

The Role of Technology in Biological Progress:

THE CREATION AND EVOLUTION OF THE MICROSCOPE

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BIOL 4270

OUR MAIN TOPICS

Introduction to **Magnification**

Spectacles!

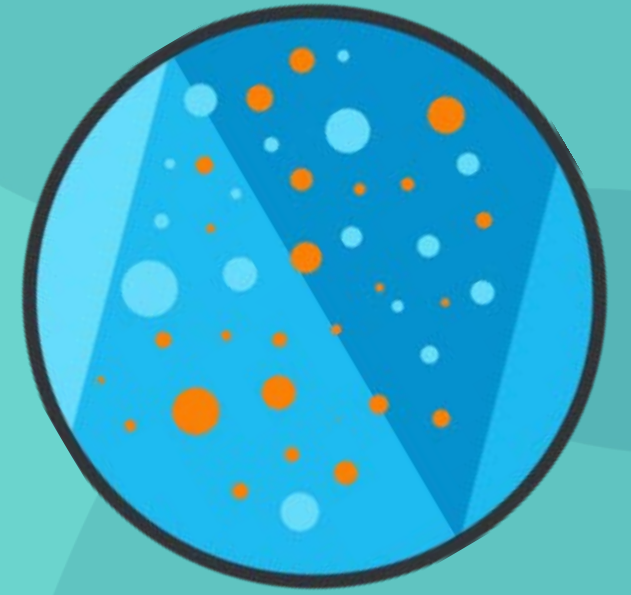
Magnification + Science = Microscope

Introduction to the **Microscope**

Principles of **Design**

Evolution of **Technology**

Microscope Technology Then vs Now



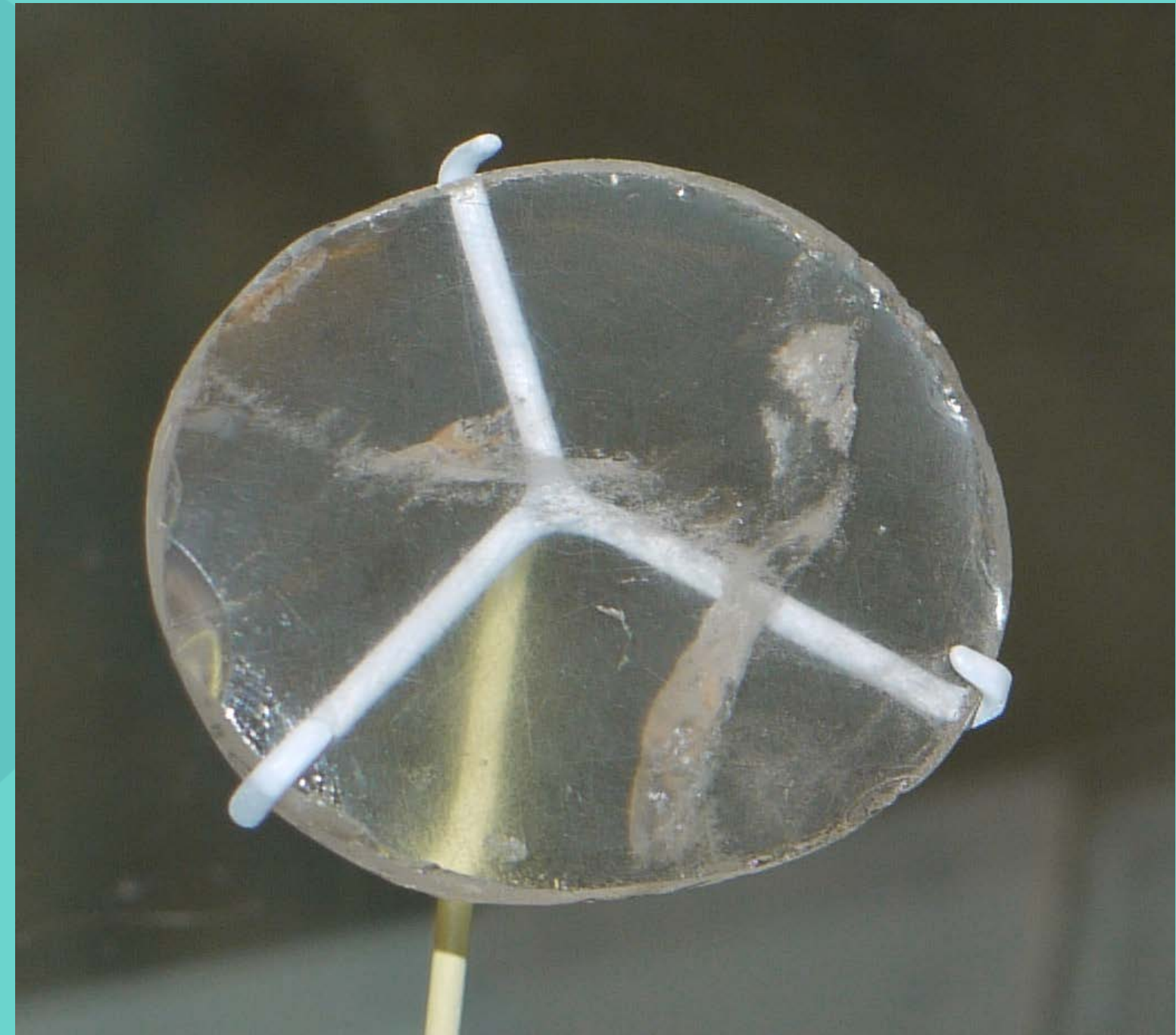


INTRODUCTION TO MAGNIFICATION

We will first start with the discovery of magnification and the implications it had at that time. The idea of **particles** and or **molecules** was not yet thought of and **religion** played a large role in the ways of thinking.

700 BCE

- The first appearance of a lens was the “**Nimrud lens**”
- It was made from **rock crystal**
- Assyrian manufactured.
- It is thought to have been used for starting fires with sunlight or magnifying at a basic scale.



1267 - Roger Bacon

- An English philosopher
- Wrote the book *Perspectiva*.
- The book mentions dust particles and how small things are **viewed differently** depending on the **angle**.
- This is the beginning of the concept of **magnification**.





SPECTACLES!

Magnification was first used for improving vision.

Spectacles were introduced in the **13th Century**.

Potential of **magnification** for science was
discovered.

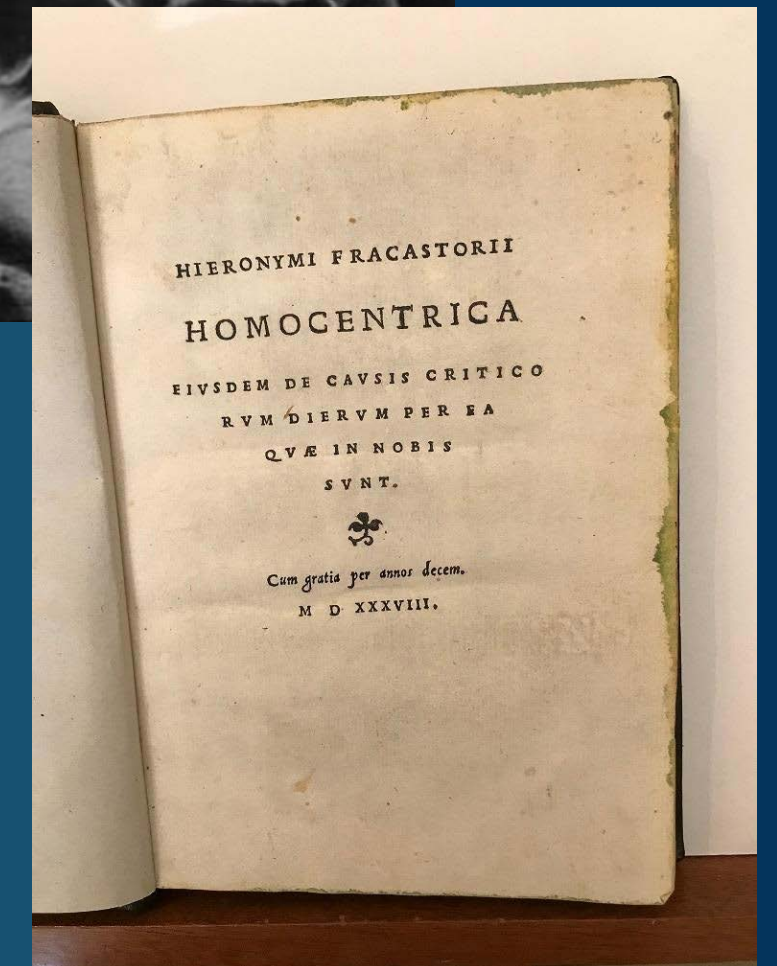
13th Century

- Lenses became more common and easier to get
- Eyeglasses were more **accessible**
- The increase in availability lead to the development of primitive microscopes



1538 - Girolamo Fracastoro

- An Italian physician
- Wrote the novel *Homocentrica*
- He proposed the idea of looking through **two spectacle glasses** to **superimpose** the image.
- This would allow for a larger picture.



MAGNIFICATION + SCIENCE = MICROSCOPE



Once the science of magnification was perfected, it was only a matter of time before many great minds realized its potential for scientific advancements.

