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

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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
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
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

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

From 2\textsuperscript{nd} 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
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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
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, néé Schatter, (1827 – 1850) who dies during the birth of son Roderich (23 February 1850)

17 May 1853

Marries Ottilie, néé 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
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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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 be 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 length 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 exceptionally.

- First microscope „produced with science“ is released.
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!
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 diffraction and resolution…
Collaboration with Ernst Abbe

Resolution limit in a light microscope

Prof. Ernst Abbe
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.
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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
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
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.
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
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After the death of Carl Zeiss, Abbe bought the remaining shares of the company and became the sole owner of the company.

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 negatively affect the survival of his company and harm the company's achievements....
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
19 May 1889

Ernst Abbe founds the foundation, honorably calling it Carl Zeiss foundation, and donates his company CARL ZEISS to the 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
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)
## International success, separation and reunion

### After World War II

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

Carl Zeiss foundation

CARL ZEISS AG

Daughter companies

SCHOTT AG

Daughter companies
International success, separation and reunion
International success, separation and reunion

Business Unit 'Microscopy'

Headquarter: Jena, Germany

Revenue: 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?

- High-quality products and unique history by ZEISS

...appreciated and Made in Germany