

Chapter 12

Water and Major Minerals

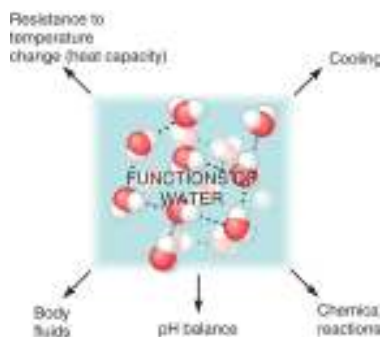


Water and the Body Fluids

- The main role of water is to maintain an appropriate water balance to support vital functions.
- To maintain water homeostasis, intake from liquids, foods, and metabolism must equal losses from the kidneys, skin, lungs, and feces.

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Functions of Water



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Water and the Body Fluids

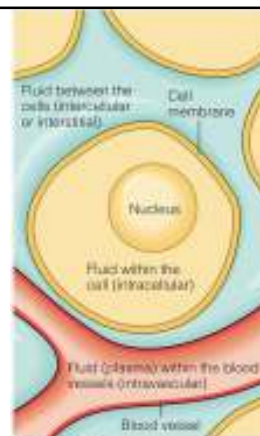
- Water's roles in the body
 - ✓ Carries nutrients and waste products
 - ✓ Maintains the structure of large molecules
 - ✓ Participates in metabolic reactions
 - ✓ Solvent for minerals, vitamins, amino acids, glucose and others
 - ✓ Lubricant and cushion around joints, inside the eyes, the spinal cord, and in amniotic fluid during pregnancy
 - ✓ Regulation of body temperature
 - ✓ Maintains blood volume

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Water and the Body Fluids

- Water Balance and Recommended Intakes
 - ✓ Intracellular fluid (inside the cells) makes up about two-thirds of the body's water.
 - ✓ Extracellular fluid (outside the cells) has two components—the interstitial fluid and plasma.
 - ✓ Water Intake
 - Thirst is a conscious desire to drink and is regulated by the mouth, hypothalamus, and nerves.

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Water and the Body Fluids

- Water Intake
 - ✓ Dehydration occurs when water output exceeds input due to an inadequate intake or excessive losses.
 - 1-2% loss of body weight – thirst, fatigue, weakness, vague discomfort, and loss of appetite
 - 3-4% loss of body weight – impaired physical performance, dry mouth, reduction in urine, flushed skin, impatience, and apathy
 - 5-6% loss of body weight – difficulty in concentrating, headache, irritability, sleepiness, impaired temperature regulation, and increased respiratory rate
 - 7-10% loss of body weight – dizziness, spastic muscles, loss of balance, delirium, exhaustion, and collapse

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Water and the Body Fluids

- Water Intake
 - ✓ Water intoxication is excessive water contents in all body fluid compartments.
 - It is rare.

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Water and the Body Fluids

- Water Balance and Recommended Intakes
 - ✓ Water sources include water, other beverages, fruit, vegetables, meat, cheese, and the byproduct of metabolism.
 - ✓ An intake of 1450 to 2800 milliliters of water is usually represented by:
 - Liquids – 550 to 1500 mL
 - Foods – 700 to 1000 mL
 - Metabolic water – 200 to 300 mL

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TABLE 12-2 Percentage of Water in Selected Foods

100%	Water
90-99%	Fat-free milk, strawberries, watermelon, lettuce, cabbage, celery, spinach, broccoli
85-89%	Fruit juice, yogurt, apples, grapes, oranges, carrots
70-79%	Shrimp, bananas, corn, potatoes, avocado, cottage cheese, ricotta cheese
60-69%	Beets, legumes, salmon, ice cream, chicken breast
50-59%	Ground beef, hot dogs, feta cheese
40-49%	Pizza
30-39%	Cheddar cheese, bagels, bread
20-29%	Pepperoni sausage, cake, biscuits
10-19%	Butter, margarine, raisins
1-9%	Crackers, cereals, pretzels, taco shells, peanut butter, nuts
0%	Oils, sugar