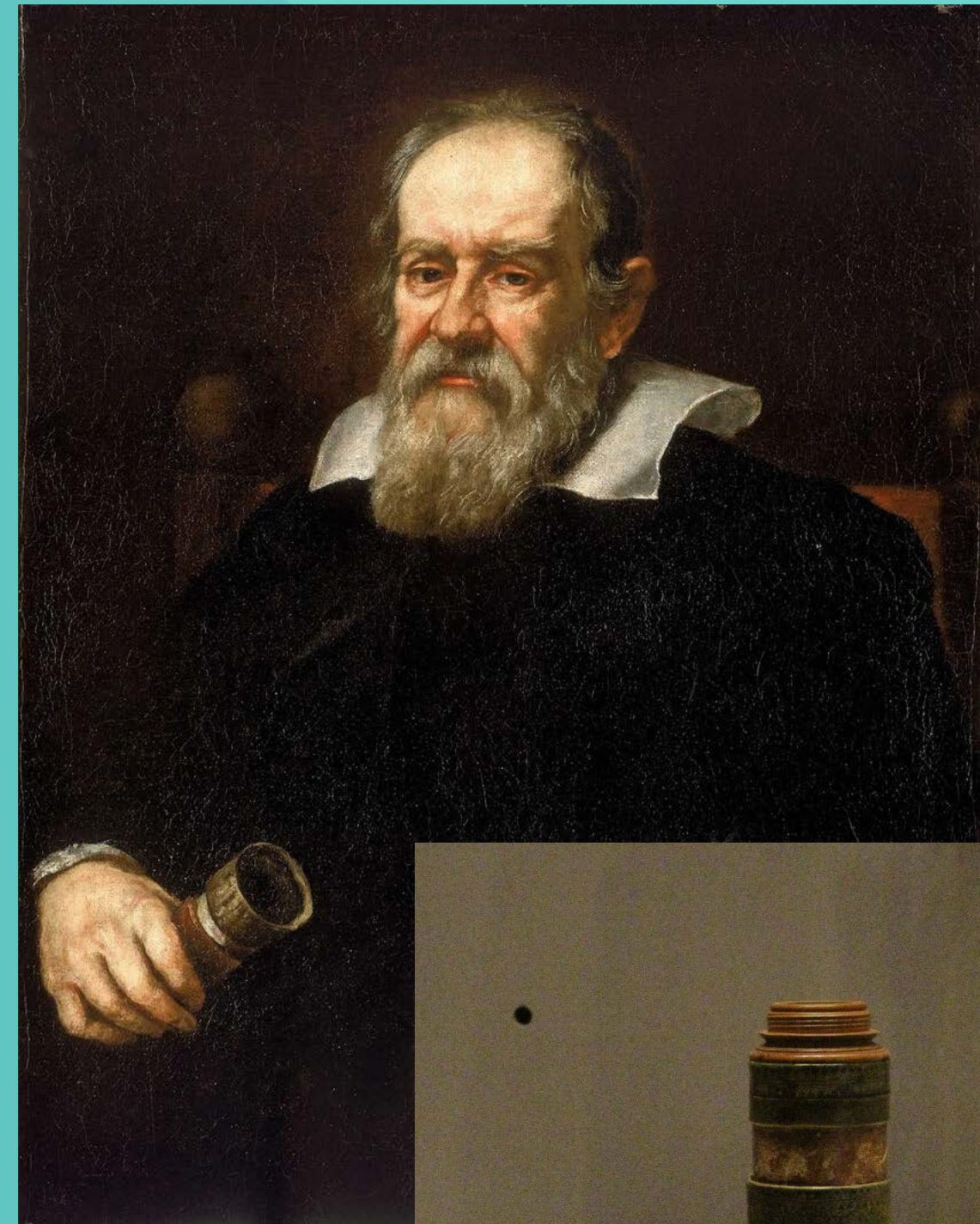


1590 - Hans Janssen, Zacharias Janssen and Hans Lippershey

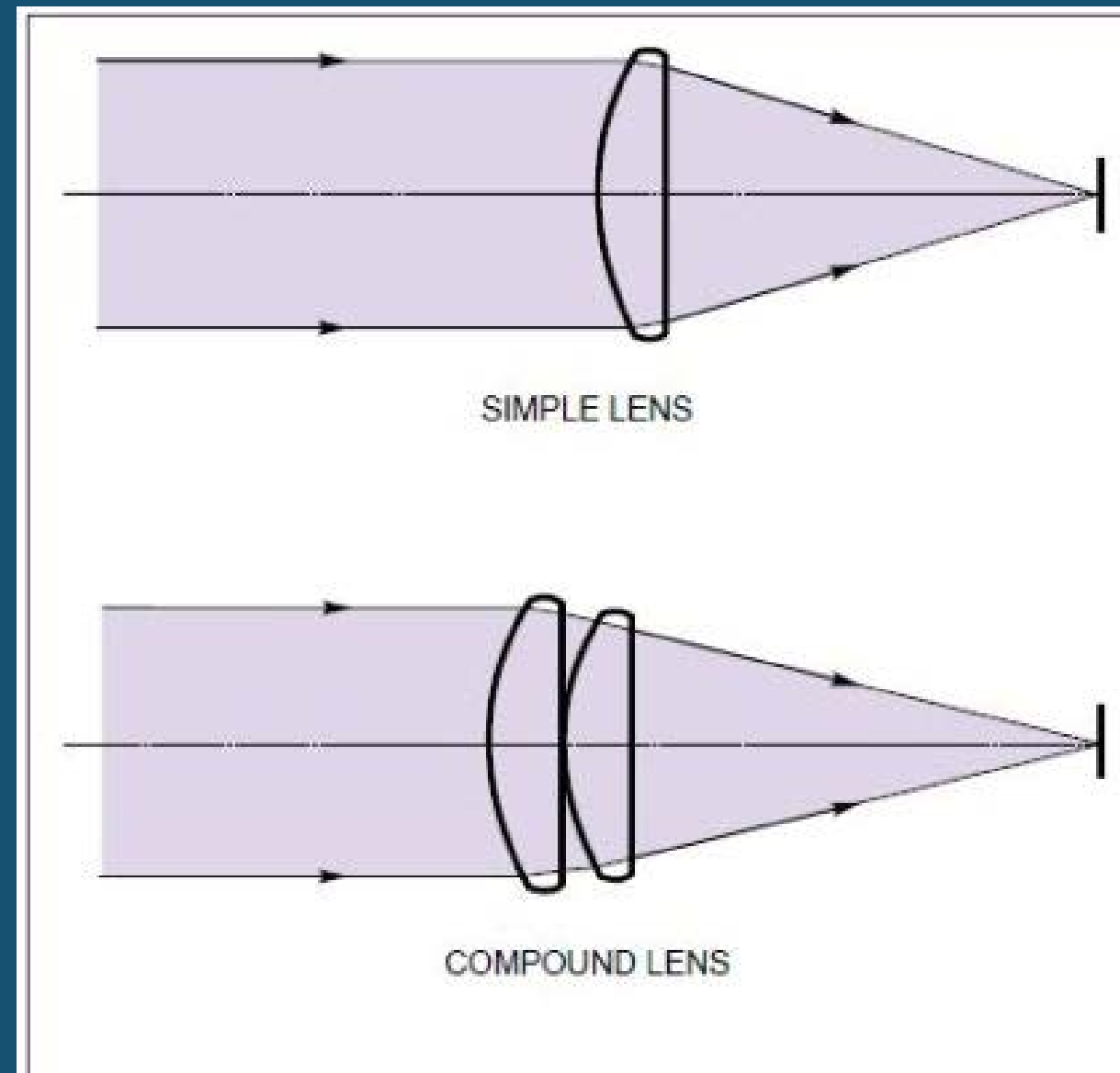
- A group of **Dutch spectacle makers**
- They invented the earliest version of the **microscope.**
- The design was primitive, but was the foundation for future microscopes.

1609 - Galileo Galilei

- An Italian astronomer, physicist and engineer
- improved the original microscope design by applying designs from the **telescope**
- He added a **bi-convex objective** and a **bi-concave eyepiece** which created a functional compound microscope.

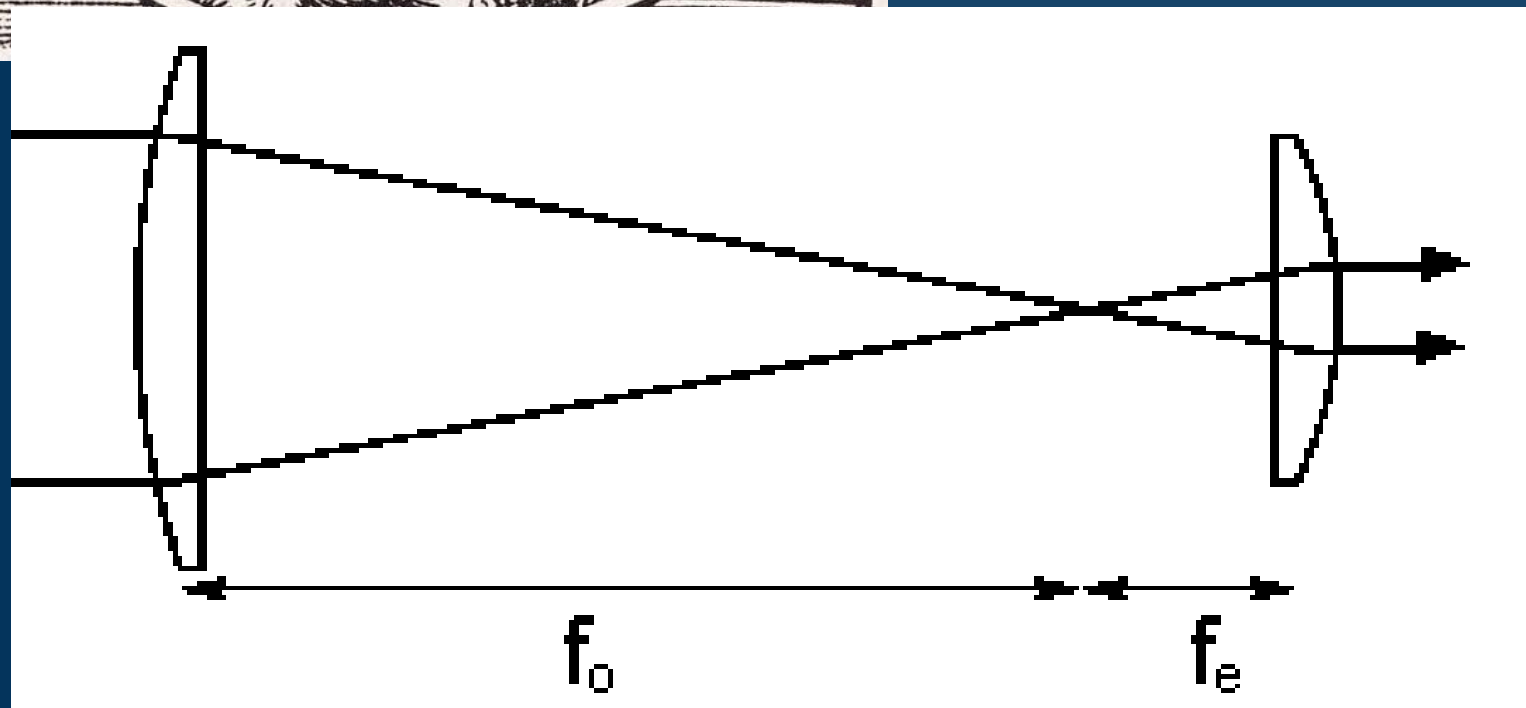


The Simple Microscope vs. The Compound Microscope

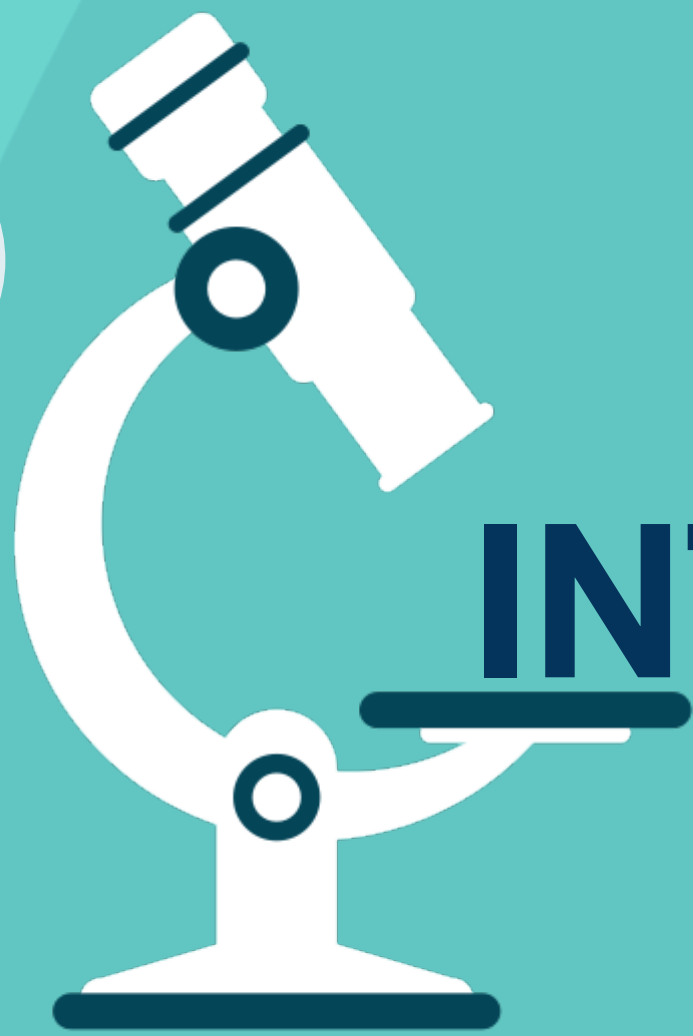


The Simple Microscope vs. The Compound Microscope

- Single lens
 - Magnification is limited to the power of the single lens
 - Uses a natural source of light
 - Typically only has one adjustment knob for focusing
- Multiple lenses, usually 3 to 5 objective lenses and an eyepiece lens (10x)
 - Magnification depends on the lens in use (4x, 10x, 40x,)
 - Has a condenser lens to adjust the intensity of light
 - Has its own light source
 - Has multiple knobs for adjusting focus, aperture, and intensity of light



