1.5

Technological Advances of the Microscope

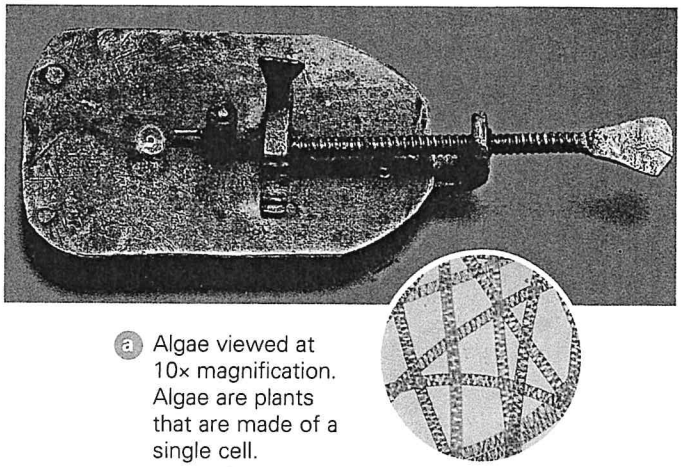
Advances in cell biology are directly linked with advances in optics. As biologists see and learn more about cells, they want instruments that provide them with greater detail. Optical scientists and technologists respond by investigating light and solve the problems of the biologists by creating better and better microscopes. Better microscopes allow biologists to develop a deeper understanding of how the cells that make up organisms function.

The Single-Lens Microscope

Some of the best of the earliest microscopes were made by Anton van Leeuwenhoek in the 1660s. He was curious about the microscopic world and constantly worked at improving his design. His microscopes, **Figure 1**, had only a single lens that magnified things 10 or more times. Nevertheless, he was astonished when he looked at a water drop and saw numerous tiny organisms.

Figure 1

Leeuwenhoek's microscopes used a single lens mounted between two brass plates to magnify objects.



(a) Algae viewed at 10× magnification. Algae are plants that are made of a single cell.

The Compound Light Microscope

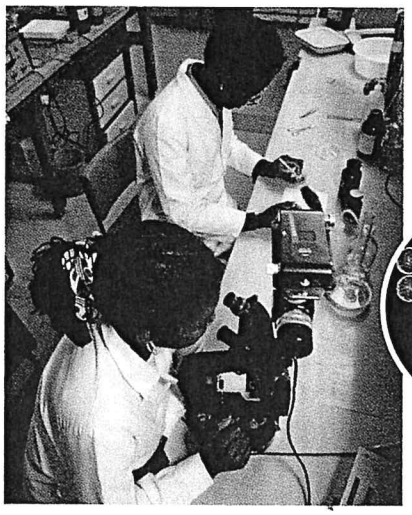
Biologists found a single lens limiting—they couldn't see the details needed to understand how cells work. An important advance came when a second lens was added to the microscope. An image magnified 10× by the first lens and 10× by the second lens is viewed as 100× larger.

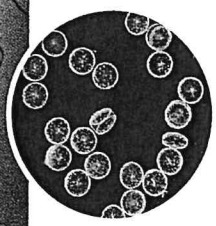
There is a limit to what can be done with glass lenses and light. To make images larger, lenses must become thicker. But as lenses become thicker, the images they produce begin to blur. Eventually the image is so blurred that no detail can be seen.

The light microscope (**Figure 2**) is limited to about 2000× magnification. To see the detail within a human cell, greater magnification is needed. The development of the electron microscope provided this window.

Figure 2

Light microscope





(a) Algae cells seen through a light microscope

The Transmission Electron Microscope

These microscopes are capable of 2 000 000× magnification! Instead of light, transmission electron microscopes use a beam of electrons that pass through the specimen of cells or tissues. (Electrons are tiny particles that travel around the nucleus of an atom.)

Transmission electron microscopes (**Figure 3**) have two major limitations. First, specimens that contain many layers of cells, such as a blood vessel, cannot be examined. The electrons are easily deflected or absorbed by a thick specimen. Very thin slices of cells (sections) must be used. These thin sections are obtained by encasing a specimen in plastic, and then shaving very thin layers off the plastic. The second limitation is that mounting cells in plastic kills them. That means only dead cells can be observed. Although the transmission electron microscope is ideal for examining structures within a cell, it does not allow you to examine the details of a many-celled insect eye, or a living cell as it divides.

Figure 3

The transmission electron microscope uses magnets to concentrate a beam of electrons directed at a specimen.

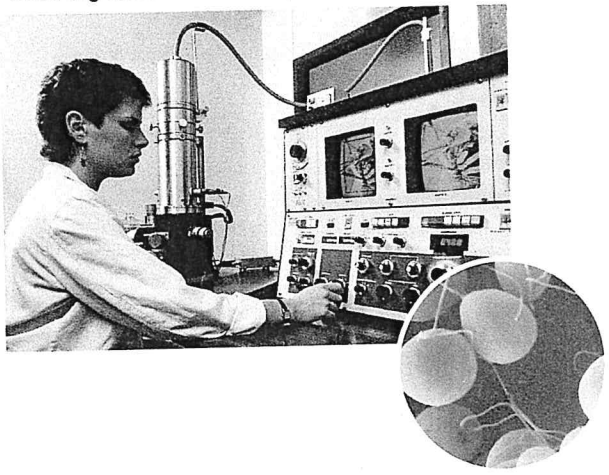
(a) Algae cell seen through a transmission electron microscope

The Scanning Electron Microscope

The scanning electron microscope (**Figure 4**) was a response to the limitations of the transmission microscope. It uses electrons that are reflected off a specimen. This allows a digital three-dimensional image to be created. Because this instrument uses only reflected electrons, it doesn't matter how thick the specimen is, but only the outside of the specimen can be seen. Also, the scanning electron microscope cannot magnify as much as the transmission microscope.

Figure 4

Scanning electron microscope



(a) Algae cell seen through the scanning electron microscope

Understanding Concepts

1. Give one advantage of a compound light microscope over a single-lens microscope.
2. Give one advantage of a scanning electron microscope over a transmission electron microscope.
3. Describe differences in the appearance of algae cells when viewed with each of the microscopes.
4. Which microscope would you recommend for viewing each of the following? Give reasons for your choice.
   - **(a)** the detailed structure of a cell's nucleus
   - **(b)** a single cell

Reflecting

5. Imagine that you could direct a team of technologists to invent a new microscope. What would you want that new microscope to do? How would this benefit society?