

Chapter Summary

Bones are organs that contain metabolically active tissues composed primarily of minerals and a fibrous protein called collagen. The three types of bone activity are growth, modeling, and remodeling. Bone density can be measured most accurately by dual-energy x-ray absorptiometry. Calcium is a mineral that plays a major role in providing structure to bones and teeth. Blood calcium is maintained within a very narrow range. Bone calcium is used to maintain normal blood calcium when necessary. Calcium is necessary for nerve and muscle function and blood clotting. Consuming excessive calcium leads to mineral imbalance, while consuming inadequate calcium leads to osteoporosis.

Vitamin D is a fat-soluble vitamin and hormone. It regulates blood calcium levels and maintains bone health. Vitamin D can be produced from cholesterol in the skin when the skin is exposed to UV light; however, most Americans do not produce enough. Hypercalcemia results from excessive consumption of vitamin D. Rickets in children and osteoporosis and osteomalacia in adults are the consequence of vitamin D deficiency. Vitamin K is a fat-soluble vitamin and coenzyme that is important for blood clotting and bone metabolism. Phosphorus is the major negatively charged electrolyte inside the cell. It helps maintain fluid balance and bone health. It also assists in regulating chemical reactions and is a primary component of ATP, DNA, and RNA. Magnesium is a major mineral and is important for bone health, energy production, and muscle function. Excessive pharmacological magnesium results in diarrhea, dehydration, and cardiac arrest. Hypomagnesemia leads to low blood calcium with accompanying symptoms and increases the risk for some chronic diseases. Fluoride is a trace mineral whose primary function is to support the health of teeth and bones. Osteoporosis is a major disease of concern to the elderly in the United States. Osteoporosis increases risk for fractures and premature death from subsequent illness. Factors that increase risk include genetics, being female, being of the Caucasian or Asian race, cigarette smoking, alcohol abuse, sedentary lifestyle, and diets low in calcium and vitamin D. Treatments for osteoporosis reduce bone loss, increase bone density, and reduce the risk of fractures.

Nutrition Myth or Fact addresses the question: Preserving Bone Mass: Are Supplements the Solution?

Learning Objectives

After studying this chapter, the student should be able to:

1. Identify the functions of bone in the human body and distinguish between cortical and trabecular bone (pp. 426–427).
2. Describe the processes of bone growth, modeling, and remodeling (pp. 427–429).

3. Identify the most accurate tool for assessing bone density and the significance of the T-score (pp. 429–430).
4. Explain the critical role of calcium in maintaining bone health and other body functions (pp. 430–431).
5. Discuss foods that are good sources of calcium and factors that affect its absorption (pp. 432–435).
6. Discuss the contributions of vitamin D to bone health, and the process by which the body synthesizes vitamin D from exposure to sunlight (pp. 437–438).
7. Identify the contributions of vitamin K, phosphorus, and magnesium to bone health, as well as good food sources (pp. 442–447).
8. Describe the main functions of fluoride in the development and maintenance of teeth and bones, and the results of consuming too much and too little fluoride (pp. 447–449).
9. Define *osteoporosis* and identify the factors that influence the risk for developing the disease (pp. 449–453).
10. Describe osteoporosis treatment (pp. 453–454).

Key Terms

bioavailability	ergocalciferol	osteomalacia
bone density	fluorohydroxyapatite	osteoporosis
calcitriol	fluorosis	parathyroid hormone
calcium tetany	hypercalcemia	phylloquinone
calcium rigor	hypermagnesemia	remodeling
cholecalciferol	hypocalcemia	resorption
collagen	hypomagnesemia	rickets
cortical bone (compact bone)	matrix Gla protein	T-score
dual energy x-ray absorptiometry (DXA, DEXA)	menaquinone	trabecular bone (spongy bone)
	osteoblasts	
	osteocalcin	
	osteoclasts	

Chapter Outline

I. How Does the Body Maintain Bone Health?

- A. The composition of bone provides strength and flexibility.
 1. About 65% of bone tissue is made up of minerals, primarily calcium and phosphorus.
 2. About 35% of bone tissue is organic substances, including collagen, that provide strength, durability, and flexibility.
 3. There are two types of bone.
 - a. Cortical bone, or compact bone, is very dense and comprises 80% of the skeleton covering the outside of all bones.
 - b. Trabecular bone, or spongy bone, is porous bone tissue that makes up 20% of the skeleton.