- ## 1621 - Cornelis Drebbel
- A Dutch engineer and inventor
 - He designs and presents a compound microscope with a **convex objective** and a **convex eyepiece**
 - This is known as a "**Keplerian**" microscope.



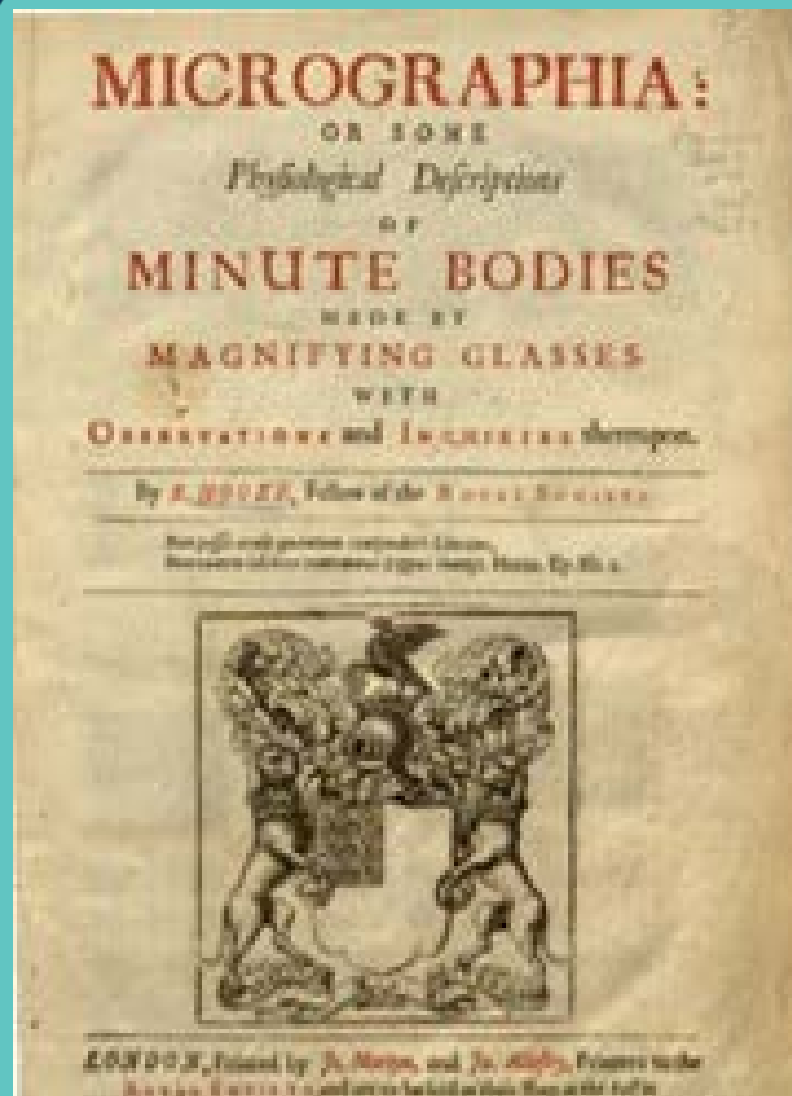
INTRODUCTION TO THE MICROSCOPE

With the advancing use of magnification and its applied use to the field of microscopy, comes the development of the primitive compound microscope leading to some of the early discoveries of microscopic organisms.

1665 - Robert Hooke

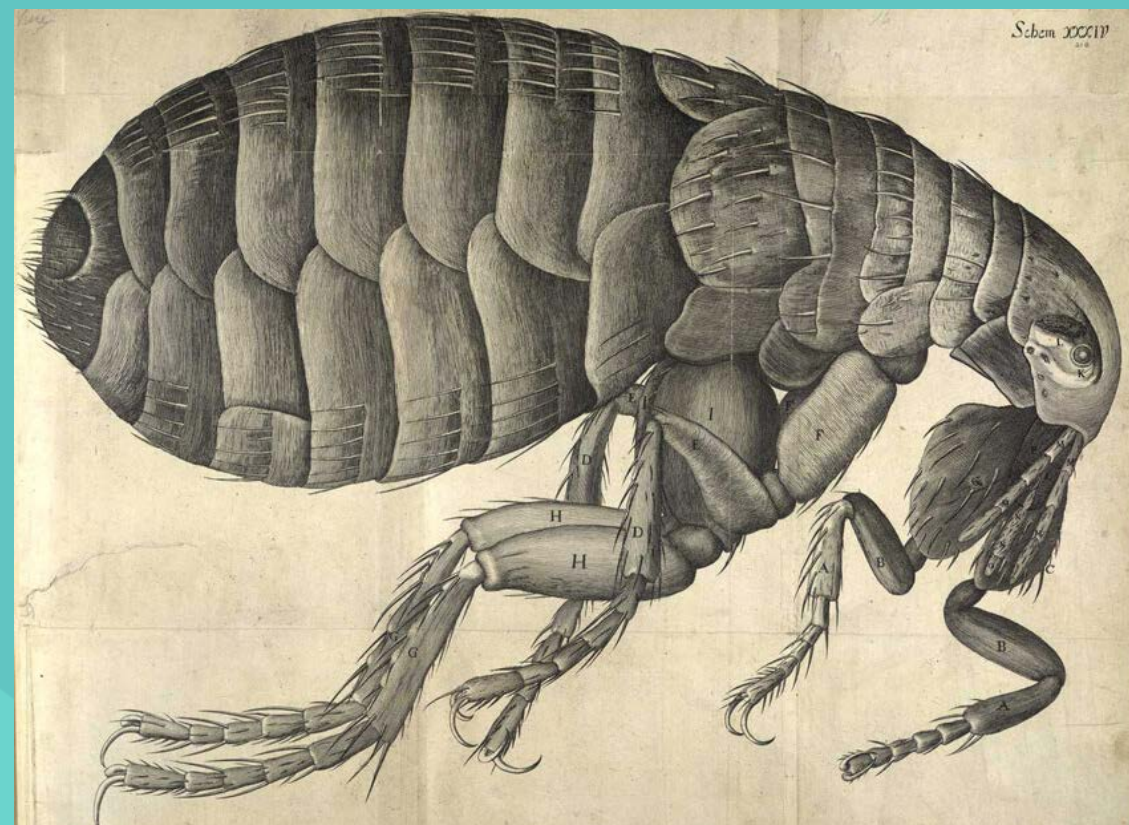
- An English natural philosopher
- He used the compound microscope to make demonstrations for the new **Royal Society**.
- Writing the popular book *Micrographia*





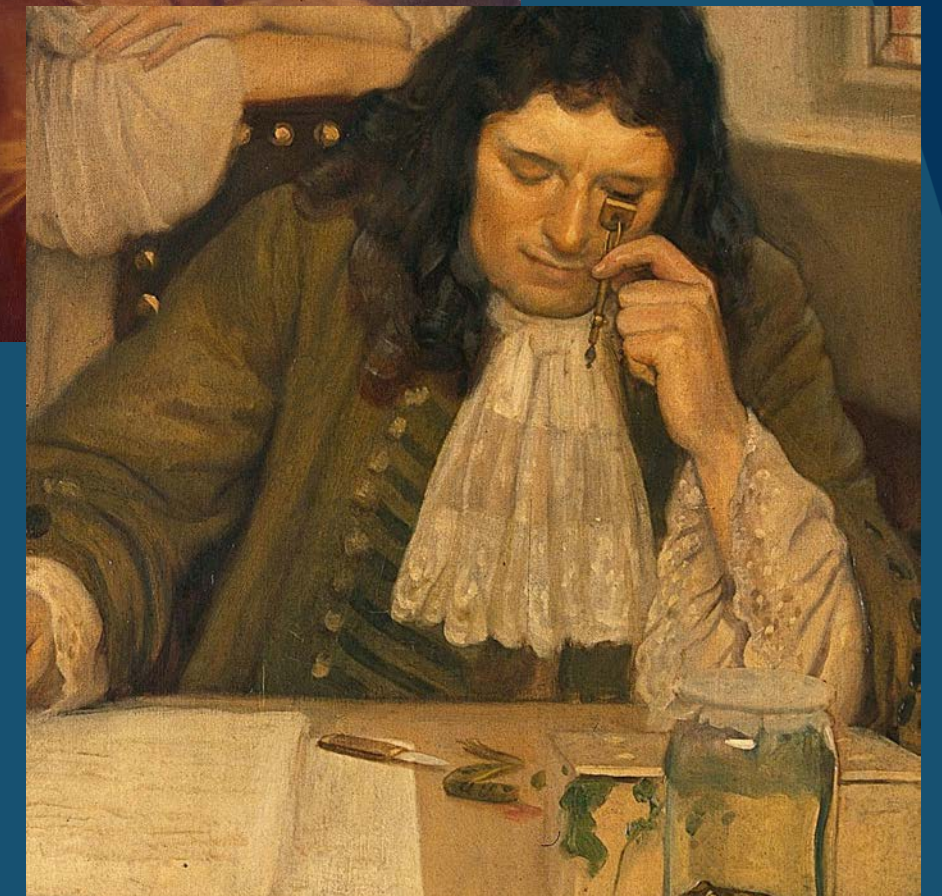
Micrographia

- The first book to illustrate various flora and fauna viewed at the **microscopic level**.
- He coined the term “**cell**” for the structures he discovered
- The book was a bestseller and sparked interest in the emerging field of microscopy.



