Founder and entrepreneur

CARL ZEISS (1816 – 1888)

200th BIRTHDAY

Founding Fathers of the ZEISS foundation …and modern Microscopy

Otto Schott

The Glassmaker

Ernst Abbe

Mathematician & Visionary

Carl Zeiss

Founder & Entrepreneur

Agenda

1. Childhood, youth and training
2. Founding and early years of the company
3. Collaboration with Ernst Abbe
4. Founding of the *Jenaer Glaswerk*
5. Latter years and death
6. ZEISS foundation
7. International success, separation and reunion

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Childhood and youth

11 September 1816 Born in Weimar as the fifth of twelve children of Johanna Antoinette Friederike and the art wood turner Johann Gottfried August Zeiss

Weimar, 1825

Childhood and youth

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His godfather is Grand Duke Carl Friedrich (Grand Duchy of Saxony-Weimar-Eisenach) (1783 – 1853)

Attends **high school** in Weimar up to penultimate class and passes special graduation exam, 1832

Keen **interest in technology** at an early age

Weimar, 1825

Grand Duke Carl Friedrich

Training

1834 – 1838
Apprenticeship with university mechanic
Dr. Friedrich Körner (1778 – 1847) in the nearby city of Jena

From 2nd year of apprenticeship onward, parallel university studies in science and mathematics

1838 – 1845
Travel as a journeyman to southern Germany:
Stuttgart, Darmstadt (Hektor Rössler),
to Austria: Vienna (*Rollé & Schwilgué* and lectures at the *K.K Polytechnischen Institut*) **and to Berlin**

1845 – 1846
Period in Jena "to primarily **study** chemistry and advanced mathematics" and to acquire citizenship of and right of abode in Jena

Dr. Friedrich Körner

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Founding and early years of the company

17 November 1846
Opening of a workshop ("atelier for mechanics")
in the Neugasse in Jena

In early 1847
first assistant recruited

1 July 1847
Relocation to a **larger workshop**

In 1847
first simple microscope produced

Carl Zeiss, ca.1860

Founding and early years of the company

Why did Carl Zeiss focused business on microscopes?

- **Personal interest**
- **Meat inspection law in Prussia/Germany**
  By Rudolf Virchow

First microscopes were „simple microscopes“

- One lens
- Specimen stage
- Mirror for transmitted light illumination

In 1846 Carl Zeiss was competing with ~100 microscope makers only in Germany

Scientific microscopes are rare as gold dust ….mainly because of the price

Founding and early years of the company

Microscopes for fun – Not only for Science

Who sponsored microscopes in the old days?

For many years the majority of microscopes were gold plated and ivory-handled.

- **A friend of the rich and beauty**

It was mainly used for entertainment, not science

Maybe one reason why the image quality was not so good…

The family of Carl Zeiss

29 May 1849

Marries Bertha, neé Schatter, (1827 – 1850) who dies during the birth of son Roderich (23 February 1850)

17 May 1853

Marries Ottilie, neé Trinkler (1819 – 1897),
mother of son Otto (1854 – 1925)
and daughters Hedwig (1856 – 1935)
and Sidonie (1861 – 1920)

Ottilie Zeiss, ca.1880

Roderich Zeiss

Development of company until 1866

1857
Builds the first compound microscope

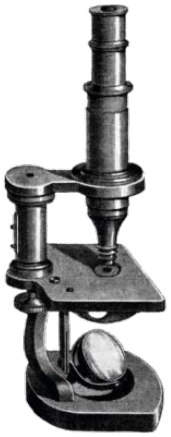
13 September 1860
Appointed as a university mechanic

23 July 1860
1st prize and gold medal at the 2nd General Thuringian Trade Exhibition

1863
Zeiss becomes court mechanic

28 May 1866
Production of the 1000th microscope

Carl Zeiss at the age of around 50

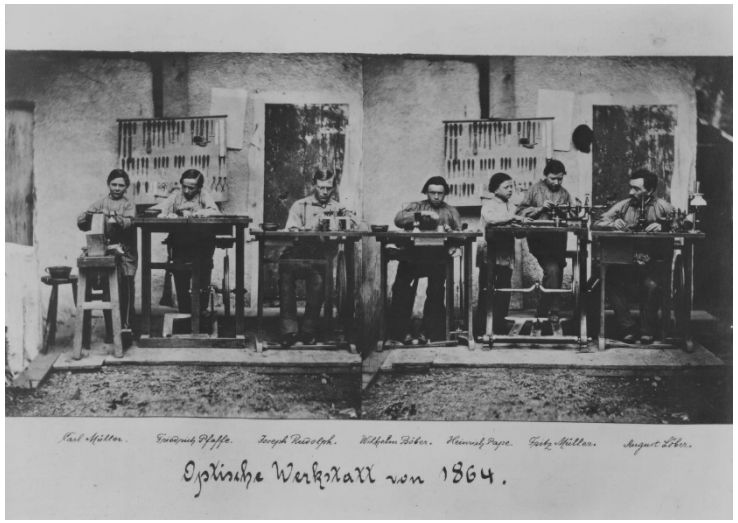


First compound microscope

Development of company until 1866

Despite of his success….

