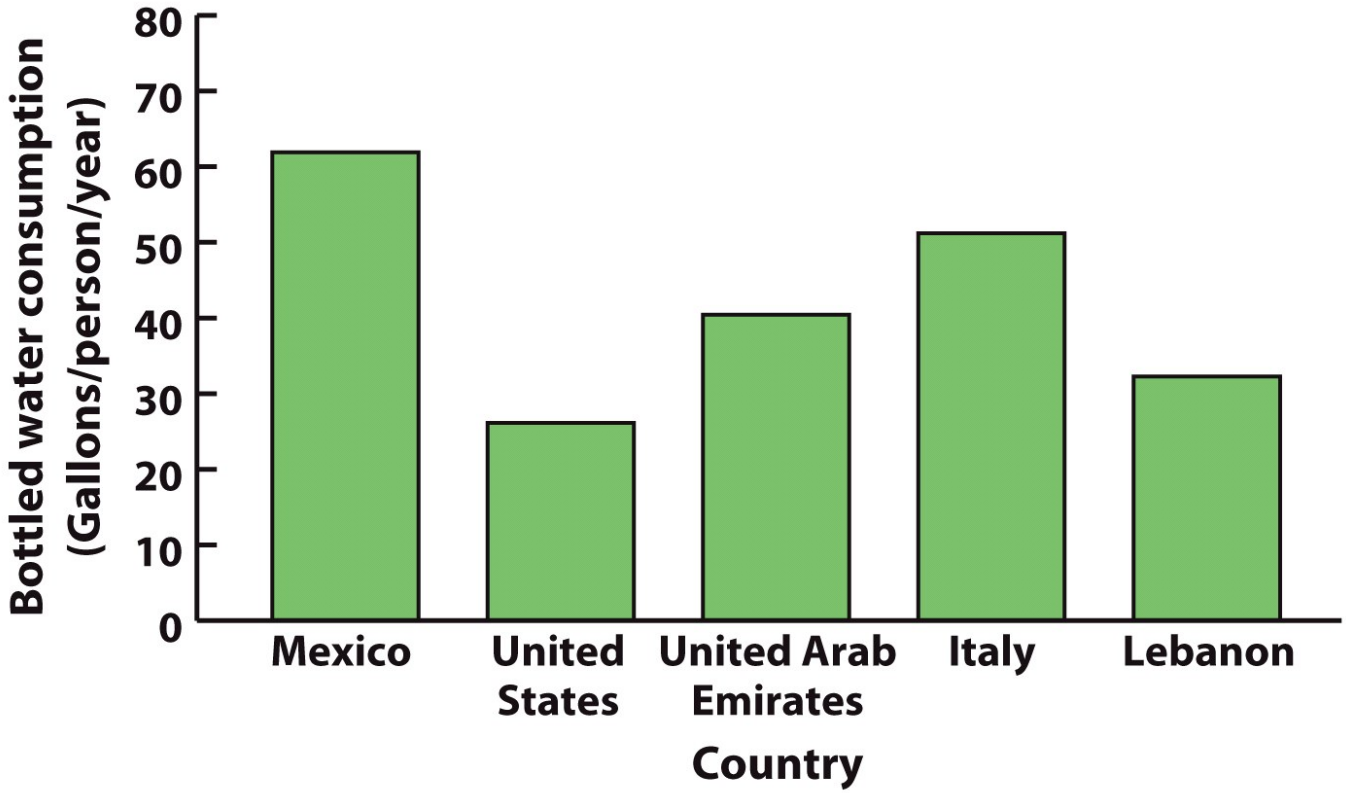
- Water intake is greater than water loss
- Sodium in blood is diluted causing hyponatremia
  - Hypo means low, Na is the chemical symbol for sodium, emia means in the blood
  - Water moves by osmosis from the blood into the tissues to try to dilute the higher concentration of solutes causing tissue swelling, or edema

Meeting water needs

- AI: men = 3.7 liters/day, women = 2.7 liters/day
- Need increased intake with:
  - Increased activity
  - Increased temperature
  - Decreased humidity
  - Low-calorie diet
  - High-salt diet
  - High-fiber diet
  - Alcohol intake

Debate

Is bottled water better?



Concept check

- How does osmosis affect the distribution of water in the body?
- What is the role of antidiuretic hormone?
- How does water help cool the body?
- Why do water needs increase when you exercise more?

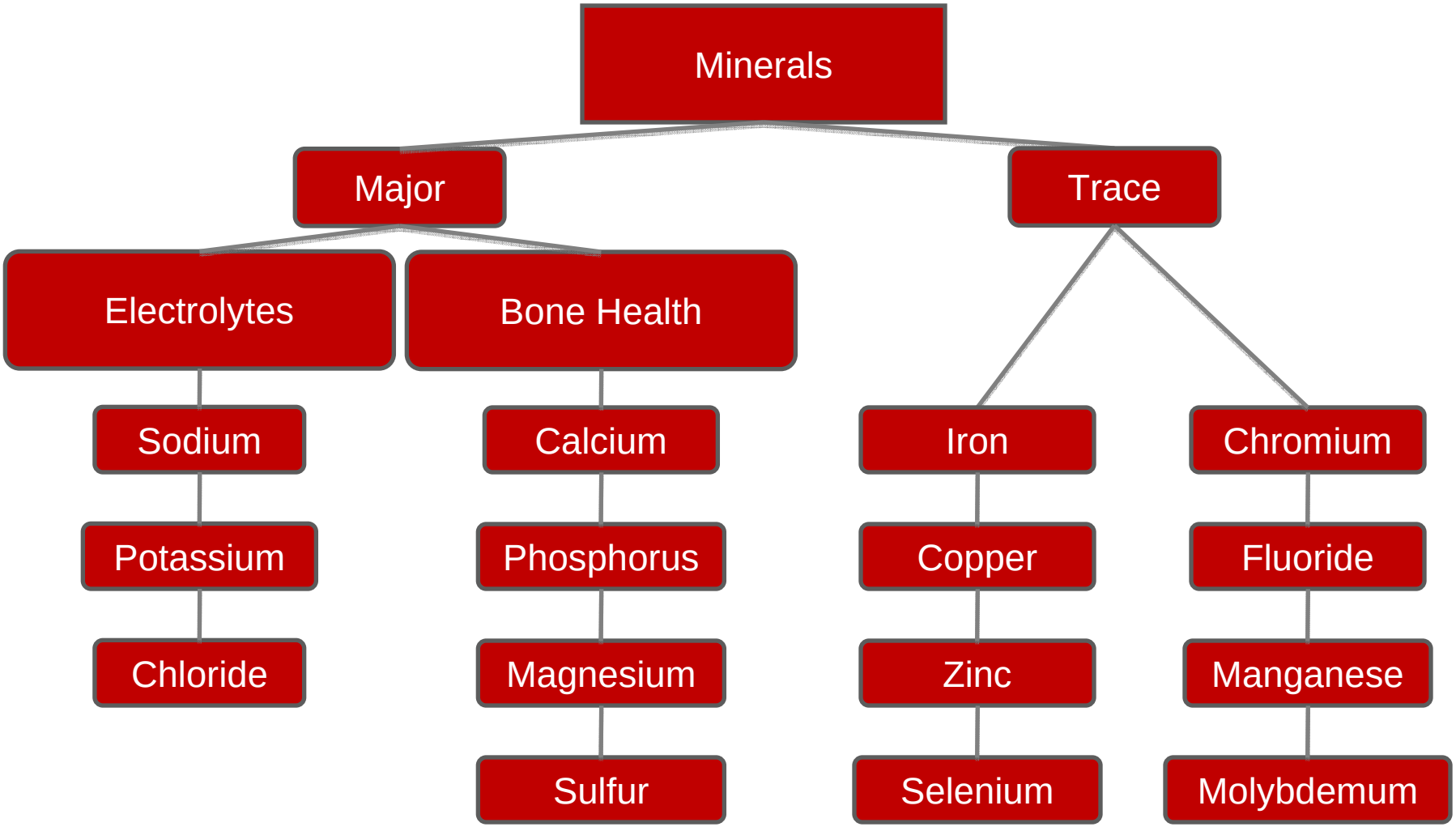
THINK about this – then share within a PAIR – then SHARE with the class

- What do you know about minerals?

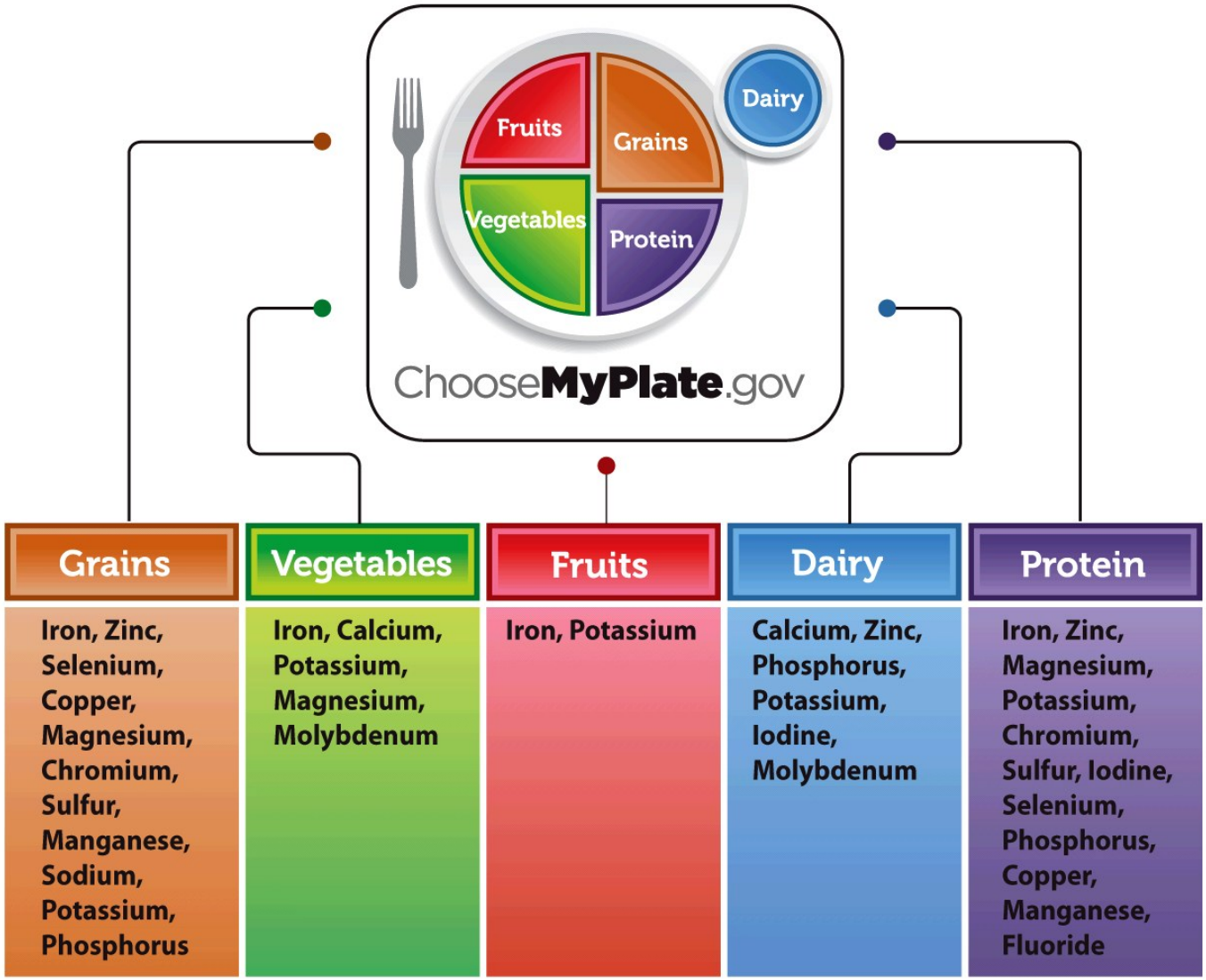
Minerals

- 20 needed by the body in small amounts
- Maintain structure and regulate chemical reactions and body processes
- Major mineral: need >100 milligrams/day
  - sodium, potassium, chloride, calcium, phosphorus, magnesium, and sulfur
- Trace mineral: need <100 milligrams/day
  - iron, copper, zinc, selenium, iodine, chromium, fluoride, manganese, molybdenum, and others

Minerals



Minerals



Minerals from food

- From plant and animal sources
- Affected by:
  - Amount in soil
  - Processing // Added (for example, during fortification) or // Removed (for example, by cooking or removing skins, bran, or germ)
  - Absorption and bioavailability // Inhibited by substances in plants, other minerals, or amount in body

Minerals from food

Oxalates, found in spinach, rhubarb, beet greens, and chocolate, have been found to interfere with the absorption of calcium and iron.

Tannins, found in tea and some grains, can interfere with the absorption of iron.

Phytates, found in whole grains, bran, and soy products, bind calcium, zinc, iron, and magnesium, limiting the absorption of these minerals. Phytates can be broken down by yeast, so the bioavailability of minerals is higher in yeast-leavened foods such as breads.

Charles D. Winters

Mineral functions

- Contribute to body structures
- Regulate body processes
- Regulate water balance
- Regulate energy metabolism
- Affect growth and development through their role in the expression of certain genes
- Act as cofactors needed for enzyme activity

Mineral functions

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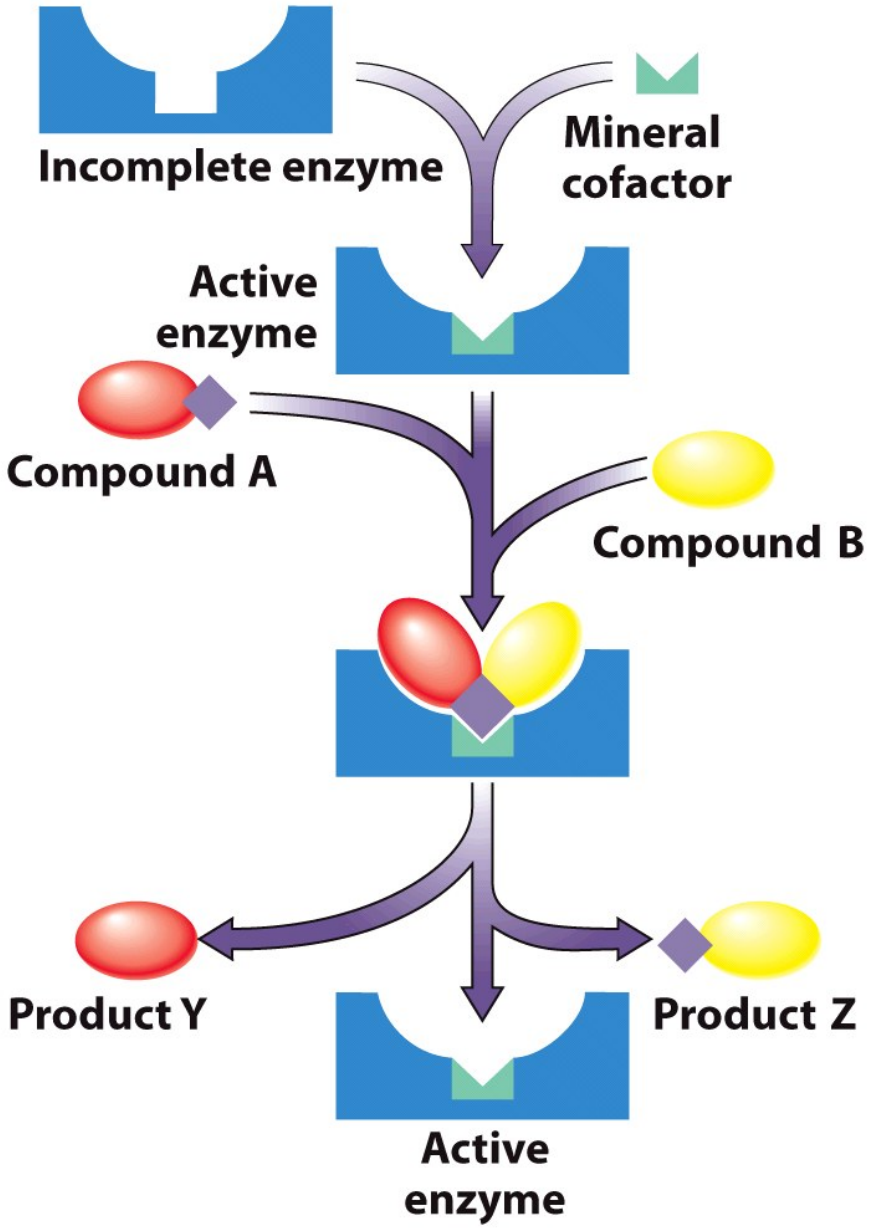
Mineral functions – as a cofactors



Concept check

- How do minerals and vitamins differ?
- How do phytates, oxalates, and tannins decrease mineral bioavailability?
- What is the function of a cofactor?