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Water and the Body Fluids

- Water Balance and Recommended Intakes
 - ✓ Water losses occur through urine output, water vapor from the lungs, sweating, and feces.
 - ✓ An output of 1450 to 2800 milliliters of water is usually represented by:
 - Kidneys – 500 to 1400 mL
 - Skin – 450 to 900 mL
 - Lungs – 350 mL
 - GI tract – 150 mL

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Water and the Body Fluids

- Water Balance and Recommended Intakes
 - ✓ Water Recommendations
 - 1.0 to 1.5 mL/kcal expended for adults (approximately 2-3 liters for a 2,000 kcalorie expenditure)
 - 1.5 mL/kcal expended for infants and athletes
 - ½ cup per 100 kcal expended
 - Adequate Intake for males is 3.7 L/day.
 - Adequate Intake for females is 2.7 L/day.
 - Both caffeine and alcohol can have a diuretic effect.

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Water and the Body Fluids

- Water Balance and Recommended Intakes
 - ✓ Health Effects of Water
 - Meeting fluid needs
 - Protect the bladder, prostate, and breast against cancer
 - Protect against kidney stones

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Water and the Body Fluids

- Water Balance and Recommended Intakes
 - ✓ Kinds of water
 - Hard Water
 - Water with high calcium and magnesium content
 - Leaves residues
 - May benefit hypertension and heart disease
 - Soft water
 - Water with high sodium and potassium content
 - May aggravate hypertension and heart disease
 - Dissolves contaminate minerals in pipes
 - Practical advantages

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Water and the Body Fluids

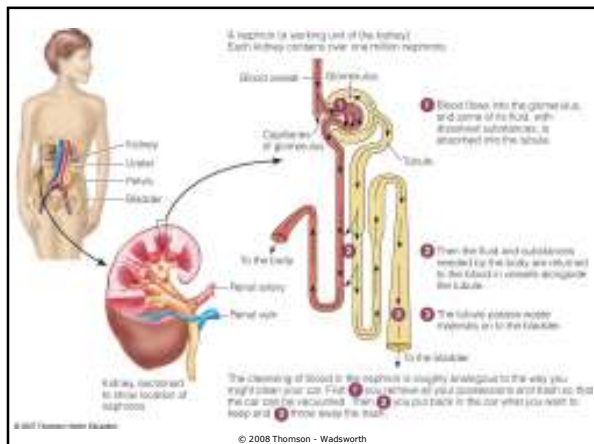
- Other types of water:
 - ✓ Artesian water – water drawn from a well that taps a confined aquifer in which the water is under pressure
 - ✓ Bottled water – drinking water sold in bottles
 - ✓ Carbonated water – water that contains carbon dioxide gas, either natural or added
 - ✓ Distilled water – free of dissolved minerals
 - ✓ Filtered water – water treated by filtration with lead, arsenic, and some microorganisms removed
 - ✓ Mineral water – water from a spring or well that contains about 250-500 parts per million of minerals
 - ✓ Natural water – water from a spring or well that is certified to be safe and sanitary
 - ✓ Public water – water from a city or county water system that has been treated and disinfected
 - ✓ Purified water – water that has been treated to remove dissolved solids
 - ✓ Spring water – water originating from an underground spring or well
 - ✓ Well water – water drawn from ground water by tapping into an aquifer

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Water and the Body Fluids

- Blood Volume and Blood Pressure
 - ✓ Fluids are essential to the regulation of blood volume and blood pressure.
 - ✓ ADH and Water Retention
 - Antidiuretic hormone (ADH) is released from the pituitary gland and causes kidneys to reabsorb water, thus preventing losses
 - Vasopressin is another name for ADH
 - ✓ Renin and Sodium Retention
 - Kidneys release renin to reabsorb sodium
 - Helps to restore blood pressure and blood volume