- c. Trabecular bone has a higher rate of turnover, and is therefore more sensitive to changes in hormones and nutritional deficiencies.

B. The constant activity of bone tissue promotes bone health.

1. Through the process of bone growth, the size of bones increase.
 - a. Bone growth continues through childhood and adolescence.
2. Bone modeling determines the shape of bones and continues to change with stress.
3. Bone density, or the compactness of bones, develops into early adulthood.
 - a. Peak bone density can be affected by late pubertal age in boys, late onset of menstruation in girls, inadequate calcium intake, low body weight, and physical inactivity during adolescence.
4. Bone remodeling maintains a balance between breakdown and repair once peak bone mass is achieved in early adulthood.
 - a. Bone mass is regularly recycled, strengthened, and repaired through remodeling.
 - b. Resorption involves the action of osteoclasts eroding and smoothing the bone surface and providing minerals for blood and for repair of fractures.
 - c. Bone formation involves the action of osteoblasts laying down collagen-containing substances, which result in crystallization of hydroxyapatite.
 - d. At about age 40, bone resorption occurs more rapidly than formation, decreasing bone density and height with age.

Key Terms: cortical bone (compact bone), trabecular bone (spongy bone), bone density, remodeling, resorption, osteoclasts, osteoblasts

Table and Figures:

Figure 11.1: The structure of bone.

Figure 11.2: Bone develops through three processes

Figure 11.3: Bone remodeling involves resorption and formation.

Table 11.1: Functions of Bone in the Human Body

II. How Do We Assess Bone Health?

- A. Dual-energy x-ray absorptiometry (DXA or DEXA) provides a measure of bone density.
 1. A normal T-score is between 1 and -1 .
 2. Low bone mass is indicated by a T-score of -1 to -2.5 .
 3. A T-score of less than -2.5 indicates osteoporosis.
- B. Other bone-density measurement tools, which are more portable and useful for preliminary screening, have been developed.

Key Terms: dual-energy x-ray absorptiometry (DXA or DEXA), T-score

Figure:

Figure 11.4: Dual-energy x-ray absorptiometry is a safe and simple procedure that assesses bone density.

III. Why Is Calcium Critical to Healthy Bone?

- A. Calcium is the most abundant major mineral in the body.
 1. Calcium is absorbed via active transport and passive diffusion.
 - a. Low-to-moderate calcium intake is reliant on vitamin D for active transport.

- b. At high-calcium intakes, passive diffusion is a function of the calcium concentration gradient.
2. Calcium plays many roles critical to body functioning.
 - a. Calcium provides structure to bones and teeth.
 - b. Blood calcium levels assist with acid–base balance and remain fairly constant through the action of parathyroid hormone (PTH) and vitamin D.
 - c. Calcium is critical for normal transmission of nerve impulses.
 - d. Calcium assists in muscle contraction with inadequate calcium, resulting in calcium tetany and high levels resulting in calcium rigor.
 - e. Calcium helps to maintain healthy blood pressure, initiates blood clotting, and regulates various hormones and enzymes.
 3. How much calcium should we consume?
 - a. The RDA for men aged 19 to 70, and women aged 19 to 50, is 1,000 mg. For men older than 70, and women older than 50, the RDA increases to 1,200 mg. For boys and girls ages 9 to 18 years, the RDA is 1,300 mg. The UL is 2,500 for all ages, but need varies with age and gender.
 - b. The bioavailability of calcium depends on age, need for calcium, how much is consumed at one time, and dietary factors.
 - c. Good food sources of calcium include dairy products, green leafy vegetables, and food fortified with calcium.
 - d. Those who consume little dietary calcium would benefit from supplementation.
 4. What happens if we consume too much calcium?
 - a. Consuming excess calcium can interfere with absorption of other minerals.
 - b. Hypercalcemia, abnormally high blood calcium levels, is caused by alterations in the body’s ability to regulate blood calcium and not by excessive consumption.
 - c. Hypercalcemia can result in calcium deposits in the soft tissues, organ failure, coma, and death.
 5. What happens if we don’t consume enough calcium?
 - a. There are no short-term symptoms associated with consuming too little calcium, as our bodies will remove calcium from bone if necessary.
 - b. The long-term repercussion of low calcium intake is osteoporosis.
 - c. Hypocalcemia, abnormally low blood calcium levels, is not caused by inadequate intake but by certain diseases.

