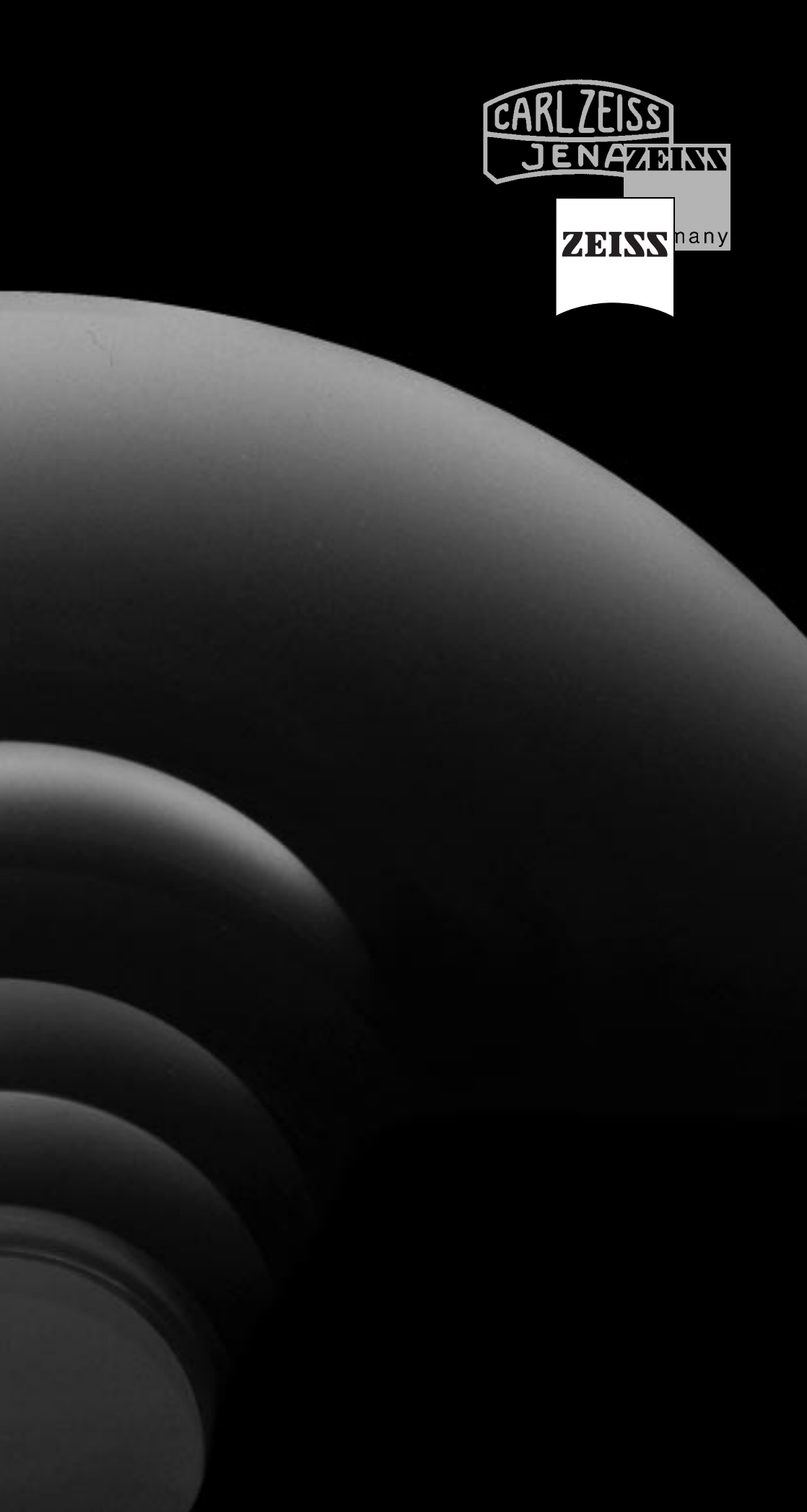
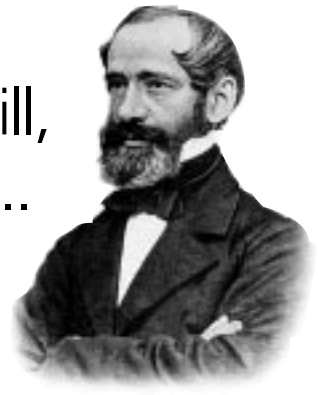

CARL ZEISS
JENA
ZEISS
ZEISS
many

Anticipating the Future

"Anticipating the Future"
is the title of this portrait, which covers,
in words and pictures,
the 150 years' history of Zeiss microscopes.

