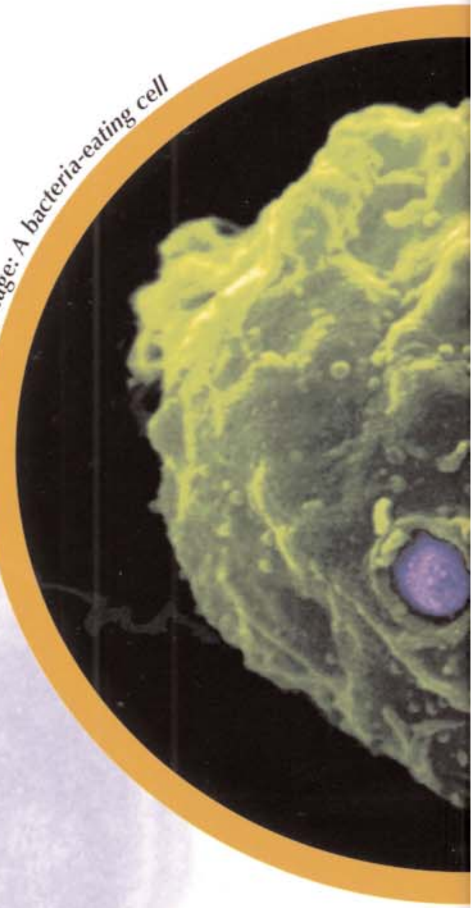
Electron Microscopy:

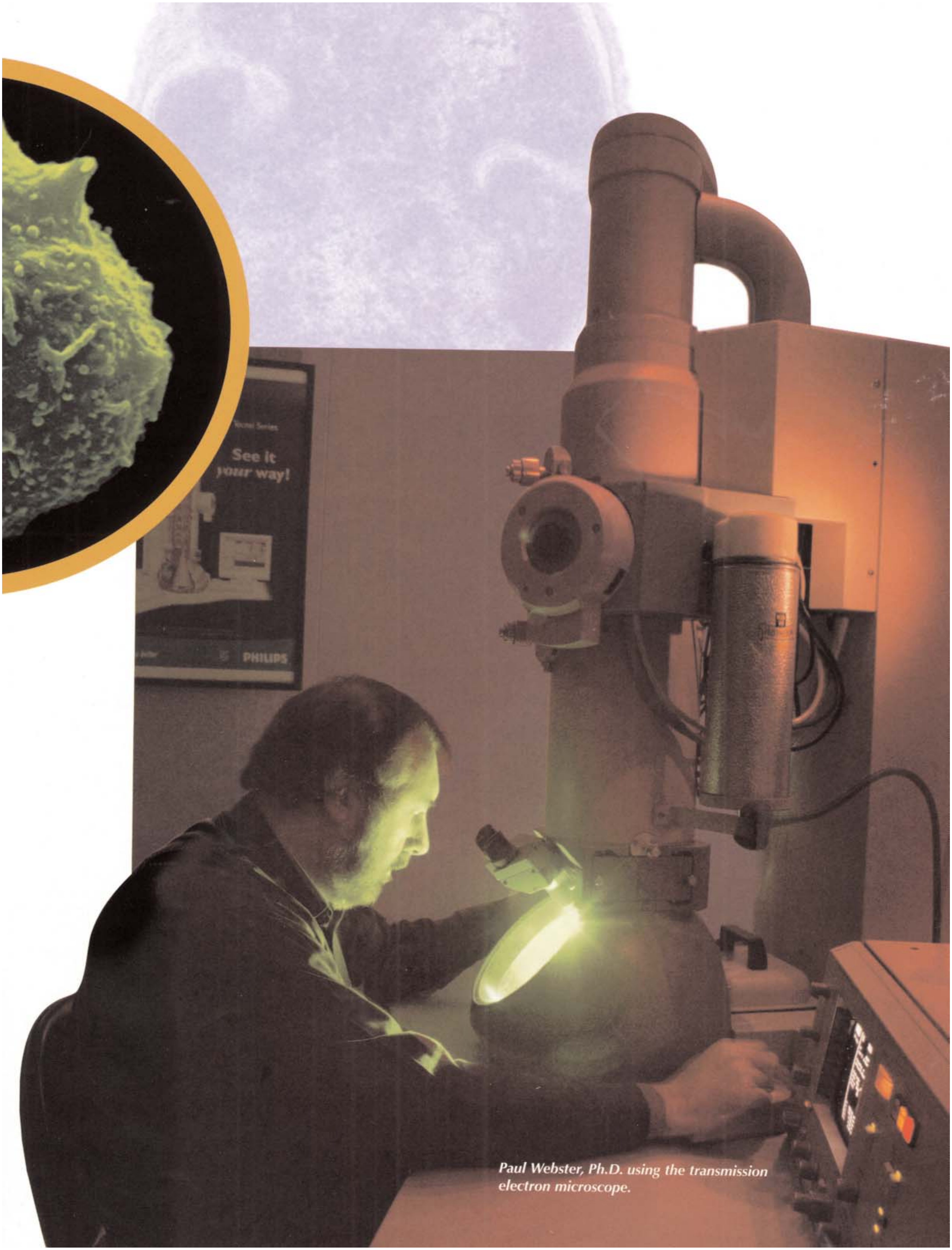
The Eyes of Science



Macrophage: A bacteria-eating cell

Scientists in the Gonda (Goldschmied) Cell and Molecular Biology Department at the House Ear Institute (HEI) study the molecular structures of the ear and related systems using the enlarged visual images provided by microscopes to elucidate the tiny details of these structures. Electron microscopes can magnify a specimen up to one million times, revealing patterns that illustrate the minutest cellular and molecular forms and functions required for scientific study and the creative beauty of Mother Nature. In fact, the sheer beauty and aesthetic quality of the images created by electron microscopy has recently become a topic of discussion in scientific literature.

In a February 2002 article from *Nature Reviews* titled "Microscopy: an Art?" authors Lelio Orci and Michael S. Pepper state that "Microscopy, as a technique in scientific investigation, has had a key role in uncovering nature's beauty, which has led some to propose that microscopy could be described as an art or even an art form." Yet, the importance of electron microscopy in providing crucial information for scientific data acquisition and analysis cannot be over-emphasized.



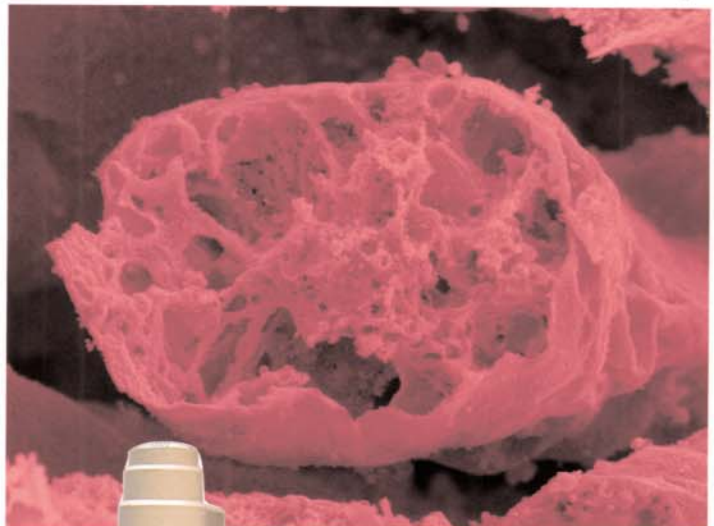
Paul Webster, Ph.D. using the transmission electron microscope.

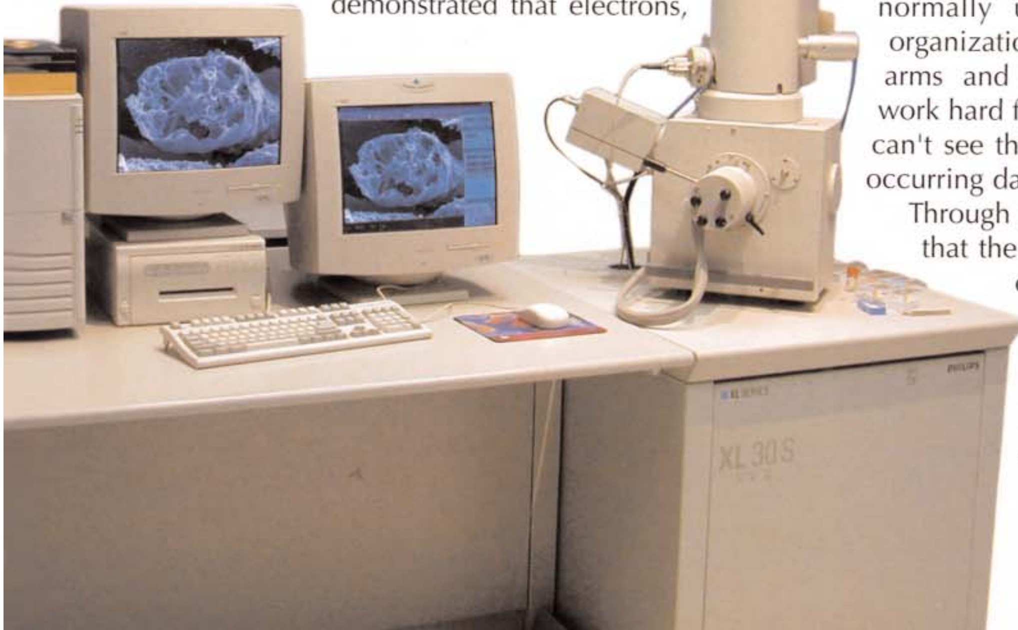
While the illustrative and instructive images made by HEI's electron microscopes are of great educational benefit to the hundreds of visitors who tour the Institute's labs each year, it is their ability to produce scientific data for use in advancing hearing science that is most valued by Paul Webster, Ph.D., of the Ahmanson Advanced Electron Microscopy and Imaging Center at the House Ear Institute. In this article, Dr. Webster provides *House Calls* readers with an overview of the historical and scientific contributions made by electron microscopy.

