TABLE 2.2 Primary Subdivisions of Cellular Organisms That Are Now Recognized

Group	Cell structure	Properties	Constituent groups
Eucaryotes	Eucaryotic	Multicellular; extensive differentiation of cells and tissues	Plants (seed plants, ferns, mosses) Animals (vertebrates, invertebrates)
		Unicellular, coenocytic or mycelial; little or no tissue differentiation	Protists (algae, fungi, protozoa)
Eubacteria	Procaryotic	Cell chemistry similar to eucaryotes	Most bacteria
Archaebacteria	Procaryotic	Distinctive cell chemistry	Methanogens, halophiles, thermoacidophiles

With permission, from R. Y. Stainer et al., *The Microbial World*, 5th ed., Pearson Education, Upper Saddle River, NJ, 1986.

2.1.3. Viruses

Viruses are very small and are obligate parasites of other cells, such as bacterial, yeast, plant, and animal cells. Viruses cannot capture or store free energy and are not functionally active except when inside their host cells. The sizes of viruses vary from 30 to 200 nanometers (nm). Viruses contain either DNA (DNA viruses) or RNA (RNA viruses) as genetic material. DNA stands for deoxyribonucleic acid, and RNA is ribonucleic acid; we will soon discuss these molecules in more detail. In free-living cells, all genetic information is contained on the DNA, whereas viruses can use either RNA or DNA to encode such information. This nuclear material is covered by a protein coat called a *capsid*. Some viruses have an outer envelope of a lipoprotein and some do not.

Almost all cell types are susceptible to viral infections. Viruses infecting bacteria are called *bacteriophages*. Some bacteriophages have a hexagonal head, tail, and tail fibers. Bacteriophages attach to the cell wall of a host cell with tail fibers, alter the cell wall of the host cell, and inject the viral nuclear material into the host cell. Figure 2.1 describes the attachment of a virus onto a host cell. Bacteriophage nucleic acids reproduce inside the host cells to produce more phages. At a certain stage of viral reproduction, host cells lyse or break apart and phage particles are released, which can infect new host cells. This mode of reproduction of viruses is called the *lytic cycle*. In some cases, phage DNA may be incorporated into the host DNA, and the host may continue to multiply in this state, which is called the *lysogenic cycle*.

Viruses are the cause of many diseases, and antiviral agents are important targets for drug discovery. Additionally, viruses are directly important to bioprocess technology. For example, a phage attack on an *E. coli* fermentation to make a recombinant protein product can be extremely destructive, causing the loss of the whole culture in vessels of many thousands of liters. However, phages can be used as agents to move desired genetic material into *E. coli*. Modified animal viruses can be used as vectors in genetically engineering animal cells to produce proteins from recombinant DNA technology. In some cases a killed virus preparation is used as a vaccine. In other cases genetic engineering allows production of viruslike particles that are empty shells; the shell is the capsid and all nucleic acid is removed. Such particles can be used as vaccines without fear of viral replication, since all of the genetic material has been removed. For gene therapy one approach