Carl Zeiss realizes that his traditional way of manufacturing microscope lens systems („Pröbeln“) is inefficient and cannot guarantee a constant optical quality of his instruments



- **Turning Point**

In 1866 Ernst Abbe joins the young company as the first and sole scientific staff member

His tasks were to increase production efficiency at high quality and to comprehend image formation of a microscope

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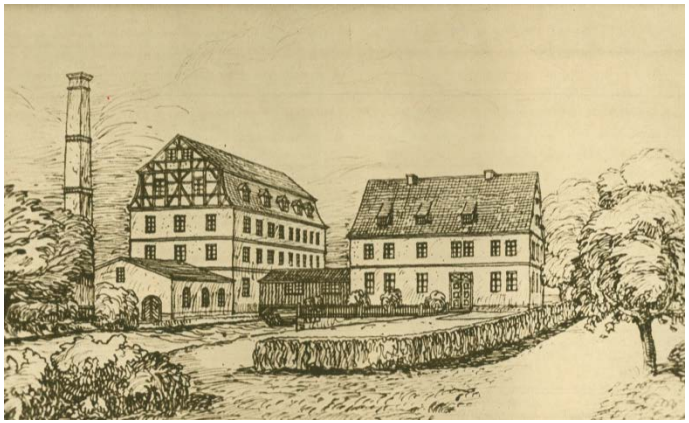
Ernst Abbe (1840 – 1905)



Born on **23 January 1840** in Eisenach
Parents: master spinner and subsequent factory foreman Georg Adam Abbe and
Elisabeth Christina, neé Barchfeld

Good student, promoted by teacher and father's supervisor

Studies in Jena and Göttingen between 1857 and 1861

- **In Jena:** lectures in mathematics, science and physics, also humanities
- **In Göttingen:** lectures about optics, meteorology and astronomy

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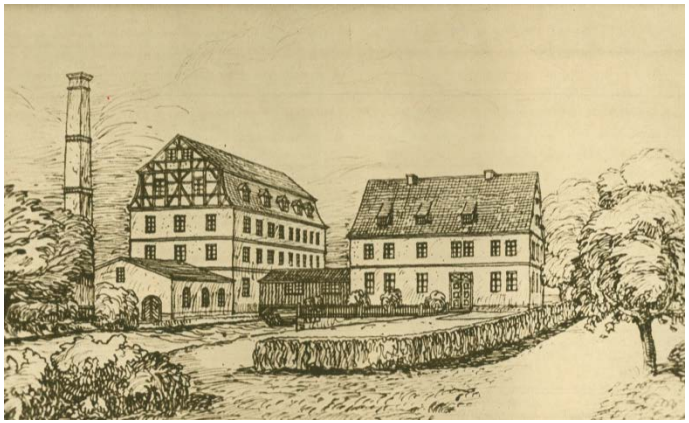

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Earns a living through scholarships, coaching and prize money in mathematics competitions

Completes **doctorate** with exceptional success on 23 March 1861 in Göttingen with a thesis on the subject "Experiential substantiation of the principle of the mechanical theory of heat"

Collaboration with Ernst Abbe

Enters into **collaboration** with Carl Zeiss in 1866:
Abbe wishes to place the development of microscope optics on a sound scientific foundation

Abbe realizes that precision can only me measured with precise measuring tools – so far almost unknown and unused in industry….

Ernst Abbe

Collaboration with Ernst Abbe

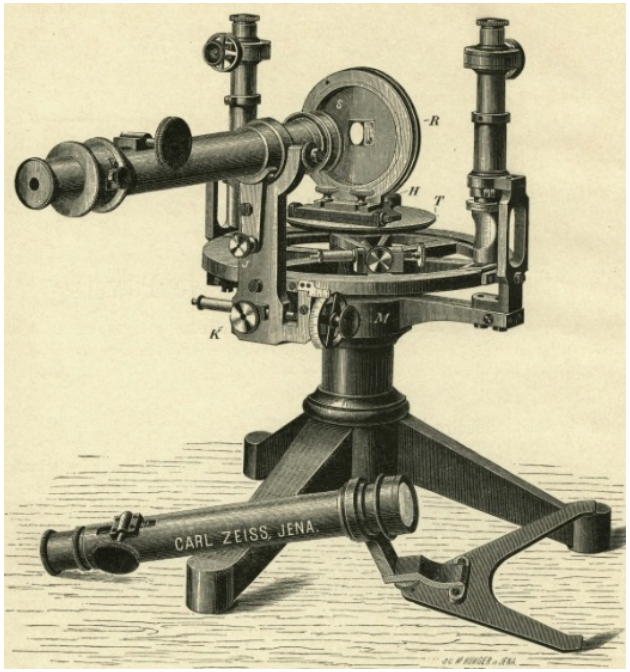
Abbe first invents instruments for measuring the focal lenght of optical systems as well as other tools for increasing production standards to an unknown level

