# Review of Historical Development, Types, Function and Design Features of Microscope

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## ABSTRACT

A microscope from ancient Greek words (mikros) which means "small" and (skopeo) meaning to look at, examine or inspect) in an instrument used to examine objects that are too small to be seen easily by the naked eye. There are many types of microscopes from the optical microscopes which insight to magnify sample to the electron microscope, ultra microscope and various types of scanning probe microscopes.The term microscope was suggested by Johannes Givanni Faber of Bambery. The identity of its inventor has not been clearly established. Aristotle about 24 centuries before Leeuwenhoek described the working of microscope in some detail. The earliest record of optical lenses was date from13th century when spectacles came into use. Rogen Bacon in his "Opus Magnus" of 1268 spoke of the use of lenses for magnifying objects. About 4 centuries later, Leeuwenhock built over 200 simples' of microscope and become the father of protozoology and bacteriology. After the creation of the microscope it evolved slowly hampered both by the lack of theoretical understanding and mechanical technology needed for making precision instruments. About 1800 the compound microscope of the better makers began to resemble their modern counterparts. In 20$^{th}$ century the fundamental principles which were discovered led immediately to the development of oil immersion objectives and remain as the basis of microscope design. Overall this research provides an overview of the historical progression of microscopes, highlighting key milestones in their development and the contributions of notable authors like Leeuwenhoek and Faber. Understanding the evolution of microscopes is crucial in appreciating the revolutionary impact they have had on scientific research and our understanding of the microscopic world.

**Keyword**: Microscope, Historical, Working Principle, Functions, micros, skopeo, electron

## 1. INTRODUCTION

Microscope is optical instruments with lenses which make very small objects appear larger. [2] [3]. The simple microscope or magnifier is merely a lens held near the eye and usually, it is limited to very low powers of magnification by various technical factors. Ordinarily the term microscope refers to the compound (several lenses) microscope, which is similar in principle to the astronomical telescope [2] (an optical instrument shaped like a tube, with lenses to make distant objects appear larger and nearer).The specimen is illuminated with light from below which shines through it up towards the eye. The objective lens just above the specimen on the stage could be changed for different magnifications [2].The earliest records of optical lenses date from the late 13th century when spectacles came into use but when the simple lens began to be used as a microscope it is not clear [3] [4].About 1880 the advances of microscope were climaxed by Ernst Abbe's theoretical studies which clarified the relation between angular aperture and resolving power. The fundamental principle he discovered led immediately to the development of the oil-immersion objective and remains as the basis of microscope design [2].

## 2. THE HISTORICAL DEVELOPMENT OF MICROSCOPE

1000AD: The first vision aid called reading stone was created (inventor unknown).It was a glass sphere that magnified in the 13th century (1284): Salvino D' Armato an Italian inventor, invented the first wearable eye glasses that would magnify objects allowing the user to see better. [3] [5] [8]. In the 16th century (1590): Two Dutch eye glass makers Zacharias Janssen and Hans Janssen invented what is regarded as the first compound microscope. They experimented with multiple lenses placed in a tube. They observed that objects viewed in front of the tube appeared greatly enlarged thus, creating both the telescope and therefore runner of the compound microscope. [2] [3] [5] [7] [8]. Though, the images were still blurring, microscope still allowed formagnification of about 9x when extended and 3x when closed [5]. In 17th century (1609); Galilei Galileoan Italian mathematician and scientist used lenses with a shorter focal length to turn his telescope into a microscope which was better than the already existing one with magnification of about 30 xs. The name microscope was called by Giovanni Faber in 1625. Robert Hooke an English national philosopher and physicist made improvements to the compound microscope. In 1665 he published his 'micrographia' [6] an outstanding text describing his compound microscope observation. Hooke's microscope was a single lens microscope that was illuminated by a candle. In 1674, Antonie Van Leeuwenhoek the father of microscope, using Hooke's work he took microscope design to new levels of sophistication. He invented new methods for grinding and polishing microscope lenses in order to improve the optical quality. This microscope model was very small (about two inches longand one inch across). The microscope was capable of providing magnification of between 70 and 270x. Leeuwenhoek's lenses were the best available lenses at that time. Using this microscope it was possible to observe bacteria [3][5]. In the 18th century, 1730's there was a major step in the history of microscope with the invention of the achromatic lens by Charles Hall where he discovered that by using a second lens of different shapes and refracting properties he could realign colours with minimum impact on the magnification of the first lens. In the 1740, Benjamin Martin, BritishLexicogrpher and spectacle maker improved the microscope and sold pocket version of it. In 1744, Cuff's microscope includes most of the features of the modern microscope. The body is smaller and made of brass. It is carried on two pillars and coarse adjustment is effected by sliding one pillar on the other. Many improvements have been made since Cuff's time but the fundamental principles of the Cuff microscope remain. With this microscope the origin of the compound microscope may be said to end.