Key Terms: parathyroid hormone (PTH), calcium tetany, calcium rigor, bioavailability, hypercalcemia, hypocalcemia

Table and Figures:

Figure 11.5: Regulation of blood calcium

Figure 11.6: Common food sources of calcium.

Figure 11.7: Serving sizes and energy content of various foods that contain the same amount of calcium as an 8-fl. oz. glass of skim milk.

Table 11.2: Overview of Nutrients Essential to Bone Health

IV. How Does Vitamin D Contribute to Bone Health?

- A. Vitamin D is a fat-soluble vitamin and a hormone.

1. Vitamin D can be made from a cholesterol compound when the skin is exposed to UV light.
 - a. UV light reacts with 7-dehydrocholesterol, which is converted to cholecalciferol, provitamin D₃.
 - b. Cholecalciferol is converted to calcidiol and stored in the liver until it is needed.
 - c. Calcidiol is transported to the kidneys for conversion to calcitriol, active vitamin D.
2. Vitamin D has many regulatory functions.
 - a. Vitamin D works with PTH and calcitonin to regulate blood calcium levels.
 - i. They regulate absorption of calcium and phosphorus from the small intestine.
 - ii. They signal the kidneys to excrete more or less calcium in urine.
 - iii. Vitamin D and PTH stimulate osteoclasts when calcium is needed elsewhere in the body.
 - b. Vitamin D assists in the normal calcification of bone, prevents growth of some cancers, and plays a role in cell differentiation.
3. How much vitamin D should we consume?
 - a. The RDA is based on an assumption that an individual is not getting adequate sun exposure. Latitude and time of year are the most significant factors.
 - b. Vitamin D synthesis is influenced by proximity to the equator, amount of sun exposure, time of day, skin color, age, and obesity status.
 - c. The established RDA for men and women aged 19 to 70 years is 600 IU. For adults older than 70, it is 800 IU. The UL is 4,000 IU for all ages.
 - i. There is controversy as to whether the recommended RDA is sufficient.
4. Vitamin D can be obtained from fish, fortified foods, supplements, or sunlight.
5. What happens if we consume too much vitamin D?
 - a. Sun exposure or food consumption cannot cause vitamin D toxicity.
 - b. Toxicity can occur only when supplementing and can result in hypercalcemia.
6. What happens if we don't consume enough vitamin D?
 - a. The primary symptom of vitamin D deficiency is loss of bone mass.
 - b. Diseases that cause intestinal malabsorption of fat often lead to vitamin D deficiency.
 - c. Vitamin D deficiency causes rickets in children, osteomalacia in adults, and increases the risk of osteoporosis.
 - d. Vitamin D deficiency is most common in breast fed babies, children with darker skin, elderly individuals living in institutions, and those taking certain medications.

Key Terms: cholecalciferol, calcitriol, ergocalciferol, rickets, osteomalacia

Table and Figures:

Figure 11.8: The process of converting sunlight into vitamin D in our skin.

Figure 11.9: This map illustrates the geographic location of 37° latitude in the United States.

Figure 11.10: Common food sources of vitamin D.

Figure 11.11: A vitamin D deficiency causes a bone-deforming disease in children called rickets.

Table 11.3: Factors Affecting Sunlight-Mediated Synthesis of Vitamin D in the Skin