The quality to precision making increases dramatically

Production efficiency increases strongly

The reputation of products coming from the „Optical Workshop of Carl Zeiss in Jena“ increases rapidly and exeptionally

- **First microscope „produced with science“ is released**



Collaboration with Ernst Abbe

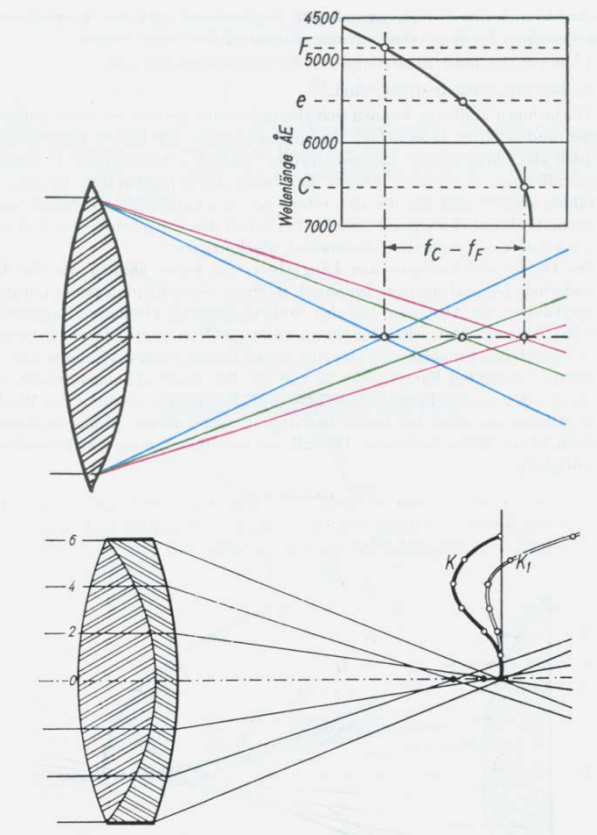
In 1870, Abbe defines the precondition of an object, lens and image plane that are necessary to produce a sharp image, also remote of the optical axis.

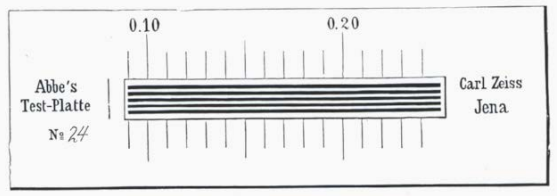
This precondition is called the “sine condition” of a lens

Abbe manages to understand image aberrations that normally decrease the microscopical image clarity

Mainly these image flaws are described as “color fringes” and “haze”

Abbe calls them **“chromatical” and “spherical” aberration**



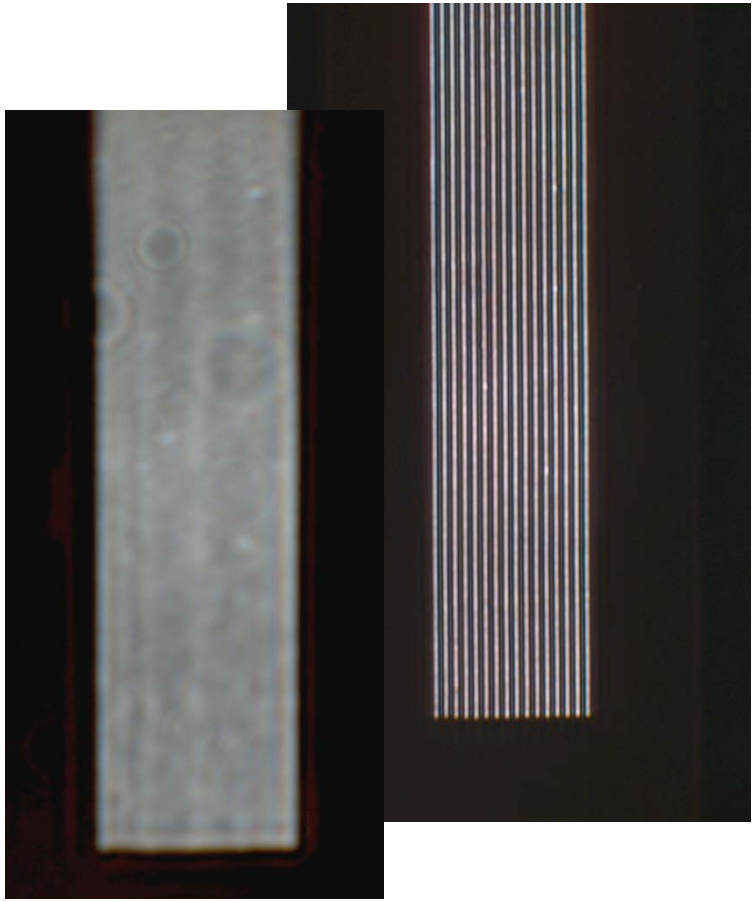


Collaboration with Ernst Abbe

Despite Abbe‘s intellectual and Zeiss‘ heavy financial efforts, the **first ever scientifically calculated objectives are a total disaster** regarding their image sharpness!