1670 - Antonie van Leeuwenhoek

- A Dutch civil servant
- He observed freshwater microorganisms.
- He produced extremely fine specimens with details down to $0.7\mu\text{m}$ using a simple microscope.
- This collectively launched the field of **microbiology** in 1674



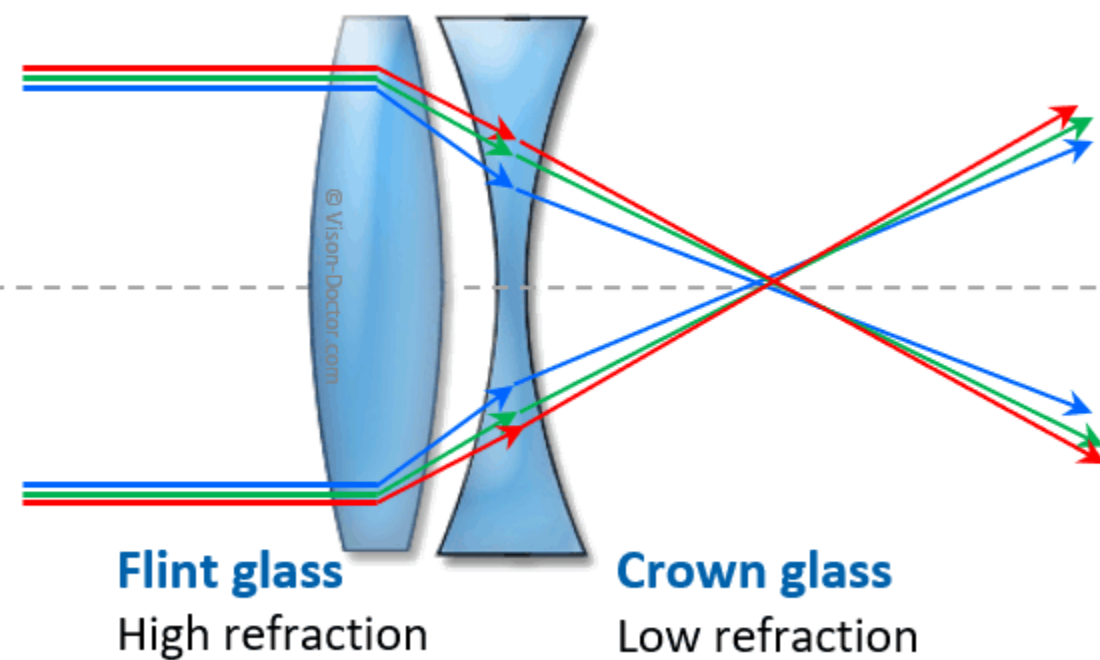
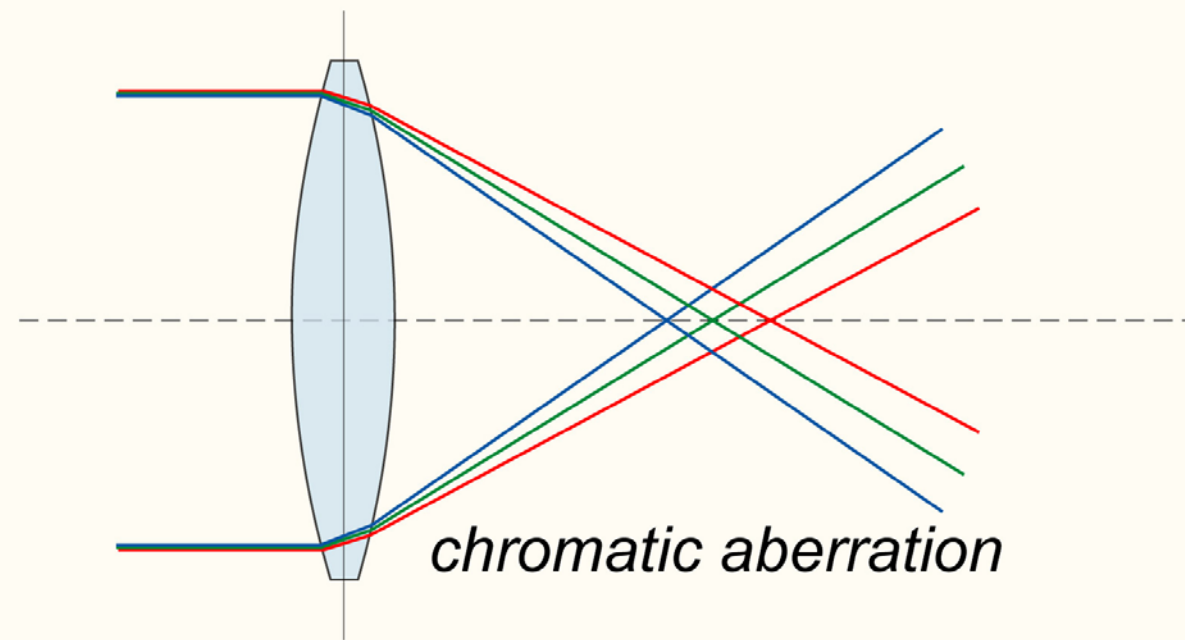


PRINCIPLES OF DESIGN

Many scientists contributed to the developing design of the compound microscope. Many of these advancements in microscope design are still used in today's microscopes.

1733 - Chester Moor Hall

- An English amateur optician
- Through trial and error discovered that a combination of a convex crown-glass lens and a concave flint-glass lens could help to correct **chromatic aberration** in a telescope.
- This could then be applied to microscope design.