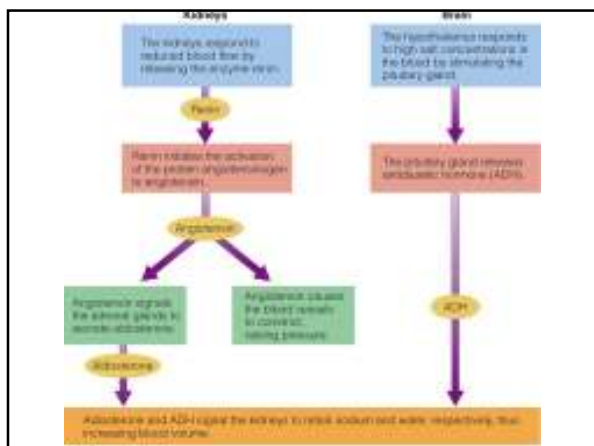
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Water and the Body Fluids

- Blood Volume and Blood Pressure
 - ✓ Angiotensin and Blood Vessel Constriction
 - Angiotensinogen converts to angiotensin
 - A vasoconstrictor that raises blood pressure by narrowing blood vessels
 - ✓ Aldosterone and Sodium Retention
 - Angiotensin mediates the release of aldosterone from the adrenal glands
 - Kidneys retain sodium in order to retain water

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Water and the Body Fluids

- Fluid and Electrolyte Balance
 - ✓ Several minerals including sodium, chloride, potassium, calcium, phosphorus, magnesium, and sulfur are involved in fluid balance.
 - ✓ Dissociation of Salt in Water
 - Dissociates into positive ions called cations and negative ions called anions
 - Ions carry electrical current so they are called electrolytes.
 - Solutions are called electrolyte solutions.
 - Positive and negative charges inside and outside the cell must be balanced.
 - Milliequivalents is the concentration of electrolytes in a volume of solution.

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The negatively charged electrons that bond the hydrogens to the oxygen spend most of their time near the oxygen atom. As a result, the oxygen is slightly negative, and the hydrogens are slightly positive (see Appendix B).

In an electrolyte solution, water molecules are attracted to both anions and cations. Notice that the negative oxygen atoms of the water molecules are drawn to the sodium cation (Na⁺), whereas the positive hydrogen atoms of the water molecules are drawn to the chloride ion (Cl⁻).

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Water and the Body Fluids

- Fluid and Electrolyte Balance
 - ✓ Electrolytes Attract Water
 - Water molecules are neutral, polar
 - Oxygen is negatively charged. Hydrogen is positively charged.
 - Enables body to move fluids

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Water and the Body Fluids

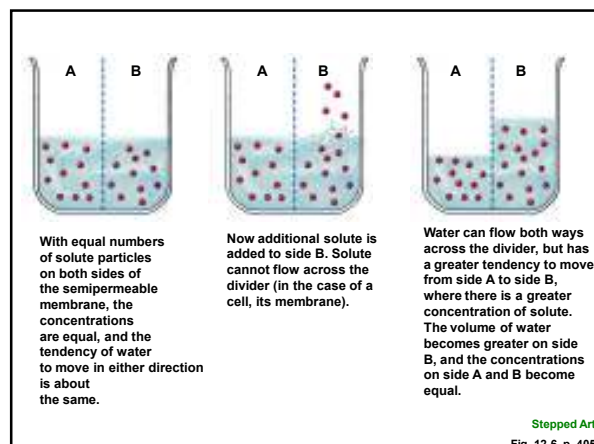
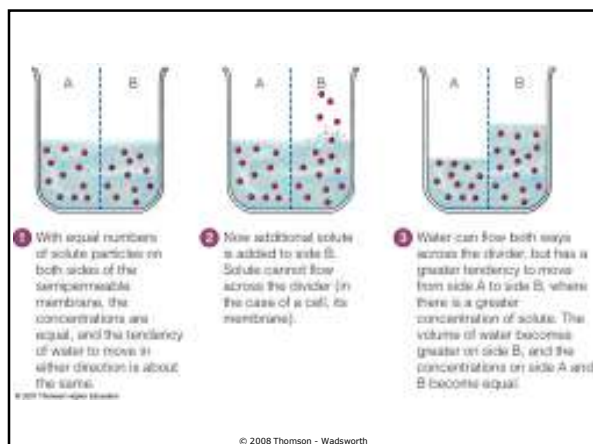
- Fluid and Electrolyte Balance
 - ✓ Water Follows Electrolytes
 - Sodium and chloride are primarily outside the cell.
 - Potassium, magnesium, phosphate and sulfur are primarily inside the cell.
 - Osmosis is the movement of water across the cell membrane toward the more concentrated solutes.
 - Osmotic pressure is the amount of pressure needed to prevent the movement of water across a cell membrane.