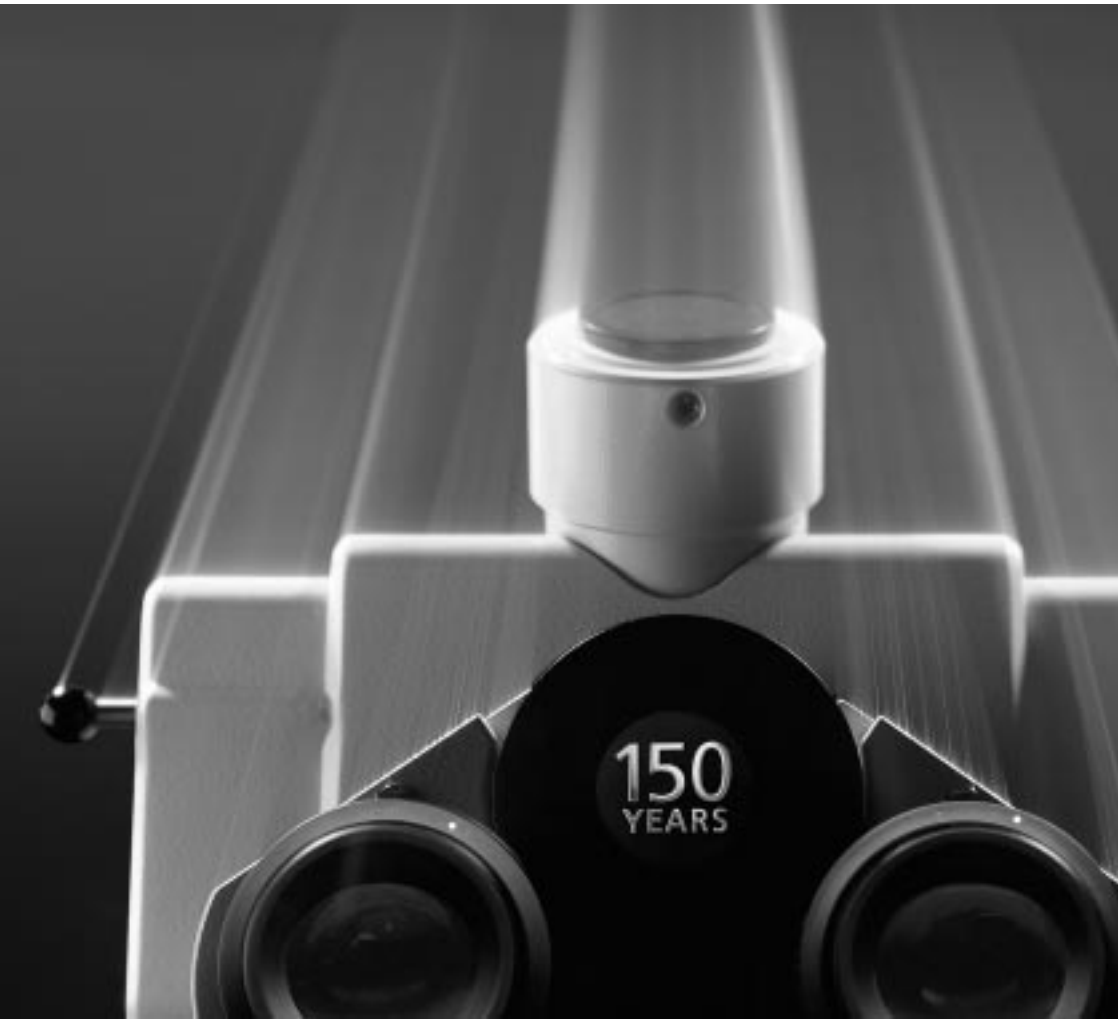
"Anticipating the Future"
might also be the motto of the worldwide
community of Carl Zeiss microscope users,
whose demands for quality have given birth
and constant stimulus to progress
in microscope design.

A man of skill,
experience ...



... and foresight

150 years, and the legend keeps growing



Questions like these may be pointless, but they are nevertheless intriguing: Is a glass of champagne (to suit the occasion), with half of its contents sipped, half empty or half full? And does a 150th anniversary make its subject 150 years old or 150 years young?

Well, it is all a matter of how you look at it. To be sure, with all the tradition, handed-down values and sound standards of quality involved, the 150-year-old cannot be denied a distinct maturity. On the other hand, there is an undiminished, youthful vitality and an inexhaustible urge for permanent innovation and improvement.

Surprising? Not quite. After all, the innovative power, the future-anticipating spirit of progress are part of the tradition. They have been there from the very onset.