V. What Other Nutrients Help Maintain Bone Health?

- A. Vitamin K serves as a coenzyme contributing to bone health.**
- 1. Vitamin K, a fat-soluble vitamin, is a family of compounds known as quinones.**
 - a. Phylloquinone, the primary dietary form of vitamin K, is found in plants.**
 - i. Absorption occurs in the small intestine and is dependent on the normal flow of bile and pancreatic juice. Dietary fat enhances its absorption.**
 - ii. It is transported through lymph as a component of chylomicrons and is primarily stored in the liver.**
 - b. Menaquinone is the animal form of vitamin K and is produced by bacteria in the large intestine.**
 - i. Absorption is not well understood and its contribution to the maintenance of vitamin K status has been difficult to assess.**
 - 2. Vitamin K serves as a coenzyme in the production of specific proteins.**
 - a. Vitamin K assists in production of osteocalcin and matrix Gla protein, two bone proteins.**
 - 3. How much vitamin K should we consume?**
 - a. In addition to the vitamin K obtained from food, it is produced by the bacteria in the large intestine.**
 - b. There is no RDA or UL for Vitamin K. The recommended AI for men is 120 µg per day, and 90 µg per day for women.**
 - c. Good food sources of vitamin K include green leafy vegetables and vegetable oils, particularly soy and canola.**
 - 4. What happens if we consume too much vitamin K?**
 - a. There appear to be no side effects associated with consuming excessive vitamin K.**
 - 5. What happens if we don't consume enough vitamin K?**
 - a. Vitamin K deficiency is associated with disease conditions or medications and not with inadequate food intake.**
 - b. Vitamin K deficiency is associated with a reduced ability to form blood clots.**
 - c. Vitamin K deficiency may affect bone health, but the relationship is not clear.**
- B. Phosphorus is part of the mineral complex of bone.**
- 1. Phosphorus is the major intracellular negatively charged electrolyte.**
 - 2. Phosphorus has several important functions.**
 - a. Phosphorus plays a critical role in bone formation.**
 - b. Phosphorus helps activate and deactivate enzymes.**
 - c. Phosphorus plays a role in fluid balance.**
 - d. Phosphorus is a component of ATP, DNA, RNA cell membranes, and lipoproteins.**
 - 3. How much phosphorus should we consume?**
 - a. The RDA is 700 mg for adults. Phosphorus is widespread in many foods and is found in high amounts in protein-containing foods.**
 - b. Phosphorus is found in many foods as a food additive.**
 - c. Although phosphorus in soft drinks was theorized to negatively affect bone health, recent studies dispute these findings.**

- d. The most recent evidence suggests that the link between soft drinks and poor bone health is that high intake of soft drinks may be a marker of overall poor dietary health.
4. What happens if we consume too much phosphorus?
 - a. Kidney disease, excessive vitamin D supplementation, or excessive use of phosphorus-containing antacids can lead to severely high blood phosphorus, causing muscle spasms and convulsions.
 5. What happens if we don't consume enough phosphorus?
 - a. Phosphorus deficiencies are rare but can occur with certain medical conditions and also in alcohol abusers, premature infants, and the elderly with poor diets.
- C. Magnesium builds bone and helps regulate calcium balance.
1. Magnesium is a major mineral, and absorption is affected by dietary intake, alcohol consumption, and medications.
 2. Magnesium has several important functions.
 - a. Magnesium is one of the minerals that make up the structure of bone, and it helps regulate bone and mineral status.
 - b. Magnesium is a cofactor for more than 300 enzymes, is necessary for ATP production, and plays an important role in DNA and protein synthesis and repair.
 - c. Magnesium supports normal vitamin D metabolism and is necessary for normal muscle contraction and blood clotting.
 - d. Supplemental magnesium improves insulin sensitivity and may decrease the risk for colorectal cancer.
 3. How much magnesium should we consume?
 - a. The RDA for magnesium varies with age and gender.
 - b. For men aged 19 to 30 years, the RDA is 400 mg per day. For women aged 19 to 30 years, the RDA is 310 mg per day. For men over the age of 31 the RDA is 420 mg per day; for women older than 31 it is 320 mg per day. There is no UL for magnesium consumed in food or water. The UL for pharmacological magnesium is 350 mg per day.
 - c. Good food sources of magnesium include green leafy vegetables, whole grains, seeds, and nuts.
 - d. Refined and processed foods are low in magnesium.
 - e. The "harder" the drinking water, the higher the magnesium content.
 - f. Fiber and phytates reduce the absorption of magnesium, and protein enhances absorption.
 4. What happens if we consume too much magnesium?
 - a. Toxicity does not result from dietary intake of magnesium.
 - b. Toxicity from supplements may include diarrhea, nausea, and abdominal cramps.
 - c. Individuals with impaired kidney function who consume excessive non-dietary magnesium suffer from hypermagnesemia.
 5. What happens if we don't consume enough magnesium?
 - a. Magnesium deficiency results from kidney disease, chronic diarrhea, chronic alcohol abuse, and extremely low dietary intakes.