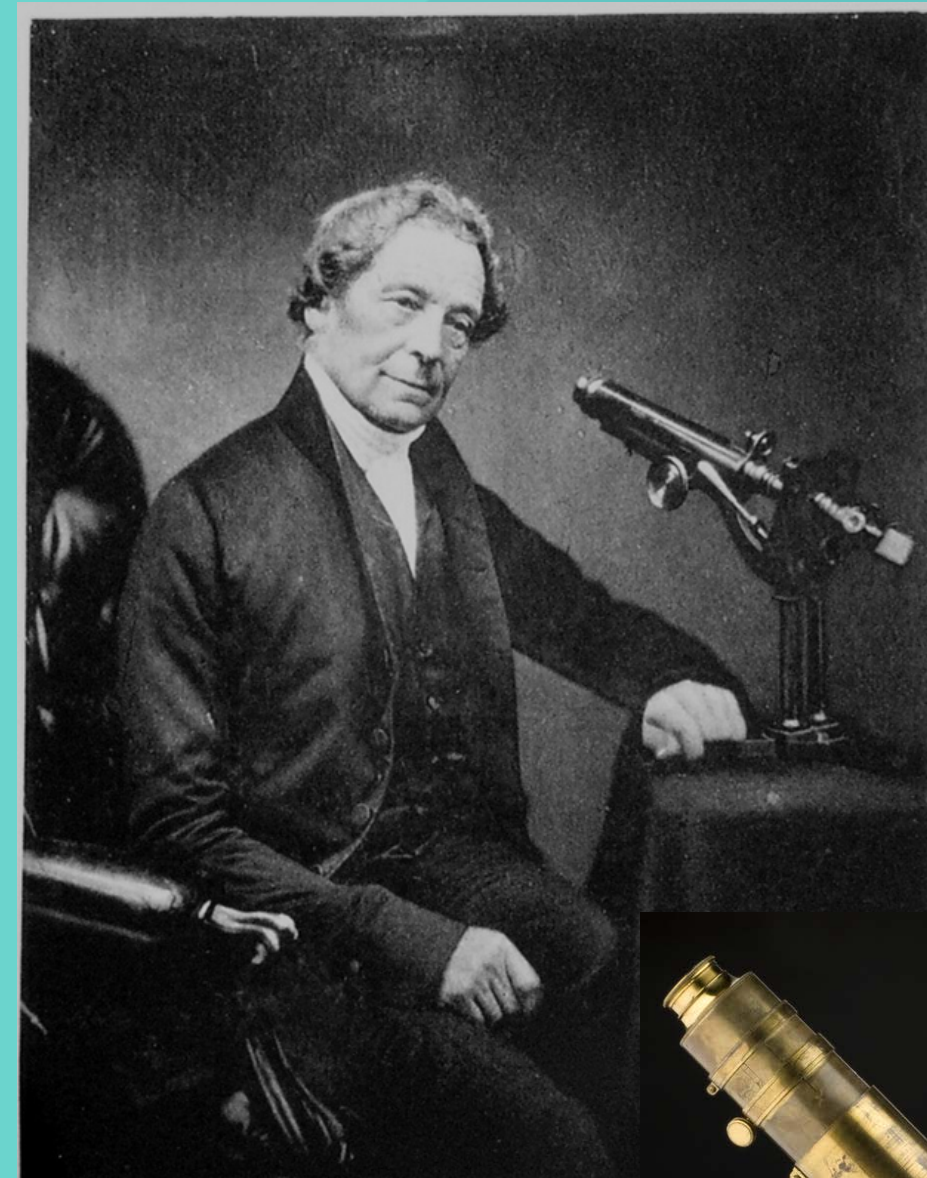
1774 - Benjamin Martin

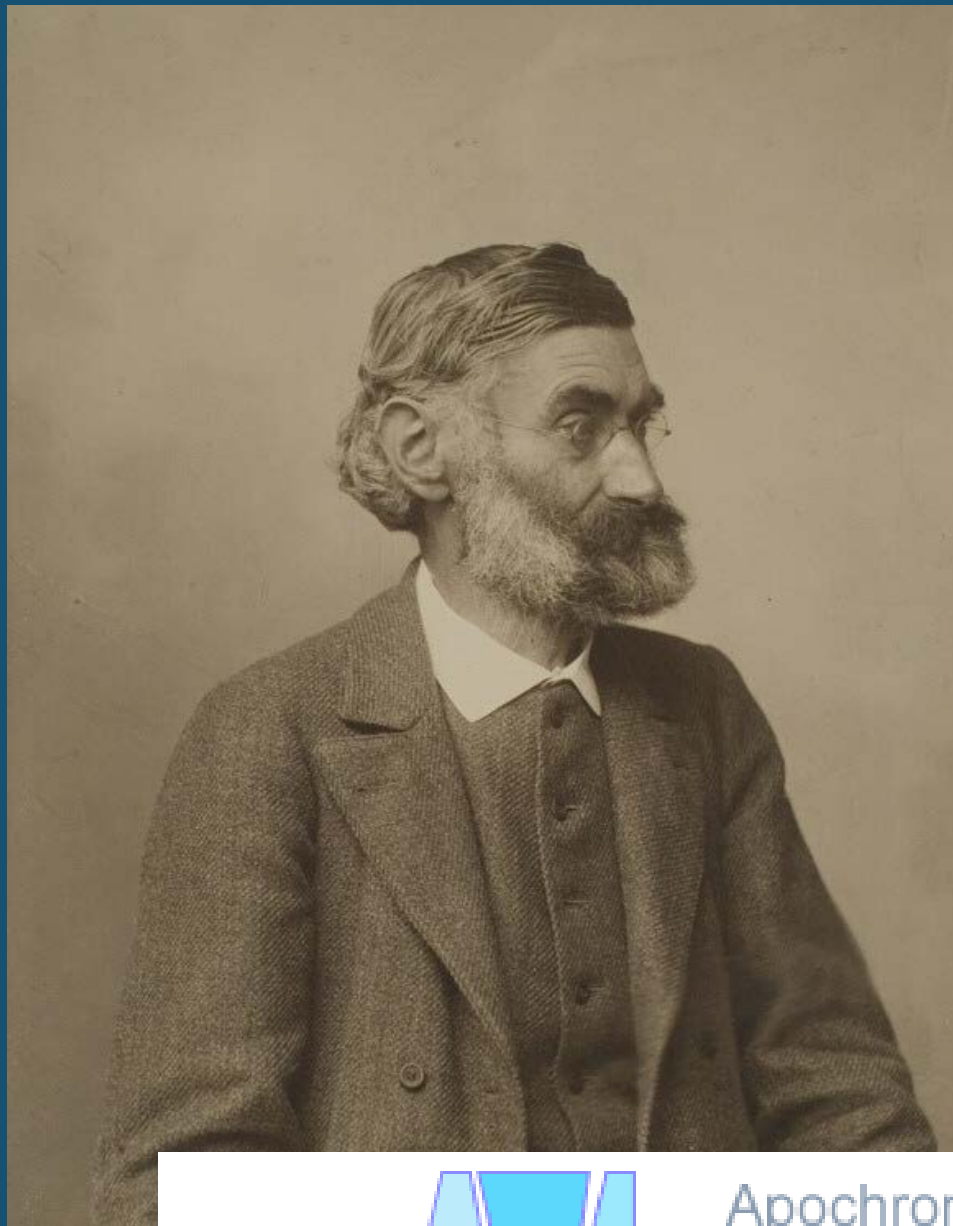
- An American scientist and instrument maker
- Produced a set of **colour-corrected lenses** for a microscope
- The design was based on the theory developed by Chester Moor Hall



1830 - Joseph Jackson Lister

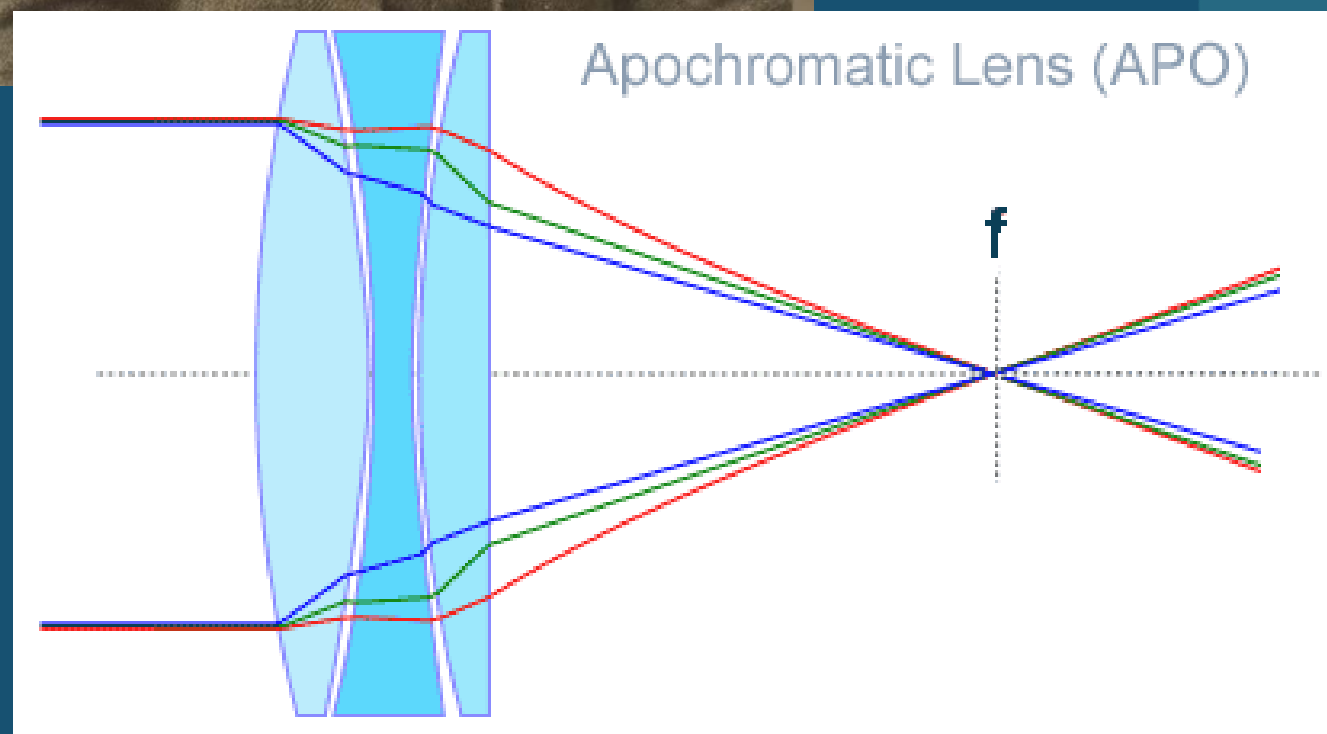
- An English scientist
- described the theoretical approach to the design of **microscope objectives**.
- developed a set of combined lenses which cancels both **spherical and chromatic aberration**.





1868 - Ernst Abbe

- A German physicist
- He invented an **apochromatic** system of lenses
- These had even better colour correction than **achromatic** lenses.
- He went on to publish a comprehensive analysis of **lens theory**.