In the 19th Century (1824): A diamond microscope was made by Andrew Pritcard an English Nationalism and natural history dealer. In 1826 Joseph Jackson Lister, an English Mine merchant and scientist was able to develop an achromatic lens thereby eradicating/reducing the chromatic effect (spherical aberration) by showing that several weak lenses used together at certain distances provided good magnification withoutblurring the image [7].This was a great breakthrough in microscopy and helped make microscopes important tools in medical research.In the 1870's a German Physicist Ernst Abbe developed a mathematical formula called "Abbe sine condition: this formula provided calculations that allowed for the maximum possible resolution in microscopes. He modernized the microscopes by adding the achromatic objective and the oil immersion device. He added the technique of phase contrast microscopy [5] [7].

The 20th century saw further development in the field of microscopy. In 1903, Richard Zsigmondy, Austrian chemist developed the ultramicroscope capable of studying objects below the wave length of light. For this, he won the Noble prize in chemistry in 1925. In 1931 Ernst Ruska co-invented the Transmission electron microscope with Maxknoll. This microscope used electron instead of light. Electron microscope makes it possible to view objects as small as the diameter of an atom. In 1932 the phase contrast microscope was developed by Fritz Zernike [3] [5] [7], thus microscope was used for the study of colourless and transparent biological materials (specimen). In 1942, Ernst Ruska improved in transmission electron microscope (TEM) by building the first scanning electron microscope (SEM) which transmits a beam of electron across the surface of a specimen. In 1957; Martin Minsky patents the principle of confocal imaging. Using a scanning point of light confocalmicroscope gives slightly higher resolution than conventional light, microscope and makes it easier to view virtual slices' through a thick specimen. In 1962 Green Fluorescent protein was discovered by Osamu Shimomura, Frank Johnson and YoSaiga but it was cloned in 1992 with its derivatives being used in fluorescence microscopy. [3][5][7][8].The most recent innovation has been the arrival of the digital microspore. Digital microscopes allow for live image transmission to a TV or computer screen and have helped revolutionize microphotography. Digital microscope simply integrates a digitalmicroscope camera on the trinocular point of a stand and microscope. Alternatively is simple to place a digital microscope camera on a trinocular microscope.

