pISSN:2349-5707 Volume:13,Issue 5, May -2026 eISSN:2349-5715

THE IMPORTANCE OF ELECTRON MICROSCOPY METHODS IN MEDICINE

M.X. Boboqulova
"ASIA INTERNATIONAL UNIVERSITY"
Assistant teacher of the department of "General Technical Sciences"
https://doi.org/10.5281/zenodo.20205690

Abstract

This article extensively discusses the theoretical foundations of electron microscopy methods, their types, and their practical significance in medicine. The role of electron microscopy in studying the ultrastructure of cells and tissues, its diagnostic capabilities in detecting diseases, and its applications in modern medicine are analyzed.

Keywords: electron microscopy, diagnostics, cell, nanostructure, pathology

Introduction

In modern medicine, studying structures at the micro- and nanoscale is of great importance. Highly precise instruments are required to identify structures that cannot be observed using conventional optical microscopes. In this regard, electron microscopy is considered a revolutionary technology in science and medicine. Electron microscopy methods make it possible to investigate the structure of biological objects at the atomic and molecular levels. This plays a crucial role in the early diagnosis of diseases, understanding their mechanisms, and developing effective treatment methods.Electron microscopy is based on the use of electron beams instead of light. Since electrons have an extremely short wavelength, their resolving power is thousands of times greater than that of optical microscopes.The main components of an electron microscope include:an electron source (cathode), electromagnetic lenses, a vacuum system, detectors. When electrons pass through or are reflected from a sample, various signals are generated. Images are formed based on these signals. Electron microscopy is a modern examination method that allows scientists and doctors to observe extremely small objects with very high magnification and resolution. Internal cell structures, viruses, and molecular-level changes that cannot be seen with ordinary light microscopes can be identified using an electron microscope. In medicine, this method plays an important role in diagnosing diseases, conducting scientific research, and developing new treatment methods.In electron microscopy, a beam of electrons is used instead of light rays to produce images. Since electrons have a very short wavelength, they can create images with extremely high resolution.In this type of microscope, electrons pass through the specimen to form an image. TEM is used to study the internal structure of cells.SEM provides detailed images of the surface of objects. It is used to examine the surface of cells, tissues, and microorganisms.Many viruses are too small to be seen with ordinary microscopes. With the help of an electron microscope, scientists can study:the shape of viruses; their size; their effect on cells; and their reproduction process.For example, microorganisms such as the coronavirus, influenza virus, and hepatitis viruses are deeply analyzed using electron microscopy.The structure of cancer cells differs from that of normal cells. Electron microscopy is used to:determine the origin of tumors; distinguish between malignant and benign tumors;observe pathological changes in cells. This method is especially important in complex diagnostics.Electron microscopy is widely used in nephrology. The tiny filtration structures of the kidneys can only be clearly observed through an electron microscope.This helps in diagnosing diseases such as:glomerulonephritis; hereditary kidney diseases;and nephrotic syndrome.Electron microscopes also help study bacteria by examining:the cell wall; the capsule; movement structures; and internal structures.This is important in developing antibiotics and researching infectious diseases.Pathologists use electron microscopy to identify extremely small changes in tissues. This method makes it possible to detect:cell damage; degenerative changes; and early signs of hereditary diseases.Electron microscopy is also used in:research related to DNA and RNA;studying cell organelles; and

pISSN:2349-5707 Volume:13,Issue 5, May -2026 eISSN:2349-5715

investigating genetic mutations. This is highly important in the study of hereditary diseases.The effects of medicines and vaccines on cells are also examined through electron microscopy. The effectiveness and safety of new drugs are evaluated during laboratory research.

Electron microscopy is considered one of the most important modern technologies in medicine. It plays a major role in the detailed study of cells and microorganisms, accurate disease diagnosis, and the development of new treatment methods. The importance of electron microscopy is especially great in the fields of virology, oncology, nephrology, and genetics. In the future, this technology is expected to continue developing and contribute even more to the advancement of medicine.

Transmission Electron Microscopy (TEM).In TEM, electrons pass through the specimen and provide information about its internal structure. This method is particularly important for studying cell organelles.Advantages:Extremely high resolution (up to 0.1 nm), visualization of the internal structure of cells. Disadvantages**:**sample preparation is complex, only very thin sections can be examined.

Scanning Electron Microscopy (SEM). In SEM, electrons scan the surface of the sample, producing a three-dimensional image.Advantages:ability to obtain 3D images, clear visualization of surface structures. Disadvantage:**p**rovides limited information about internal structures.