In 1674 Antoni van Leeuwenhoek of Holland constructed a small device to magnify single celled animals living in water. This first microscope was little more than a metal plate with a hole and a single glass lens, but it could magnify up to 250 times. Nevertheless it revealed a world of objects smaller than could be seen by the human eye and fuelled a discovery process that has resulted in the development of sophisticated microscopes and specialist centers throughout the world. Today, the word "microscopic" is part of our everyday vocabulary, and the small worlds that surround, inhabit and make up our being can be examined with relative ease.

Microscopes that use electrons instead of light to form images of biological specimens have played an important role in discovering what cells are and how they work. The first electron microscopes, built in the early 1930's, were based on a theoretical design that demonstrated that electrons, with a shorter wavelength than light, might be used to examine small specimens at higher resolution than light microscopes.

Biological specimens were not successfully examined by electron microscopes until the 1950's, yet it is now almost routine for them to be used to examine tissue pieces, cells, organelles and even single molecules. Using preparation methods that have developed together with the machines, it is possible to take images of cells and their contents, reveal the locations of molecules within cells or organelles, and even to measure volumes, surface areas, lengths and numbers of cell contents.

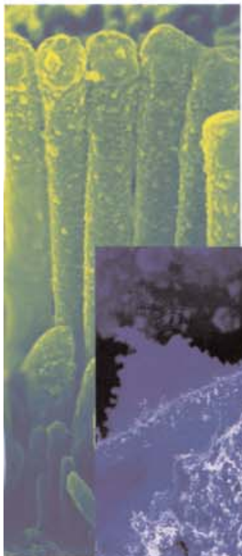


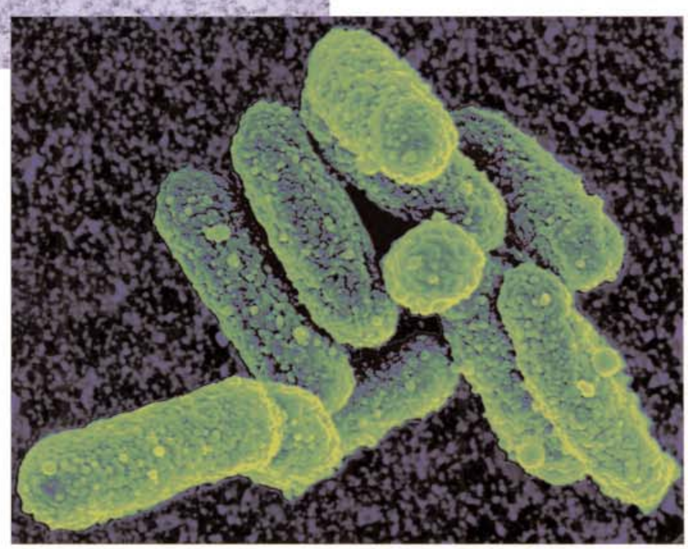


The images shown in this article uncover normally unseen worlds of exquisite micro-organization that are as essential to us as are our arms and legs. Complex micro-machines that work hard for us are taken for granted because we can't see them or the fierce life-and-death battles occurring daily around and within our bodies.

Through the use of microscopes we have seen that the cell, the smallest unit of living matter capable of independent existence, is a very complex package that operates as a small factory. The human body is an integrated society of hundreds of kinds of interdependent cells that are specialized in various ways to carry out functions essential to our survival. We have about 25 trillion blood cells that specialize in transporting oxygen to our tissues. Another 50 trillion cells are working hard each day carrying out their specialized functions that are essential for life. Of these, only 15,000 are the sensory cells in our inner ear (the cochlea), called hair cells, which provide us with the ability to hear. An understanding of how these cells function, develop, age or become diseased is essential for hearing research.

In addition to the hair cells located in the cochlea, the ear has many other cells that enable normal functions to be carried out. It is important to know how these cells work together with the hair cells and how they can be damaged by disease. For example, nerve cells that carry electrical impulses from the cochlea along the hearing nerve to the brain can stop working, or bacteria and viruses can attack cells in the middle ear causing mucus that blocks sound from reaching the hair cells. Microscopes are able to demonstrate for HEI scientists and their colleagues the damage that can occur from the different diseases and disorders they are studying. ❖





Clockwise from left: Scanning electron microscope (SEM), inside of a hair cell, stereocilia at the top of a hair cell, red blood cells in a capillary, *herpes simplex* virus particles in a cell nucleus, *Hemophilus influenzae* (bacteria that cause otitis media)

Electron microscopes used by scientists at the House Ear Institute have been generously donated by the Ahmanson Foundation.