Chloroplasts are relatively large, chlorophyll-containing, green organelles that are responsible for photosynthesis in photosynthetic eucaryotes, such as algae and plant cells. Every chloroplast contains an outer membrane and a large number of inner membranes called *thylakoids*. Chlorophyll molecules are associated with thylakoids, which have a regular membrane structure with lipid bilayers. Chloroplasts are autonomous units containing their own DNA and protein-synthesizing machinery.

Certain procaryotic and eucaryotic organisms contain *flagella*—long, filamentous structures that are attached to one end of the cell and are responsible for the motion of the cell. Eucaryotic flagella contain two central fibers surrounded by eighteen peripheral fibers, which exist in doublets. Fibers are in a tube structure called a *microtubule* and are composed of proteins called tubulin. The whole fiber assembly is embedded in an organic matrix and is surrounded by a membrane.

The *cytoskeleton* (in eucaryotic cells) refers to filaments that provide an internal framework to organize the cell's internal activities and control its shape. These filaments are critical in cell movement, transduction of mechanical forces into biological responses, and separation of chromosomes into the two daughter cells during cell division. Three types of fibers are present: *actin filaments, intermediate filaments*, and *microtubules*.

Cilia are flagellalike structures, but are numerous and shorter. Only one group of protozoa, called *ciliates,* contains cilia. *Paramecium* species contain nearly 10^4 cilia per cell. Ciliated organisms move much faster than flagellated ones.

This completes our summary of eucaryotic cell structure. Now let us turn our attention to the microscopic eucaryotes.

Fungi are heterotrophs that are widespread in nature. Fungal cells are larger than bacterial cells, and their typical internal structures, such as nucleus and vacuoles, can be seen easily with a light microscope. Two major groups of fungi are yeasts and molds.

Yeasts are single small cells of 5- to 10-μm size. Yeast cells are usually spherical, cylindrical, or oval. Yeasts can reproduce by asexual or sexual means. Asexual reproduction is by either budding or fission. In budding, a small bud cell forms on the cell, which gradually enlarges and separates from the mother cell. Asexual reproduction by *fission* is similar to that of bacteria. Only a few species of yeast can reproduce by fission. In fission, cells grow to a certain size and divide into two equal cells. Sexual reproduction of yeasts involves the formation of a *zygote* (a diploid cell) from fusion of two haploid cells, each having a single set of chromosomes. The nucleus of the diploid cells divides several times to form *ascospores*. Each ascospore eventually becomes a new haploid cell and may reproduce by budding and fission. The life cycle of a typical yeast cell is presented in Fig. 2.6.

The classification of yeasts is based on reproductive modes (e.g., *budding* or *fission*) and the nutritional requirements of cells. The most widely used yeast, *Saccharomyces cerevisiae*, is used in alcohol formation under anaerobic conditions (e.g., in wine, beer and whiskey making) and also for baker's yeast production under aerobic conditions.

Molds are filamentous fungi and have a mycelial structure. The *mycelium* is a highly branched system of tubes that contains mobil cytoplasm with many nuclei. Long, thin filaments on the mycelium are called *hyphae*. Certain branches of mycelium may grow in the air, and asexual spores called *conidia* are formed on these aerial branches. Conidia are nearly spherical in structure and are often pigmented. Some molds reproduce by sexual means and form sexual spores. These spores provide resistance against heat, freezing,