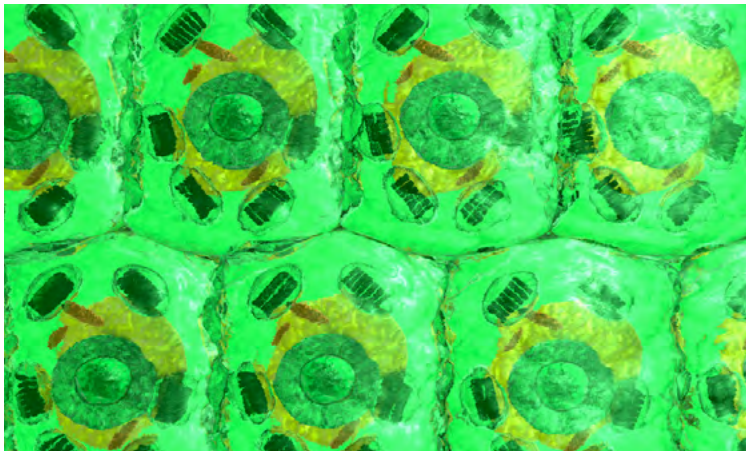
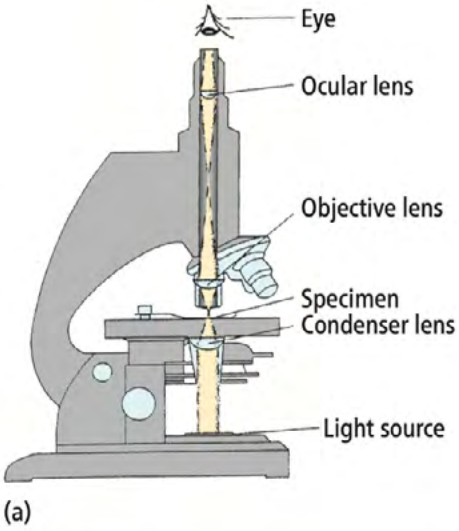
Chapter 3

The Cell

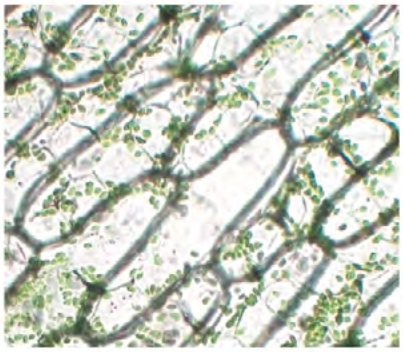


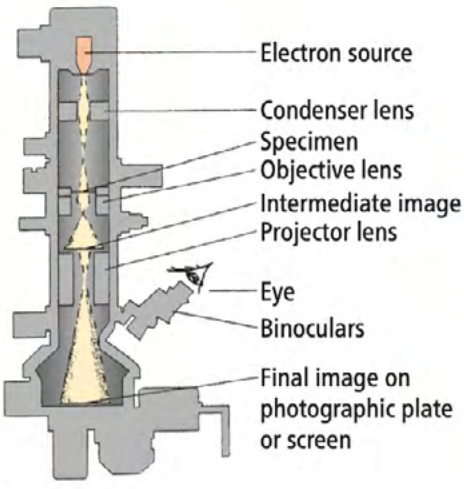
3.3 Looking at Cells

How can we look at cells? Microscopes are high-tech magnifying glasses that allow us to see very small objects with a fine level of detail. One type of microscope, the light microscope, has been around for centuries. In fact, Robert Hooke discovered the existence of cells while using one. A **light microscope** works by passing visible light through a specimen and then through a series of lenses. The lenses refract, or bend, the light in order to produce a magnified image of the specimen (Figure 3.5a).



(a)





(b)

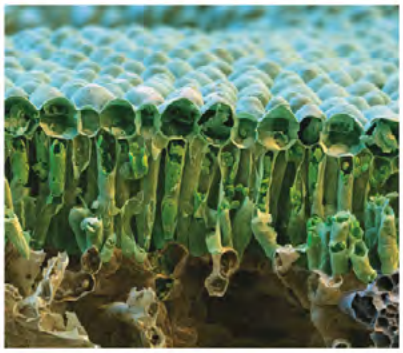


FIGURE 3.5

Microscopes enable us to examine objects that are too small for the human eye to see.

(a) Light microscopes use glass lenses to bend light and magnify specimens. The photo shows plant cells seen through a light microscope. The small green circular forms inside the cells are plant structures called chloroplasts.

(b) Electron microscopes use electric and magnetic fields to magnify specimens. This is an electron microscope photo of a leaf in cross- section. Chloroplasts can be seen inside the cells.

Light microscopes are able to resolve objects on the order of a micrometer (10^{-6} meter) in size. This means that two lines closer together than 10^{-6} meter appear as a single line. (The resolving power of the human eye is about 1 to 10 millimeters, or 10^{-4} meter.) With a resolving power of 10^{-6} meters, light microscopes allow us to view cells and to make out the larger features inside them, such as the nucleus. However, they do not really allow us to see smaller cellular structures in detail.

To get around this problem, scientists illuminate very tiny objects with electron beams rather than with light. In an **electron microscope**, electric and magnetic fields, rather than optical lenses, are used to focus electron beams (Figure 3.5b). Electron microscopes are able to resolve objects about a nanometer (10^{-9} meter) in size, which covers just about everything of biological interest (Figure 3.6).