THINK about this – then share within a PAIR – then SHARE with the class

- What do you know about electrolytes?

Electrolytes

- Ions = charged atoms

  - charge: gained a negative electron (anion)

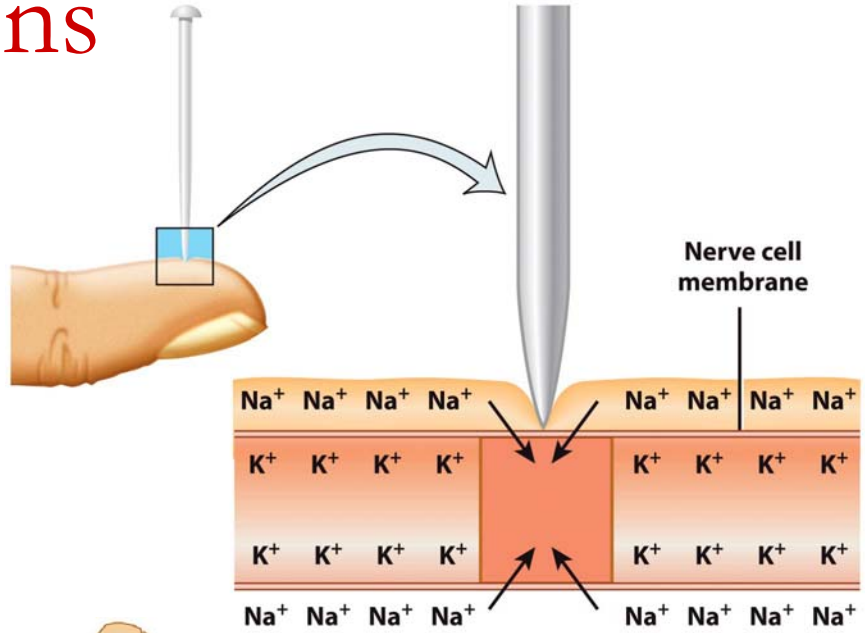
  + charge: lost a negative electron (cation)

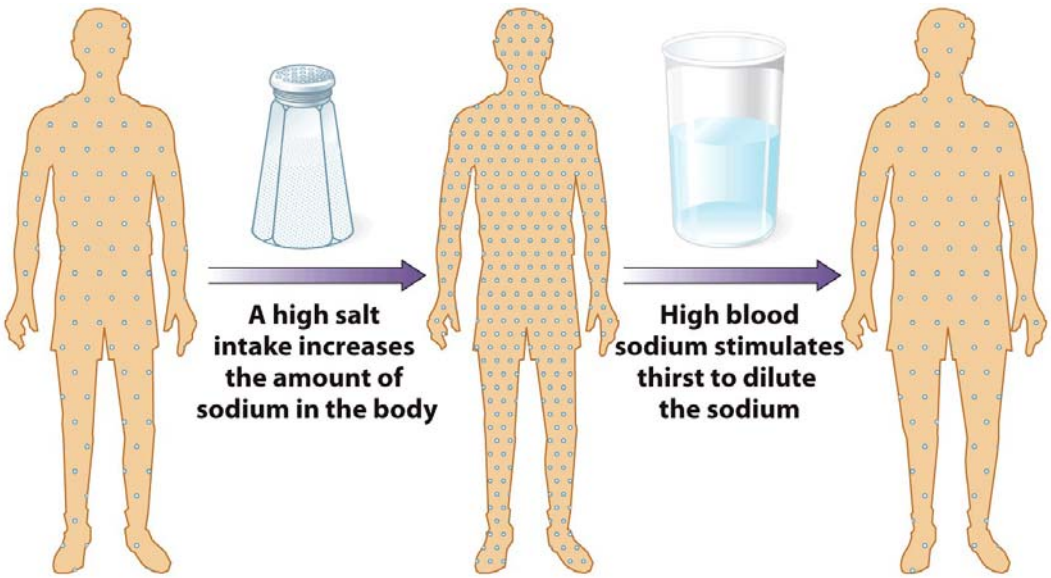
- Fluid balance maintenance, nerve impulse conduction, cellular signaling

Electrolytes

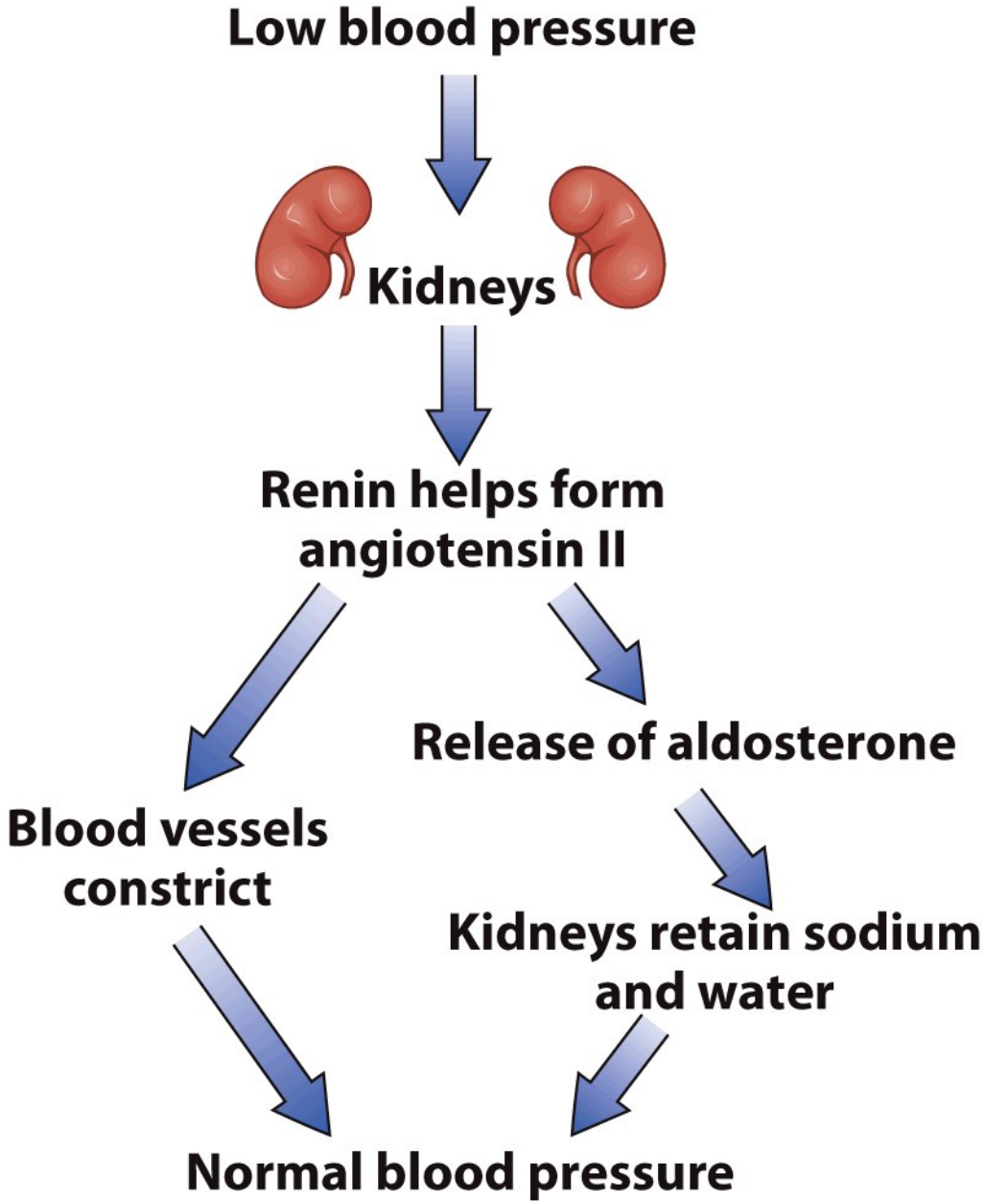
- Sodium
  - + charge: lost a negative electron
  - extracellular: outside of cells
- Potassium
  - + charge: lost a negative electron
  - intracellular: inside of cells
- Chloride
  - – charge: gained a negative electron
  - extracellular: outside of cells

Electrolyte functions





Electrolyte functions



Hypertension

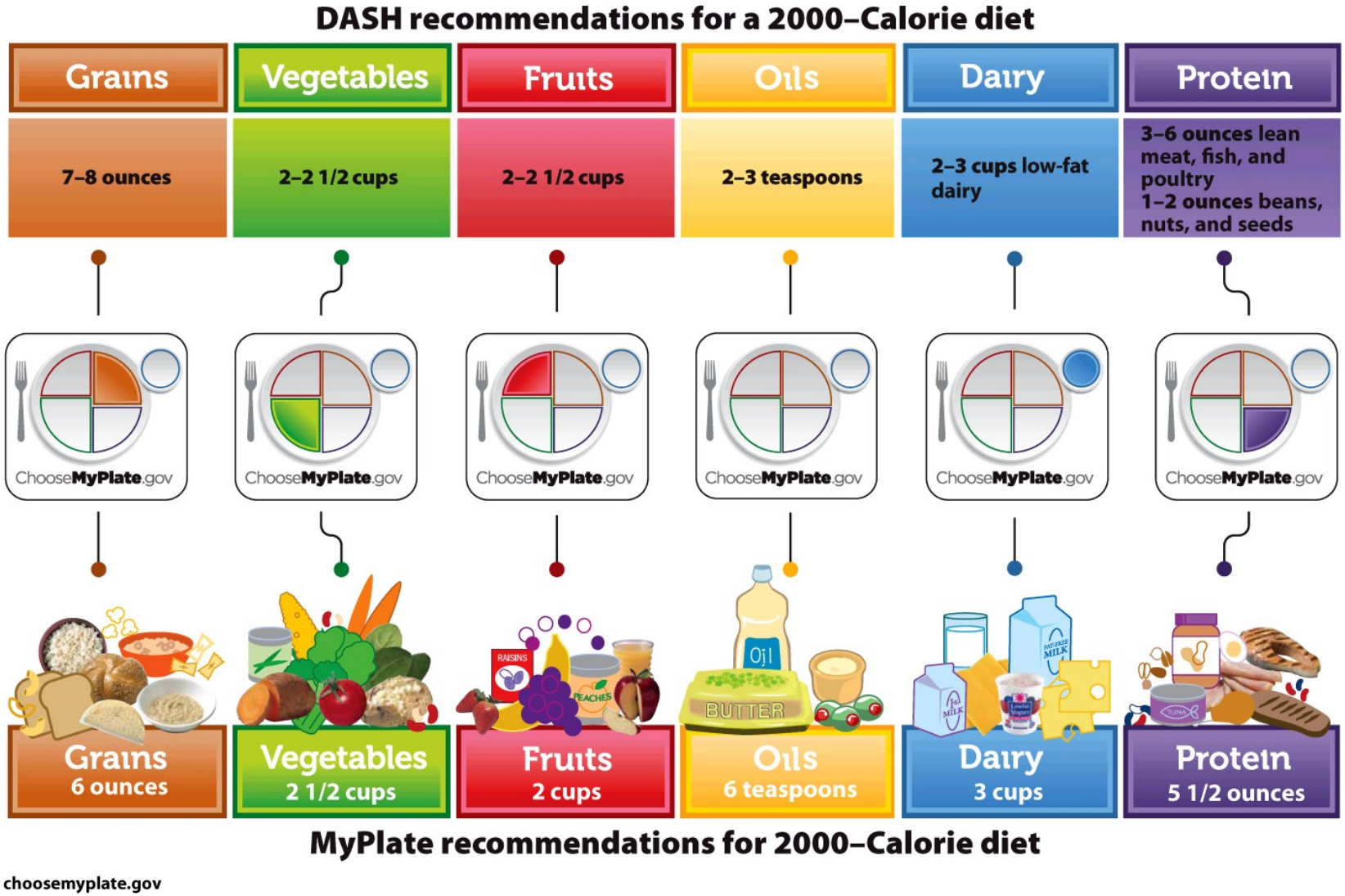
- Blood pressure consistently at or above 140/90 mm mercury
- Caused by: increased contractions of the heart, increased blood volume, or decreased radius of blood vessels
- Results in: atherosclerosis, heart attacks, strokes, death
- Treated with: diet, exercise, and medication
- Risks: genetics, race, age, obesity, diet, activity