Something still not yet fully understood……

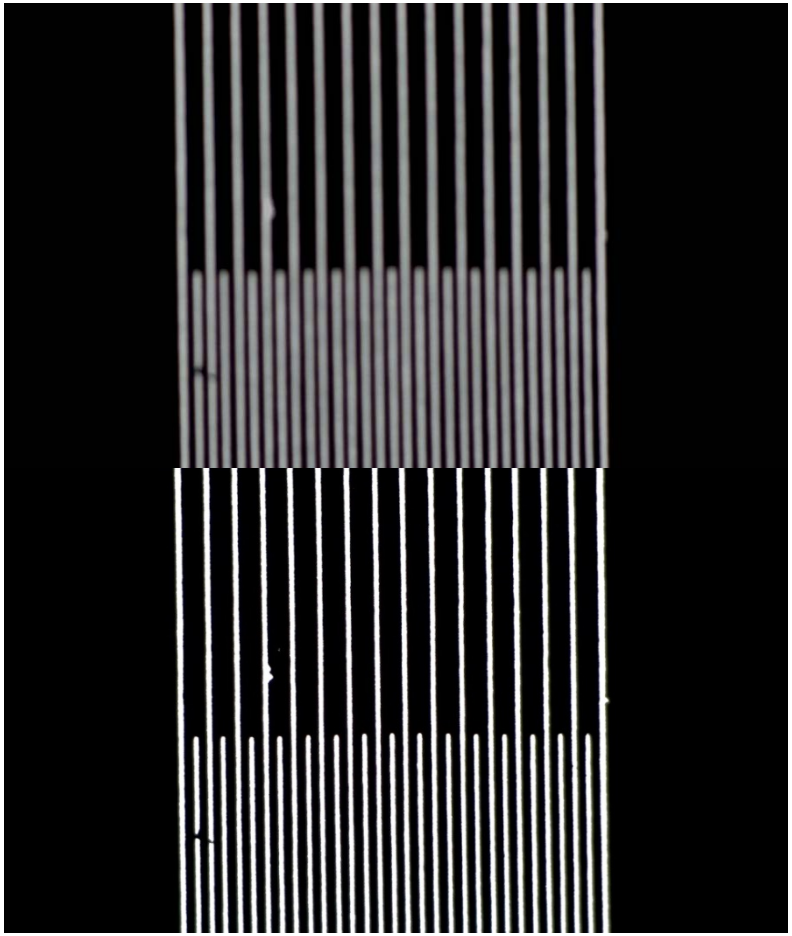
However, Carl Zeiss continues to believe in the abilities of Ernst Abbe and doesn´t stop the funds!



Collaboration with Ernst Abbe

How are images formed?

In 1872/73, Abbe suddenly realizes that the missing image sharpness is somehow related to the still unknown process of image formation of the compound light microscope and in particular inside an objective….

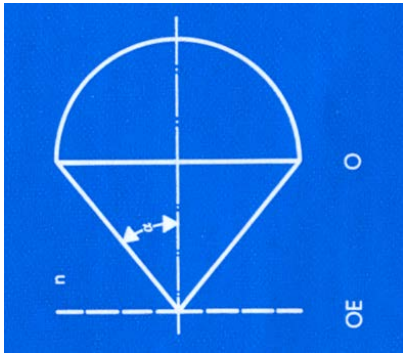


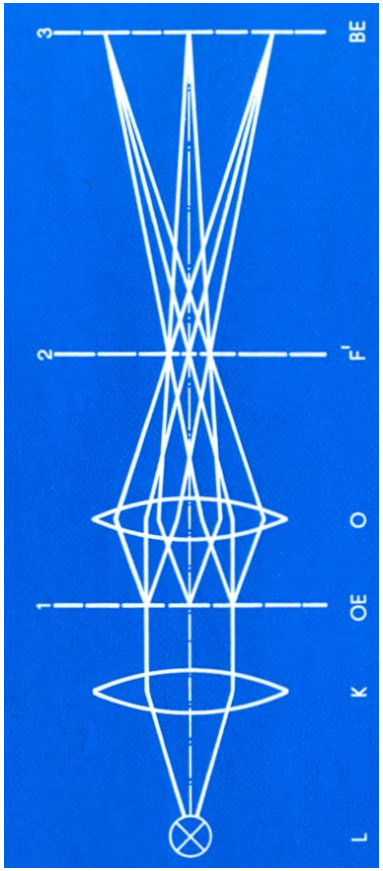
Collaboration with Ernst Abbe

How are images formed?