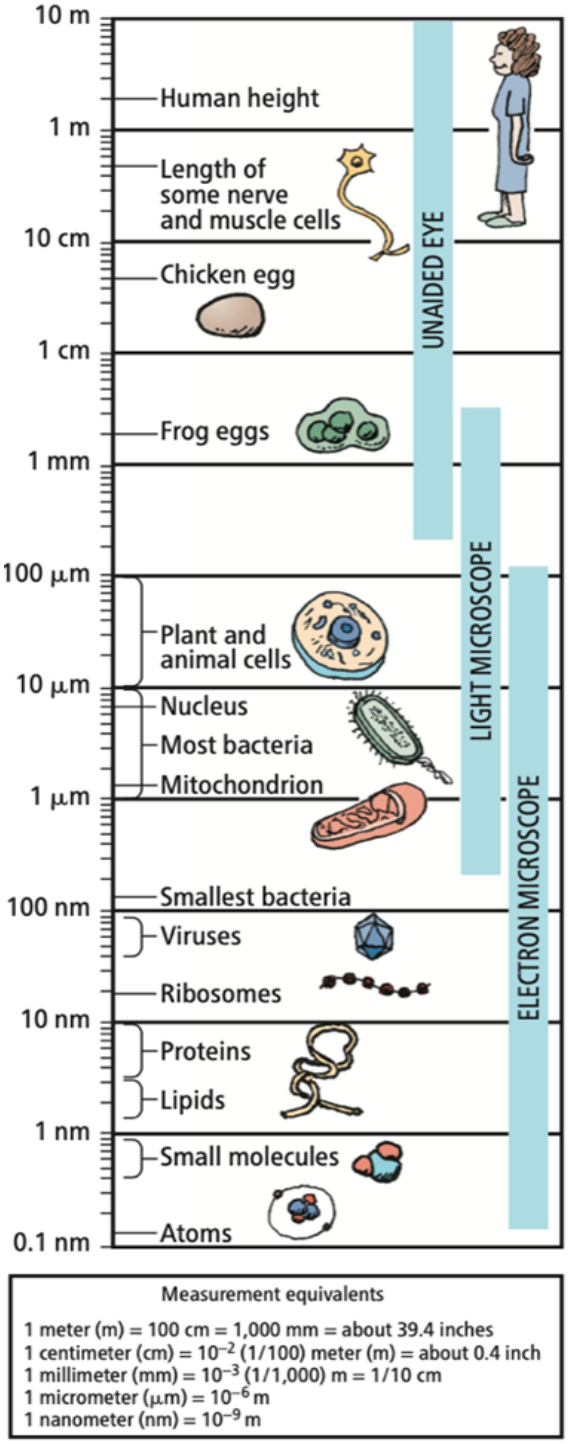


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FIGURE 3.6

Microscopes allow us to look into the world of the cell. Depending on the size of a feature, the naked eye, a light microscope, or an electron microscope may be used.

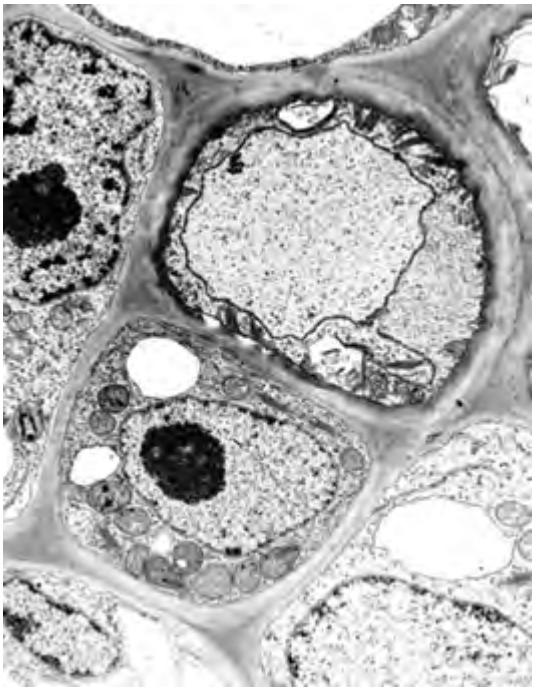

FIGURE 3.7

Katherine Esau of the University of California Santa Barbara was an early pioneer in the use of TEM for biological research. For example, she studied a special type of cell, called a sieve element, that conducts food within plants. She also used a TEM to reveal the interactions between plant cells and viruses.

There are two types of electron microscopes. Scanning electron microscopes (SEM) create a three-dimensional image of the surface of a specimen (see the photo in Figure 3.5b). Transmission electron microscopes (TEM) make images of thin sections through a specimen (Figure 3.7). To produce a TEM image, the specimen is treated with a preservative, fully dehydrated, and then set within a hard plastic. Ultra-thin slices of the specimen embedded within the plastic are then stained with a lead solution. The lead atoms bind to the structures of the specimen, which allows these structures to interact better with the electron waves. This increases the contrast of the final image providing the stunning detail.

Source: https://www.ccber.ucsb.edu/ucsb-natural-history-collections-botanical-plant-anatomy/transmission-electron-microscope

READING CHECK

Tiny bacteria called mycoplasmas have diameters as small as 0.1 micrometer. Can they be studied with light microscopes? With electron microscopes?

CHECK YOUR ANSWER

Mycoplasmas are too small to be examined with light microscopes, but they can be studied with electron microscopes.

To learn more about the history of electron microscopy, go to:

http://www.physics.emory.edu/faculty/weeks/lab/papers/bogner-micron07.pdf

You can also read more about how electron microscopes work here:

https://www.explainthatstuff.com/electronmicroscopes.html