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Chemical symbols:
 *K = potassium
 *P = phosphorus
 *Mg = magnesium
 *S = sulfate
 *Na = sodium
 *Cl = chloride

Key:
 ● Cations
 ● Anions

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Water and the Body Fluids

- Fluid and Electrolyte Balance
 - ✓ Proteins Regulate Flow of Fluids and Ions
 - Proteins attract water and regulate fluid balance.
 - Transport proteins regulate the passage of positive ions.
 - Negative ions follow.
 - Water flows toward the more concentrated solution.
 - The sodium-potassium pump uses ATP to exchange minerals across the cell membrane.

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Water and the Body Fluids

- Fluid and Electrolyte Balance
 - ✓ Regulation of Fluid and Electrolyte Balance
 - Digestive juices of GI tract contain minerals and these are reabsorbed as needed
 - Kidneys maintain fluid balance using ADH
 - Kidneys maintain electrolyte balance using aldosterone

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Water and the Body Fluids

- Fluid and Electrolyte Imbalance
 - ✓ Medications and medical conditions may interfere with the body's ability to regulate the fluid and electrolyte balance.
 - ✓ Different Solutes Lost by Different Routes
 - Vomiting or diarrhea causes sodium losses.
 - Kidneys may lose too much potassium if there is adrenal hypersecretion of aldosterone.
 - Uncontrolled diabetics may lose glucose and fluid via the kidneys.

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Water and the Body Fluids

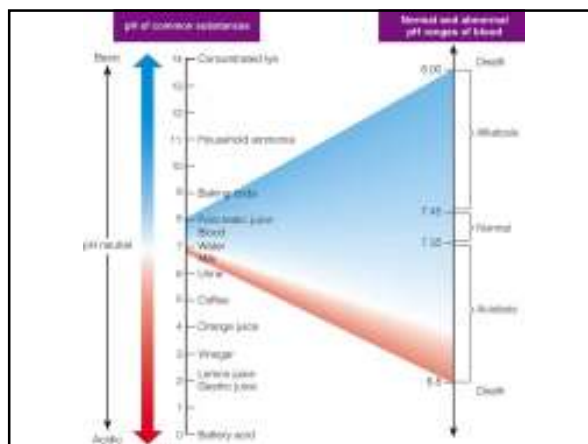
- Fluid and Electrolyte Imbalance
 - ✓ Replacing Lost Fluids and Electrolytes
 - Drink plain cool water and eat regular foods for temporary small losses.
 - Greater losses require oral rehydration therapy (ORT)
 - ½ L boiling water, 4 tsp sugar and ½ tsp salt
 - Cool before giving.

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Water and the Body Fluids

- Acid-Base Balance
 - ✓ The body must maintain an appropriate balance between acids and bases to sustain life.
 - ✓ Acidity is measured by the pH value, the concentration of hydrogen atoms.
 - ✓ Regulation by the Buffers
 - First line of defense
 - Carbonic acid and bicarbonate can neutralize acids and bases.
 - Carbon dioxide forms carbonic acid in the blood that dissociates to hydrogen ions and bicarbonate ions.