Hypertension and diet

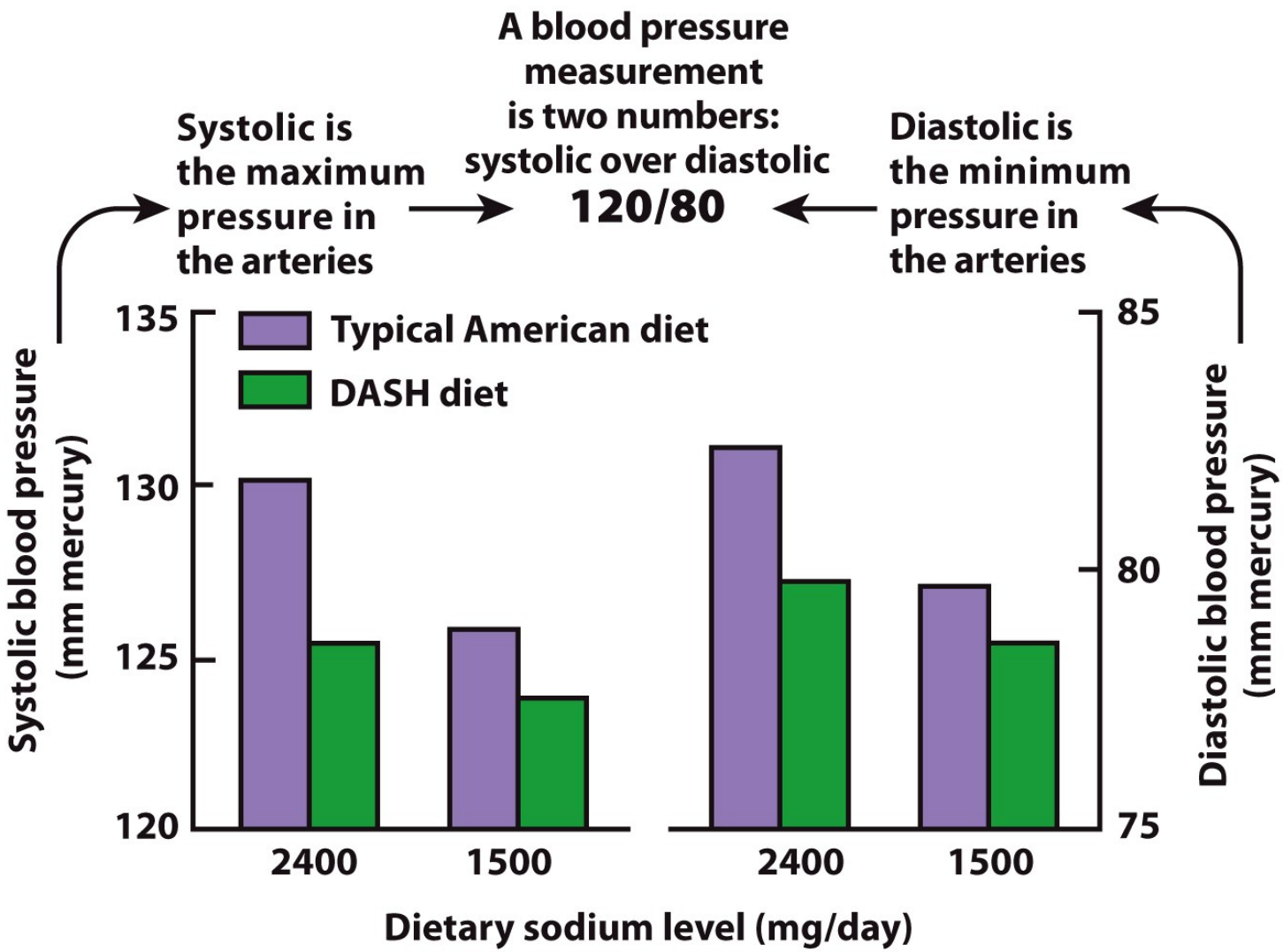
Andy Washnik

Michael Nichols/NG Image Collection

Hypertension and diet



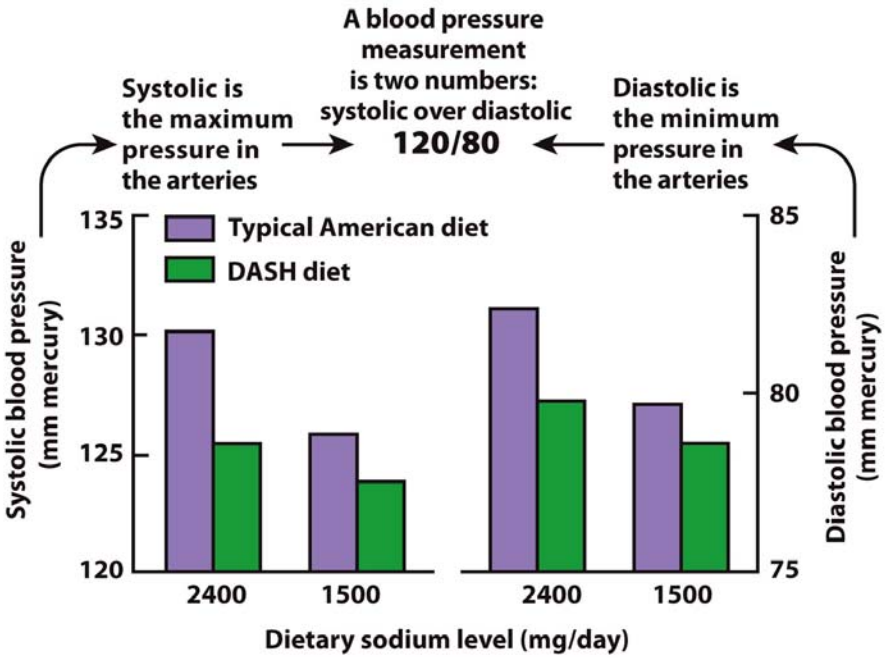
Hypertension and diet



Hypertension & diet

Based on this graph, if someone switched from a typical American diet pattern containing 2400 mg of sodium, to a DASH pattern with 1500 mg of sodium, by how much will systolic blood pressure decrease?

a) 5 mm of mercury
b) 7 mm of mercury
c) 3 mm of mercury
d) 10 mm of mercury



Electrolyte imbalance

- Deficiency:
  - Results in: acid–base imbalance, poor appetite, muscle cramps, confusion, apathy, constipation, irregular heartbeat, death
  - Caused by: heavy/persistent sweating, chronic diarrhea or vomiting, kidney disorders, or medications

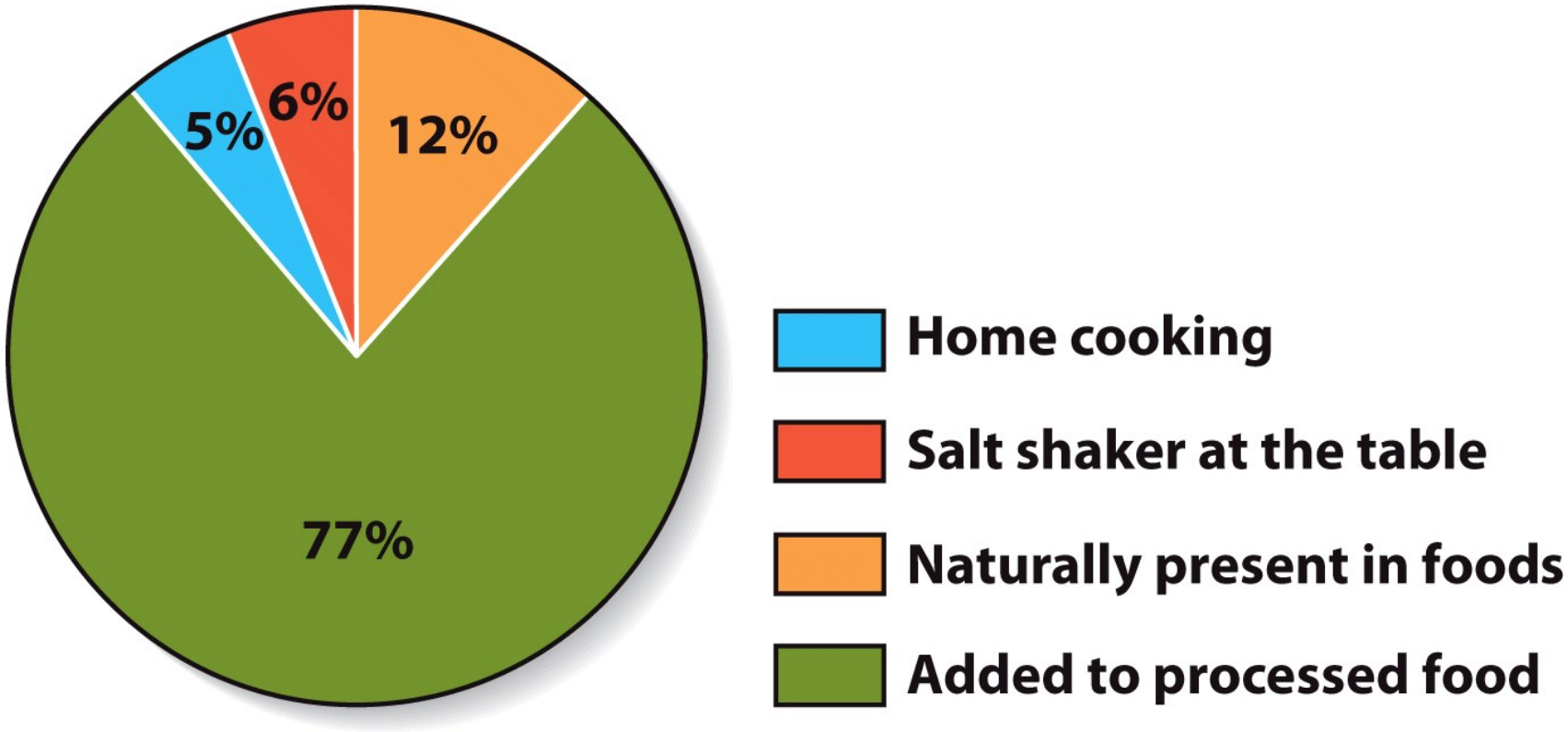
Electrolyte imbalance

- Excess:
  - Excess potassium from supplements can cause the heart to stop
  - Excess sodium from consumption or dehydration

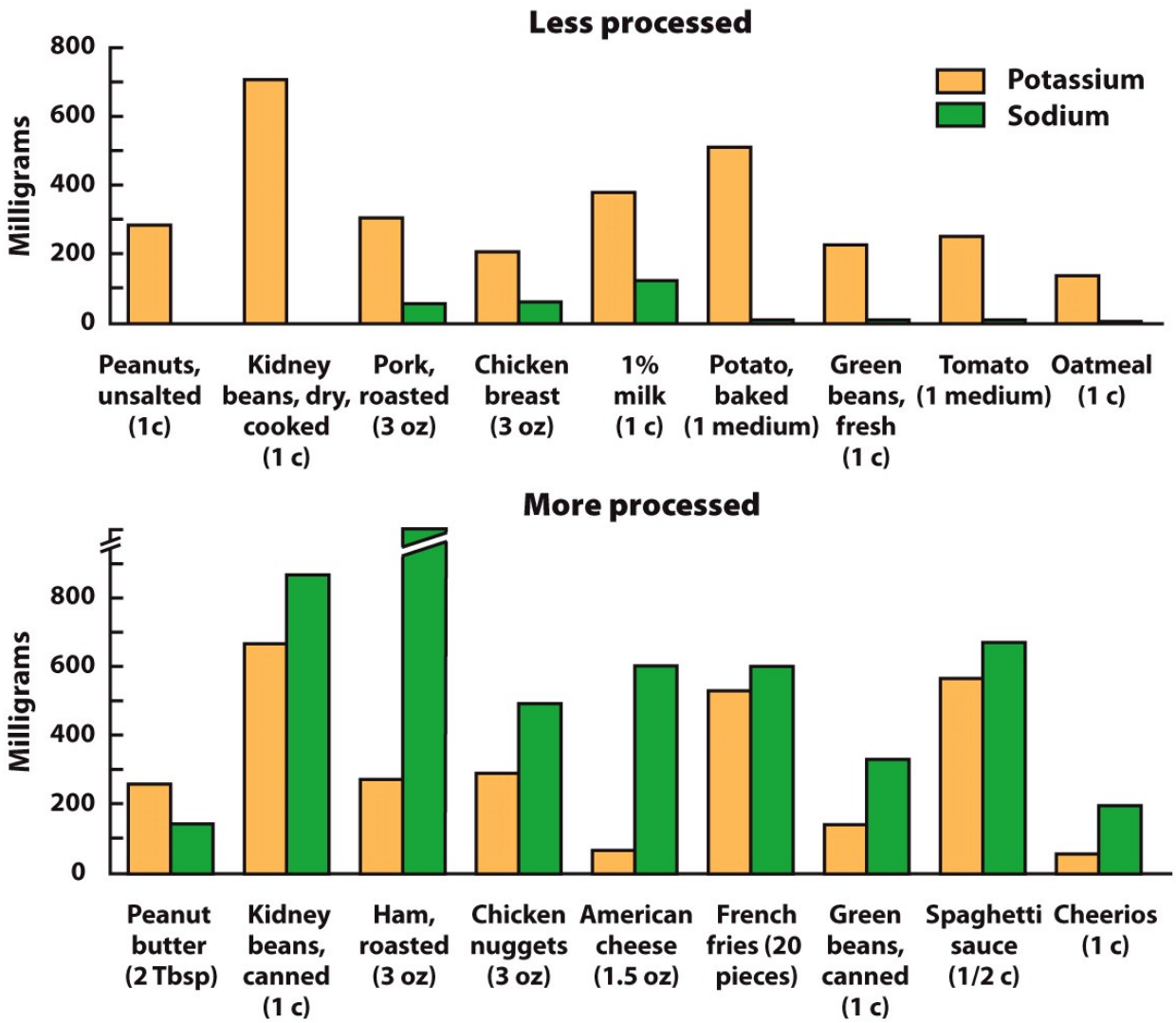
Electrolyte recommendations

- Sodium:
  - UL: 2300 mg/day
  - Over 51 years old, African American or with medical conditions = 1500 mg/day
  - Typical consumption = 3400 mg/day
- Potassium:
  - DRI = 4700 mg/day
  - DV = 3500 mg/day
  - Typical consumption = 2000-3000 mg/day

Sodium in processed foods



Sodium in processed foods



Sodium in processed foods

For a typical American, which of the following will result in the greatest reduction in sodium intake?

a) taking away the salt shaker during meals

b) reducing the amount of salt added during meal preparation

c) consuming fewer processed foods

Water & electrolyte summary

A summary of water and the electrolytes Table 8.1

Nutrient	Sources	Recommended intake for adults	Major functions	Deficiency diseases and symptoms	Groups at risk of deficiency	Toxicity	UL
Water	Drinking water, other beverages, and food	2.7-3.7 L/day	Solvent, reactant, protector, transporter, regulator of temperature and pH	Thirst, dark-colored urine, weakness, poor endurance, confusion, disorientation	Infants, people with fever and diarrhea, elderly individuals, athletes	Confusion, coma, convulsions	ND
Sodium	Table salt, processed foods	<2300 mg; ideally 1500 mg/day	Major positive extracellular ion, nerve transmission, muscle contraction, fluid balance	Muscle cramps	People consuming a severely sodium-restricted diet, those who sweat excessively	High blood pressure in sensitive people	2300 mg/day
Potassium	Fresh fruits and vegetables, legumes, whole grains, milk, meat	4700 mg/day or more	Major positive intracellular ion, nerve transmission, muscle contraction, fluid balance	Irregular heartbeat, fatigue, muscle cramps	People consuming poor diets high in processed foods, those taking thiazide diuretics	Abnormal heartbeat	ND
Chloride	Table salt, processed foods	<3600 mg/day; ideally 2300 mg/day	Major negative extracellular ion, fluid balance	Unlikely	None	None likely	3600 mg/day

Note: UL, Tolerable Upper Intake Level; ND, not determined.

Concept check

- Why does eating a salty meal cause your weight to increase temporarily?
- Why is hypertension called “the silent killer”?
- What is the DASH diet?
- Which types of foods contribute the most sodium to the American diet?

THINK about this – then share within a PAIR – then SHARE with the class

- What do you know about calcium and bones?

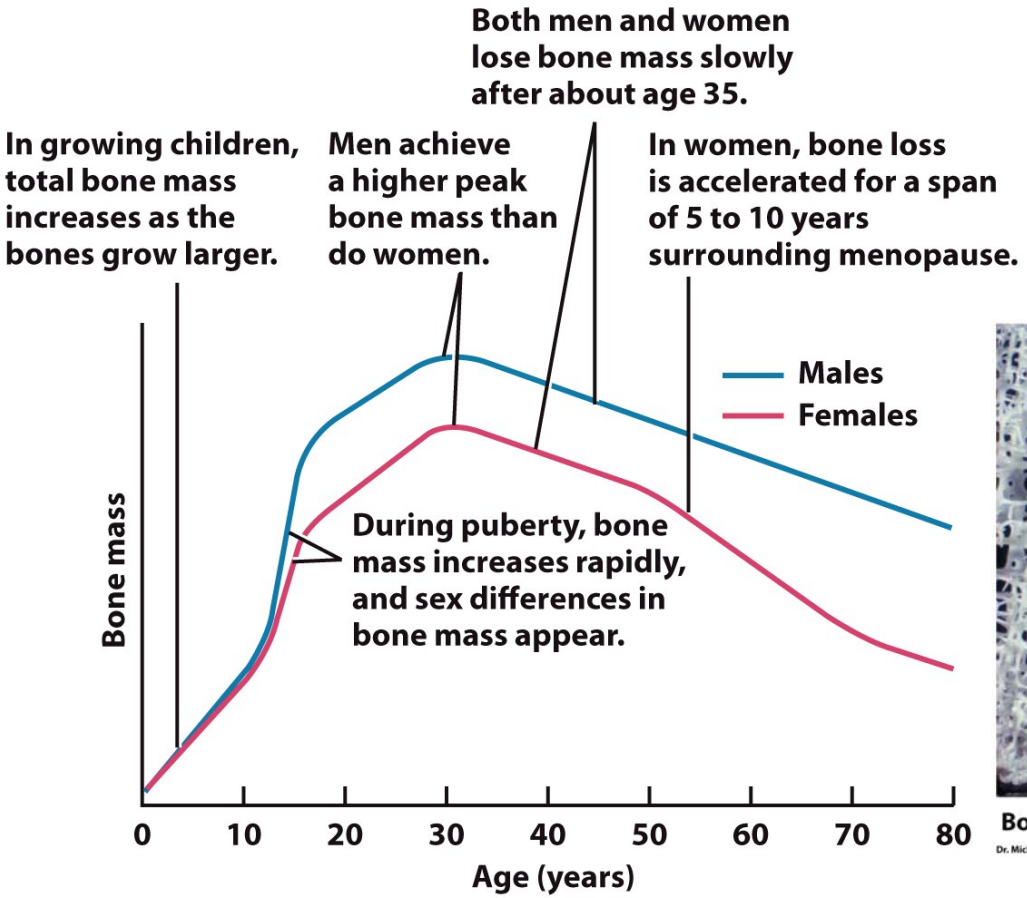
Strong bones

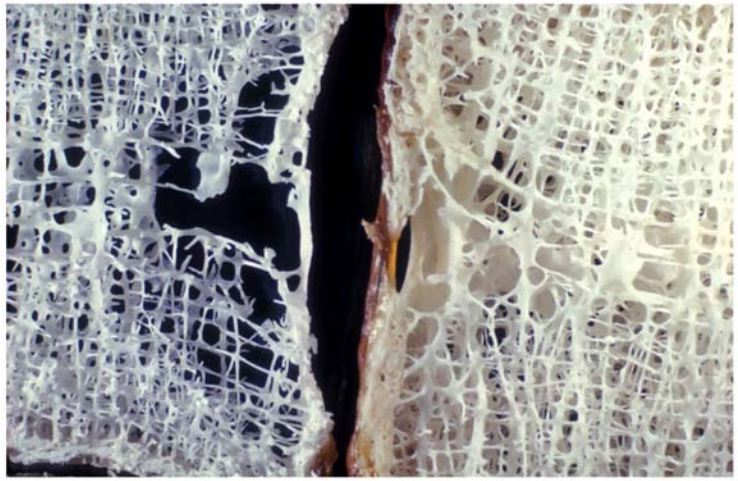
- Protein matrix: mostly collagen
- Hardened by minerals: mostly calcium, phosphorus, also magnesium, sodium, fluoride, other minerals
- Require:
  - Protein and vitamin C to maintain collagen
  - Calcium and other minerals to ensure solidity
  - Vitamin D to maintain calcium and phosphorus levels