- b. Magnesium deficiency can result in low blood calcium, muscle cramps, nausea, seizures, irritability, and confusion.
 - c. Long-term magnesium deficiency is associated with osteoporosis, heart disease, high blood pressure, and type 2 diabetes.
- D. Fluoride helps develop and maintain teeth and bones.**
1. Fluoride is the ionic form of fluorine and a trace mineral.
 2. Functions of fluoride include development and maintenance of bones and teeth.
 3. Fluoride stimulates new bone growth and is being researched as a potential treatment for osteoporosis.
 4. How much fluoride should we consume?
 - a. Need for fluoride is relatively small. There is no RDA for fluoride.
 - b. AI ranges from 1 to 4 mg per day (with a UL of 2.2 mg) for boys and girls 8 years and younger, and it is 10 mg for everyone over the age of 8.
 - c. The two primary sources of fluoride are fluoridated dental products and fluoridated water.
 5. What happens if we consume too much fluoride?
 - a. Consuming too much fluoride causes fluorosis of the teeth and skeleton.
 6. What happens if we don't consume enough fluoride?
 - a. The primary result of fluoride deficiency is dental caries.

Key Terms: phylloquinone, menaquinone, osteocalcin, matrix Gla protein, hypermagnesemia, hypomagnesemia, fluorohydroxyapatite, fluorosis

Nutrition Animations: Calcium Metabolism; Activation of Vitamin D (located in IR-DVD folder).

Figures:

Figure 11.12: The chemical structure of (a) phylloquinone, the plant form of vitamin K, and (b) menaquinone, the animal form of vitamin K.

Figure 11.13: Common food sources of vitamin K.

Figure 11.14: Common food sources of magnesium.

Figure 11.15: Consuming too much fluoride causes fluorosis, leading to staining and pitting of the teeth.

VI. What is Osteoporosis, and What Factors Influence the Risk?

- A. Osteoporosis is a disease characterized by low bone mass and deterioration of bone tissue.**
1. Osteoporosis is the single leading cause of hip and spinal fractures.
 2. Fractures in older adults increase the risk for infection, loss of height, kyphosis (dowager's hump), and premature death.
 3. Osteoporosis is common worldwide.
- B. Aging impacts osteoporosis risk.**
1. Bone density declines with age in both men and women.
 2. Hormonal changes have a significant impact on bone loss.
 3. Decreased ability to metabolize vitamin D exacerbates bone loss.
- C. Gender affects osteoporosis risk.**

1. Eighty percent of Americans with osteoporosis are women because they have lower absolute bone density, their hormonal changes impact bone density, and they live longer than men.
 2. Social pressures to be thin promote harmful eating habits that interfere with bone building during adolescence.
- D.** Genetics affects osteoporosis risk.
1. A family history of osteoporosis, especially in Caucasian and Asian women, increases risk.
- E.** Smoking, drinking alcohol, and consuming caffeine increase osteoporosis risk.
1. Cigarette smoking decreases bone density.
 2. Chronic alcoholism is associated with high rates of fracture.
 3. Excessive caffeine consumption may be detrimental to bone health in older adults.
- F.** Nutritional factors play a role in osteoporosis risk.
1. Fruits and vegetables are good sources of the nutrients needed for bone and collagen health.
 2. High protein intake has been shown to have both a negative and a positive impact on bone health.
 3. Calcium and vitamin D are important for bone health.
 4. High sodium intake increases the excretion of calcium.
- G.** Regular physical activity reduces osteoporosis risk.
1. Regular weight-bearing exercise is highly protective against bone loss and osteoporosis.
 2. The female athlete triad is a condition characterized by the coexistence of three disorders in some athletic females.
 - a. An eating disorder reduces the likelihood for proper nourishment.
 - b. Amenorrhea, which reduces estrogen and, in turn, bone density, results from inadequate food intake and strenuous activity.
 - c. Osteoporosis ensues at a younger age.
- H.** There is no cure for osteoporosis, but various treatments can slow and even reverse bone loss.
1. Adequate calcium and vitamin D and regular exercise improve bone health.
 2. Several medications (such as bisphosphonates, selective estrogen receptor modulators, and calcitonin) are available to reduce bone loss, increase bone density, and prevent fractures, although they may prompt side effects.
 3. Hormone replacement therapy can help prevent osteoporosis.
 - a. HRT has side effects and increases risk for heart disease, stroke, and breast cancer.
 - b. In some cases the preventive effects against osteoporosis and colorectal cancer outweigh the negatives.