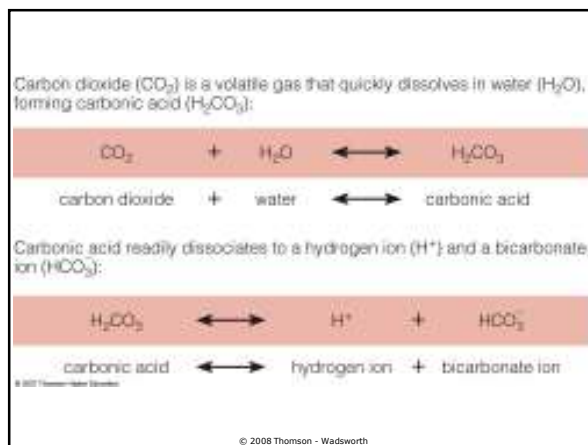
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Water and the Body Fluids

- Acid-Base Balance
 - ✓ Regulation in the Lungs
 - Respiration speeds up and slows down as needed to restore homeostasis.
 - ✓ Regulation in the Kidneys
 - Selects which ions to retain and which to excrete
 - The urine's acidity level fluctuates to keep the body's total acid content balanced.

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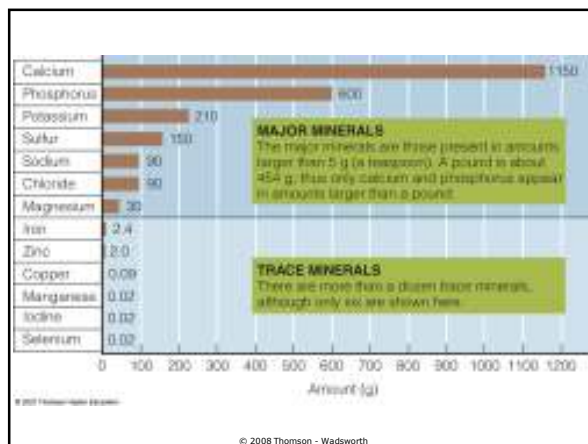


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The Minerals--An Overview

- Major minerals are found in large quantities in the body, while trace minerals are found in small quantities.
- Minerals receive special handling in the body.
- They may bind with other substances and interact with other minerals, thus affecting absorption.
- Inorganic Elements
 - ✓ Major minerals or macrominerals retain their chemical identity when exposed to heat, air, acid, or mixing.
 - ✓ Minerals can be lost when they leach into water.

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The Minerals--An Overview

- The Body's Handling of Minerals
 - ✓ Some behave like water-soluble vitamins.
 - ✓ Some behave like fat-soluble vitamins.
 - ✓ Excessive intake of minerals can be toxic.
- Variable Bioavailability
 - ✓ Binders in food can combine chemically with minerals and prevent their absorption.
 - ✓ Phytates are found in legumes and grains.
 - ✓ Oxalates are found in spinach and rhubarb.

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The Minerals--An Overview

- Nutrient Interactions
 - ✓ Sodium and calcium
 - ✓ Phosphorus and magnesium
 - ✓ Often caused by supplements
- Varied Roles
 - ✓ Sodium, potassium and chloride function primarily in fluid balance.
 - ✓ Calcium, phosphorus and magnesium function primarily in bone growth and health.

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Sodium

- Sodium is one of the primary electrolytes in the body and is responsible for maintaining fluid balance.
- Dietary recommendations include a moderate intake of salt and sodium.
- Excesses may aggravate hypertension.
- Most of the sodium in the diet is found in table salt and processed foods.

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Sodium

- Sodium Roles in the Body
 - ✓ Maintains normal fluid and electrolyte and acid-base balance
 - ✓ Assists in nerve impulse transmission and muscle contraction
 - ✓ Filtered out of the blood by the kidneys

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Sodium

- Sodium Recommendations
 - ✓ Minimum Adults: 500 mg/day
 - ✓ Adequate Intake (2004)
 - For those 19-50 years of age, 1,500 mg/day
 - For those 51-70 years of age, 1,300 mg/day
 - For those older than 70 years of age, 1,200 mg/day
 - ✓ The upper intake level for adults is 2,300 mg/day.
 - ✓ Maximum % Daily Value on food labels is set at 2400 mg/day.

