

Although the earliest light microscopes showed the cell as hardly more than a mass of amorphous fluid enclosed within a membrane, modern research has shown that the cell is not only the structural unit of living organisms but also the functional unit. Each cell carries out all the physical and chemical reactions we associate with life. This plate is an artist's reconstruction of a typical animal cell as it might look with its upper half cut away. We see that the cell is organized into many distinct structures. These are called organelles, and each is specialized for a particular function. This plate gives you an overview of these organelles; the following plates will cover the details of structure and function.

Color title A and the cell membrane with a pale color.

The *cell membrane* (sometimes called the plasma membrane or plasmalemma) completely covers the entire cell and serves to hold it together. It also actively regulates what enters and leaves the cell. It is only about 10 nanometers thick, so its thickness has to be greatly exaggerated in the drawing to give you something thick enough to color. This is also true of the membranes within the cell. Everything else is drawn to scale.

Color titles and structures B through F. Color the pores (C) with a darker color. Color D and E in rather dark colors, and leave F uncolored (all the remaining space within the nucleus).

In animal cells (as well as in plant, protist, and fungus cells), the nucleus is separated from the rest of the cell by the *nuclear envelope*. Such cells are called eukaryotic (Greek: *eu*, "true"; *karyon*, "kernel" or "nucleus") to distinguish them from prokaryotic cells (Greek: *pro*, "before"), which lack a true membrane-enclosed nucleus and are more primitively organized. (Prokaryotic cells are found only among the bacteria and their close relatives.) The nuclear envelope is made up of two layers (not shown) of membrane. These are very similar to the cell membrane but have numerous *pores*. Within the nucleus is a prominent structure called the *nucleolus*—sometimes there are two or more nucleoli—and a network of thin threads called *chromatin*. The chromatin contains the hereditary material of the cell. The fluid that fills the rest of the space in the nucleus is called the *nuclear sap*.

Color the heading Cytoplasm and titles and structures G through N. Color over the lines that represent microfilaments.

The term "cytoplasm" is still used to designate all of the cell contents outside the nucleus but inside the cell membrane, although we realize that cytoplasm is not the homogeneous substance it was once thought to be. One of the prominent organelles in the cytoplasm is the *mitochondrion*, often called the "powerhouse of the cell" because about 90 percent of the energy that eukaryotic cells get from oxidizing food molecules is developed there. The *Golgi complex* is a stack of membranous sacs in which various molecules are manufactured and packaged for "export" from the cell. *Centrioles* are cylindrical bundles of microtubules that seem to give rise to the longer spindle microtubules (not shown) that separate the two duplicate sets of chromatin at the time of cell division. Most animal cells have a pair of centrioles lined up at 90 degrees to each other. Additional *microtubules* are found singly or in groups elsewhere in the cytoplasm. They appear to provide structural support to the cell and may be involved in movement. *Vacuoles* are fluid-filled sacs of membrane that may contain anything from food being digested to oil droplets. *Lysosomes* look like small vacuoles but contain digestive enzymes. *Microbodies* look like small vacuoles as well but contain various enzymes not involved in digestion. *Microfilaments* are found in various places around the cytoplasm and are involved in movement and attachment to other cells.

Color titles and structures O and P. Be sure to use a pale color for P to avoid obscuring the ribosomes (O). Do not color Q.

Throughout the cytoplasm are many tiny structures called *ribosomes*, which manufacture proteins. Some are free in the fluid portion of the cytoplasm, but many others are attached to the *endoplasmic reticulum* (ER), a system of membranes that extends throughout much of the cytoplasm. Some parts of the endoplasmic reticulum (known as the rough ER) have many ribosomes attached; other parts (known as the smooth ER) have none. The remaining portion of the cytoplasm, which seems to be a structureless fluid, is called the *hyaloplasm*. (Some biologists call it the cell sap or the cell matrix.)

ANIMAL CELL.

CELL MEMBRANE_A
 NUCLEUS_★
 NUCLEAR ENVELOPE_B
 NUCLEAR PORE_C
 NUCLEOLUS_D
 CHROMATIN_E
 NUCLEAR SAP_{F+}
 CYTOPLASM_★
 MITOCHONDRION_G
 GOLGI COMPLEX_H

CENTRIOLE_I
 MICROTUBULE_J
 VACUOLE_K
 LYSOSOME_L
 MICROBODY_M
 MICROFILAMENT_N
 RIBOSOME_O
 ENDOPLASMIC RETICULUM_P
 HYALOPLASM_{Q+}