…
Abbe discovers that „diffracted light from a sample spans widely across into the dark space inside the objective“

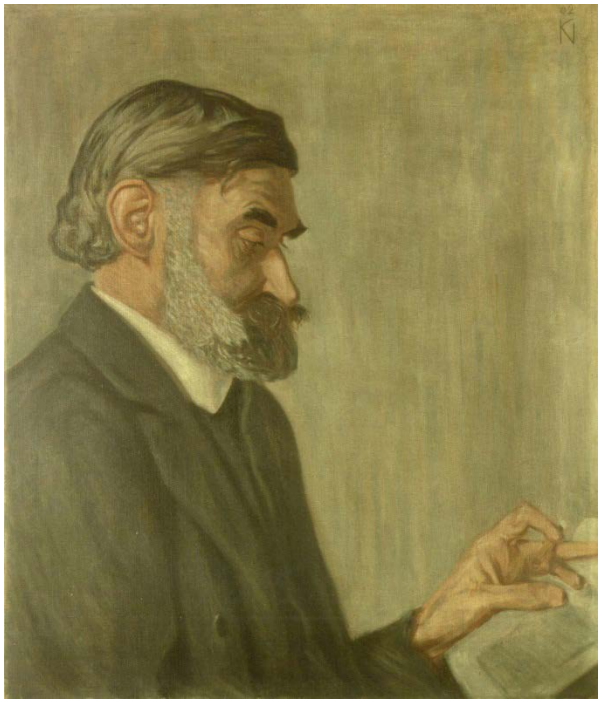
This is the moment where mankind finds the link between diffration and resolution…





Collaboration with Ernst Abbe

!
Resolution limit in a light microscope
!



Prof. Ernst Abbe

Wavelength

$$d = \frac{\lambda}{2n\sin\alpha}$$

Numerical Aperture

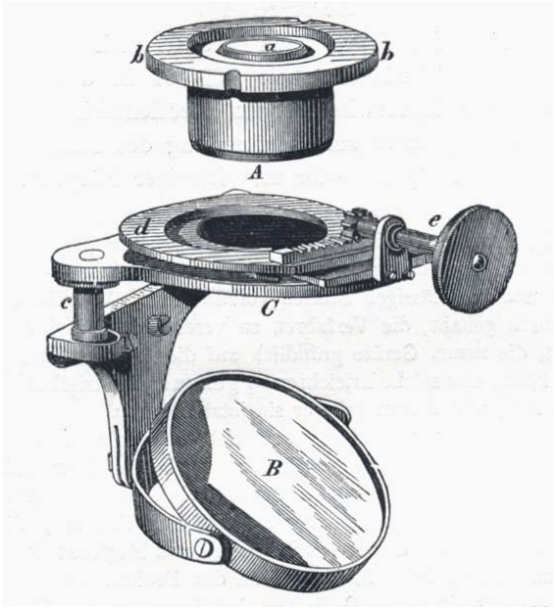
Collaboration with Ernst Abbe

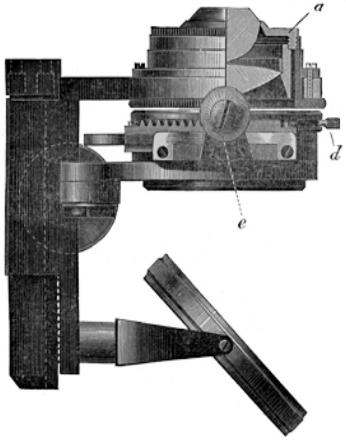
First focussable illuminator (1869/72)

From 1869 to 1872, Ernst Abbe works on a new focussable illuminator (condensor)

In a classical light microscope, the illumination is (almost) everything

Better illumination for the scientists is honoured with better detail visibility





Collaboration with Ernst Abbe

1870 – 1896 Also professor of physics at the University of Jena. He and his students lay the foundation for modern precision mechanics and optics

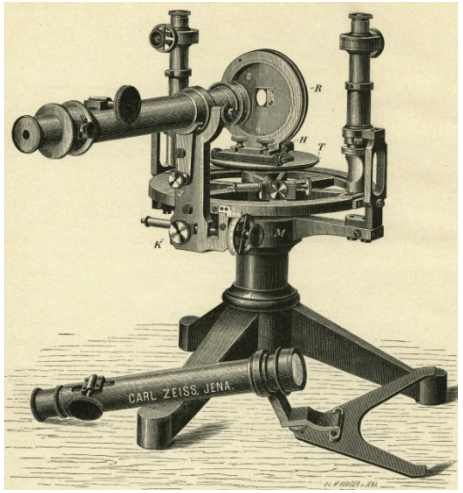
In 1876 Carl Zeiss acknowledges Abbe's contributions and **Abbe becomes a partner in the company Carl Zeiss**