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Sodium

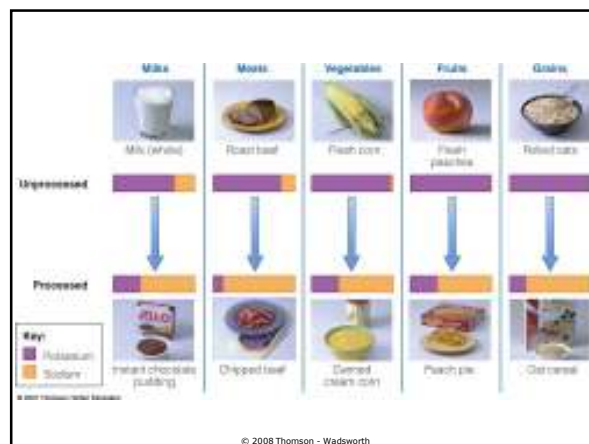
- Sodium and Hypertension
 - ✓ Salt has a great impact on high blood pressure. Salt restriction does help to lower blood pressure.
 - ✓ Salt sensitivity is a term to describe individuals who respond to a high salt intake with high blood pressure.
 - ✓ Dietary Approaches to Stop Hypertension (DASH) is a diet plan that helps to lower blood pressure.
- Sodium and Bone Loss (Osteoporosis)
 - ✓ High sodium intake is associated with calcium excretion.

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Sodium

- Sodium in Foods
 - ✓ Large amounts in processed foods (approximately 75% of sodium in the diet)
 - ✓ Table salt (approximately 15% added sodium in the diet)
 - ✓ Sodium may be present in surprisingly high amounts if chloride is removed.
 - ✓ Moderate amounts in meats, milks, breads and vegetables (approximately 10% of sodium in the diet)

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Sodium

- Sodium Deficiency
 - ✓ Sodium and water must be replaced after vomiting, diarrhea or heavy sweating.
 - ✓ Symptoms are muscle cramps, mental apathy, and loss of appetite.
 - ✓ Salt tablets without water induce dehydration.
 - ✓ Be careful of hyponatremia during ultra-endurance athletic activities.
- Sodium Toxicity and Excessive Intakes
 - ✓ Edema and acute hypertension
 - ✓ Prolonged high intake may contribute to hypertension.

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Chloride

- Chloride is an essential nutrient that plays a role in fluid balance.
- It is associated with sodium and part of hydrochloric acid in the stomach.
- Chloride Roles in the Body
 - ✓ Maintains normal fluid and electrolyte balance
 - ✓ Part of hydrochloric acid found in the stomach
 - ✓ Necessary for proper digestion

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Chloride

- Chloride Recommendations and Intakes
 - ✓ Recommendations
 - Adequate Intake (2004)
 - For those 19-50 years of age, 2,300 mg/day
 - For those 51-70 years of age, 2,000 mg/day
 - For those older than 70 years of age, 1,800 mg/day
 - Upper intake level is 3,600 mg/day
 - ✓ Chloride Intakes
 - Abundant in foods
 - Abundant in processed foods

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Chloride

- Chloride Deficiency and Toxicity
 - ✓ Deficiency is rare.
 - ✓ Losses can occur with vomiting, diarrhea or heavy sweating.
 - ✓ Dehydration due to water deficiency can concentrate chloride to high levels.
 - ✓ The toxicity symptom is vomiting.

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Potassium

- Potassium Toxicity
 - ✓ Results from supplements or overconsumption of potassium salts
 - ✓ Can occur with certain diseases or treatments
 - ✓ Symptoms include muscular weakness and vomiting.
 - ✓ If given into a vein, potassium can cause the heart to stop.

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Calcium

- Most of calcium (99%) is found in the bones.
- The remaining calcium (1%) is found in the blood and has many functions.
- Bone and blood calcium are kept in balance with a system of hormones and vitamin D.
- Blood calcium remains in balance at the expense of bone calcium and at the risk of developing osteoporosis in later years.