Key Terms: osteoporosis

Figures and Table:

Figure 11.16: The vertebrae of a person with osteoporosis (left) are thinner and more collapsed than the vertebrae of a health person (right)

Figure 11.17: These x-rays reveal the progression of osteoporosis in hip bones.

Figure 11.18: Gradual compression of the vertebrae in the upper back causes a shortening and rounding of the spine called *kyphosis*.

Table 11.4: Risk Factors for Osteoporosis

Activities

1. Prior to reading the chapter and lecture, have students determine the accuracy of their perceptions using the two assessments: Dairy Quiz from Mid East United Dairy Industry Association, at <http://www.agriscience.msu.edu/careerpathways/6-8/animalsciences/parlor/quiz.html>, and Test Your CALCIUM I.Q. at http://www.nationaldairycouncil.org/SiteCollectionDocuments/health_wellness/dairy_nutrients/TestingCalIQ.pdf. When discussing calcium and osteoporosis, allow students to share their perceptions and explore the misperceptions many people have on this topic.
2. To demonstrate the necessity of mineral deposition in bone, obtain two chicken or turkey bones (drumsticks are the best choice). Soak one of the bones in vinegar for about one week. If the bone is still hard, replace the vinegar and soak a few more days. Check to see when the bone becomes soft. Bring both bones to class and show students the difference between the two bones. Explain that the acetic acid in the vinegar dissolved the mineral salts in the soaked bone, leaving only the bone matrix.
3. To demonstrate the amount of calcium present in the body at various stages of the life cycle, obtain five clear plastic bags. Using flour to represent calcium, add the following amounts of flour to the bags:

1/4 cup flour represents	27 g calcium	present in a newborn
3 1/2 cup flour represents	400 g calcium	present in a 10-year-old
7 cups flour represents	800 g calcium	present in a 15-year-old
11 cups flour represents	1,200 g calcium	present in an adult
6 1/2 cups flour represents	750 g calcium	present in osteoporosis
4. Have students work in groups to devise two 1-day meal plans with adequate nutrients to maintain healthy bones. One plan should include dairy products and the second plan should be dairy-free. Discuss with the class which foods provided most of the calcium in each plan. Discuss the reasons a person may choose not to consume dairy products and why it would be difficult to consume enough calcium and vitamin D without dairy products.
5. As a class, develop an informational pamphlet on nutrients for bone health to be distributed on campus. (If you have a large class, divide them into groups to develop pamphlets for different audiences such as female adolescents, menopausal women, and so on) Discuss how you make the information attractive enough to entice your audience to read it. Once you have determined what areas of information need to be included in the pamphlet, divide the class into small groups, assigning each group one section. Each section should be brief and concise so that the entire pamphlet consumes no more than one 11" × 14" page, front and back, with room for graphics. You may want to discuss publication with your communications department if the work merits print.

Diet Analysis Activity

6. Have students take the Calcium Quiz: www.dairycouncilofca.org/Tools/CalciumQuiz/Default.aspx. Using the quiz results and the nutritional assessment previously completed, students should note the following:
- Do your results on the quiz agree with your nutritional assessment in terms of your calcium intake? Why or why not?
 - How many micrograms of vitamin D do you consume daily (MyDietAnalysis only)? Does the amount of sunlight exposure you get in your geographic location positively affect vitamin D production?
 - How many milligrams of magnesium do you consume daily?
 - How does your intake of these nutrients compare to recommendations?
 - What changes can you make in your diet to more closely meet recommendations? Would you benefit from a single-nutrient or multi-nutrient supplement? If so, what supplement would you choose (for example, calcium citrate versus calcium carbonate, vitamin D, vitamin K, magnesium, multivitamins)?

Nutrition Debate Activity

7. As the chapter reveals, there are many controllable risk factors at various stages of life for osteoporosis. However, little progress is being made in reducing new cases of the disease. Debate the following:
- What would it take to reverse the rates of osteoporosis incidence in the United States?
 - Which risk factors have the greatest potential for improvement? Consider:
 - government involvement
 - education
 - health insurance incentives
 - community and worksite involvement

Web Resources

MEDLINE Plus Health Information

www.nlm.nih.gov/medlineplus

American Dental Association

www.ada.org

National Osteoporosis Foundation

www.nof.org

International Osteoporosis Foundation

www.osteofound.org

National Institutes of Health Osteoporosis and Related Bone Diseases National Resource Center

www.niams.nih.gov/health_info/bone