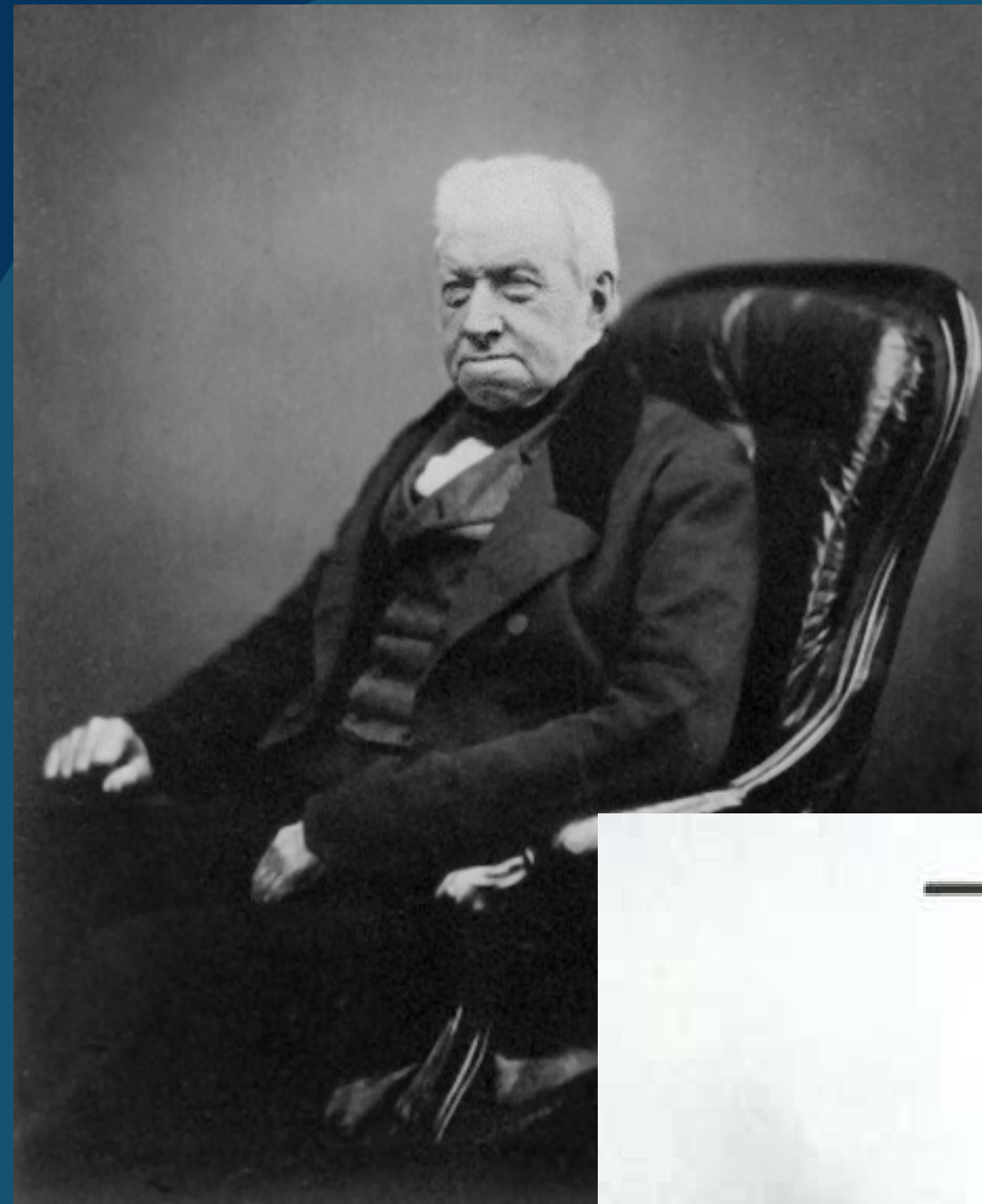


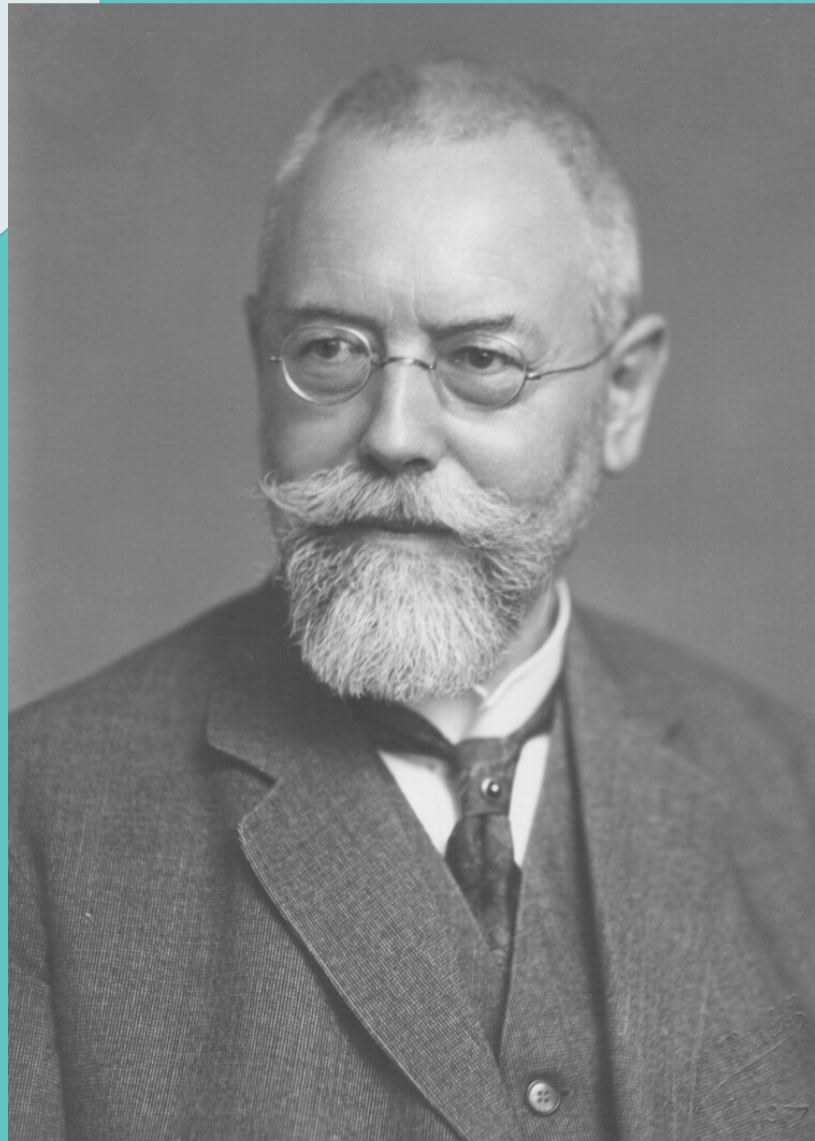
EVOLUTION OF TECHNOLOGY

Due to the advancements in microscope technology and many other tools for scientific analysis, many new “big biology” breakthroughs were able to be made.

1827 - Robert Brown

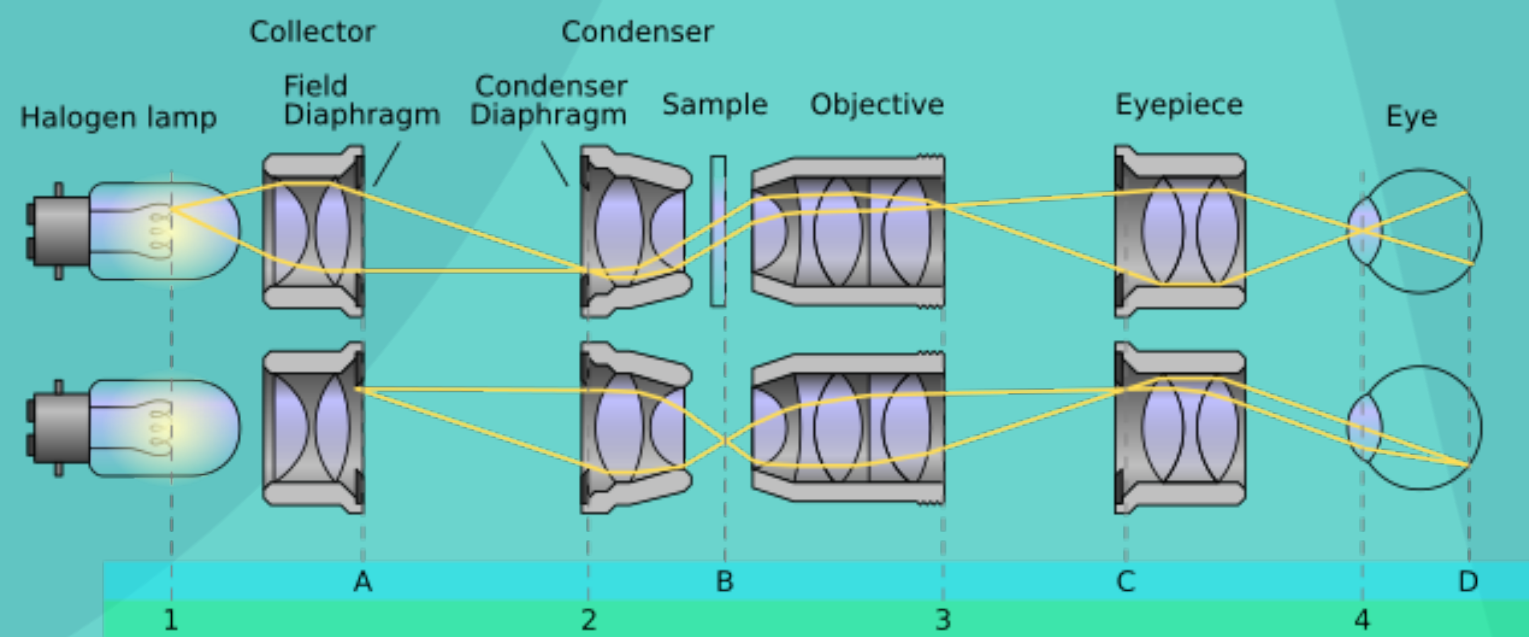
- A Scottish botanist
- Used single lens microscopes (which remained popular into the 1850s)
- Demonstrated the **ubiquity** of the cell nucleus, a term he coined in 1831





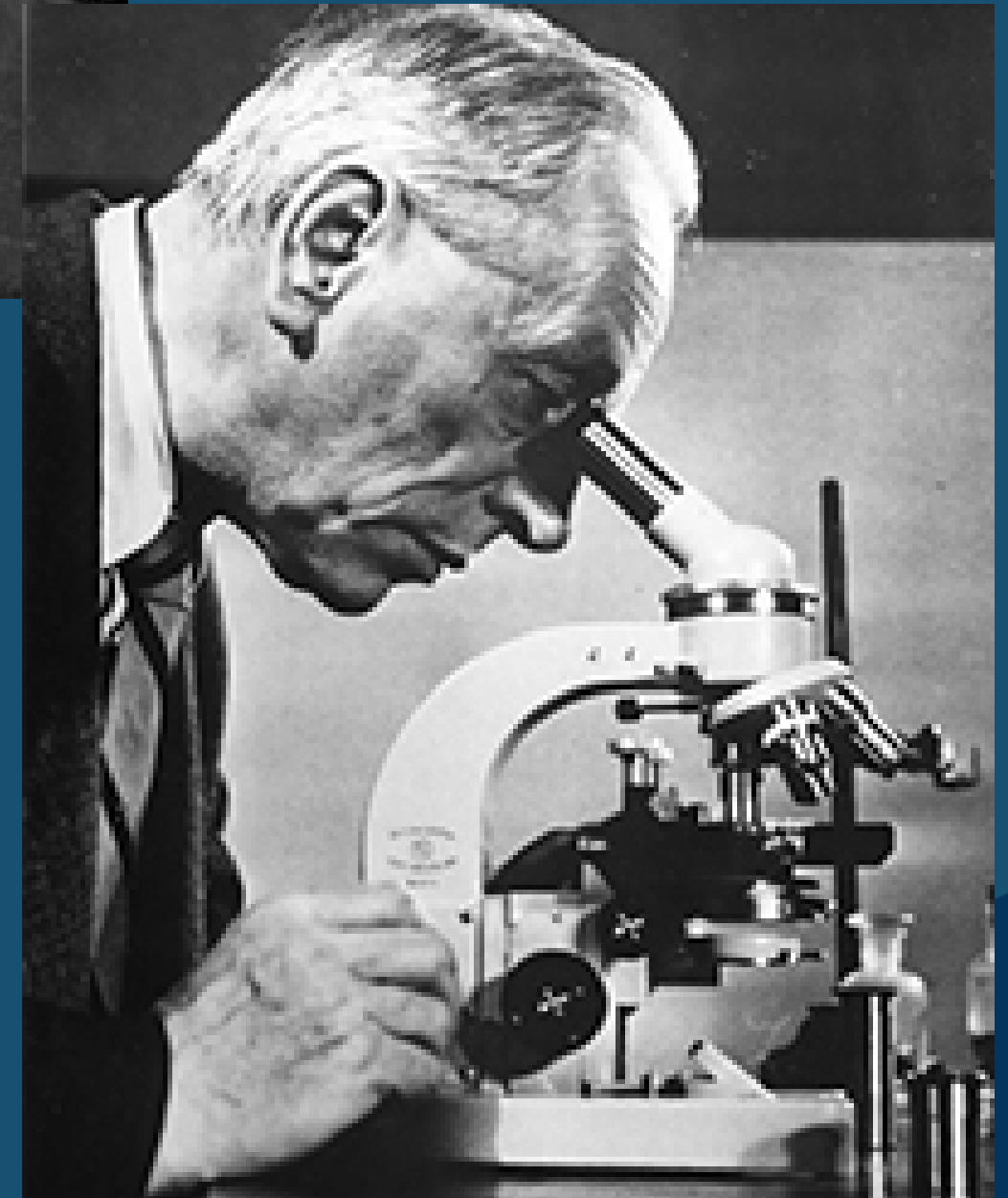
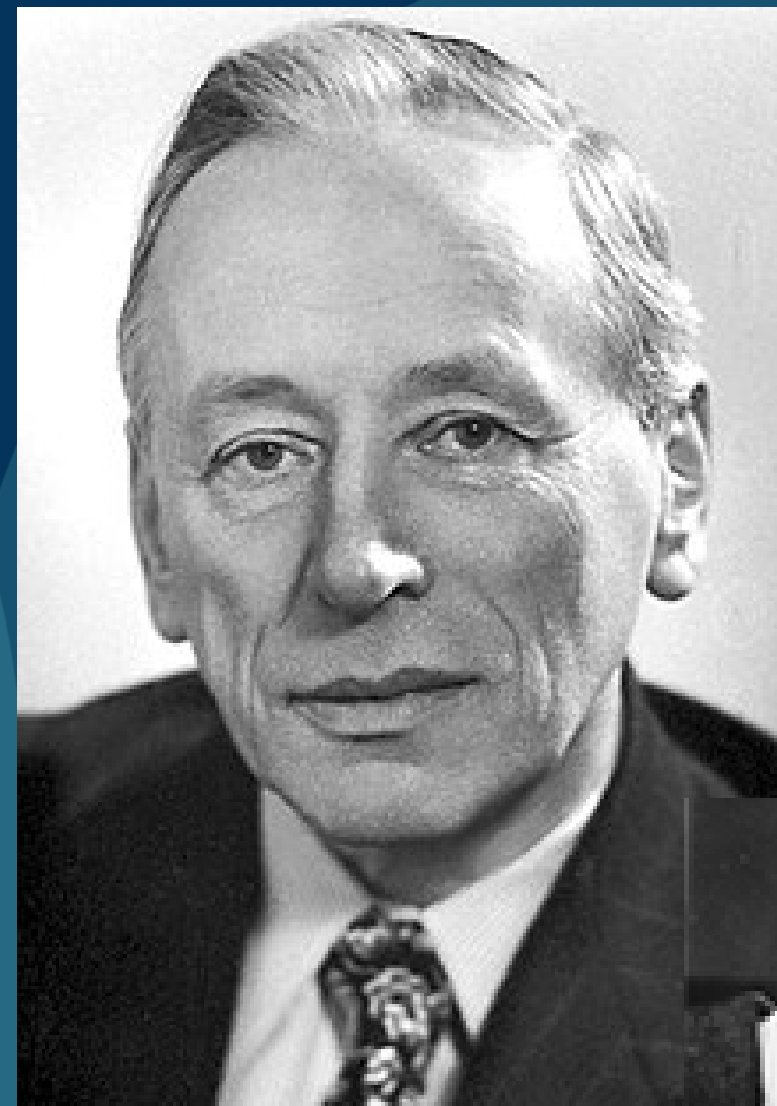
1893 - August Köhler

- A German professor
- Known for developing the microscopy technique, **Köhler illumination**.
- This technique is important for optimizing the resolution power by **evenly illuminating the field of view** of the microscope.
- This technology revolutionized light microscope design and is used in both traditional and modern digital imaging techniques.