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Calcium

- Calcium Roles in the Body
 - ✓ Calcium in Bones
 - Hydroxyapatite are crystals of calcium and phosphorus.
 - Mineralization is the process whereby minerals crystallize on the collagen matrix of a growing bone, hardening of the bone.
 - There is an ongoing process of remodeling constantly taking place.

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Calcium

- Calcium Roles in the Body
 - ✓ Calcium in Body Fluids
 - Calmodulin is an inactive protein that becomes active when bound to calcium and serves as an interpreter for hormone and nerve-mediated messages.
 - Ionized calcium has many functions.

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Calcium

- Calcium Roles in the Body
 - ✓ Calcium and Disease Prevention
 - May protect against hypertension
 - DASH diet that is rich in calcium, magnesium, and potassium
 - May be protective relationship with blood cholesterol, diabetes, and colon cancer
 - ✓ Calcium and Obesity
 - Maintaining healthy body weight
 - Calcium from dairy foods has better results than calcium from supplements.
 - More research is needed.

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Calcium

- Calcium Roles in the Body
 - ✓ Calcium Balance
 - Works with vitamin D
 - Works with parathyroid hormone and calcitonin
 - Calcium rigor develops when there are high blood calcium levels and causes the muscles to contract.
 - Calcium tetany develops when there are low blood calcium levels and causes uncontrolled muscle contractions.
 - Abnormalities are due to problems with hormone secretion or lack of vitamin D.
 - Bones get robbed of calcium before blood concentrations get low.

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Osteoporosis and Calcium

- Osteoporosis is one of the most prevalent diseases of aging.
- Strategies to reduce risks involve dietary calcium.

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Bone Development and Disintegration

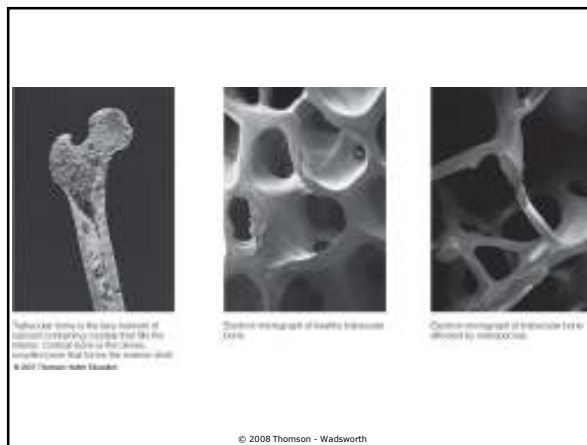
- Cortical bone is the outer shell compartment of bone.
 - ✓Creates the shell of long bones
 - ✓Creates the shell caps on the end of bones
 - ✓Releases calcium slower than trabecular bone
 - ✓Losses can begin in the 40s.

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Bone Development and Disintegration

- Trabecular bone is the inner lacy matrix compartment of bone.
 - ✓Can be affected by hormones in the body signaling the release of calcium
 - ✓Provides a source for blood calcium when needed
 - ✓Losses can become significant in the 30s for men and women.
 - Results in type I osteoporosis
 - Can result in spine and wrist fractures and loss of teeth
 - Women are affected 6 times as often as men.

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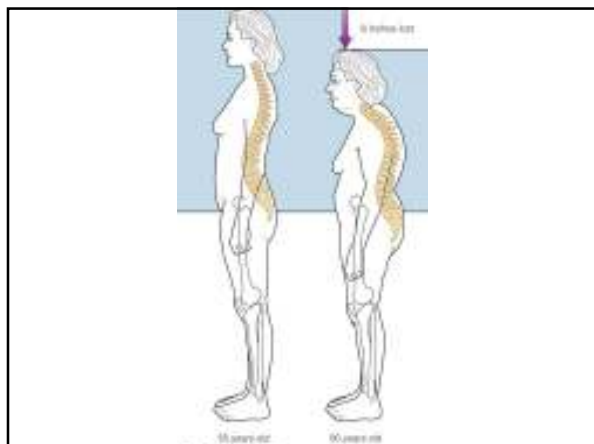
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Bone Development and Disintegration

- Losses of both trabecular and cortical bone result in type II osteoporosis.
 - ✓Can result in compression fractures of the spine
 - ✓Hip fractures can develop.
 - ✓Twice as common in women as in men
- The diagnosis of osteoporosis is performed using bone density tests.
- Individual risk factors for osteoporosis are also considered.

