combine with hydrogen ions or other cations and are excreted in the urine.

MINERALS AS NUTRIENTS

There are 22 minerals considered necessary for human nutrition. They are mainly obtained from foods or supplements. In general, nutritionists agree that a varied and well-balanced diet provides an adequate intake of minerals for most people and that dietary sources of minerals are preferred to supplement sources. However, several studies indicate that most adults and children do not ingest sufficient dietary calcium and that iron deficiency anemia is common in some populations. In addition, some conditions increase requirements (eg, pregnancy, lactation, various illnesses) and some drug-drug interactions decrease absorption or use of minerals.

Nutritional goals for mineral intake (as for vitamin intake) were established by the Food and Nutrition Board of the National Academy of Sciences as Recommended Dietary Allowances (RDAs). Although the RDAs have been extensively used to guide nutrient intake, it should be noted that they were mainly established to prevent deficiencies and that they were extrapolated from studies of healthy adults. Thus, they may not be appropriate for all age groups such as young children and older adults. Current RDAs, which were established in 1989, are in the process of being revised and replaced by standards called the Dietary Reference Intakes (DRIs; see Chap. 31). Thus far, DRIs have been established for calcium, phosphorus, magnesium, iron, fluoride, and selenium.

The DRIs consist of four subtypes of nutrient recommendations. The *estimated average requirement* (EAR) is the amount estimated to provide adequate intake in 50% of healthy persons in a specific group; the *RDA* is the average amount estimated to meet the needs of approximately 98% of healthy children and adults in a specific age and gender group; *adequate intake* (AI) is the amount thought to be sufficient when there is not enough scientific information to estimate an average requirement; the *tolerable upper intake level* (UL) is the maximum daily intake considered unlikely to pose a health risk in healthy persons of a specified group. *The UL should not be exceeded.* With minerals for adults, ULs have been established for calcium (2.5 g), phosphorus (3 to 4 g), magnesium (350 mg), fluoride (10 mg), and selenium (400 mcg). Except for magnesium, which is set for supplements only and excludes food and water sources, the stated amounts include those from both foods and supplements.

The current DRIs were established in 1997, 1998, and 2000; additional ones are expected to be established. Once established, DRIs will be periodically reviewed and updated by the Food and Nutrition Board of the Institute of Medicine and the National Academy of Science.

Macronutrients

Some minerals (calcium, phosphorus, sodium, potassium, magnesium, chlorine, sulfur) are required in relatively large amounts (>100 mg) and thus are sometimes called *macronutrients.* Calcium and phosphorus are discussed in Chapter 26. Sulfur is a component of cellular protein molecules, several amino acids, B vitamins, insulin, and other essential body substances. No RDA has been established; the dietary source is protein foods. The other macronutrients are described here in terms of characteristics; functions; DRIs, RDAs, or AIs; and food sources (Table 32–1). Imbalances of macronutrients are classified as deficiency states and excess states. Sodium imbalances (hyponatremia and hypernatremia) are described in Table 32–2, potassium imbalances (hypokalemia and hyperkalemia) in Table 32–3, magnesium imbalances (hypomagnesemia and hypermagnesemia) in Table 32–4, and chloride imbalances (hypochloremic metabolic alkalosis and hyperchloremic metabolic acidosis) in Table 32–5. Each imbalance is described in terms of causes, pathophysiology, and clinical signs and symptoms.

Micronutrients

The other 15 minerals are required in small amounts (< 100 mg) and are often called *micronutrients* or *trace elements.* Eight trace elements (chromium, cobalt, copper, fluoride, iodine, iron, selenium, and zinc) have relatively well-defined roles in human nutrition (Table 32–6). Because of their clinical importance, iron imbalances are discussed separately in Table 32–7. Other trace elements (manganese, molybdenum, nickel, silicon, tin, and vanadium) are present in many body tissues. Some are components of enzymes and may be necessary for normal growth, structure, and function of connective tissue. For most of these, requirements are unknown, and states of deficiency or excess have not been identified in humans.

INDIVIDUAL AGENTS USED IN MINERAL–ELECTROLYTE IMBALANCES

Several pharmacologic agents are used to prevent or treat mineral–electrolyte imbalances. Usually, neutral salts of minerals (eg, potassium chloride) are used in deficiency states, and nonmineral drug preparations are used in excess states. Selected individual drugs are described in the follow sections; routes and dosage ranges are listed in Drugs at a Glance: Individual Agents Used in Mineral–Electrolyte and Acid–Base Imbalances.

Alkalinizing Agent

Sodium bicarbonate has long been used to treat metabolic acidosis, which occurs with severe renal disease, diabetes mellitus, circulatory impairment due to hypotension, shock or fluid volume deficit, and cardiac arrest. The drug dissociates into sodium and bicarbonate ions; the bicarbonate ions combine with free hydrogen ions to form carbonic acid. This