Bones

- Living tissue
- Support weight and participate in movement
- Constantly broken down and re-formed during bone remodeling
- Peak bone mass: maximum bone density attained life, usually in young adulthood
- Osteoporosis: more bone loss than formation resulting in fractures

Bones



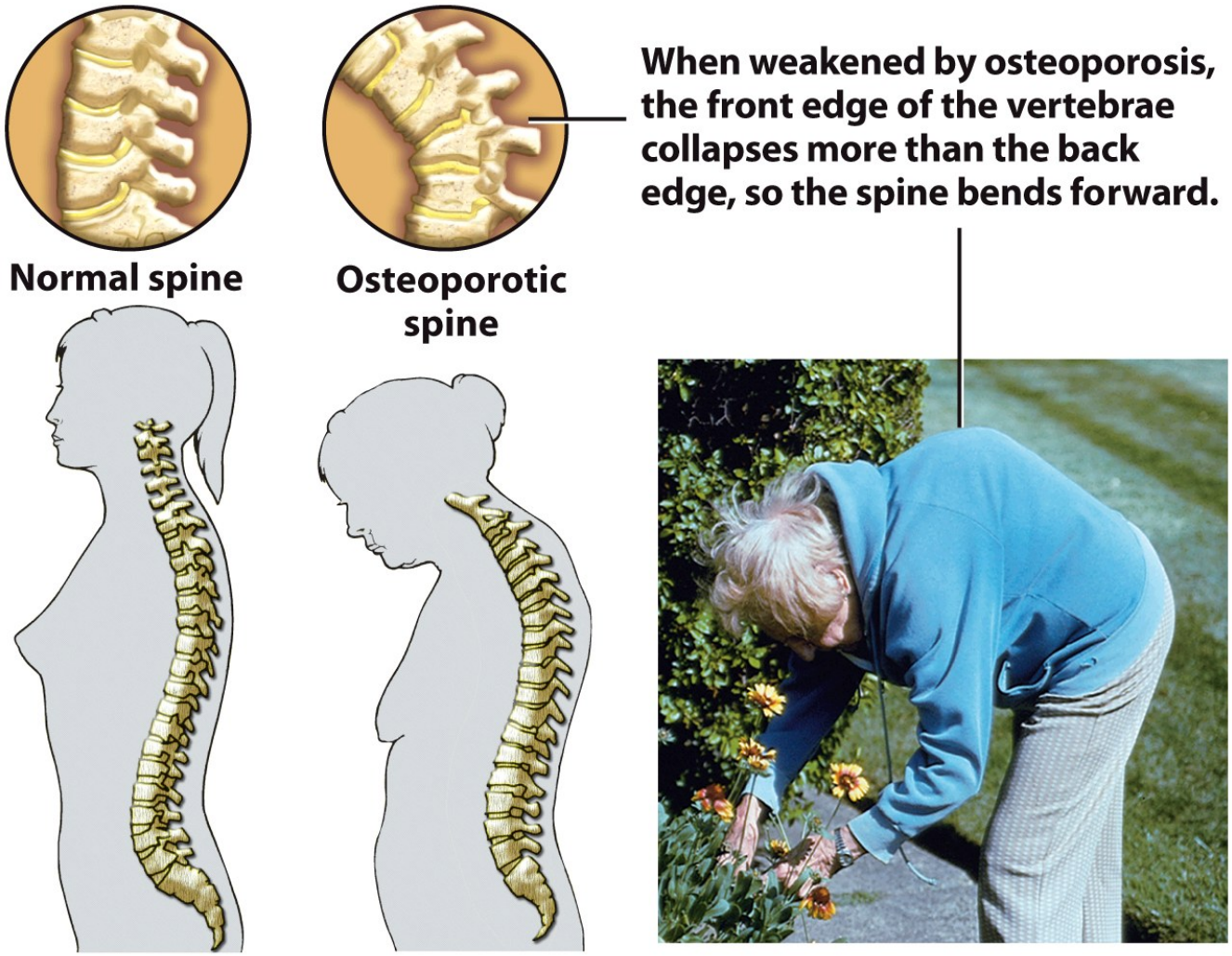


Bone weakened by osteoporosis

Normal bone

Dr. Michael Klein/Peter Arnold, Inc.

Bones



Osteoporosis

- More bone loss than formation
- Results in: fractures
- Risks: level of peak bone mass and rate at which bone is lost; affected by genetics, gender, age, hormones, low body weight, and lifestyle (smoking, alcohol, exercise, diet)
  - Women have more age-related bone loss than men when estrogen levels decrease after menopause

Osteoporosis

Factors affecting the risk of osteoporosis Table 8.2

Risk factor	How it affects risk
Gender	Fractures due to osteoporosis are about twice as common in women as in men. Men are larger and heavier than women and therefore have a greater peak bone mass. Women lose more bone than men due to postmenopausal bone loss.
Age	Bone loss is a normal part of aging, and risk increases with age.
Race	African Americans have denser bones than do Caucasians and Southeast Asians, so their risk of osteoporosis is lower.
Family history	Having a family member with osteoporosis increases risk.
Body size	Individuals who are thin and light have an increased risk because they have less bone mass.
Smoking	Tobacco use weakens bones.
Exercise	Weight-bearing exercise, such as walking and jogging, throughout life strengthens bone, and increasing weight-bearing exercise at any age can increase your bone density.
Alcohol abuse	Long-term alcohol abuse reduces bone formation and interferes with the body's ability to absorb calcium.
Diet	A diet that is lacking in calcium and vitamin D plays a major role in the development of osteoporosis. Low calcium intake during the years of bone formation results in a lower peak bone mass, and low calcium intake in adulthood can accelerate bone loss.

Soda verses milk

Tim Boyle/Getty Images, Inc.

	Low–fat milk	Cola soft drink
Serving size (oz)	12	12
Energy (Cal)	153	150
Protein (g)	12	0
Calcium (mg)	450	0
Phosphorus (mg)	588	45
Riboflavin (mg)	0.6	0
Vitamin A (μg)	216	0
Vitamin D (μg)	3.8	0
Caffeine (mg)	0	40

Calcium

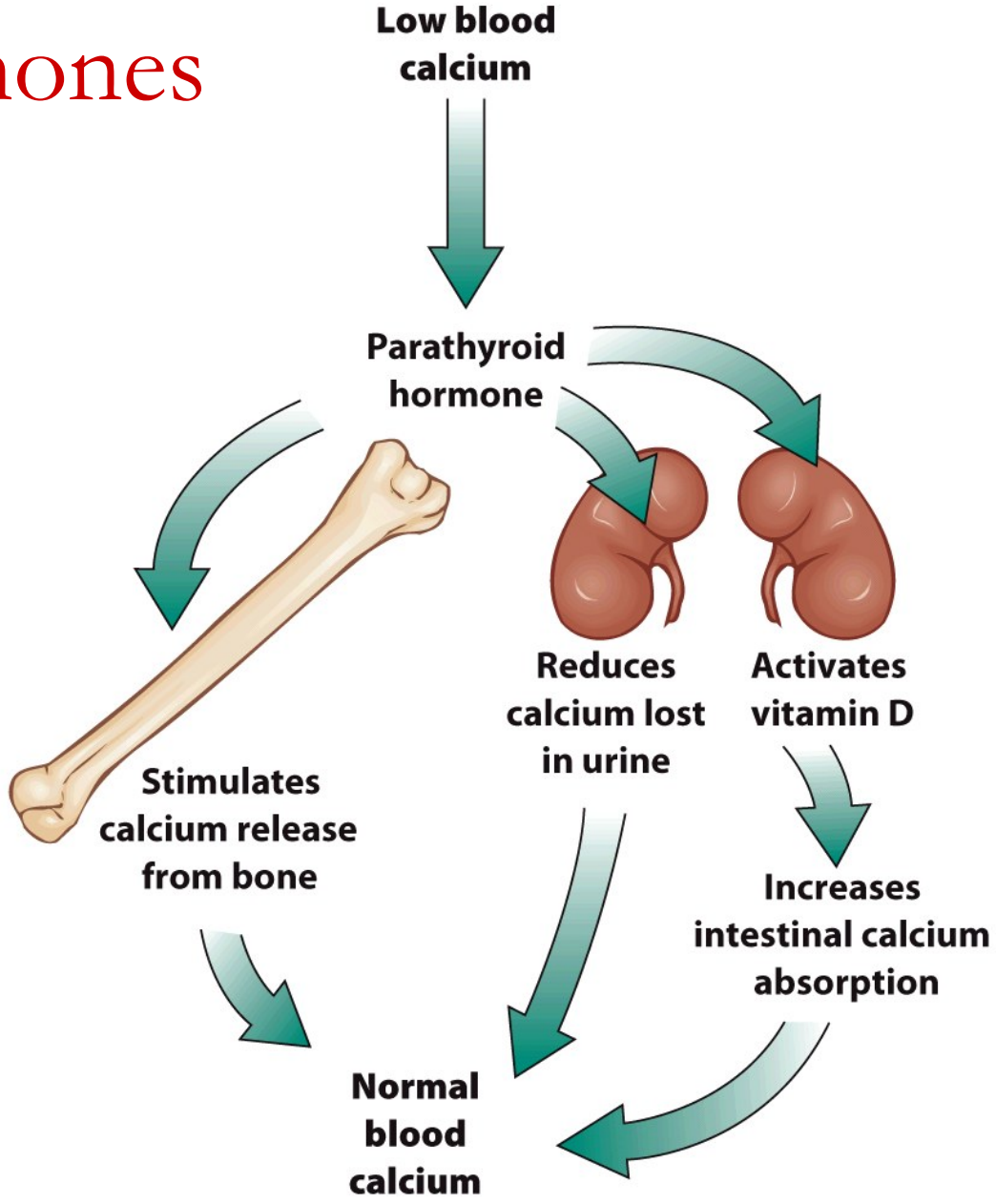
- 99% in bones and teeth
- In body cells and fluids, needed for:
  - Muscle contraction
  - Neurotransmitter release
  - Blood pressure regulation
  - Cell communication
  - Blood clotting
- Levels regulated by hormones:
  - Too high: calcitonin “tones” it down
  - Too low: PTH and calcitriol “try” to bring it up

Calcium hormones

Decreased blood calcium → PTH & Calcitriol secretion → Stimulate intestinal absorption, kindey reabsorption & bone resorption → Increased blood calcium

Increased blood calcium → Calcitonin secretion → Inhibit bone resorption → Decreased blood calcium

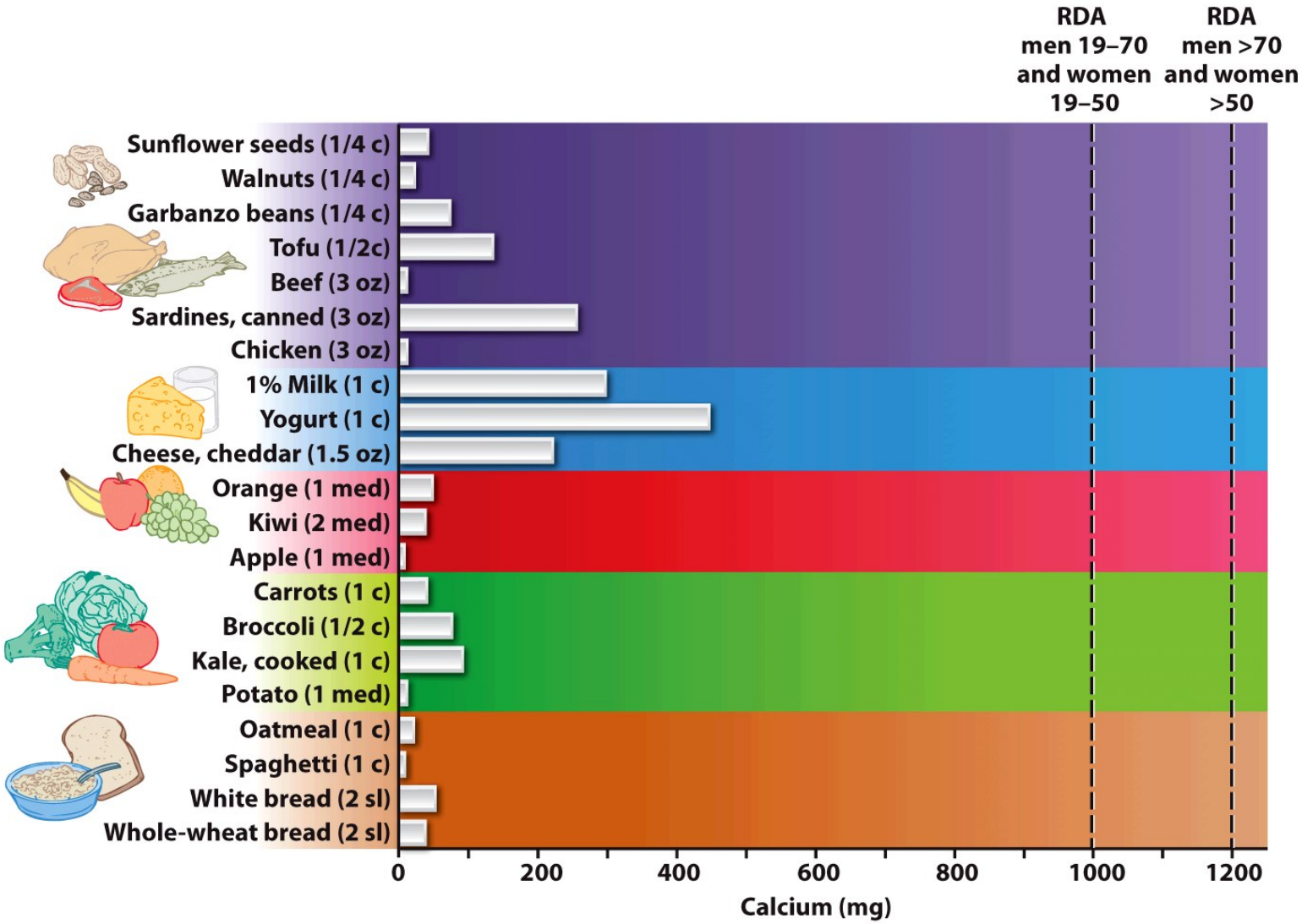
Calcium hormones



Calcium

- RDA: 19-50 years = 1000 mg/day; UL= 2500 mg/day
- Sources: dairy products, dark green vegetables, fish with bones, foods processed and fortified with calcium
- Deficiency: Osteoporosis
- Excess: caused by cancers, increased PTH, excessive calcium and/or vitamin D intake causing altered availability of iron, zinc, magnesium, phosphorus; constipation; loss of appetite, abnormal heartbeat, weight loss, fatigue, frequent urination, soft tissue calcification, kidney stones and damage

Calcium sources



Calcium supplements

Choose supplements that contain calcium carbonate or calcium citrate. Avoid products that contain aluminum and magnesium. These may actually increase calcium loss.