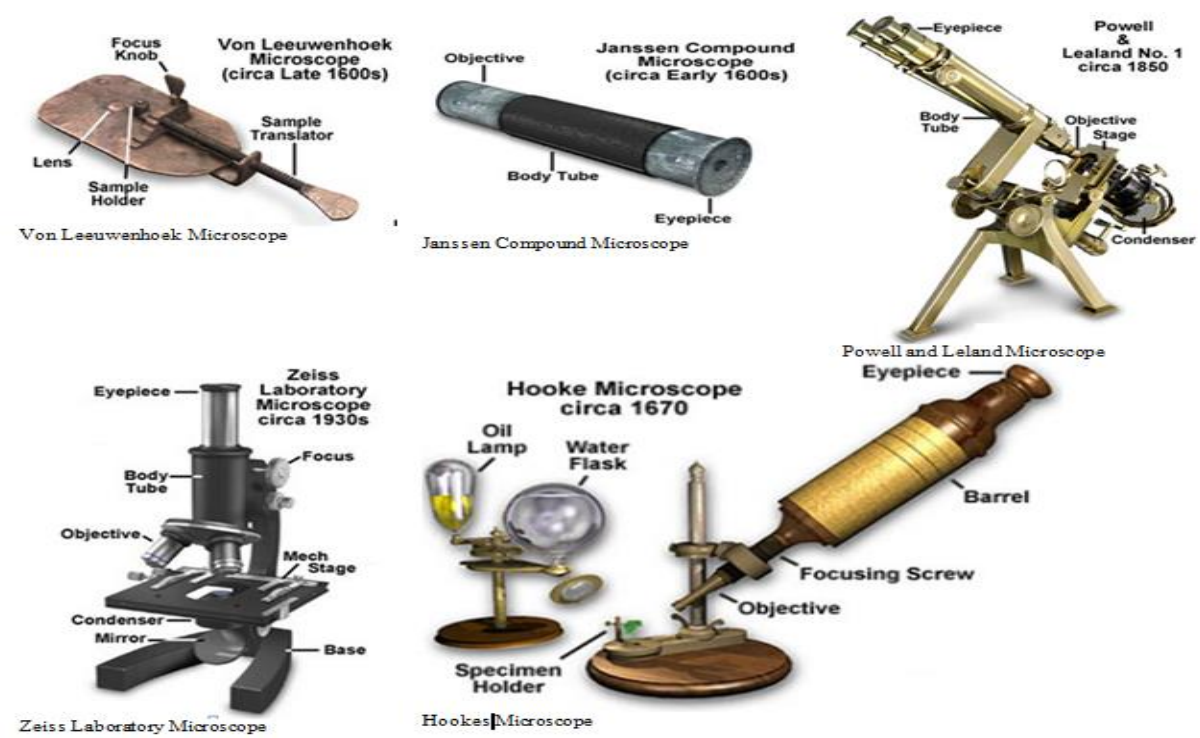


**Figure 1:** Diagrams of earliest Microscope [1]

## 3. TYPES OF MICROSCOPE

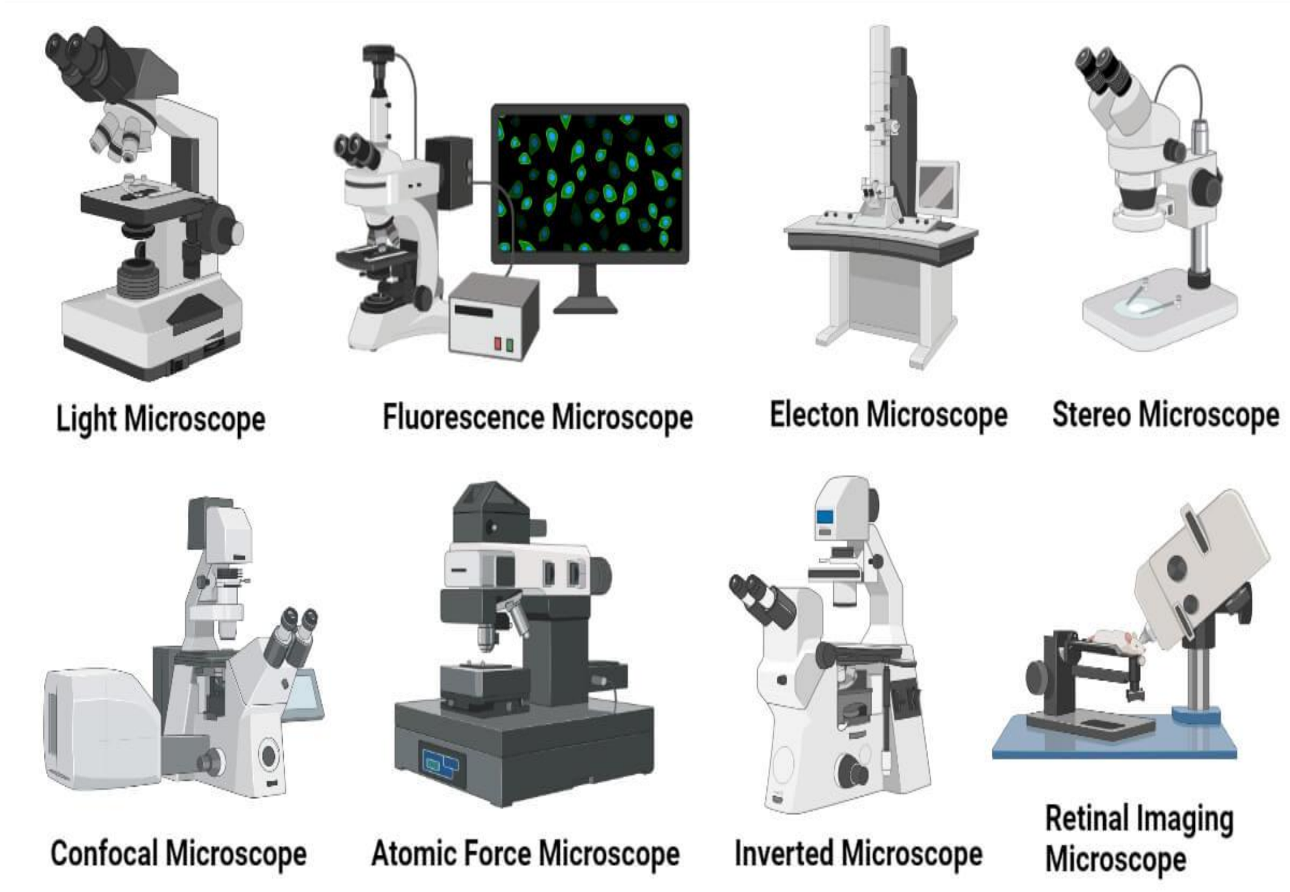


**Figure 2:** Types of Microscope [2]

From the figure 2, there are different types of microscopes. Depending on the principles of generating images, microscopes are classified into three types [9]. They include

- Light/optical microscope
- Electron microscope
- Scanning probe microscope

### 3.1. Light/Optical Microscopes

These are basic microscopes, first to be invented, that use light to magnify objects. The lenses in these microscopes refract the light for the objects beneath them to appear closer. The different types of light or optical microscopes are