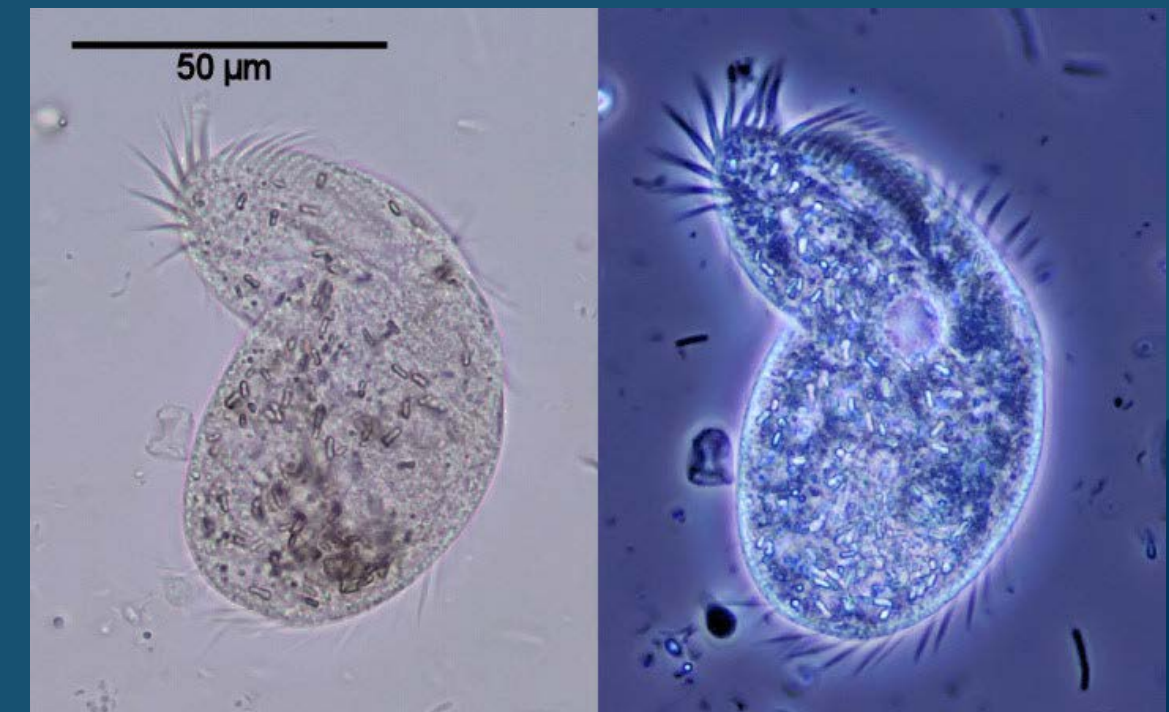
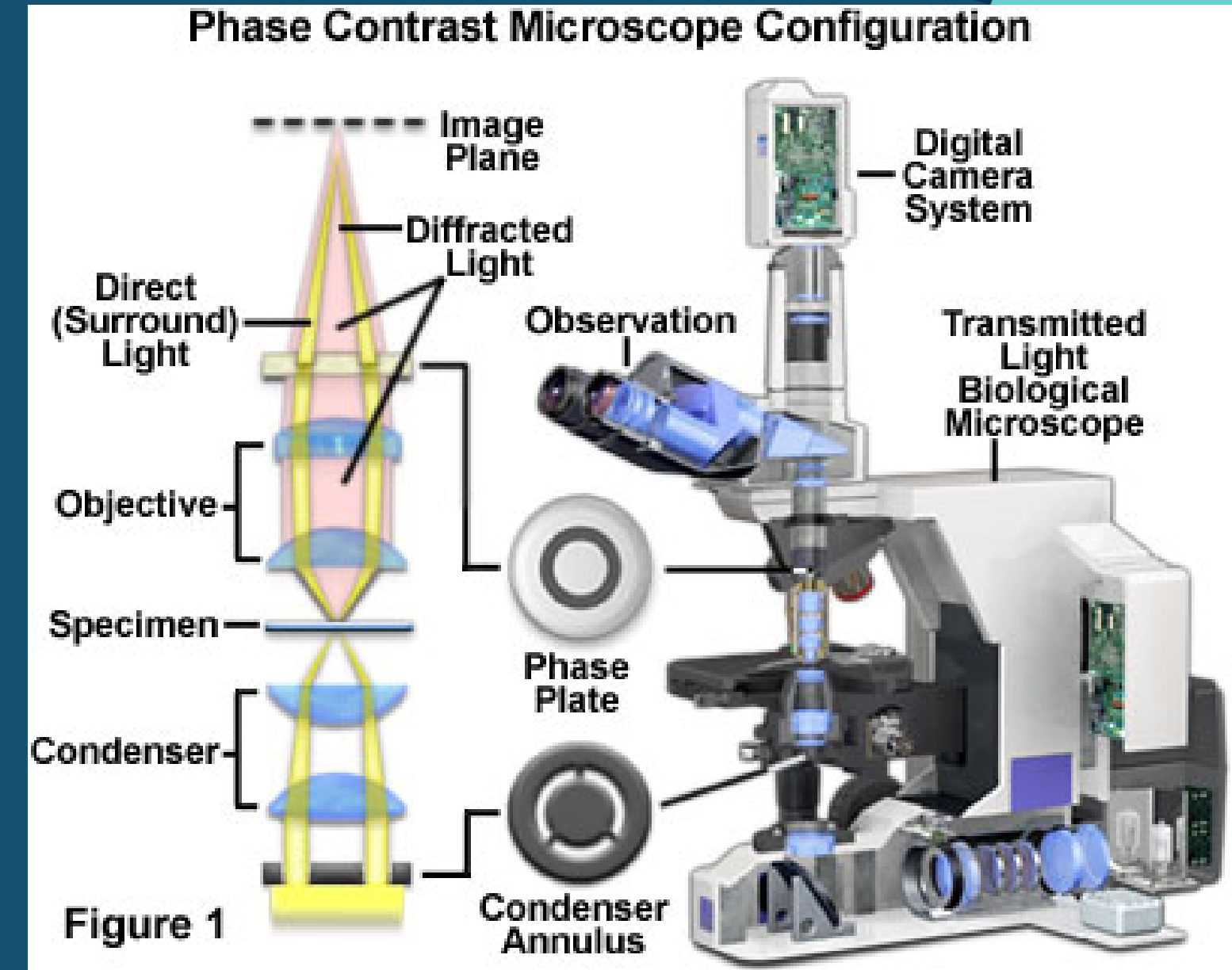
1932 - Frits Zernike

- Invented the **phase-contrast** microscope
- This allowed for the study of internal structures **without the need for staining**, which subsequently kills the specimen
- He won a Nobel Prize in Physics in 1953 for this invention



The Phase-Contrast Microscope

- Converts phase shifts in light passing through a transparent specimen to produce an image.
- Contains two objective lenses that can be focused on the specimen.
- Also has a set of condenser lenses to focus the light through the specimen for optimal image quality.



1933 - Ernst Ruska

- A German physicist
- Won the **Nobel Prize in Physics** for electron optics in 1986.
- Developed the first **electron microscope**
- This advancement allowed for **higher resolving power**.
- Leading to the identification of small structures.



The Transmission Electron Microscope (TEM)

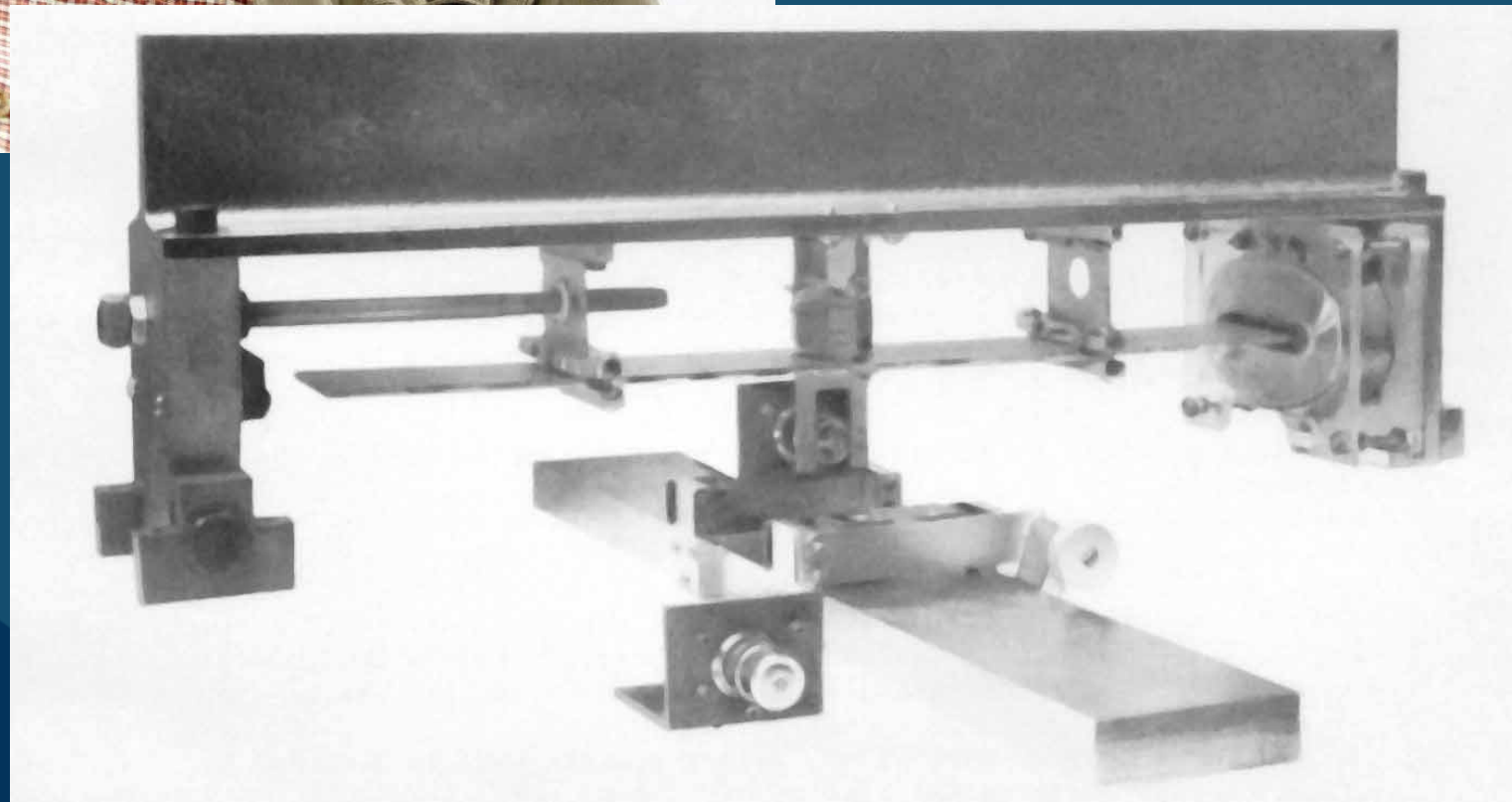
- Use shaped magnetic fields to create electron optical lens system
- **10,000,000x** magnification
- Compared to the glass lenses of a compound microscope this provides **higher resolution.**



1937- Manfred von Ardenne

- A German researcher and applied physicist
- Applied scanning to the electron beam from the TEM to invent the **Scanning Electron Microscope (SEM)**
- He hoped to **surpass the resolution** of the transmission electron microscope (TEM)
- The TEM also faced problems of chromatic aberration which was mitigated by the SEM.