Choosing a supplement with vitamin D ensures that the vitamin will be available for calcium absorption.

Calcium is absorbed best when taken in doses of 500 mg or less.

500 mg taken twice a day provides 100% of the RDA for men ages 19 to 70 and women ages 19 to 50.

Calcium Citrate with Vitamin D
DIETARY SUPPLEMENT

Suggested Use: Adults take one tablet twice daily with the meal of your choice.

Supplement Facts
Serving Size 1 Tablet

Amount per serving	% Daily Value
Vitamin D_3 400 IU	100%
Calcium 500 mg	50%

Other Ingredients: Cellulose, modified cellulose gum, magnesium stearate (vegetable source), magnesium sillicate.

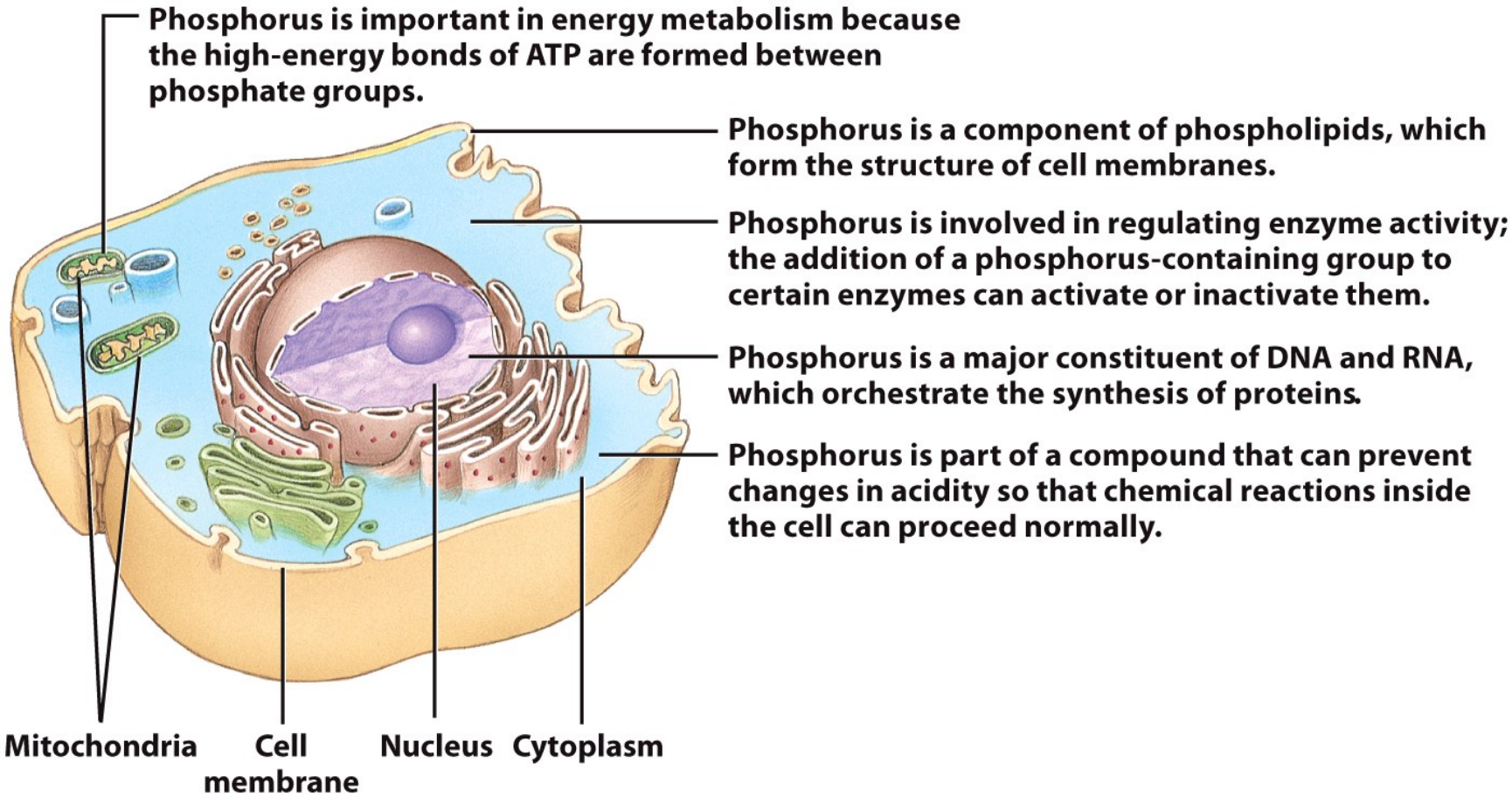
Made according to US Pharmacopeia (USP) standards.

Some antacids are sources of calcium. These are over-the-counter medications, so they carry a Drug Facts panel rather than a Supplement Facts panel.

Phosphorus

- Most found with calcium in bones and teeth
- In soft tissues, needed for:
  - Phospholipid, DNA, RNA, and ATP structures
  - Enzyme activity regulation
  - Cellular acidity maintenance // Phosphate Buffer System

Phosphorus functions



Phosphorus

- RDA: adults = 700 mg/day; UL= 4000 mg/day
- Sources: dairy products; meat; cereal;, bran; eggs; nuts; fish; and food additives used in baked goods, cheese, processed meats, and soft drinks
- Deficiency: rare; due to chronic diarrhea or poor absorption due to overuse of aluminum-containing antacids; causes bone loss, weakness, loss of appetite
- Excess: high dietary phosphorus does not appear to be harmful for healthy adults, concern with sodas

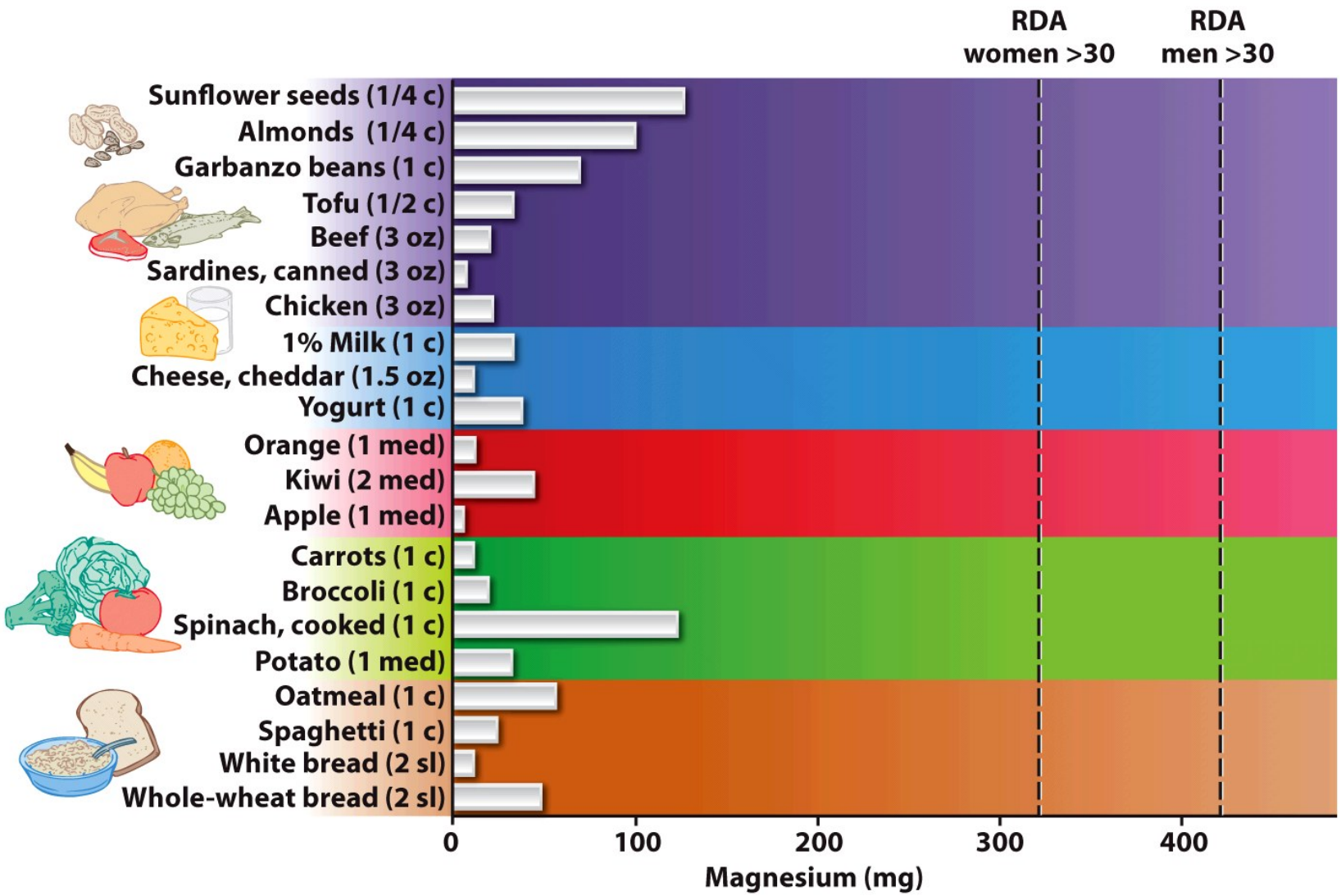
Magnesium

- 50-60% in bones
- In cells and fluids, needed for:
  - Calcium regulation
  - Blood pressure regulation
  - ATP structure stabilization which is important for:
    - Energy release from carbohydrate, fat, and protein
    - Nerve and muscle functioning
    - DNA, RNA, and protein synthesis

Magnesium

- RDA: men = 420 mg/day; women = 320 mg/day
- Sources: leafy greens, nuts, seeds, legumes, bananas, germ and bran of whole grains
- Deficiency: rare; causes osteoporosis, nausea, muscle weakness and cramping, irritability, mental derangement, blood pressure, heartbeat changes
- Excess: no effects from foods; drugs or supplements can cause nausea, vomiting, low blood pressure, and other cardiovascular changes

Magnesium sources



Sulfur

- Part of:
  - amino acids and proteins
  - glutathione – needed for detoxification
  - B vitamins thiamin and biotin
- Regulates acidity
- RDA: none
- Sources: part of dietary proteins and sulfur-containing vitamins, found in some food preservatives
- Deficiency: none known

Calcium, Phosphorous, Magnesium & Sulfur

A summary of calcium, phosphorus, magnesium, and sulfur Table 8.3

Mineral	Sources	Recommended intake for adults	Major functions	Deficiency diseases and symptoms	Groups at risk of deficiency	Toxicity	UL
Calcium	Dairy products, fish consumed with bones, leafy green vegetables, fortified foods	1000–1200 mg/day	Bone and tooth structure, nerve transmission, muscle contraction, blood clotting, blood pressure regulation, hormone secretion	Increased risk of osteoporosis	Postmeno-pausal women; elderly people; those who consume a vegan diet, are lactose intolerant, or have kidney disease	Elevated blood calcium, kidney stones, and other problems in susceptible individuals	2000–2500 mg/day from food and supple-ments
Phosphorus	Meat, dairy, cereals, baked goods	700 mg/day	Structure of bones and teeth, membranes, ATP, and DNA; acid–base balance	Bone loss, weakness, lack of appetite	Premature infants, alcoholics, elderly people	None likely	4000 mg/day
Magnesium	Greens, whole grains, legumes, nuts, seeds	310–420 mg/day	Bone structure, ATP stabilization, enzyme activity, nerve and muscle function	Nausea, vomiting, weakness, muscle pain, heart changes	Alcoholics, individuals with kidney and gastro-intestinal disease	Nausea, vomiting, low blood pressure	350 mg/day from nonfood sources
Sulfur	Protein foods, preservatives	None specified	Part of some amino acids and vitamins, acid–base balance	None when protein needs are met	None	None likely	ND

Note: UL, Tolerable Upper Intake Level; ND, not determined.

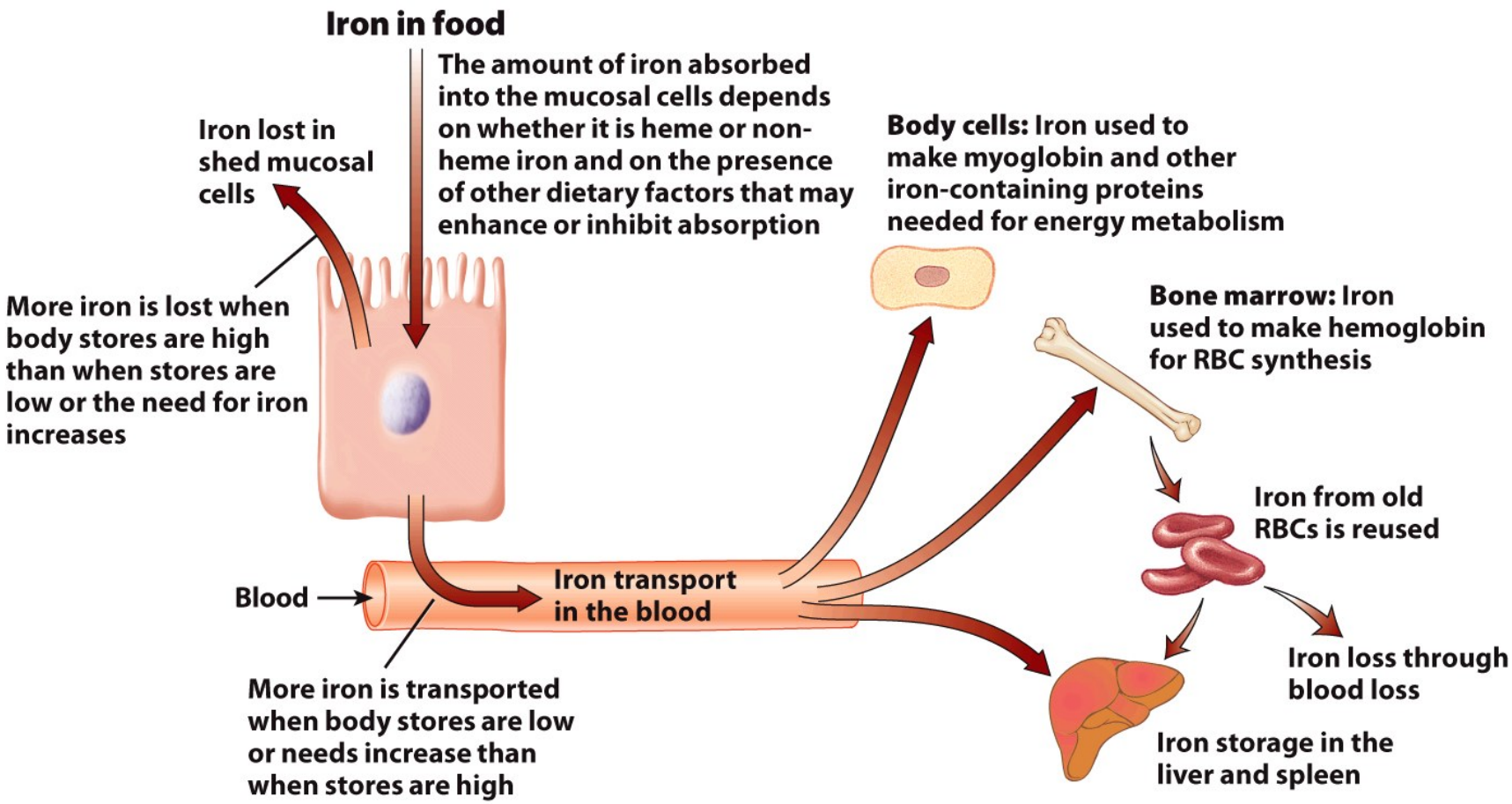
Concept check

- Why are women at greater risk for osteoporosis than are men?
- What happens when blood calcium levels decrease?
- How can vegans meet their calcium needs?
- What is the relationship between magnesium and ATP?

