Transmission (TEM) vs. Scanning (SEM) Electron Microscopes: What's the Difference?

By Alex Ilitchev (https://www.thermofisher.com/blog/author/alexilitchev/)
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Electron microscopy (EM) allows us to observe a world exponentially smaller than the one we can see with our unaided eyes or even with the familiar light microscope. Electron microscopy uses electrons to "see" small objects in the same way that light beams let us observe our surroundings or objects in a light microscope. With EM, we can look at the feather-like scales of an insect, the internal structures of a cell, individual proteins or even individual atoms in a metal alloy.

TEM vs SEM Comparison

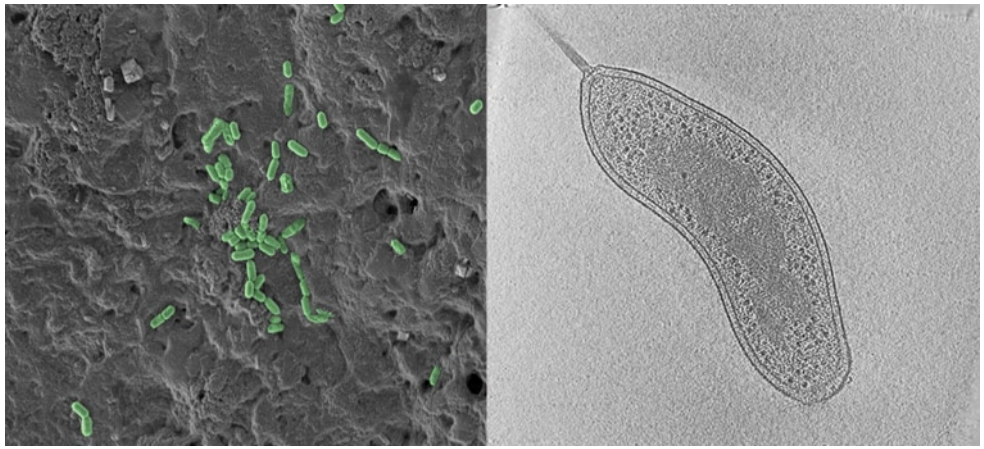
The two most common types of electron microscopes are transmission (https://ter.li/xp25r0) (TEM) and scanning (https://ter.li/97f21q) (SEM) systems, but the differences between these two instruments can be fairly nuanced. Here we hope to provide a fundamental primer for individuals looking to get started with this powerful technique.

Scanning Electron Microscope (SEM)

Imagine you are in a dark room with a weak flashlight. To explore your surroundings, you might sweep the light across the room, much like someone reading a book: left to right and top to bottom. SEM functions similarly, sweeping the electron beam across the sample and recording the electrons that bounce back. This technique allows you to see the surface of just about any sample, from industrial metals to geological samples to biological specimens like spores, insects, and cells. While SEM cannot see features to the same level of detail as TEM, it is much faster, less restrictive, and can sometimes be performed with limited or no sample preparation.

Transmission Electron Microscope (TEM)

When a movie plays in the theater, light is transmitted through an image on a film. As the beam of light passes through, it is modified by the image and the contents of the film are then displayed. TEM works in the same way but with electrons, passing through, or transmitting, an ultrathin sample to a detector below. TEM allows you to observe details as small as individual atoms, giving unprecedented levels of structural information at the highest possible resolution. As it goes through objects it can also give you information about internal structures, which SEM cannot provide. TEM is, however, limited to samples that can be thin enough to let electrons pass through them. This thinning process is technically challenging and requires additional tools to perform.



SEM (left) and TEM (right) images of bacteria. Whereas SEM shows numerous bacteria on a surface (green), the TEM image shows the interior structure of a single bacterium.

Overall, TEM offers unparalleled detail but can only be used on a limited range of specimens and tends to be more demanding than SEM. It is important to note that advanced techniques such as cryo-EM (https://ter.li/p6qmer), a method which looks at typically biological specimen in a vitrified, amorphous state, have expanded the capabilities of TEM significantly. In particular, biomedical and pharmaceutical research may benefit from the molecular and cellular details that can be revealed by cryo-EM.

In general, if you need to look at a relatively large area and only need surface details, SEM is ideal. If you need internal details of small samples at near-atomic resolution, TEM will be necessary.

To learn more about the foundations of EM, please read our *Introduction to Electron Microscopy* (https://ter.li/0ghheg) guide. *Subscribe now* (https://www.thermofisher.com/blog/microscopy/?cid=blog-conclusion) *to receive new Accelerating Microscopy posts straight to your inbox.*

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To learn more about electron microscopy, fill out this form (https://ter.li/0z8hkq) to speak with an expert.

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Comments

sophie says
March 18, 2020 at 2:37 pm (https://www.thermofisher.com/blog/microscopy/tem-vs-sem-whats-the-difference/#comment-140)

thanks

Reply

Fleur says
September 23, 2020 at 11:47 am (https://www.thermofisher.com/blog/microscopy/tem-vs-sem-whats-the-difference/#comment-671)

Hi can you let us know what the magnification of these images were?

Reply

Knowledge Sourcing (https://www.knowledge-sourcing.com/report/electron-microscope-market) says
October 23, 2020 at 12:07 pm (https://www.thermofisher.com/blog/microscopy/tem-vs-sem-whats-the-difference/#comment-980)
Thanks! for sharing your great post.

Reply

Joelia says
December 4, 2020 at 9:27 pm (https://www.thermofisher.com/blog/microscopy/tem-vs-sem-whats-the-difference/#comment-1211)

Today I finally understand the difference between TEM and Sem like when they say TEM is electrons passed through it I didn't see the big difference between the electrons scattered in SEM. But after reads tons of Google stuff and reading scientific articles and even doing SEM and TEM myself and writing a research report. Only after reading this article I understand it!

Reply

anonymous says
December 12, 2020 at 6:44 pm (https://www.thermofisher.com/blog/microscopy/tem-vs-sem-whats-the-difference/#comment-1249)

thank you so much!

Reply

Rayan omen says
June 19, 2021 at 6:01 pm (https://www.thermofisher.com/blog/microscopy/tem-vs-sem-whats-the-difference/#comment-1758)

Thanks ,it was really helpful

Reply

IORHUNA fater says

September 7, 2021 at 5:54 am (https://www.thermofisher.com/blog/microscopy/tem-vs-sem-whats-the-difference/#comment-2058)

Thank you for this information. It was same to me when I was taught. But which one use backscatterd electron and secondary electron?

Reply

‹ Unlocking the Mysteries Behind Today's Complex Diseases (https://www.thermofisher.com/blog/microscopy/unlocking-the-mysteries-behind-todays-complex-diseases/)

Cryo-EM Helps Researchers Understand the Underlying Science Behind AIzheimer's (https://www.thermofisher.com/blog/microscopy/cryo-em-helps-researchers-understand-the-underlying-science-behind-alzheimers/) ›