- Simple microscope
- Compound microscope
- Dissection or stereomicroscope: is also a simple microscope
- Fluorescence microscope: is also a compound microscope

**3.1.1 Simple microscope**: A simple microscope is a type of microscope that uses a single lens for magnification. They work on natural light and there is less usage of hooks and knobs for adjustments. It uses a single convex lens of a small focal length for magnification. In general, its magnification is about 10X. Its magnifying power (m) is given by;

m=1+ D/F. . . . (1)
where,
D = least distance of distinct vision
F = focal length of the lens of a microscope

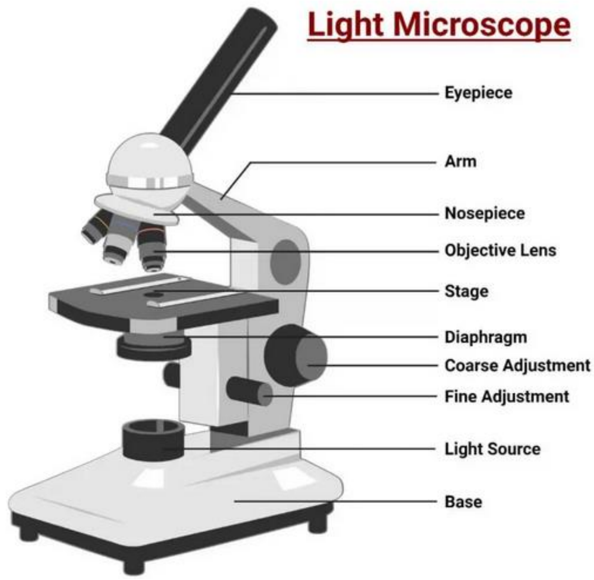


**Figure 3:** Simple Light Microscope[1]

**3.1.2 Compound Microscope** is a type of microscope that used visible light for illumination and multiple lenses system for magnification of specimen. More so, a compound microscope is a higher power microscope that magnification levels than a low-power or dissection microscope.Its magnification is most commonly 40x, 100x, 400x and sometimes 1000x.