Iron

- Part of hemoglobin which transports oxygen to body cells and carries carbon dioxide away from them for elimination by the lungs
- Needed for other iron-containing proteins such as myoglobin, a muscle protein which increases oxygen available for contraction
- Essential for ATP production
- Heme iron in proteins is absorbed more than twice as efficiently as the nonheme iron in plant sources

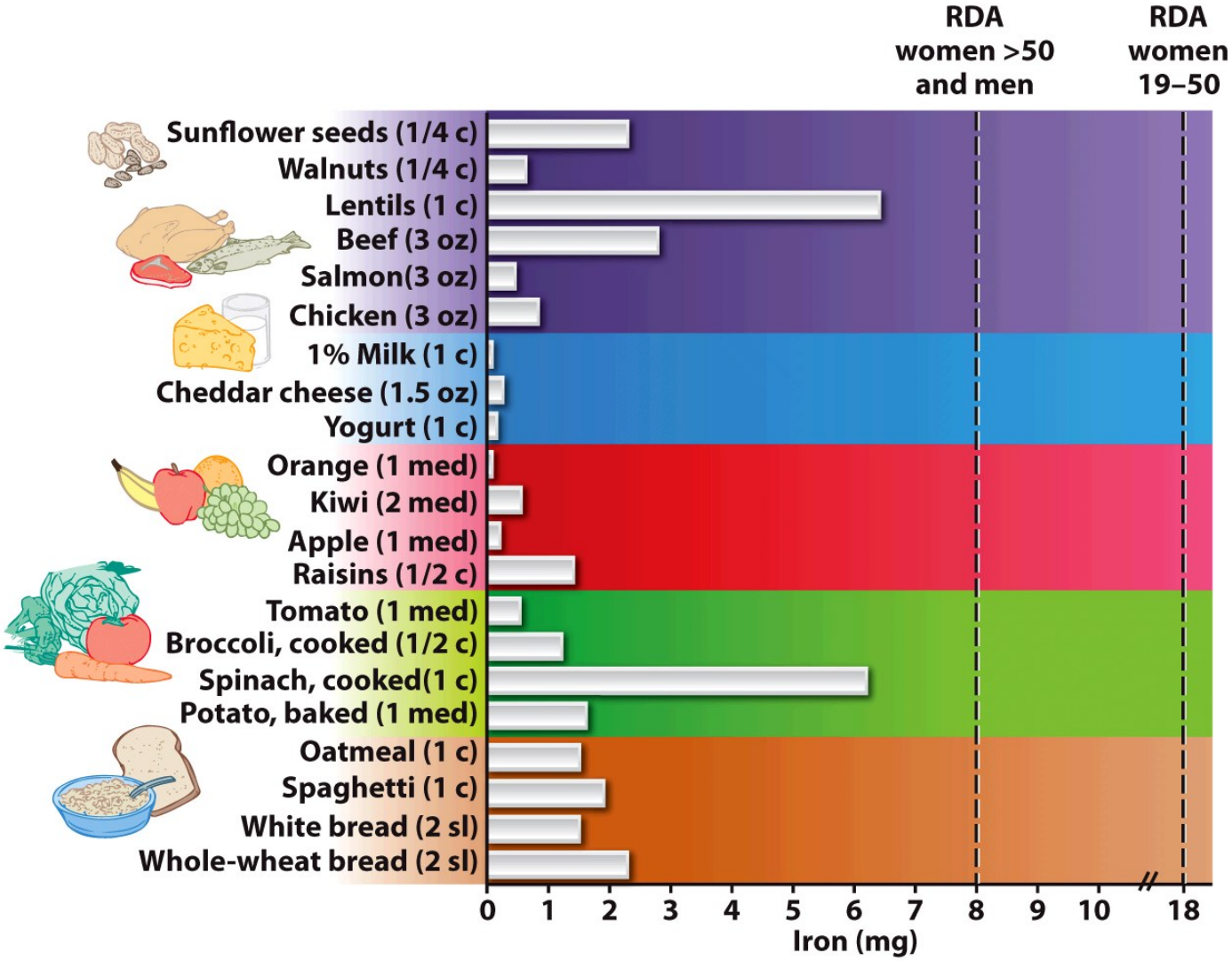
Iron availability



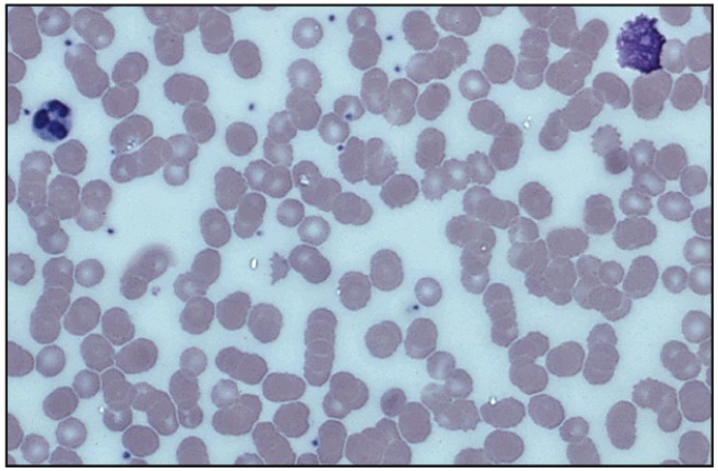
Iron

- RDA: adults = 8 mg/day; UL = 45 mg/day
- Sources: red and organ meats, legumes, leafy greens, whole and enriched grains
-
- Deficiency: iron-deficiency anemia causing fatigue, weakness, headache, decreased work capacity, body temperature problems, behavior changes, increased infection, impaired development, lead poisoning
- Excess: intestinal lining damage, abnormal body acidity, shock, liver failure; iron overload from inherited hemochromatosis

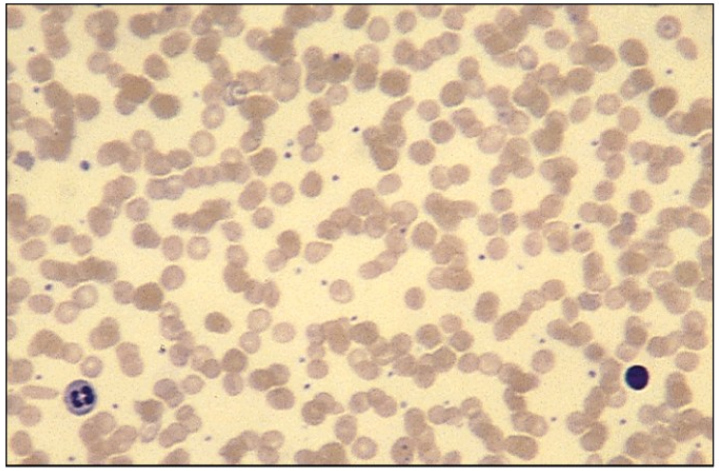
Iron sources



Iron deficiency

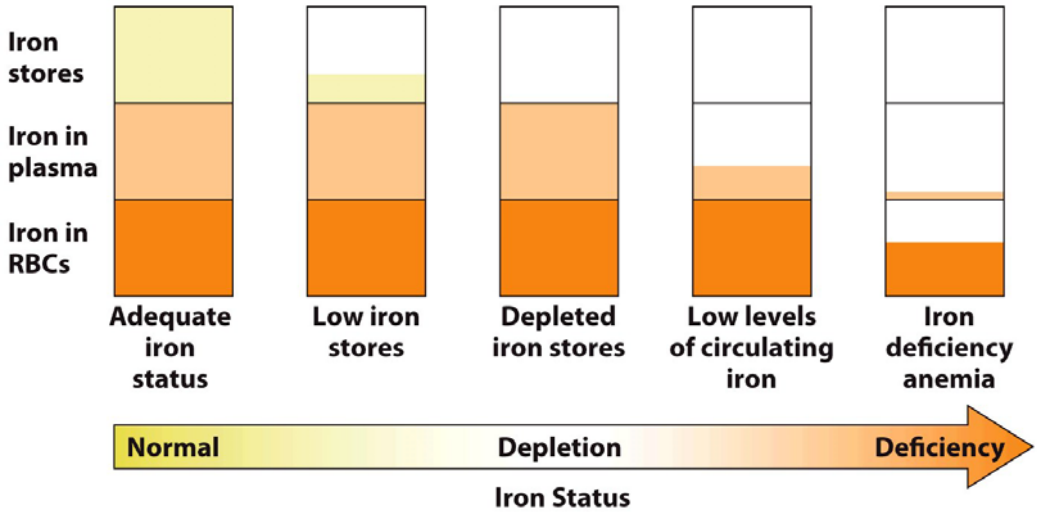


Normal red blood cells

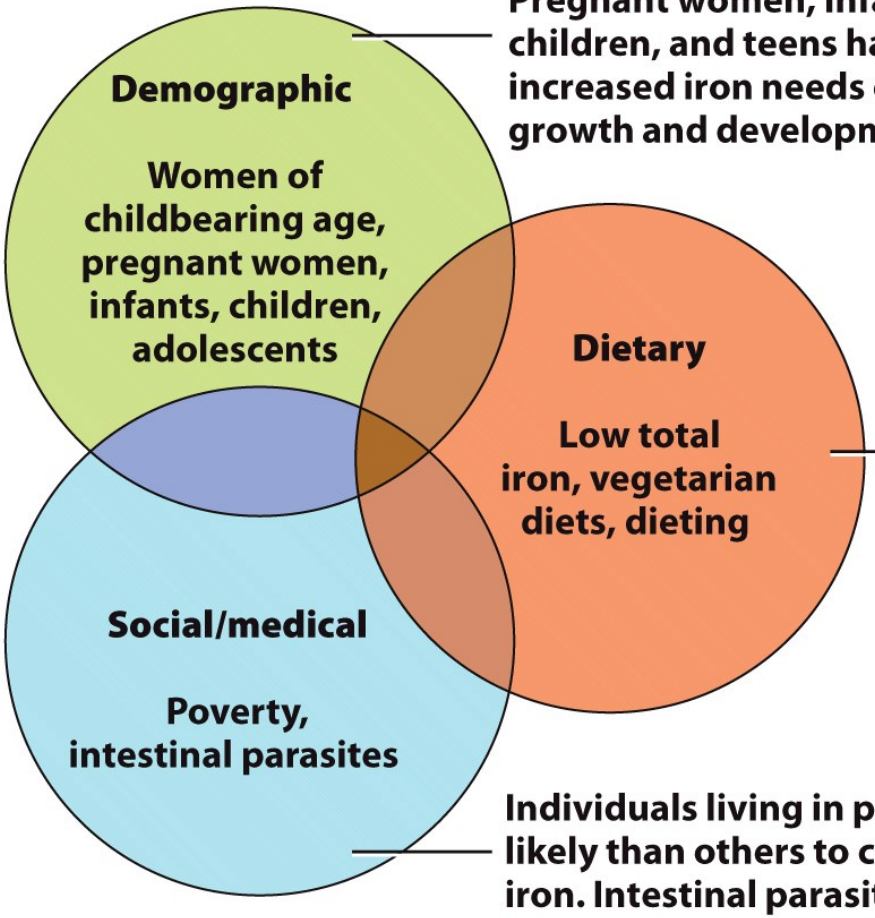


Iron deficiency anemia

(left) B &B Photos/Custom Medical Stock Photo, Inc. (right) Custom Medical Stock Photo, Inc.



Iron deficiency



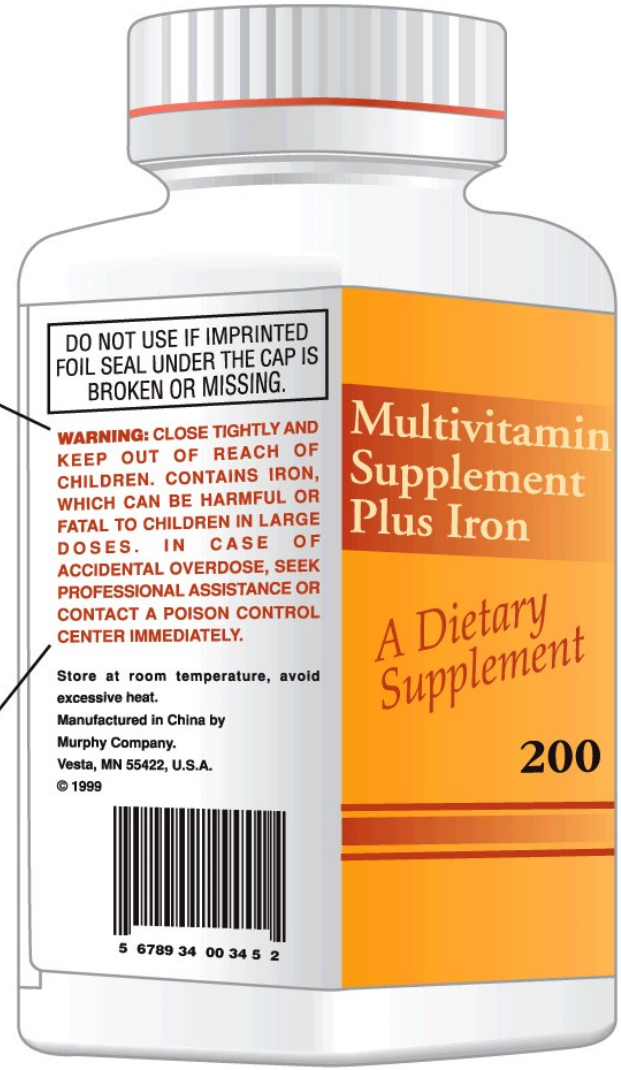
Women of childbearing age lose iron due to menstruation. Pregnant women, infants, children, and teens have increased iron needs due to growth and development.

Diets that are low in meat, which contains the most readily absorbed form of iron (heme iron), and high in phytates and fiber, which reduce iron absorption, increase the risk of deficiency. Low-calorie diets can also reduce iron intake.

Individuals living in poverty are less likely than others to consume adequate iron. Intestinal parasites cause blood loss, which increases iron losses.

Iron excess

WARNING: CLOSE TIGHTLY AND KEEP OUT OF REACH OF CHILDREN. CONTAINS IRON, WHICH CAN BE HARMFUL OR FATAL TO CHILDREN IN LARGE DOSES. IN CASE OF ACCIDENTAL OVERDOSE, SEEK PROFESSIONAL ASSISTANCE OR CONTACT A POISON CONTROL CENTER IMMEDIATELY.