In the late 1870's Zeiss and Abbe started a quest to obtain better glass material to further improve the optical quality of their instruments

- **Turning Point**

A collaboration with a young glass maker and chemist, Otto Schott starts

Ernst Abbe



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Otto Schott (1851 – 1935)

Son of glass manufacturer Simon Schott (1809 – 1874) and his wife Karoline (1811 – 1899), daughter of a master glazier

Studies in **chemistry,** mineralogy and physics in Aachen, Würzburg and Leipzig and doctorate in Jena in 1875: "Contributions to the theory and practice of glass fabrication"

Works in different chemical companies in Germany and **Spain**; study trips to **England**, **Scotland** and **France**

From 1879, conducts **research into various chemical substances** during melting, glass formation and crystallization

Otto Schott, 1890

Founding of the glassworks

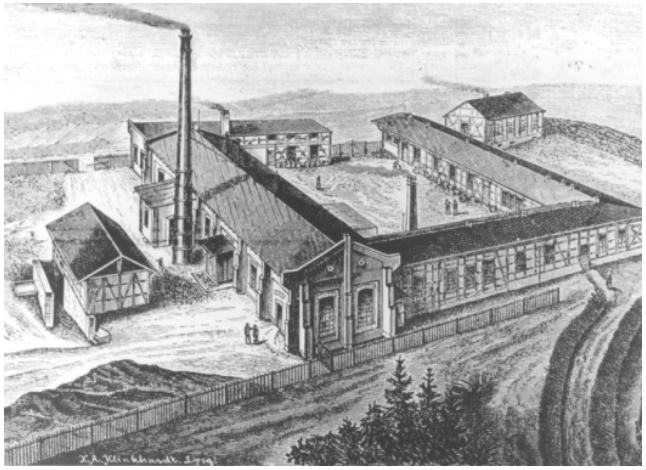
In May 1879 Otto Schott sends a specimen of lithium glass to **Ernst Abbe;** beginning of scientific **correspondence**

Relocation to **Jena** in 1882

1 January 1884 **Founding of the *Glastechnisches Laboratorium* (glass laboratory)**, later to become *Jenaer Glaswerks Schott & Gen.* (today SCHOTT AG) by Otto Schott, Ernst Abbe, Carl Zeiss and Roderich Zeiss

Development of new types of optical glass and laying of scientific foundations for special-purpose glass

1887 – 1893 Invention of chemically and thermally resistant **borosilicate glass**

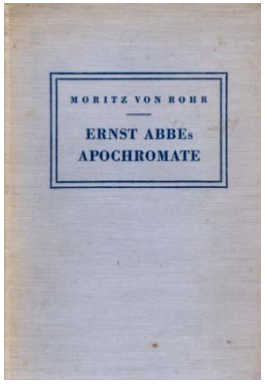


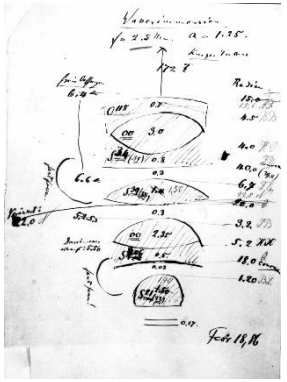
Jenaer Glaswerk, 1884

Founding of the glassworks

1886
With the new glasses, Ernst Abbe was able to reliably produce the first objectives worldwide that were visibly totally free from traces of color fringes

