patic and renal function are required to produce the active metabolite.

Deficiency of vitamin D causes inadequate absorption of calcium and phosphorus. This, in turn, leads to low levels of serum calcium and stimulation of PTH secretion. In children, this sequence of events produces inadequate mineralization of bone (rickets), a rare condition in the United States. In adults, vitamin D deficiency causes osteomalacia, a condition characterized by decreased bone density and strength.

Calcium and Phosphorus

Calcium and phosphorus are discussed together because they are closely related physiologically. These mineral nutrients are found in many of the same foods, from which they are absorbed together. They are regulated by PTH and excreted through the kidneys. They are both required in cellular structure and function and, as calcium phosphate, in formation and maintenance of bones and teeth. Their characteristics and functions are summarized in Box 26–1.

Bone Metabolism

Bone is mineralized connective tissue that functions as structural support and a reservoir for calcium, phosphorus, magnesium, sodium, and carbonate. The role of bone in maintaining serum calcium levels takes precedence over its structural function (that is, bone may be weakened or destroyed as calcium leaves bone and enters serum).

Bone tissue is constantly being formed and broken down in a process called remodeling. During childhood, adolescence, and early adulthood, formation usually exceeds breakdown (resorption) as the person attains adult height and peak bone mass. After approximately 35 years of age, resorption is greater than formation. Hormonal deficiencies, some diseases, and some medications (eg, glucocorticoids) can also increase resorption, resulting in loss of bone mass and osteoporosis.

Calcium and Bone Disorders

The calcium disorders are hypocalcemia and hypercalcemia, either of which can be life threatening. The bone disorders discussed in this chapter are those characterized by increased resorption of calcium and loss of bone mass. These disorders weaken bone and lead to fractures, pain, and disability. Calcium and selected bone disorders are described in Box 26–2.

DRUGS USED FOR CALCIUM AND BONE DISORDERS

Drugs from several groups are used to treat calcium and bone disorders. Calcium and vitamin D supplements are used to treat hypocalcemia and to prevent and treat osteoporosis. These agents are described in the following sections; names and dosages of individual drug preparations are listed in Drugs at a Glance: Calcium and Vitamin D Preparations. Drugs used for hypercalcemia include bisphosphonates, calcitonin, corticosteroids, 0.9% sodium chloride intravenous (IV) infusion, and others. Those used for osteoporosis inhibit bone breakdown and demineralization and include bisphosphonates, calcitonin, estrogens, and antiestrogens. These drugs are described in the following sections; indications for use and dosages are listed in Drugs at a Glance: Drugs Used in Hypercalcemia and Selected Bone Disorders.

Bisphosphonates

Alendronate (Fosamax), **etidronate** (Didronel), **pamidronate** (Aredia), **risedronate** (Actonel), **tiludronate** (Skelid), and **zoledronate** (Zometa) are drugs that bind to bone and inhibit calcium resorption from bone. Although indications for use vary among the drugs, they are used mainly in the treatment of hypercalcemia and osteoporosis. Etidronate also inhibits bone mineralization and may cause osteomalacia. Newer bisphosphonates do not have this effect.

These drugs are poorly absorbed from the intestinal tract and must be taken on an empty stomach, with water, at least 30 minutes before any other fluid, food, or medication. The drugs are not metabolized. The drug bound to bone is slowly released into the bloodstream; most of the drug that is not bound to bone is excreted in the urine.

Calcitonin-salmon (Calcimar, Miacalcin) is used in the treatment of hypercalcemia, Paget's disease, and osteoporosis. In hypercalcemia, calcitonin lowers serum calcium levels by inhibiting bone resorption. It is most likely to be effective in hypercalcemia caused by hyperparathyroidism, prolonged immobilization, or certain malignant neoplasms. In acute hypercalcemia, calcitonin may be used along with other measures to lower serum calcium levels rapidly. A single injection of calcitonin decreases serum calcium levels in approximately 2 hours; effects last approximately 6 to 8 hours.

In Paget's disease, calcitonin slows the rate of bone turnover, improves bone lesions on radiologic examination, and relieves bone pain. In osteoporosis, calcitonin prevents further bone loss in the presence of adequate calcium and vitamin D. In addition, calcitonin helps to control pain in clients with osteoporosis or metastatic bone disease. Both subcutaneous injections and intranasal administration relieve pain within 1 to 12 weeks. The drug is given daily initially, then two to three times a week. The mechanism by which pain is reduced is unknown.

Calcitonin-human (Cibacalcin) is a synthetic preparation used in Paget's disease. Compared with calcitonin-salmon, calcitonin-human is more likely to cause nausea and facial flushing and less likely to cause antibody formation and allergic reactions.