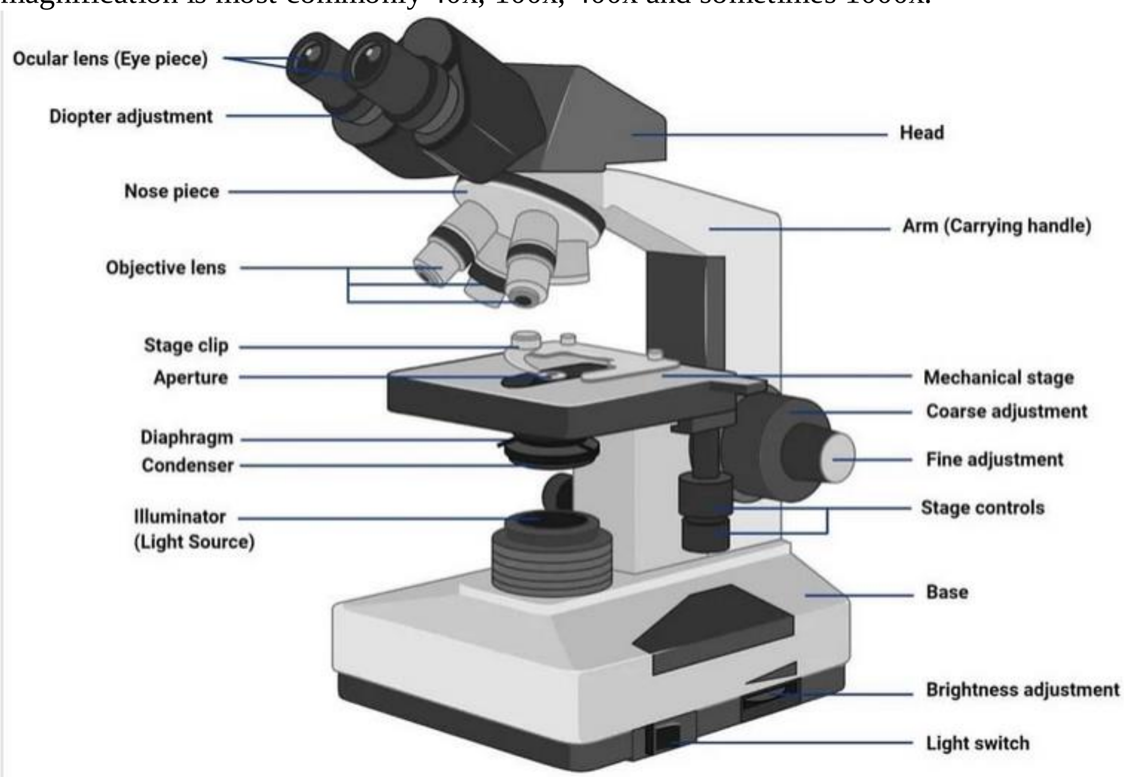


**Figure 4:** Simple Light Microscope [1]

It is used in laboratories, schools, waste water treatment plants, veterinary offices for histology and pathology. It can be used to view samples like: blood cells, bacteria, algae, tissue etc compound microscopes are used to view samples that cannot be seen with naked eye. Generally, it consists of two lenses; objective lens and ocular lens. Its magnifying power is equal to the product of magnifying power of the objective lens in use and the ocular lens,[1].Mathematically it is expressed as;

$m = D/f_0 \times L/f_e$ . . . . . . . . . . . . (2)

where,

m = magnifying power

D = least distance of distinct vision

L = length of the tube

$f_e$ = focal length of the ocular lens

$f_0$ = focal length of objective lens

It is the most widely used microscope in biological fields like medicine, microbiology, life-sciences, pathology, hematology, anatomy, molecular biology, etc.

### 3.1.3 Dissecting Microscope or Stereo Microscope

This is a type of light microscope that uses lights reflected from the surface of a specimen to produce an image of low magnification. It is primarily used during dissecting and viewing dissected specimens, hence called dissecting microscope. Dissection or stereo microscopesare used to look at variety of samples that you would be able to hold in your hand. A stereo microscope can be used to view objects in 3 dimensions, it provides a 3D image and typically will provide magnification between 10 x 40x. The stereomicroscope is used in manufacturing, quality control, can collecting, neuroscience and botany. A stereo microscope typically provides both transmitted and reflected illumination and can be used to view a sample that will not allow light to pass through it. Samples often viewed under a stereomicroscope include: coins, flowers, insects, plastics or metal parts etc.


**Figure 5:** Stereo Microscope [1]

### 3.1.4 A fluorescence microscope

This is an optical microscope that uses fluorescence instead of other light properties (such as scattering, reflection and absorption) to generate an image (figure 6). Fluorescence microscope allows us to look at a particular flourophore that has a specific spectrum. The combination of fluorescence microscope and biochemical staining has become a very powerful tool for biomedical research. For example, by using the specificity of an antibody to its antigen to label

specific proteins or other molecules within the cell (a technique called immunofluorsence) scientist can study all kinds of bimolecules that are usually invisible to regular light microscope many ongoing researches that help us to cure diseases, such as diabetes, heart attack and cancers, use this tool to see what is many inside the cells at a molecule scale.
A fluorescence microscope can be a simple or a complete one such as confocal microscope enables optical sectioning in thick specimen by removing the out of focus blur.