Since then, these objectives are called
APOCHROMAT objectives





Founding of the glassworks

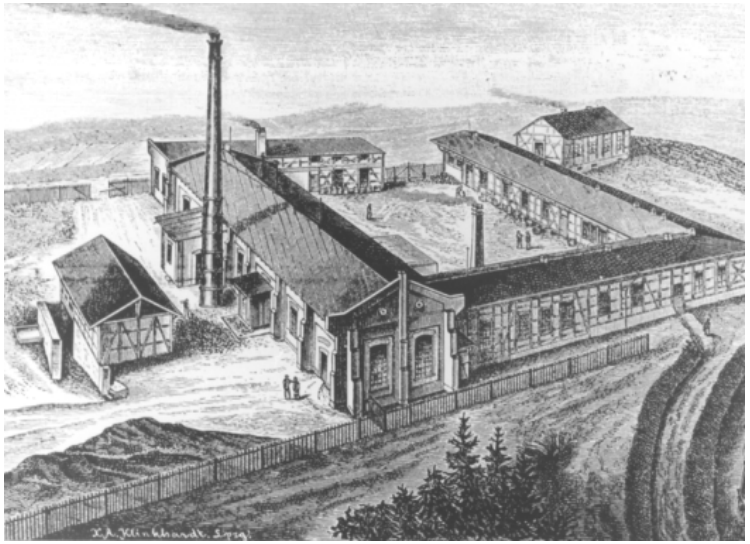
Zeiss, Abbe and Schott

Not only glass for better microscopes

Better glass for astronomic and photographic instruments, planetarium

Better glass for other industries

SCHOTT quickly became a brand for high quality glass



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Latter years and death

December 1885

Carl Zeiss suffers a minor stroke

24 September 1886

Production of the 10,000th microscope

3 December 1888

Carl Zeiss dies in Jena

Employees in 1888

Grave of Carl and Ottilie Zeiss

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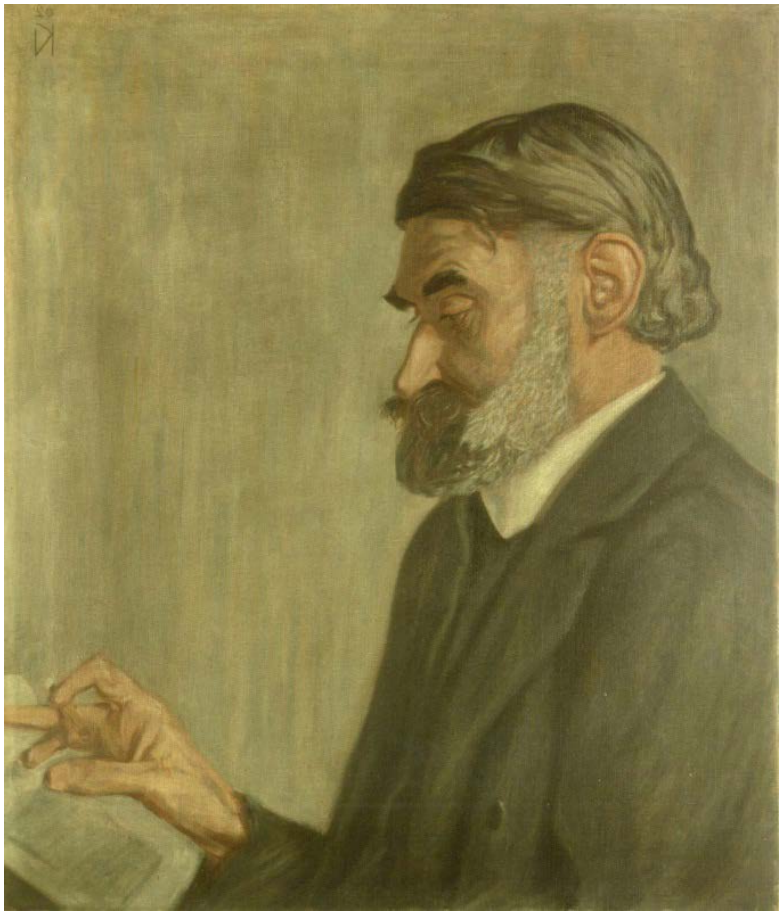
ZEISS foundation

After the death of Carl Zeiss, Abbe bought the remaining shares of the company and became the sole owner of the company CARL ZEISS

He wants to keep the company alive for many years to come

Abbe fears that his successors, too much capitalistic thinking or political influence might negativly effect the survival of his company and harm the company‘s achievements….



ZEISS foundation

Zeiss and Abbe were very proud of the company‘s…

Technical achievements

Brand reputation

Social achievements

1875	Company health insurance
1886	Support fund for Jena University
1888	Company pension system

Ernst Abbe

Carl Zeiss

ZEISS foundation

19 May 1889

Ernst Abbe founds the foundation, honorably calling it Carl Zeiss foundation, and donates his company CARL ZEISS to the foundation

Carl Zeiss foundation

CARL ZEISS

Last page of the foundation certificate

ZEISS foundation

Further social achievements

1889 Profit share for employees, University of Jena and the city of Jena

1891 9h working day

1892 Unlimited, fixed salary working contracts and paid overtime

1893 Saving accounts for employees

1896 Indemnity, paid holidays, labor union, residential building cooperative, political independent library

1900 8h working day

1903 Awards for ideas for improvements

Ernst Abbe

Carl Zeiss

ZEISS foundation

14 January 1905

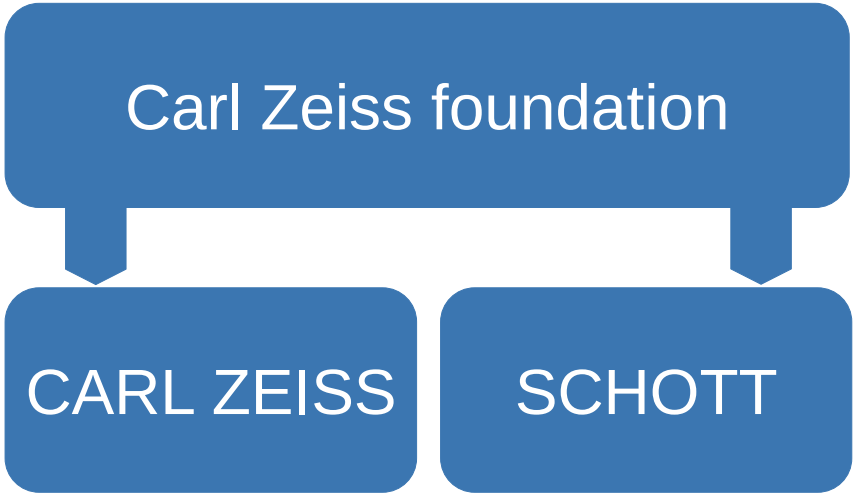
Ernst Abbe dies in Jena

1919

Otto Schott donates his company SCHOTT to the foundation

- 2 main business groups

Last page of the foundation certificate



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International success, separation and reunion