Copper

- A copper-containing protein is needed for iron transport from intestinal cells
- Component of proteins and enzymes involved in:
  - Connective tissue synthesis
  - Lipid metabolism
  - Heart muscle maintenance
  - Immune and central nervous system functions

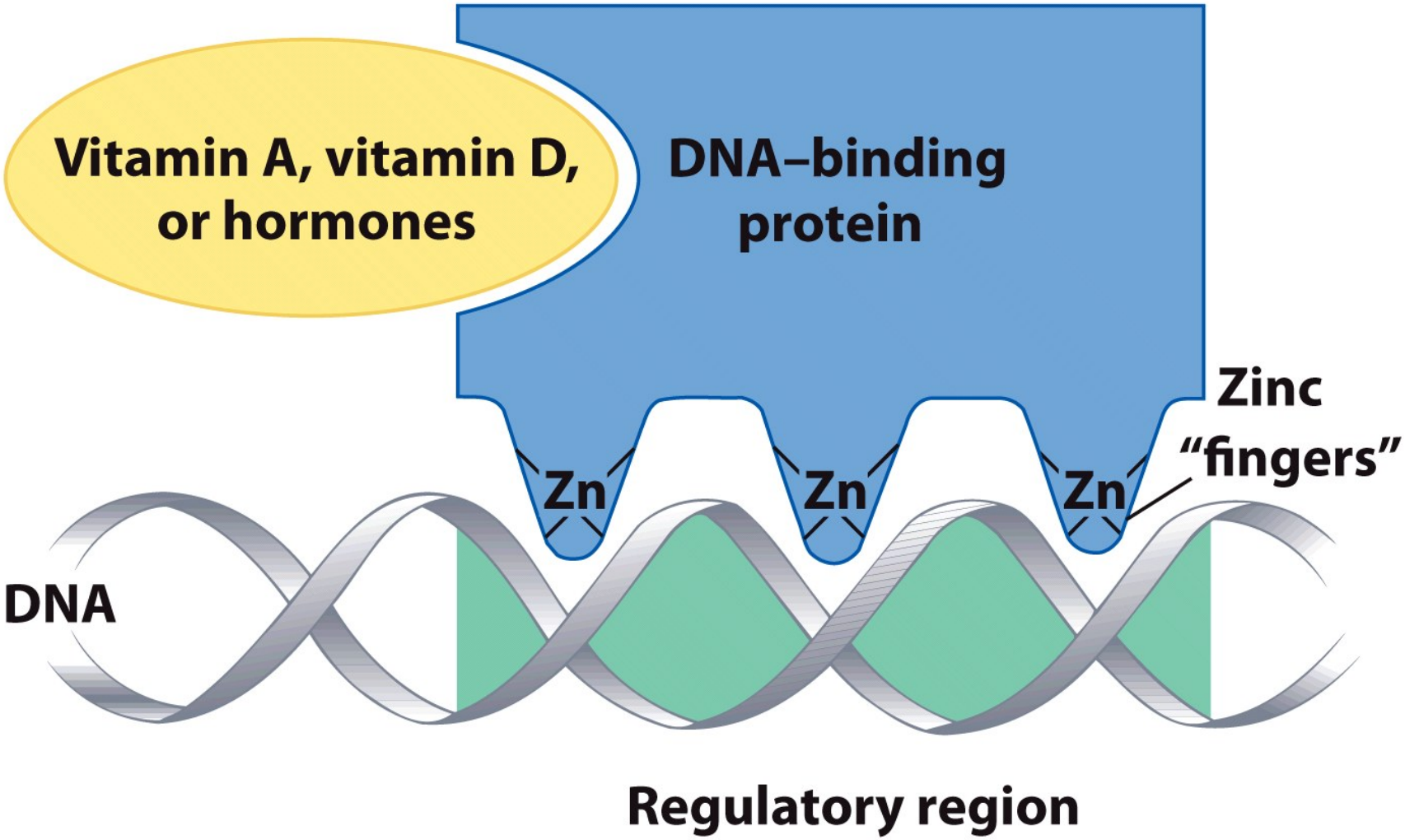
Copper

- RDA: adults = 900 micrograms/day; UL = 10 mg/day
- Sources: organ meats, seafood, nuts, seeds, whole-grain breads and cereals, chocolate
- Deficiency: iron-deficiency anemia, decreased collagen, high blood cholesterol, impaired growth, heart and nervous system degeneration, hair color and structure changes, increased infections, decreased antioxidants
- Excess: from supplements, copper containers, contaminated water, causing abdominal pain, vomiting, diarrhea

Zinc

- Involved in the functioning enzymes involved in:
  - Scavenging free radicals
  - DNA and RNA synthesis
  - Carbohydrate metabolism
  - Acid–base balance
  - Absorption of folate from food
  - Storage and release of insulin
  - Mobilization of vitamin A from liver
  - Stabilization of cell membranes
  - Influences hormonal regulation of cell division

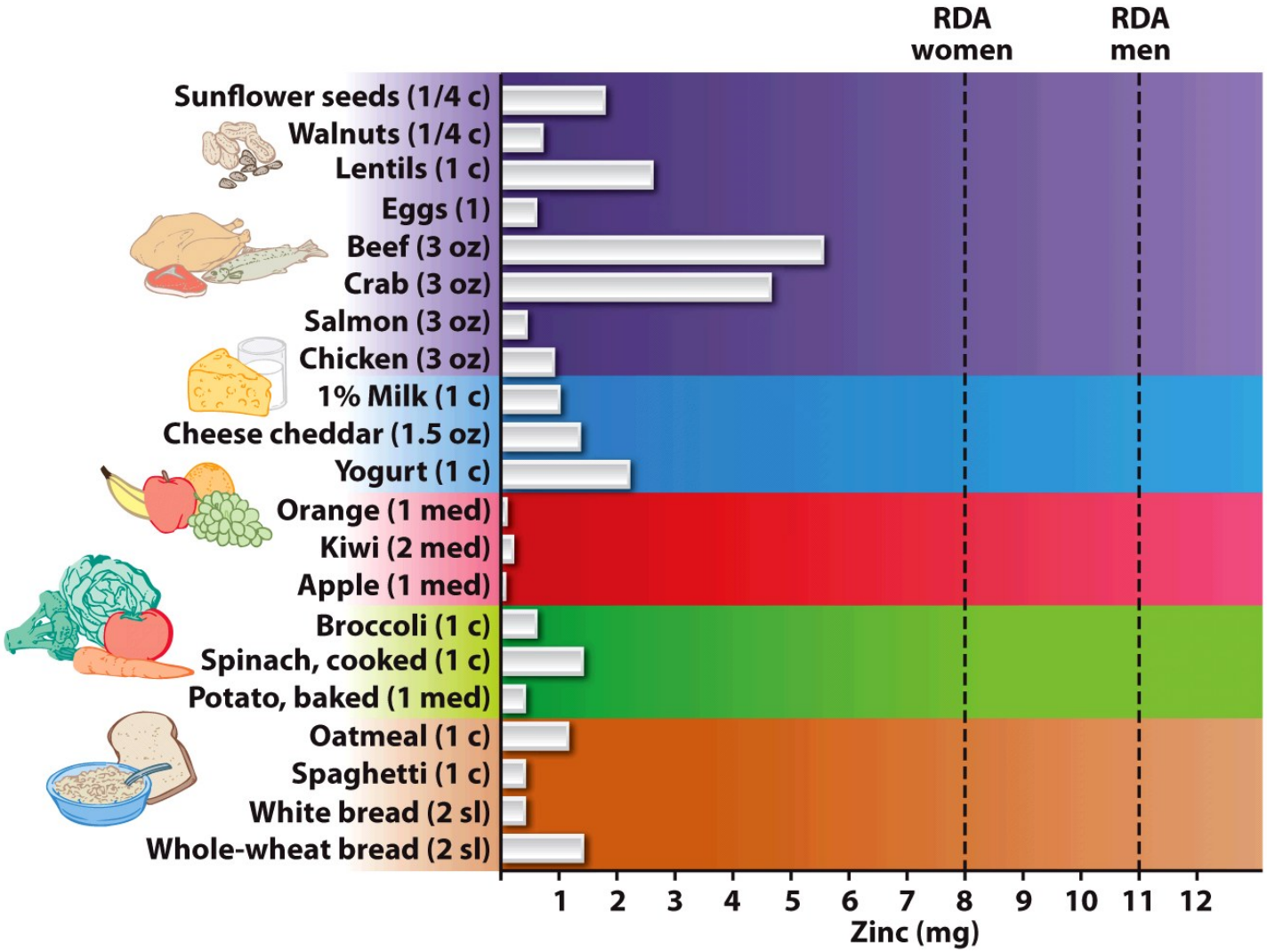
Zinc & gene expression



Zinc

- RDA: men = 11 mg/day; women = 8 mg/day
- Sources: meat, liver, eggs, dairy products, vegetables, legumes, seeds
- Deficiency: decreased growth, development and immunity; skin rashes; diarrhea
- Excess: from supplements causing gastrointestinal irritation; vomiting; appetite loss; diarrhea, abdominal cramps; headaches; decreased immunity, HDL, copper and iron absorption

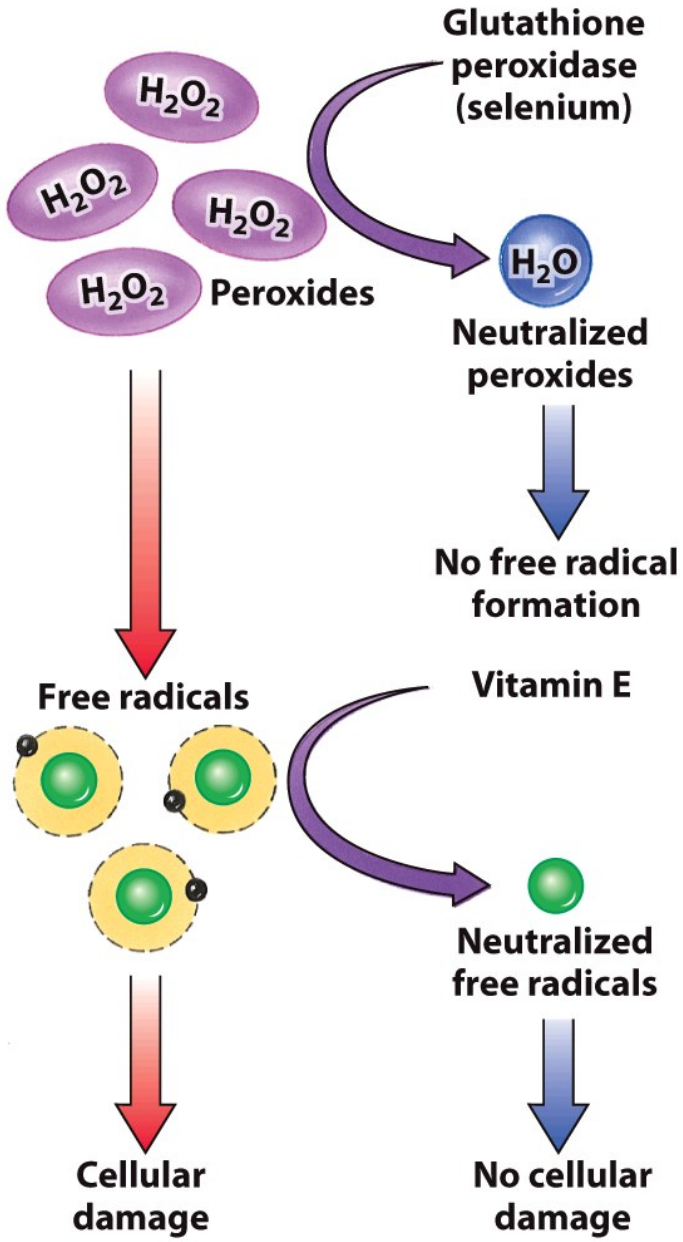
Zinc sources



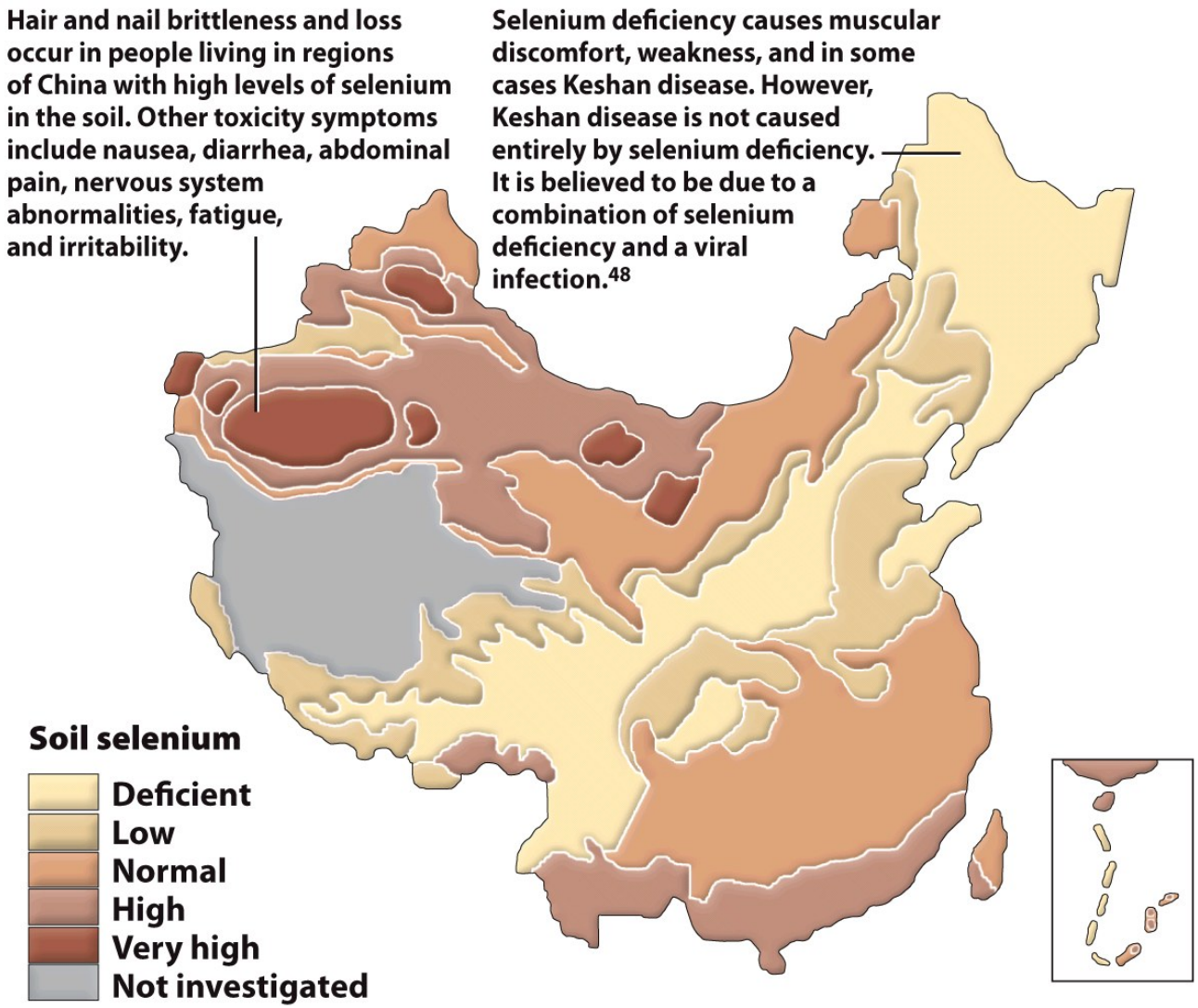
Selenium

- Incorporated into the structure of certain proteins:
  - Glutathione peroxidase which decreases oxidative damage
  - A protein needed to make thyroid hormones
- RDA: adults = 55 mg/day; UL = 400 mg/day
- Sources: seafood, kidney, liver, eggs, grains, nuts, seeds
- Deficiency: Keshan disease = heart disease in China /// increased risk of cancer

Selenium



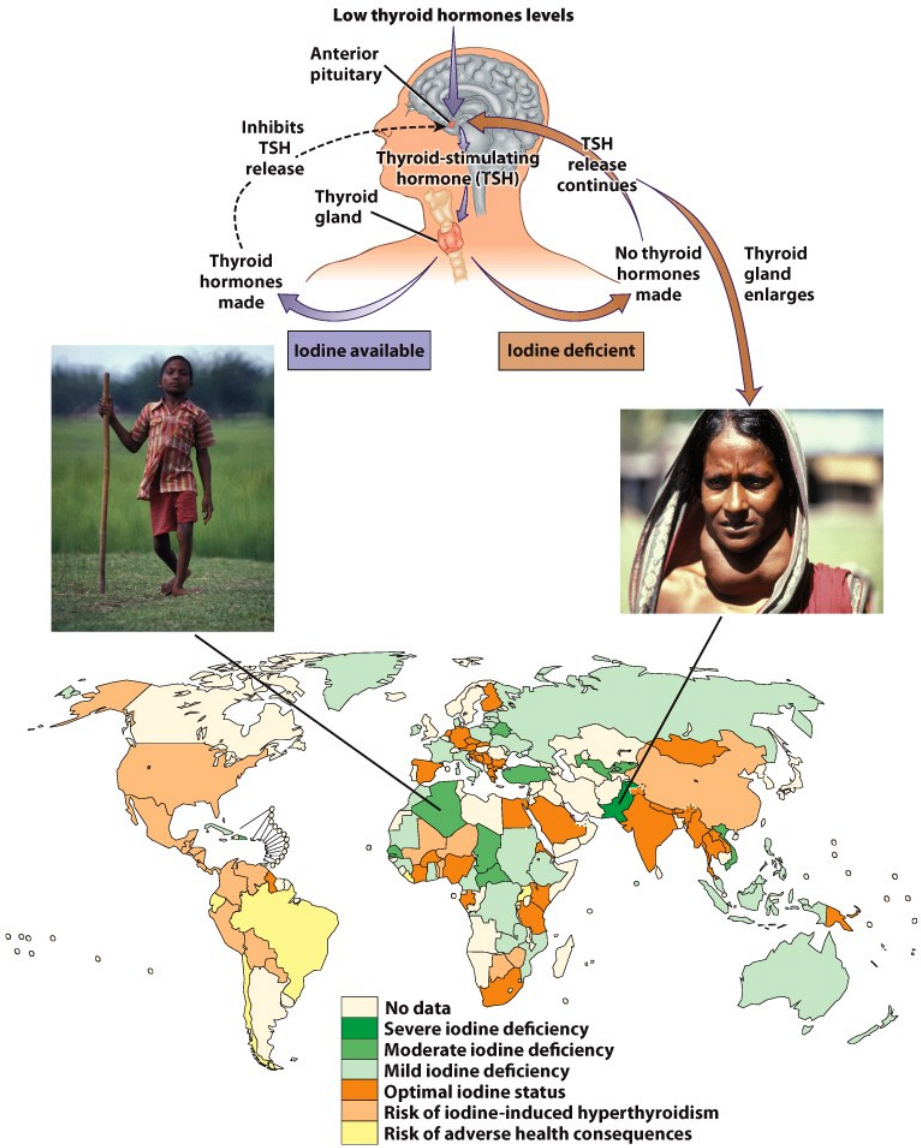
Selenium deficiency



Iodine

- ¾ of mineral found in the thyroid gland
- Component of thyroid hormones which regulate metabolic rate, growth, and development and promote protein synthesis

Iodine



Source: de Benoist B et al., eds. Iodine status worldwide. WHO Global Database on Iodine Deficiency. Geneva, World Health Organization, 2004. Data was produced by WHO using the best available evidence and do not necessarily correspond to the official statistics of Member States.

