anaerobically. Some organisms can switch the metabolic pathways to allow them to grow under either circumstance. Such organisms are *facultative*.

Often organisms can grow in environments with almost no obvious source of nutrients. Some *cyanobacteria* (formerly called blue-green algae) can grow in an environment with only a little moisture and a few dissolved minerals. These bacteria are photosynthetic and can convert CO_2 from the atmosphere into the organic compounds necessary for life. They can also convert N_2 into NH_3 for use in making the essential building blocks of life. Such organisms are important in colonizing nutrient-deficient environments.

Organisms from these extreme environments (*extremophiles*) often provide the human race with important tools for processes to make useful chemicals and medicinals. They are also key to the maintenance of natural cycles and can be used in the recovery of metals from low-grade ores or in the desulfurization of coal or other fuels. The fact that organisms can develop the capacity to exist and multiply in almost any environment on earth is extremely useful.

Not only do organisms occupy a wide variety of habitats, but they also come in a wide range of sizes and shapes. Spherical, cylindrical, ellipsoidal, spiral, and pleomorphic cells exist. Special names are used to describe the shape of bacteria. A cell with a spherical or elliptical shape is often called a *coccus* (plural, *cocci*); a cylindrical cell is a rod or *bacillus* (plural, *bacilli*); a spiral-shaped cell is a *spirillum* (plural, *spirilla*). Some cells may change shape in response to changes in their local environment.

Thus, organisms can be found in the most extreme environments and have evolved a wondrous array of shapes, sizes, and metabolic capabilities. This great diversity provides the engineer with an immense variety of potential tools. We have barely begun to learn how to exploit these tools.

2.1.2. Naming Cells

The situation is complicated by the bewildering variety of organisms present. A systematic approach to classifying these organisms is an essential aid to their intelligent use. *Taxonomy* is the development of approaches to organize and summarize our knowledge about the variety of organisms that exist. Although a knowledge of taxonomy may seem remote from the needs of the engineer, it is necessary for efficient communication among engineers and scientists working with living cells. Taxonomy can also play a critical role in patent litigation involving bioprocesses.

While taxonomy is concerned with approaches to classification, *nomenclature* refers to the actual naming of organisms. For microorganisms we use a dual name (binary nomenclature). The names are given in Latin or are Latinized. A genus is a group of related species, while a species includes organisms that are substantially alike. A common gut organism that has been well studied is *Escherichia coli*. *Escherichia* is the genus and *coli* the species. When writing a report or paper, it is common practice to give the full name when the organism is first mentioned, but in subsequent discussion to abbreviate the *genus* to the first letter. In this case we would use *E. coli*. Although organisms that belong to the same species all share the same major characteristics, there are subtle and often technologically important variations within species. An *E. coli* used in one laboratory may differ from that used in another. Thus, various strains and substrains are designated by the