By the end of the 19th century, **ZEISS instruments** were highly coveted by scientists and industry – and they were already exported to many countries

The company set up its own office in London in 1894

Branches soon followed in:

- Vienna (1902)
- St. Petersburg (1903)
- Paris, Milan and Tokyo (1911)
- Buenos Aires (1914)

London


Vienna


St. Petersburg


Paris


Milan


Tokyo


Buenos Aires

International success, separation and reunion

After World War II

February	1945	Jalta conference, allies plan the occupation zones in Germany Thuringia falls to the soviet zone
April	1945	US troops occupy Jena, Thuringia
May	1945	The German Empire declares its defeat
June	1945	US troops leave Jena and take 77 executives and scientists with them to South-West Germany
October	1946	New company (Opton precision engineering factory) was founded in West Germany
October	1946	Order to dismantel the Jena factory and deport about 245 employees with the obligation to set up optical industry in the Soviet Union
June	1948	VEB Carl Zeiss Jena, a state-owned enterprise in the field of scientific instrument, is founded in Jena
Until	1953	Collaboration between the East and West companies
November	1989	Berlin Wall fell
Until	1990	Two ZEISS companies coexisted

International success, separation and reunion

29 May 1990

Declaration from both companies to reunite
‚Biebelried declaration‘

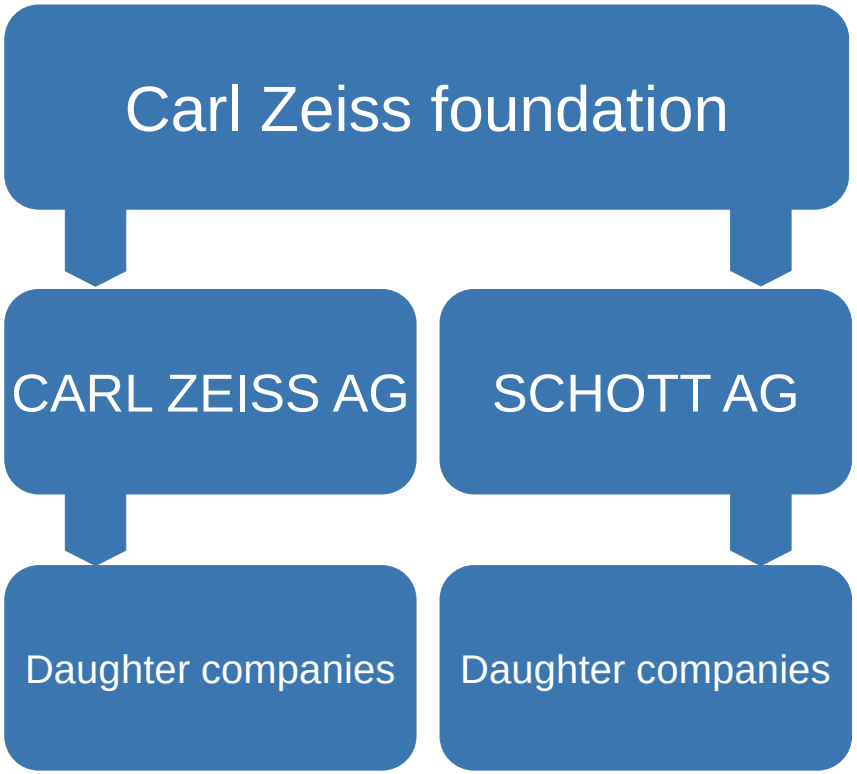
International success, separation and reunion

Nowadays…

ZEISS at a Glance

Industry:	Optics and optoelectronic company
Revenue:	~4.5 billion € (2014/15)
Employees:	25.000 in more than 40 countries

International success, separation and reunion



International success, separation and reunion

International success, separation and reunion

Business Unit ‚Microscopy‘

Headquarter:	Jena, Germany	
Renevue:	728 million € (2014/15)	
Employees:	3000 worldwide	
Local hubs:	Göttingen	Germany
	Munich	Germany
	Oberkochen	Germany
	Cambridge	UK
	Peabody	USA
	Pleasanton	USA

International success, separation and reunion

Economic success – How profitable is Carl Zeiss Microscopy?

- **Can you print money with microscopes?**

YES!

- **High-quality products and unique history by ZEISS**

…appreciated and Made in Germany


ZEISS