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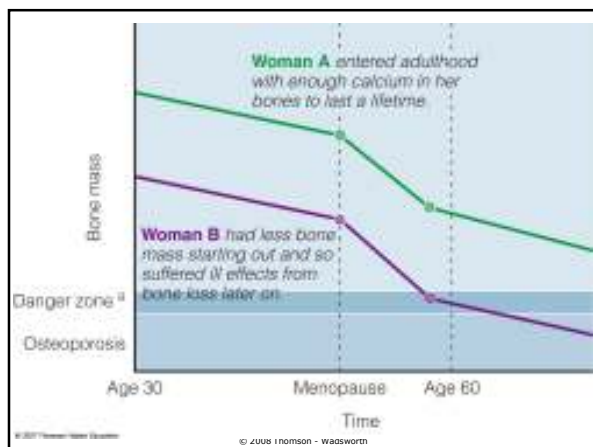




Age and Bone Calcium

- Maximizing Bone Mass
 - ✓ Children and adolescents need to consume enough calcium and vitamin D to create denser bones.
 - ✓ With a higher initial bone mass, the normal losses of bone density that occur with age will have less detrimental effects.
- Minimizing Bone Loss
 - ✓ Ensuring adequate intakes of vitamin D and calcium are consumed
 - ✓ Hormonal changes can increase calcium losses.

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Gender and Hormones

- Men at lower risk than women
- Hormonal changes
- Rapid bone loss in nonmenstruating women
- Medications can be used that inhibit osteoclasts or stimulate osteoblasts.
- Soy offers some protection.

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Genetics and Ethnicity

- Genes may play a role.
- Environment also – diet and calcium
- Physical activity, body weight, alcohol, and smoking have a role.

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Physical Activity and Body Weight

- Muscle strength and bone strength go together.
- Heavy body weights and weight gains place a stress on bones and promote bone density.

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Smoking and Alcohol

- Smokers
 - ✓ Less dense bones
 - ✓ Damage can be reversed when smoking stops.
- Alcohol abuse
 - ✓ Enhances fluid excretion, thus increases calcium losses
 - ✓ Upsets hormonal balance for healthy bones
 - ✓ Slows bone formation
 - ✓ Stimulates bone breakdown
 - ✓ Increases risks of falling

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Nutrients

- Dietary Calcium – the key to prevention
- Other Nutrients
 - ✓ Adequate protein
 - ✓ Adequate vitamin D
 - ✓ Vitamin K protects against hip fractures.
 - ✓ Magnesium and potassium help to maintain bone mineral density.
 - ✓ Vitamin A
 - ✓ Omega-3 fatty acids
 - ✓ Fruits and vegetables
 - ✓ Reduce salt

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A Perspective on Supplements

- Calcium-rich foods are best.
- Supplements may be needed when requirements are not met through foods.
- Types of supplements
 - ✓ Antacids contain calcium carbonate.
 - ✓ Bone meal or powdered bone, oyster shell or dolomite are calcium supplements.
 - ✓ Contain lead??
 - ✓ Small doses are better absorbed.
 - ✓ Different absorption rates from different types of calcium supplements

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Some Closing Thoughts

- Age, gender and genetics are beyond control.
- There are effective strategies for prevention that include adequate calcium and vitamin D intake, physical activity, moderation of alcohol, abstaining from cigarettes, and supplementation if needed.

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Healthy Eating Pyramid

- Harvard School of Public Health
<http://www.hsph.harvard.edu/nutritionsource/what-should-you-eat/pyramid/>

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