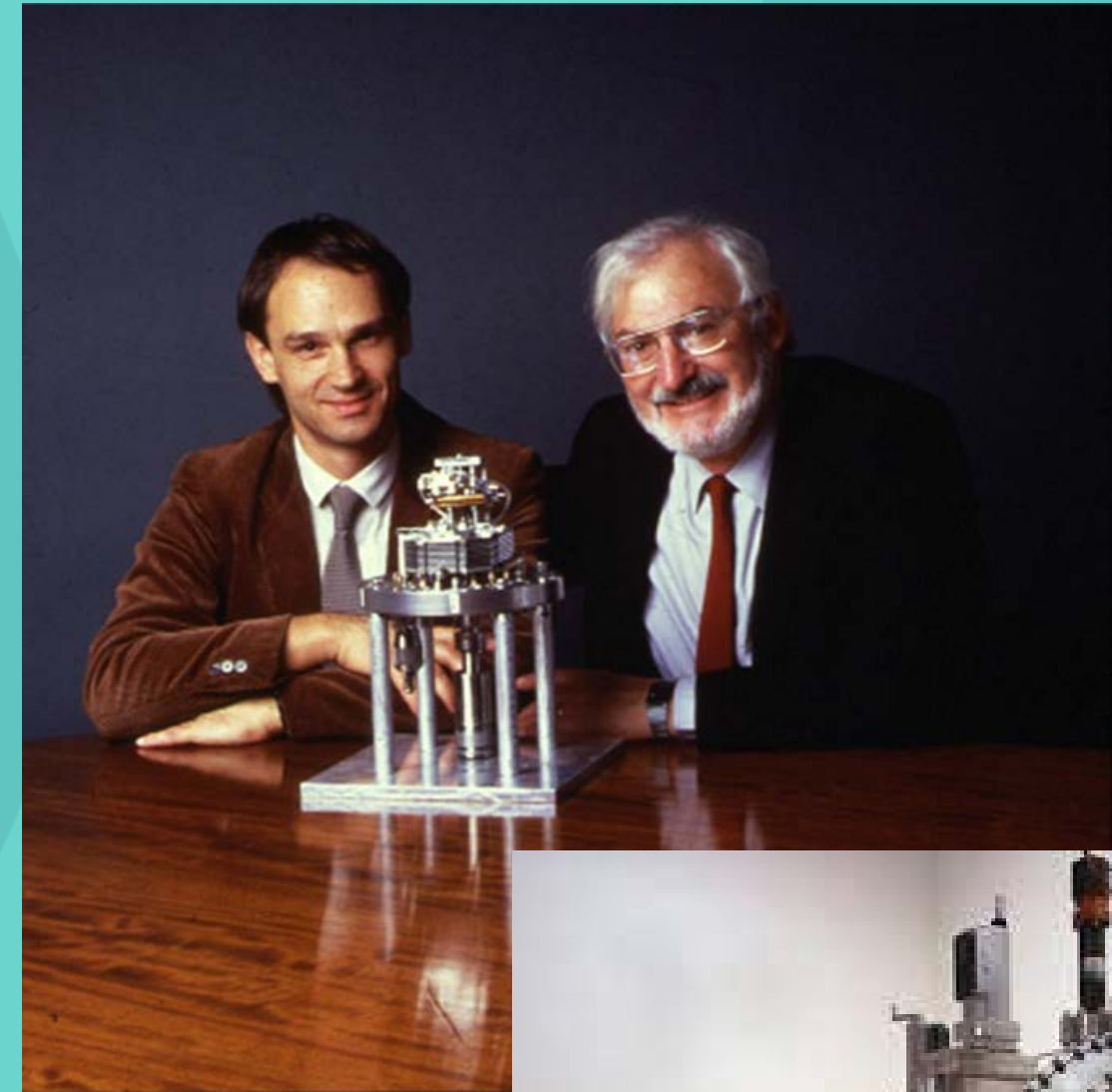


1957- Marvin Minsky

- An American cognitive scientist
- Patented the **confocal** microscope
- This microscope increases **optical resolution** and **contrast** of a micrograph
- Uses **spacial pinholes** to block out-of-focus light

1981- Gerd Binnig & Heinrich Rohrer

- A German and Swiss duo of physicists
- Developed the **Scanning Tunneling Microscope**
- Based on the concept of **quantum tunneling**
- Has the ability to image and manipulate atoms within materials
- Earned them a Nobel Prize in Physics in 1986.





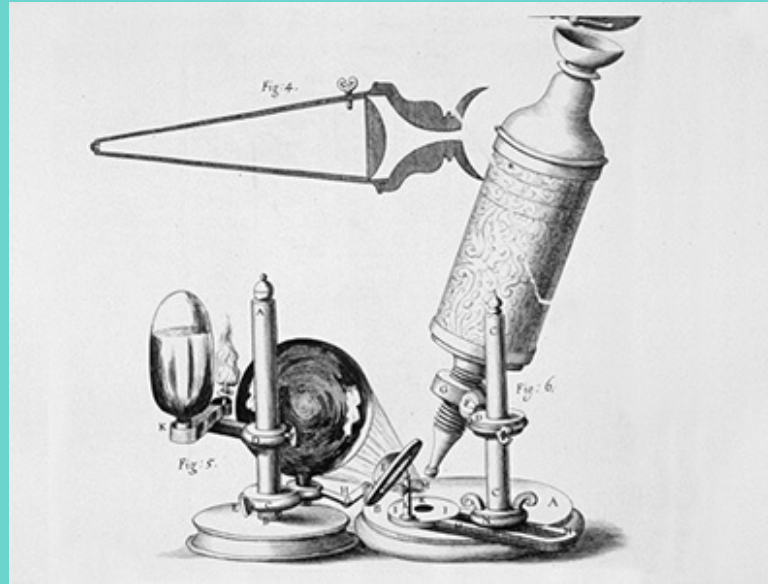
MICROSCOPE TECHNOLOGY THEN VS NOW

Types of Microscopes:

- Simple Microscope
- Compound Light Microscope
- Phase-Contrast Microscope
- Transmission Electron Microscope
- Scanning Electron Microscope (SEM)
- Confocal Microscope
- Scanning Tunneling Microscope (STM)
- Many more.....



1590



1621



1670

1609



1665

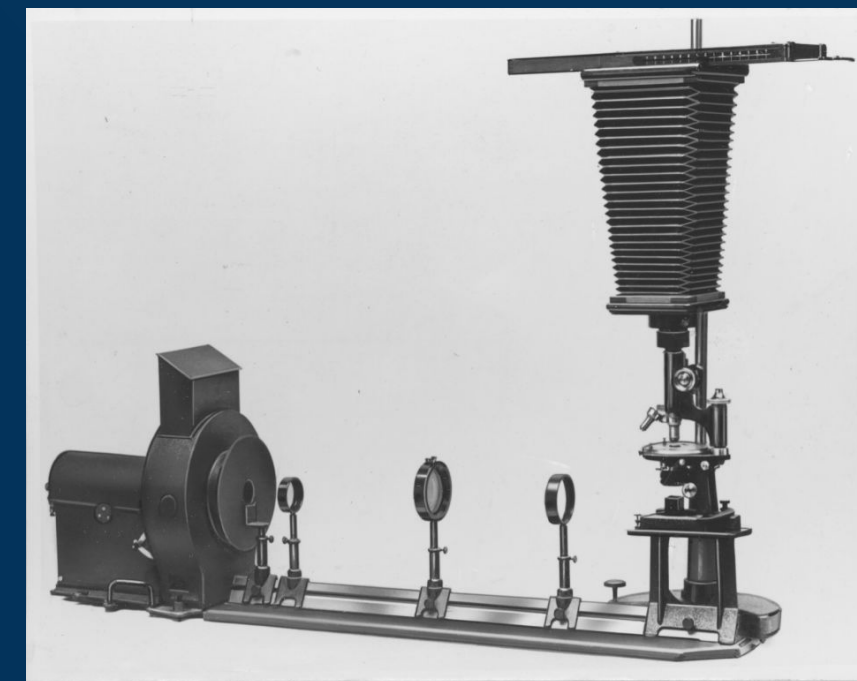




1733



1830



1893

1774



1868





1932



1937

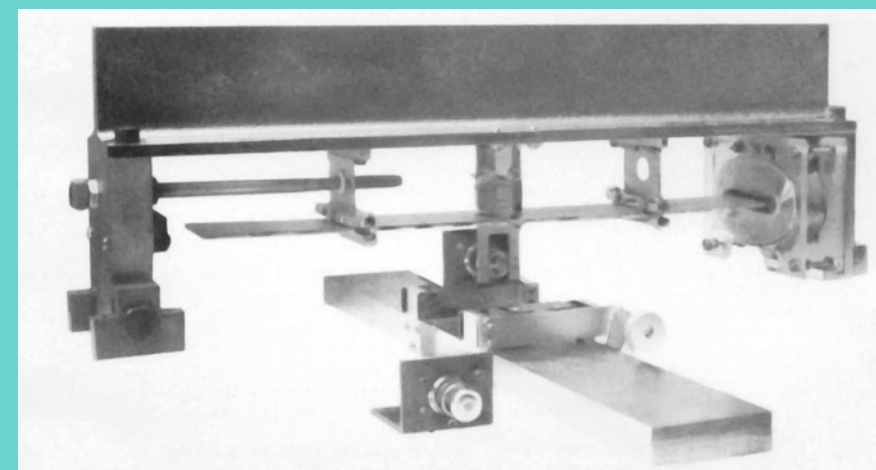


1981

1933



1957



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