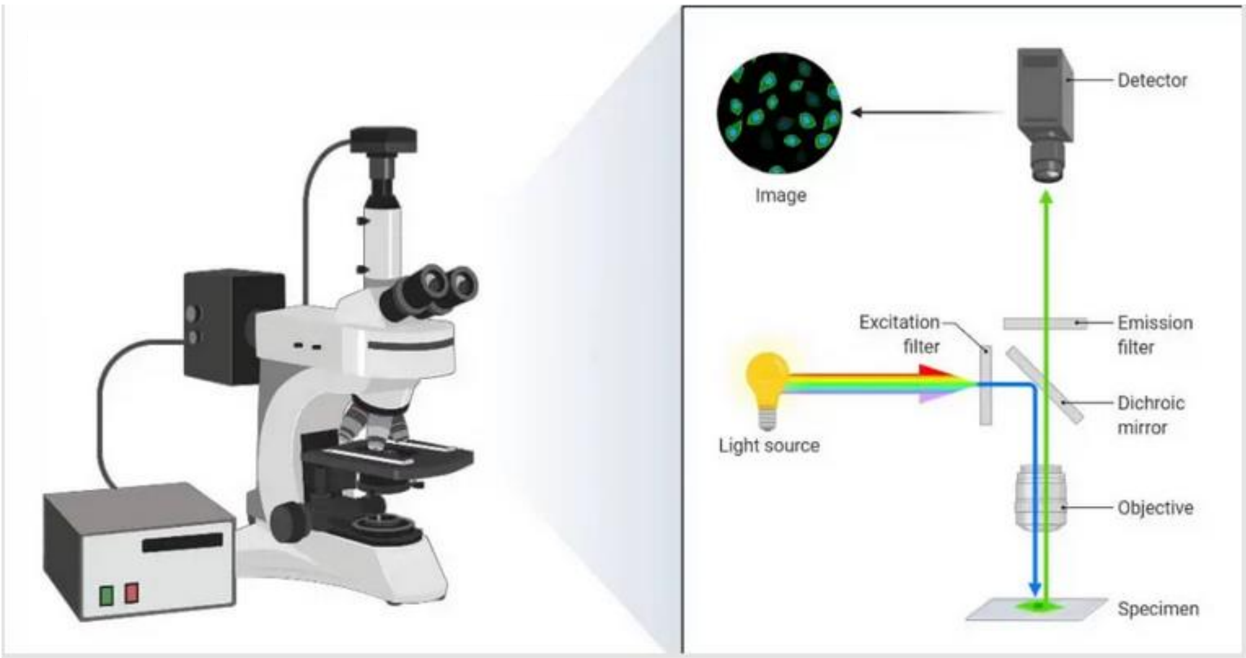


**Figure 6:** Fluorescence Microscope [1]

It uses point illumination (by focusing laser beam) and a pinhole in an optically conjugate plane in front of the detector to eliminate out-of-focus-signal. As a result only light produced by fluorescence very close to the focal plane (in focus) can be detected.

### 3.2 Electron microscopes (EM)

These microscopes are beams of electrons to generate images instead of light. Electron microscopes use electron optics logons to the glass lenses f an optical light microscope. As the wavelength of an electron can be up to 100,000 times shorter than that of visible light, electron microscopes have a higher resolution of about 0.1nm, which compares to about 200nm for light microscopes. The two well known electron microscopes are: Transmission Electron Microscope (TEM) and STM. A TEM is a type of electron microscope that uses broad beam to create an image of the internal structure of the sample. The electrons transmit or pass through a very thin specimen; off less than 150nm thick, to allow electrons to pass through them. TEM creates 2-D images.

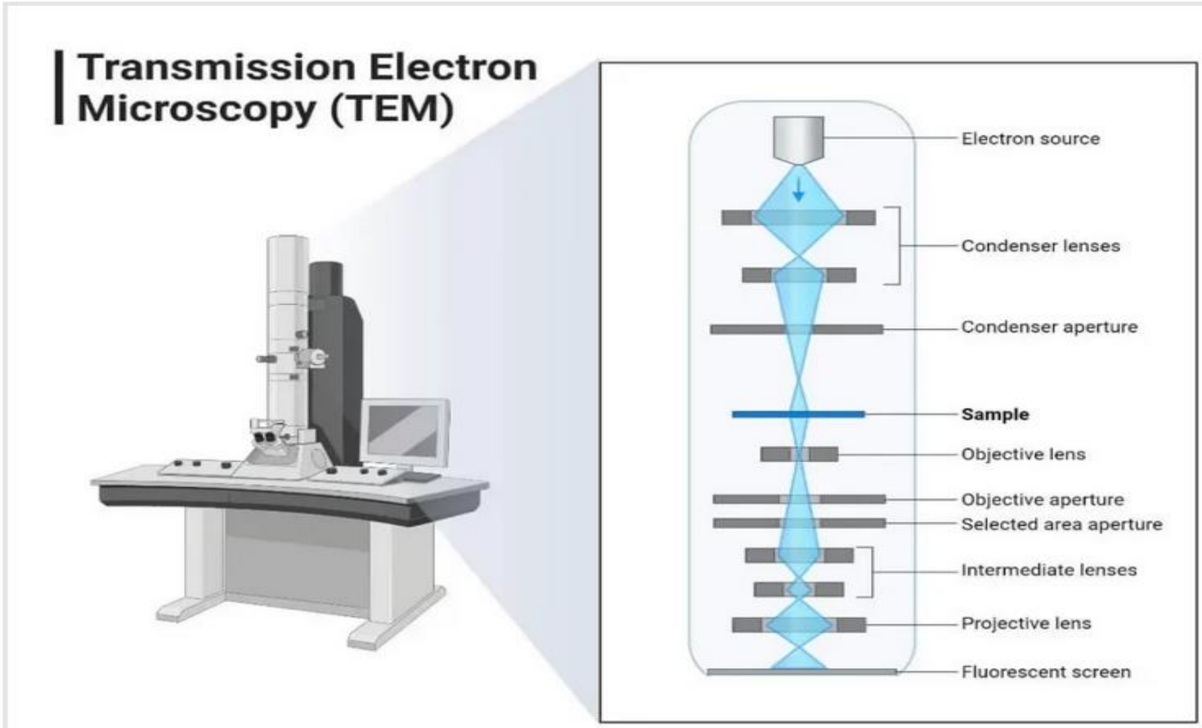


**Figure 7:** Transmissions Electron Microscope [1]

**SEM** – SEM is a type of electron microscope that uses a fine beam of focused electrons to scan a sample's surface. It scans through the surface of the specimen by focusing the electron beam. STM images give one sight into a sample's surface topography and composition, therefore it creates 3D images.

