

## The History of the SEM and What it Does

While a scientist is able to look at specimens and see the smaller parts with his or her imagination, s/he also has the tools to help magnify and examine things. The scanning electron microscope (SEM) is one of those tools. I did not know how to explain what this tool does so I went to a Website, and here is what I found:

An electron microscope is an electron accelerator that focuses an electron beam with the aid of electromagnetic lenses. Lenses focus the electron beam and magnify the image after the electrons pass through the specimen. The lenses and the specimen stage are mounted in a vertical, lead-lined cylindrical column that allows the interior to be maintained under vacuum. The vacuum is needed so that the electrons do not collide with air molecules and get knocked off course before they reach the specimen.

In the *scanning electron microscope* (SEM), a beam of accelerated electrons is used to image surface features of specimens. The surface topography of a specimen is generated by the electrons reflected (backscattered) or given off (secondary electrons) by the specimen struck by the electron beam. This is accomplished by focusing a narrow, intense beam of electrons to form a very small spot of illumination on the specimen. This fine spot is then moved sideways by deflecting the beam so that a very narrow ribbon of specimen, whose width corresponds to the diameter of the spot, is traversed by the electron probe spot. Excerpted from: <http://www.itg.uiuc.edu/ms/modalities/#electron>

I cannot imagine how something like this could be invented. I know about telescopes and binoculars, and I know that scientists need powerful microscopes to see fine details, but how did any one get the idea of using electrons in a focused beam, and scanning the beam over the specimen to gather information about it?

Of course, I had to look this up.

This time I was not so lucky. I found someone's personal homepage without any information, then I found another site that just wanted to sell me things. Another site had a lot of misspellings on it and there was not any information about the author. Along the way I found out that there are whole college courses to learn how to take images using the SEM, in courses on "Scanning Electron Microscopy." I also found out that the machines can be very expensive and difficult to get access to, so some scientists have never used an SEM before, even though they want to.

Finally, I found a site that looked like it was credible (not misspellings, I could read about the author, and it has the information I needed...) The Encarta encyclopedia online noted that Sir Charles Oatley invented the SEM in its present form in 1952. He

did this in England and after World War II had ended. You have probably already heard that Robert Hooke first used the microscope around 1665, magnifying images 30x.

Can you imagine what your classroom would look like if everyone was suddenly 30x bigger? But as you know, the microscope doesn't make things bigger, only our view changes focus. Hooke was working over three hundred and thirty years ago. He first used the word "cell" when using his microscope. A decade after Hooke was working in England, Antony van Leeuwenhoek discovered "bacteria" while working in Holland, using a microscope that magnified by 300x.

I still couldn't understand why Oatley invented the SEM, all I really knew was his name and the date. So I read a little more. Apparently, he based his work on earlier work done in the 1930s by Max Knoll and Ernst Ruska. When I searched online I found the Nobel Prize Website and I could actually read an essay by Ruska. In it he recalled:

I...was responsible for the development of television receivers and transmitters, as well as photoelectric cells with secondary amplification. Convinced of the great practical importance of electron microscopy for pure and applied research I attempted during this time to continue the development of high-resolution electron microscopes with larger materials, this time working with Dr Bodo von Borries. This work was made possible in 1936-7 by Siemens & Halske. In Berlin-Spandau in 1937 we set up the Laboratory for Electron Optics and developed there until 1939 the first customised electron microscopes (the 'Siemens Super Microscope'). Parallel to the development of this instrument my brother, Dr Med. Helmut Ruska, and his colleagues worked on its application, particularly in the medical and biological fields. In order to promote its usage in different scientific areas as quickly as possible we suggested to Siemens that they set up a visiting institute for research work to be carried out using electron microscopy. This institute was founded in 1940. From this institute, in which we worked together with both German and foreign scientists, around 200 scientific papers were published before the end of 1944. My task consisted in the development and production of the electron microscope, such that by the beginning of 1945 around 35 institutions were equipped with one.

In the years following 1945 I, together with a majority of new colleagues, reconstituted the Institute of Electron Optics in Berlin-Siemensstadt, which had been disbanded due to bombing, so that by 1949 electron microscopes were again being built. This new period of development led in 1954 to 'Elmiskop 1', which since then has been used in over 1200 institutions the world over. At the same time I sought the further physical development of the electron microscope by working at other scientific institutions. ...I retired on 31 December 1974....My publications in the area of electron optics and electron microscopy include several contributions to books and over 100 original scientific papers.  
<http://nobelprize.org/physics/laureates/1986/ruska-autobio.html>

I found out he died on May 25, 1988. I found his story interesting, learning that he worked on television reception, as well as how he promoted the SEM even after being bombed in WWII.

I was able to understand this history, but I still didn't know who what I would see might be different from any other tool. I have used a magnifying glass before and I used a light microscope in my science class lab, so how is this any different? I didn't know what to say about this, because I didn't know, so I looked for more information and this is what I found....

Electron Microscopes are scientific instruments that use a beam of highly energetic electrons to examine objects on a very fine scale. This examination can yield the following information:

- Topography: The surface features of an object or "how it looks", its texture; direct relation between these features and materials properties (hardness, reflectivity...etc.)
- Morphology: The shape and size of the particles making up the object; direct relation between these structures and materials properties (ductility, strength, reactivity...etc.)
- Composition: The elements and compounds that the object is composed of and the relative amounts of them; direct relationship between composition and materials properties (melting point, reactivity, hardness...etc.)

Crystallographic Information: How the atoms are arranged in the object; direct relation between these arrangements and materials properties (conductivity, electrical properties, strength...etc.) <http://www.unl.edu/CMRACfem/em.htm>