Cryogenic Electron Microscopy (Cryo-EM). This modern technique studies biological samples in a frozen state. It is highly important for investigating the structure of proteins and viruses.The Importance of Electron Microscopy in Medicine.Electron microscopy allows the study of the ultrastructure of cells and tissues. Using this method, the following structures can be examined:mitochondria, ribosomes,endoplasmic reticulum,cell membranes. This enables comparisons between normal and pathological conditions.Electron microscopy plays an important role in diagnosing the following diseases:viral infections (detection of viral particles), kidney diseases (glomerular structure analysis),lung diseases,oncological diseases.For example, some viruses can only be detected using electron microscopy.Cancer cells differ structurally from normal cells. Electron microscopy:identifies changes in tumor cells,studies the process of metastasis, evaluates the effects of drugs.Electron microscopy also makes it possible to determine the:shape, size,capsid structure of viruses.This is essential in the development of vaccines and antiviral drugs.In diagnosing kidney diseases, electron microscopy is extremely important because it helps determine:the thickness of the glomerular basement membrane, the localization of immune complexes. Electron microscopy is also used to:study interactions between drug molecules and cells, assist in the development of new pharmaceuticals,analyze nanoparticle-based drugs.With the advancement of nanomedicine, the importance of electron microscopy has increased even further. It is used in the study of nanorobots, drug-delivery nanoparticles, and biomaterials.Currently, electron microscopy is developing in the following areas:image analysis using artificial intelligence, 3D reconstruction technologies, improvement of cryogenic technologies,high-speed microscopy.Physical Principles of Electron Microscopy.Unlike classical optical microscopy, electron microscopy is based on the use of electron beams instead of light. Its operation relies on several important physical laws and concepts.Electrons possess not only particle properties but also wave properties. This is expressed through the de Broglie wavelength:

$$\lambda = \frac{h}{mv}$$

Where: λ — wavelength of the electron,

h — Planck's constant,

m— mass of the electron,

v — velocity of the electron.

An important point is that the wavelength of electrons is extremely small (around10^{-12} m), which provides very high resolving power.Electrons are emitted from a special cathode and accelerated using high voltage. This process increases their kinetic energy:

pISSN:2349-5707 Volume:13,Issue 5, May -2026 eISSN:2349-5715

E=eU

Where: e — electron charge,

U — voltage.

The greater the voltage, the higher the electron velocity and the shorter the wavelength.While ordinary microscopes use glass lenses, electron microscopes use magnetic and electrostatic lenses. These lenses focus the electron beam and form images. This phenomenon is based on the laws governing the movement of charged particles in electromagnetic fields.Electrons are easily scattered in air; therefore, a high vacuum is created inside the microscope. This ensures the directed and stable movement of electrons.When electrons strike a specimen, the following processes occur:scattering (elastic and inelastic), absorption, emission of secondary electrons. These interactions form the basis of image generation.In optical microscopy, the resolution limit is determined by diffraction. In electron microscopy, however, the wavelength is much smaller, making it possible to obtain images at the nanometer and even atomic level.

Conclusion

Electron microscopy is an important scientific and practical tool in medicine. It plays a major role in studying the detailed structure of cells and tissues, diagnosing diseases, and improving treatment methods.Combined with modern technologies, electron microscopy will remain one of the leading directions in medicine in the future.The physical foundations of electron microscopy include:the wave nature of electrons, high-speed electron beams,focusing using electromagnetic lenses,operation in a vacuum environment, interactions between electrons and matter.

References

1. Boboqulova, M. X. (2025). SUYUQ KRISTALLAR VA ULARNING XUSUSIYATLARI. *Science, education, innovation: modern tasks and prospects*, *2*(6), 9-18.

2. MEXANIK TO ‘LQINLARNING INSON ORGANIZMIGA TA’SIRI

MX Boboqulova - Science, education, innovation: modern tasks and …, 2025

3. Boboqulova, MX (2025). IDEAL VA YOPISHQOQ SUYUQLIK. BERNULLI TENGLAMASI. Pedagogika va psixologiya ta’limiga yangi innovatsion texnologiyalarni joriy etish, 2(5), 122-129.

4. Boboqulova, MX (2025). RADIOAKTIVLIK. IONLASHTIRUVCHI NURLANISHNING ORGANIZMGA TA'SIRI. Pedagogika va psixologiya ta’limiga yangi innovatsion texnologiyalarni joriy etish, 2(5), 18-26.

5. Boboqulova, MX (2025). VODOROD ATOMINING KVANT NAZARIYASI. Pedagogika va psixologiya ta’limiga yangi innovatsion texnologiyalarni joriy etish, 2(5), 113-121.

6. Boboqulova, MX (2025). O 'TA O 'TKAZUVCHANLIK. Pedagogika va psixologiya ta'limiga yangi innovatsion texnologiyalarni joriy etish, 2(5), 60-67.

7. Boboqulova, MX (2025). QATTIQ JISMLARNING ERISH ISSIQLIGI. Pedagogika va psixologiya ta’limiga yangi innovatsion texnologiyalarni joriy etish, 2(4), 26-32.

8. Boboqulova, MX (2025). SUYUQ KRISTALLAR VA ULARNING XOSSALARI. Fan, ta’lim va texnologiyaning innovatsion rivojlanish bosqichidagi muammolar va yechimlar, 2(4), 42-49.

9. Boboqulova, MX (2025). TIRIK SISTEMALAR TERMODINAMIKASI. Ta'lim tizimida innovatsion va raqamli texnologiyalarni qo'llash usullari, 2(4), 20-27.