### 3.3 Scanning probe microscope (SPM)

These microscopes use very thin probes to scan the surface of the objects to generate images. You can imagine that you use your finger to feel the texture of cotton cloth, but at an atomic scale. This scanning probe microscope like Atomic Force microscope (AFM) can detect the surface up and down (topology) at single atom resolution. The probe can even move and arrange a single atom [10].

## 4. Functions of microscope

The primary function of a microscope is to study biological specimens a microscope solely functions on two concepts magnification and resolution. Magnification is simply the ability of the microscope to enlarge the image where as the ability to analyzeminute details depends on the resolution.

### 4.1 Functions of compound microscope

- It simplifiers the study of viruses and bacteria
- They are used in pathology labs to make an easy diagnosis of diseases.
- They are also used in forensic laboratories to identity human finger prints.

- It is also found in schools for academic purpose.

Both simple and compound microscopes can be used for microbiological studies. Specimen like fungi and algae can be viewed under these microscopes. Microscopes can also be used to study soil particles.

### 4.2 Function of dissection / stereomicroscope

- It helps to study the topographyof solid samples
- It is used for dissections and microsurgical procedures.
- It is also used in forensic engineering

### 4.3 Functions of electron microscope

Electron microscopes are expensive devices that are mostly used in industrial and medical research.

- They are used for microcharacterization of a sample.
- Helps in tissue imaging
- Device testing
- Mineral liberation analysis

### 4.4 Functions of scanning probe microscope

- It does examination of specimens at nanoscale level
- It is used to study the magnetic and electrical properties of objects.
- Information can be transferred to the specimen using this microscope.

## 5. Construction of Microscope

Any microscope is constructed based on mechanical and optical adjustments.[12] Hence could be separated into mechanical and structural parts as presented in the table 1.

**Table 1: Part of Microscope Construction**

| LIST OF MECHANICAL PARTS | LIST OF OPTICAL PARTS |
|---|---|
| 1. Base/metal stand foot | 1. Light source/illuminator |
| 2. Pillar | 2. Diaphragm |
| 3. Inclination point | 3. Sub stage – condense |
| 4. Curved arm | 4. Objective lens |
| 5. Stage | 5. Ocular lens/eye piece |
| 6. Stage knobs | |
| 7. Stage clip | |
| 8. Revolving nose piece | |
| 9. Course adjustment | |
| 10. Fine adjustment | |
| 11. Body tube | |
| 12. Draw tube | |

- Eye piece/ocular lens: Eye piece is the lens present at the top and is used to see the objects under study. Eye piece lens contains a magnification of 10x or 15x.
- Body tube: connects the eyepiece to the objective lenses.
- Resolving nose piece: it is also known as the turret. It has holders for different objective lenses. It allows the rotation of the lenses while viewing.
- Objective lenses: Generally, three or four objective lenses are found on a microscope, with ranges of 10x, 40x, 100x power. Lenses are colour coded, the shortest lens is of the lowest power and the longest lens is high power and the longest lens is high power lenses.
- Diaphragm: It helps in controlling the amount of light that is passing through the opening of the stage. It is helpful in the adjustment of the control light that enters.
- Coarse adjustment Knob: used for focus on scanning. Usually the low power lens is used enabling the movement of the tube.
- Stage: is where the specimen to be viewed is placed.
- Arm: it supports the tube of the microscope and connects to the base of the microscope.
- Stage clip: stage clips hold the slides in proper place.
- Condenser: the main function of condenser lens is focusing the light on the specimen under observation. When vey high powers of 400x are used, consider lenses are very important. Presence of consider lens gives a sharper image as compared to the microscope with no condenser lens.
- Base: Provides based support for the microscope
- Power switch: The main power switch that turns the illumination on or off.[13]

## 6. Working principles/how a microscope works

Bothdissecting and compound light microscope workby capturing and redirecting light reflected and refracted from a specimen. Compound microscopes also capture light that is transmitted through a specimen. Light is captured by convex lenses above the specimen; these are called objective lenses. Compound microscopes have several objective lenses of varying strengths, magnification from 40 to 1000 times. The image at the focal point; the point at which light is redirected or converged will appear magnified to the observer. Microscopes with a smaller working distance have the distance between the focal point and the front lens have greater magnification than those with a larger one.[11]

TFM work similarly to optical microscopes but instead of light or photons, they use beam electrons. An electron gun is the source of the electron and functions like a light source in optical microscope. The negatively charged electrons are attracted to an anode a ring shaped device with a positive electrical charge.

