Freezing and refrigeration (i.e., cold storage) are among the oldest methods of food preservation, but it was not until 1875 that a mechanical ammonia refrigeration system capable of supporting commercial refrigerated warehousing and freezing was invented. This major advance was hampered by the lack of proper facilities, a prime requirement for any refrigerated or frozen food industry. Thus, as late as the 1920s, food delivered to a market in a frozen state commonly thawed before it could be brought home or else thawed in household ice boxes and generally was of marginal to poor quality. Starting in the 1920s, Clarence Birdseye pioneered research on quick-freezing processes, equipment, frozen products, and frozen food packaging. As household refrigerators and freezers became more common, the modern frozen food industry grew rapidly.

Refrigeration today markedly influences the practices of agriculture and marketing and sets the economic climate of the food industry. Without mechanical refrigeration in transit, much of world trade in perishable food commodities would be impossible. Large cities that are distant from growing areas would cease to enjoy abundant fruits and vegetables. Refrigeration and cold storage equalize food prices throughout the year and make products available year round. Without them, prices would be very low at time of harvest and extremely high later on, if indeed the foods were available at all.

**DISTINCTION BETWEEN REFRIGERATION AND FREEZING**

The difference between refrigeration and cool storage on the one hand and freezing and frozen storage on the other should be noted. Cool storage generally refers to storage at temperatures above freezing, from about 16°C down to −2°C. Commercial and household refrigerators are usually operated at 4.5–7°C. Commercial refrigerators sometimes are operated at a slightly lower temperature when a particular food is being favored. Whereas pure water will freeze at 0°C, most foods will not begin to freeze until about −2°C or lower. Frozen storage refers to storage at temperatures that maintain food in frozen condition. Good frozen storage generally requires temperatures of −18°C or below. Refrigerated or cool storage generally will preserve perishable foods for days or weeks, depending on the food. Frozen storage will preserve foods for months or even years if properly packaged.

Further distinctions between refrigeration and freezing temperatures are related to microorganism activity (Fig. 9.1). Most food spoilage microorganisms grow rapidly at temperatures above 10°C but some grow at temperatures below 0°C as long as there
is unfrozen water available. Food held under good refrigeration temperatures can still spoil due to microorganism growth. However, until recently, it was thought that although properly refrigerated food could spoil due to undesirable changes in odor, flavor, and appearance, this did not cause a safety problem because disease-causing organisms did not grow appreciably at these low temperatures. Indeed, this is true for many such microorganisms, but in recent years, food scientists have found that some