Iodine

- RDA: adults = 150 mg/day; UL = 1100 mg/day
- Sources: seafood, iodinized salt, food contaminants and additives
- Deficiency: decreased thyroid hormones causing decreased metabolic rate, fatigue, weight gain; goiter (enlarged thyroid); during pregnancy causes spontaneous abortions, stillbirths, cretinism (brain damage)
- Excess: goiter

Iodinized salt

George Semple

Chromium

- Component of “glucose tolerance factor,” a small peptide required to maintain normal blood glucose levels
- RDA: ages 19–50: men = 35 micrograms/day; women = 25 micrograms/day
- Sources: liver, brewer’s yeast, nuts, whole grains
- Deficiency: rare in US
- Excess: little evidence

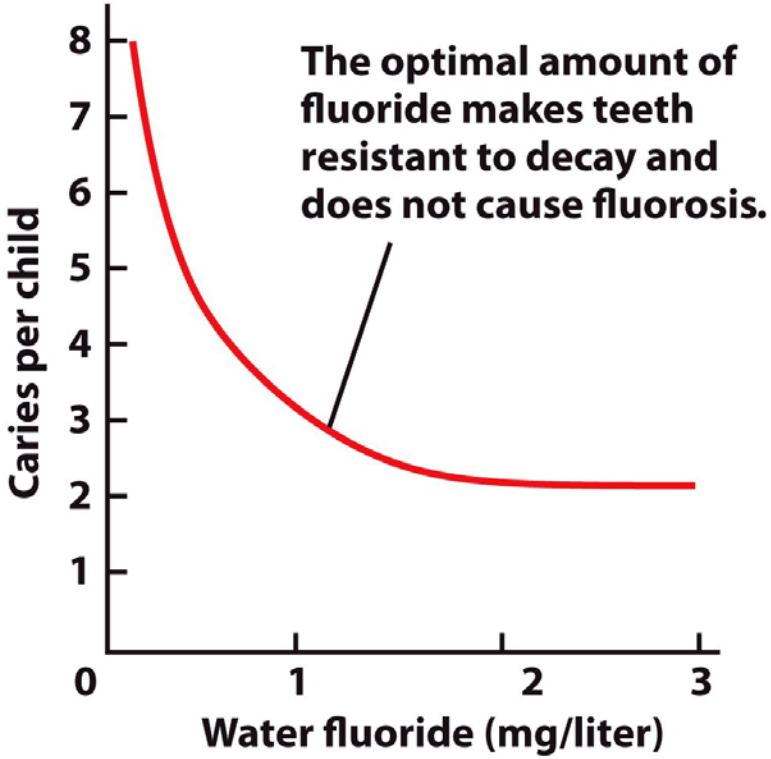
Fluoride

- Incorporated into crystals in tooth enamel which protects against cavity-causing acids produced by bacteria
- In saliva, decreases bacterial acid production, inhibits dissolution of tooth enamel by acid, and increase enamel re-mineralization after acid exposure
- Incorporated into crystals in bone

Fluoride

- RDA: 0.05 mg/kg/day; UL = 0.1 mg/kg/day for infants and children less than 9 years old and 10 mg/day between 9 and 70 years
- Sources: in small amounts in almost all soil, water, plants, and animals; toothpaste; tea; marine fish with bones; fluoridated water
- Deficiency: tooth decay
- Excess: fluorosis causing black and brown stains and cracking and pitting of the teeth

Fluoride



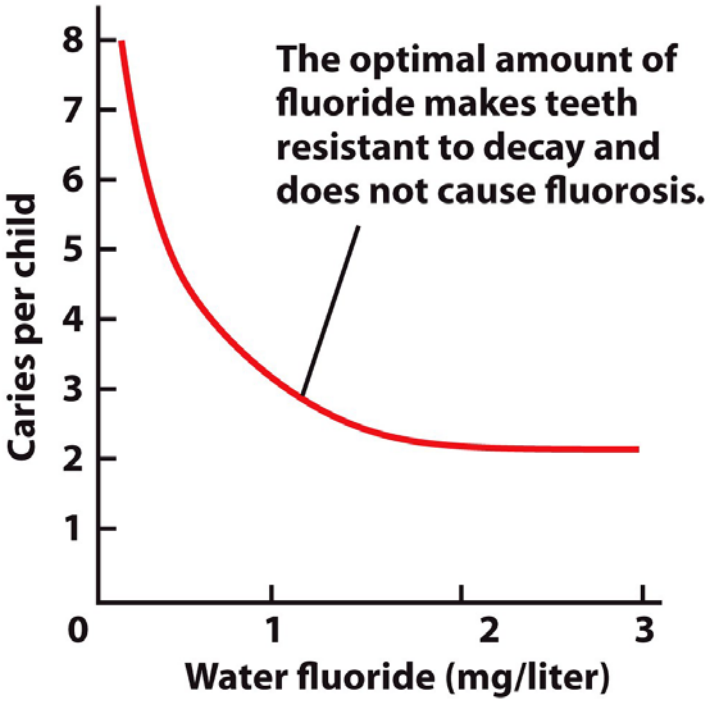
Medicimage/The Medical File/Peter Arnold, Inc.

Science Photo Library/Photo Researchers, Inc.

Hypertension & diet

Based on this graph what concentration of water fluoride will protect against dental caries but not cause fluorosis?

a) 2.5 mg/liter
b) 2 mg/liter
c) 1 mg/liter
d) 0.5 mg/liter



Manganese

- Constituent of some enzymes and activator of others involved in:
  - Carbohydrate and cholesterol metabolism
  - Bone formation
  - Urea synthesis
  - Oxidative damage prevention
- RDA: men = 2.3 mg/day; women = 1.8 mg/day
- Sources: whole grains, nuts, legumes, leafy green vegetables

Molybdenum

- Needed to activate enzymes functioning in:
  - Metabolism of sulfur-containing amino acids and nitrogen-containing compounds in DNA and RNA
  - Production of uric acid (waste product)
  - Oxidation and detoxification of other compounds
- Readily absorbed from foods
- Regulated by excretion in the urine and bile
- RDA: adults = 45 mg/day
- Sources: milk and milk products, organ meats, breads, cereals, legumes

Trace minerals

A summary of the trace minerals Table 8.4

Mineral	Sources	Recommended intake for adults	Major functions	Deficiency diseases and symptoms	Groups at risk of deficiency	Toxicity	UL
Iron	Red meats, leafy greens, dried fruit, legumes, whole and enriched grains	8–18 mg/day	Part of hemoglobin (which delivers oxygen to cells), myoglobin (which holds oxygen in muscle), and proteins needed for ATP production; needed for immune function	Iron deficiency anemia: fatigue; weakness; small, pale red blood cells; low hemo-globin levels; inability to maintain normal body temperature	Infants and preschool children, adolescents, women of childbearing age, pregnant women, athletes, vegetarians	Acute: Gastro-intestinal upset, liver damage Chronic: fatigue, heart and liver damage, increased risk of diabetes and cancer	45 mg/day
Copper	Organ meats, nuts, seeds, whole grains, seafood, cocoa	900 µg/day	A component of proteins needed for iron transport, lipid metabolism, collagen synthesis, nerve and immune function, protection against oxidative damage	Anemia, poor growth, skeletal abnormalities	People who consume excessive amounts of zinc in supplements	Vomiting, abdominal pain, diarrhea, liver damage	10 mg/day
Zinc	Meat, seafood, whole grains, dairy products, legumes, nuts	8–11 mg/day	Regulates protein synthesis; functions in growth, development, wound healing, immunity, and antioxidant enzymes	Poor growth and development, skin rashes, decreased immune function	Vegetarians, low-income children, elderly people	Decreased copper absorption, depressed immune function	40 mg/day
Selenium	Meats, seafood, eggs, whole grains, nuts, seeds	55 µg/day	Antioxidant as part of glutathione peroxidase, synthesis of thyroid hormones, spares vitamin E	Muscle pain, weakness, Keshan disease	Populations in areas where the soil is low in selenium	Nausea, diarrhea, vomiting, fatigue, changes in hair and nails	400 µg/day

Trace minerals

(Continued) **Table 8.4**

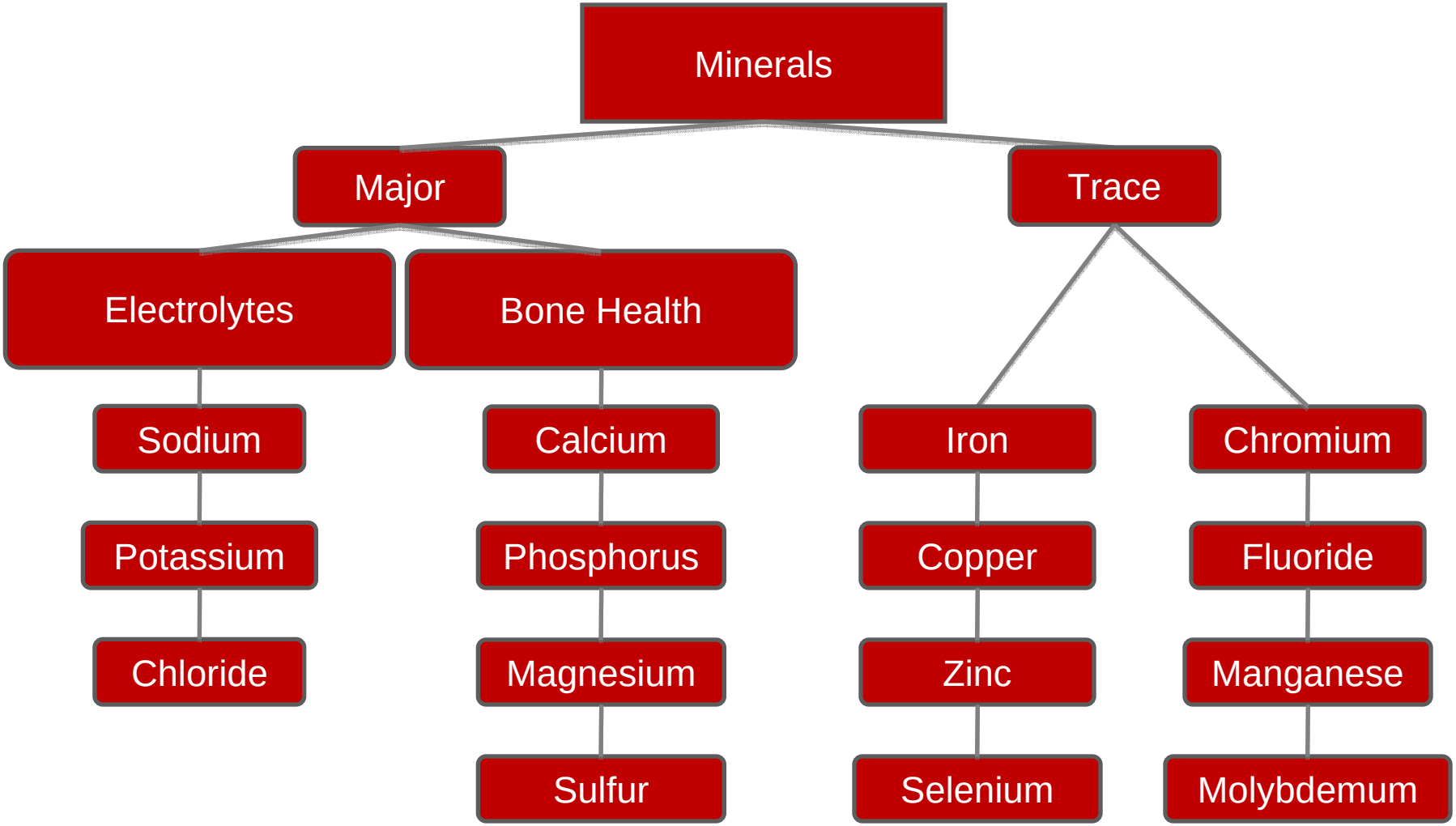
Mineral	Sources	Recommended intake for adults	Major functions	Deficiency diseases and symptoms	Groups at risk of deficiency	Toxicity	UL
Iodine	Iodized salt, seafood, seaweed, dairy products	150 µg/day	Needed for synthesis of thyroid hormones	Goiter, cretinism, impaired brain function, growth and developmental abnormalities	Populations in areas where the soil is low in iodine and iodized salt is not used	Enlarged thyroid	1110 µg/day
Chromium	Brewer's yeast, nuts, whole grains, meat, mushrooms	25–35 µg/day	Enhances insulin action	High blood glucose	Malnourished children	None reported	ND
Fluoride	Fluoridated water, tea, fish, toothpaste	3–4 mg/day	Strengthens tooth enamel, enhances re-mineralization of tooth enamel, reduces acid production by bacteria in the mouth	Increased risk of dental caries	Populations in areas with unfluoridated water, those who drink mostly bottled water	Fluorosis: mottled teeth, kidney damage, bone abnormalities	10 mg/day
Manganese	Nuts, legumes, whole grains, tea, leafy vegetables	1.8–2.3 mg/day	Functions in carbohydrate and cholesterol metabolism and antioxidant enzymes	Growth retardation	None	Nerve damage	11 mg/day
Molybdenum	Milk, organ meats, grains, legumes	45 µg/day	Cofactor for a number of enzymes	Unknown in humans	None	Arthritis, joint inflammation	2 mg/day

Note: UL, Tolerable Upper Intake Level; ND, not determined.

What should I eat?

- Stay hydrated
- Increase potassium intake
- Decrease sodium intake
- Get calcium into your body and your bones
- Don’t fret about phosphorus
- Maximize your magnesium
- Add more iron and increase iron absorption
- Think zinc
- Trace down your minerals

Minerals



What are similarities and differences between:

- Minerals and vitamins?
- Major and trace minerals?
- Sodium, potassium, and chloride?
- Calcium, phosphorus, magnesium, and sulfur?

Nutrition in the news

- Bottled vs. tap water
- Privatization of water
- Water shortages
- Soda decreasing bone density
- Fluoride in water

Checking student learning outcomes

- What advice would you give to a loved one about water and mineral consumption?