A magnetic lens focuses the beam of electrons as they travel through the vacuum within the microscope. These focused electrons strike the specimen on the stage and bounce off the specimen creating x-rays in the process. The bounded or scattered electrons, as well as the x-rays, are converted into a signal that feeds an image to a television screen where the scientist views the specimen.

## 7. FUTURE OF MICROSCOPE

Advances in microscope tackle future challenges

- Miniaturization for added mobility
- UVmicroscopy – short wavelength for increased resolution and contrast enhancement
- Automated system for more throughputs.
- Liquid lens integration for quick focus adjustments.

Optical microscopes have enabled advancement in science, medicine and industrial application since the 17th century [15] they are continually evolving to tackle the challenges of the future. Compact, miniaturized objectives allow microscopy to be portable, enabling rapid response in the field. Electrically – tunable liquid lens integration and system automation help drastically increase the throughput of industrial applications. These developments allows microscope to meet the demanding requirement of emerging application.

## 8. Contribution to Knowledge

Without microscope, we would have no idea about the existence of cells or how plants breathe or how rocks change over time. Our understanding of the world around us would be severely limited and this is why many scientists see microscopes as the most important scientific instrument there is.By using Microscopes scientists, researchers and students were able to discover the existence of microorganisms, study the structure of cells and see the smallest parts of plants, animals and fungi and Following the invention of the electron microscope in 1931 and the first attempts to study biological samples by transmission electron microscopy (TEM) in 1934 [9], the technique made it possible to image cells and tissues at much higher resolutions than light microscopy.

## 9. Finding

The microscope has had a major impact in the medical field. This research presents that without the microscope, mankind would not have been so developed and many diseases would still have no cure [15]. Researchers were able to describe the body at the microscopic level more consistently and with greater confidence in what they saw.A common issue in microscopy is the poor contrast produced when light passes through very thin specimens or reflects from surfaces with a high degree of reflectivity. To overcome poor contrast, various optical techniques have been developed to increase contrast and provide color variations in specimens.

## 10. Conclusion

Microscopes are invaluable tools that enable us to explore the intricate details of objects, revealing a world beyond what is visible to the naked eye. They play a pivotal role in expanding our knowledge and understanding of various phenomena, such as the existence of cells, the respiration process in plants, and the geological transformations of rocks over time. Without microscopes, our comprehension of the world around us would be significantly constrained. Over time, microscopes have undergone remarkable advancements, incorporating multiple lenses, filters, polarizers, beamsplitters, sensors, and diverse illumination sources. These sophisticated components work in unison, allowing scientists and researchers to delve deeper into the microcosms of life and materials. As a result, we gain profound insights that contribute to scientific discoveries, medical breakthroughs, and technological innovations. The evolution of microscopes has revolutionized the way we perceive and investigate the natural world. By empowering us to peer into the microscopic realm, they continue to be indispensable tools in unlocking the mysteries that lie hidden beneath the surface, enriching our understanding of the complexities and wonders of life and matter.

**REFERENCE**


1. Prashant Dahal&Sagar AryalJuly 29, 2022“16 Types of Microscopes with Parts, Functions, Diagrams”. https://thebiologynotes.com/types-of-microscopes/
2. Poyan N. 2016; A voyage to beyond the human eye by MicroscopeLeeuwenhoek’s invention open Access Library Vol. 3 No 1
3. https://www.microscopemaster.com microscope timeline 2021
4. The evolution of the micrsocpesavile Bradbury Elvsevier 2014 book.google.com.ng
5. Racheal 2023 History of Microscope and types of microscopes https://rsscience.com/micrscope
6. From animaculum to single molecules: 300 years of the light microscope April 2015 Adam J.M
7. Mosloni 19 August 2019: The microscope https://www.sciencemuseum.org.uk
8. https://en.wikipedia.org/wiki/scanning-probe-mircscopy
9. Mary Belis December 2019: History of Microscopeshttps://www.thoughtco.com/historyofmicroscopes
10. Karthik 2023 types, parts and functions of microscope https://byjus.com/biology types, parts and functions of microscope
11. Stacy Taylor March 2018 difference between compound and dissecting microscope. https://www.sciencing.com/microscopes-how a microscope works.
12. Nethravathi sin May 2021 construction of microscope- basics (https://www.slideshare.net construction of microscope-basics
13. Emmanuel IfeoluwaseyiAkaiso October 2018 components of a microscope and its functions https://researchgate.net/components of a microscope and its functions.
14. Mortimer Abramowitz & Michael W. Davidson**,** 2022 “Anatomy of a Microscope”. https://www.olympus-lifescience.com/en/microscope-resource/primer/anatomy/introduction/
15. David Bardell, 2004 “The Invention of the Microscope” Vol. 75, No. 2 (May, 2004), pp. 78-84 (7 pages). https://www.jstor.org/stable/4608700.Published By: Beta BetaBeta Biological Society