

# Electron Microscopy

---

- What are Electron Microscopes?

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 [liefern, ergeben] 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 (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 [Leitfähigkeit], electrical properties, strength...etc.)

- Where did Electron Microscopes Come From?

Electron Microscopes were developed due to the limitations of Light Microscopes which are limited by the physics of light to 500x or 1000x magnification and a resolution [Auflösung] of 0.2 micrometers. In the early 1930's this theoretical limit had been reached and there was a scientific desire to see the fine details of the interior structures of organic cells (nucleus, mitochondria...etc.). This required 10,000x plus magnification which was just not possible using Light Microscopes.

The Transmission Electron Microscope (TEM) was the first type of Electron Microscope to be developed. Here a focused beam of electrons is used instead of light to "see through" the specimen [Untersuchungsobjekt]. It was developed by Max Knoll and Ernst Ruska in Germany in 1931.

The first Scanning Electron Microscope (SEM) debuted in 1942 with the first commercial instruments around 1965. Its late development was due to the electronics involved in "scanning" the beam of electrons across the sample. The photos taken present three-dimensional images.

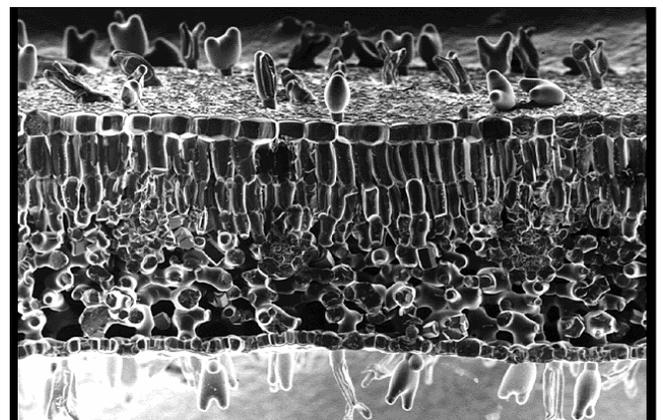
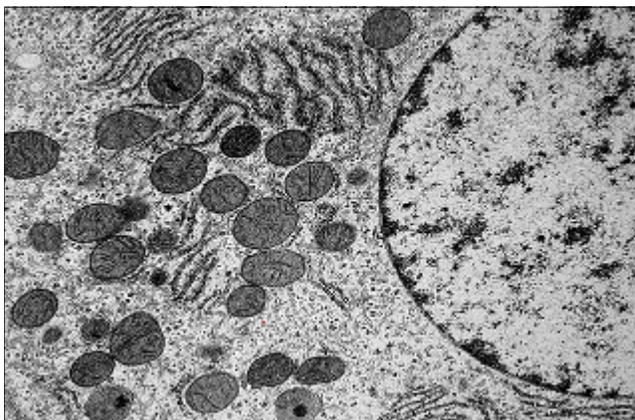
- How do Electron Microscopes Work?

Electron Microscopes (EMs) function exactly as their optical counterparts [optische Gegenstücke = Lichtmikroskope] except that they use a focused beam of electrons instead of light to "image" the specimen and gain information as to its structure and composition [Zusammensetzung].

The basic steps involved in all EMs:

1. A stream of electrons is formed (by the Electron Source) and accelerated [beschleunigt] toward the specimen using a positive electrical potential.
2. This stream is confined [begrenzt, eingeschränkt] and focused using metal apertures [Öffnung, Blende] and magnetic lenses into a thin, focused, monochromatic [= schwarz-weiß] beam.
3. This beam is focused onto the sample using a magnetic lens.
4. Interactions occur inside the irradiated [bestrahlt] sample, affecting the electron beam.

These interactions and effects are detected [erkennen, entdecken] and transformed into an image.



The above steps are carried out in all EMs regardless of type.

Photos taken with Transmission Electron Microscope (left) and Scanning Electron Microscope (right).

Also, both these microscopes are large, expensive, and not easy to learn or use. However, they are very powerful and thus they are necessary in many research projects.

---