Whether considered old or young, Carl Zeiss is a legend. But a legend that is very much alive. No matter in which part of the world: wherever someone mentions Carl Zeiss, the name invokes microscopes. And, reportedly, it has caused the normally matter-of-fact face of many a scientist to mirror enthusiasm.

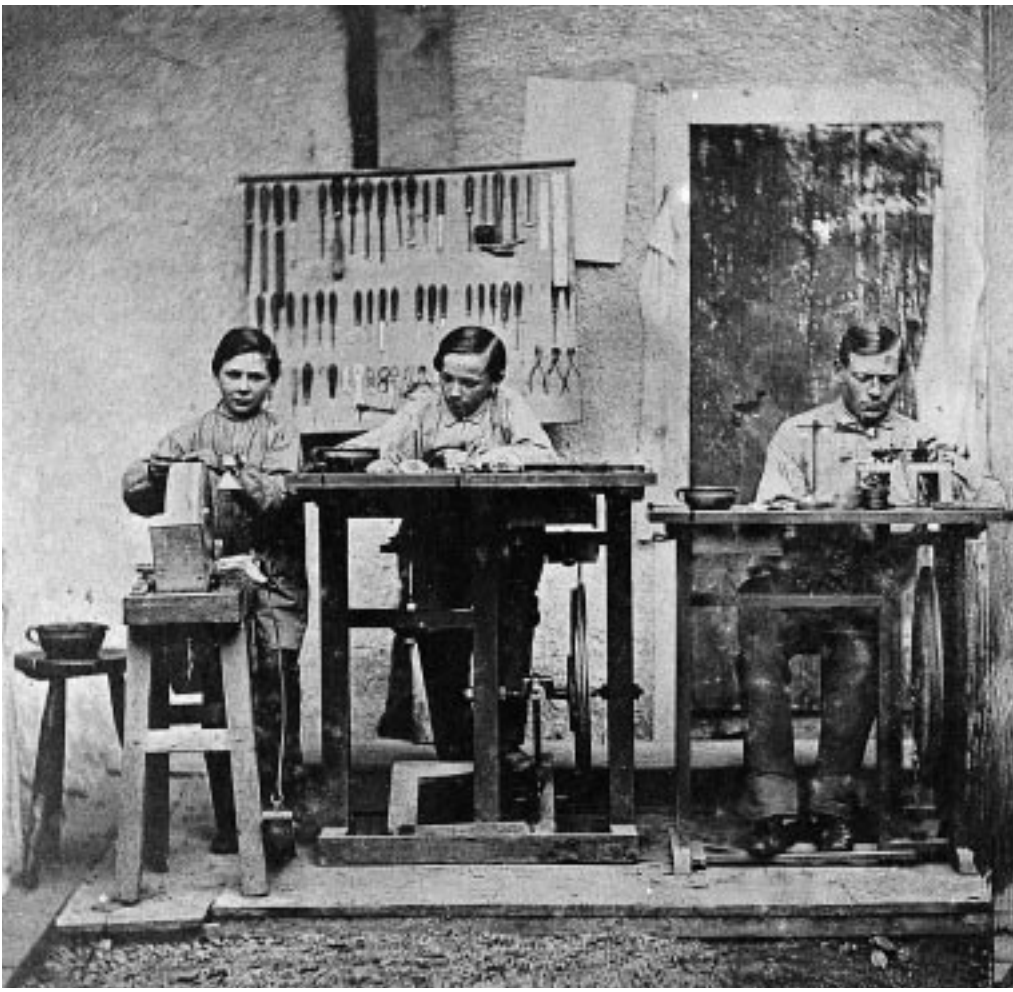
Like Rome, a reputation like that was not built in a day. To trace it back to its roots, there is hardly a fitter occasion than this 150th anniversary. Well then, let's stroll back into the history of Carl Zeiss, to find out

how everything started.

Microscopes from Zeiss

May 10, 1846. A certain Carl Zeiss submits an application to the state authorities in Weimar, asking for permission to establish a mechanic's workshop. To the Grand-Ducal government this is a matter for run-of-the-mill bureaucracy and not to be handled with undue speed (there has not been much change since, it seems). Anyhow, a deed is issued on November 19, permitting the applicant to set up a workshop in Jena and to make and sell mechanical and optical instruments.

Carl Zeiss does not dither about. The fact that the workshop has actually been opened two days earlier, on the 17th, speaks of the young mechanic's ambition. Some people say he started with a borrowed sum of 100 thalers. First address: Jena, Neugasse 7. Carl Zeiss? Who's that? Your particulars, please, Sir! Zeiss, Carl Friedrich, born in Weimar in 1816, grammar school, apprenticeship with Dr. Friedrich Körner, mechanic and supplier to the court (who has been

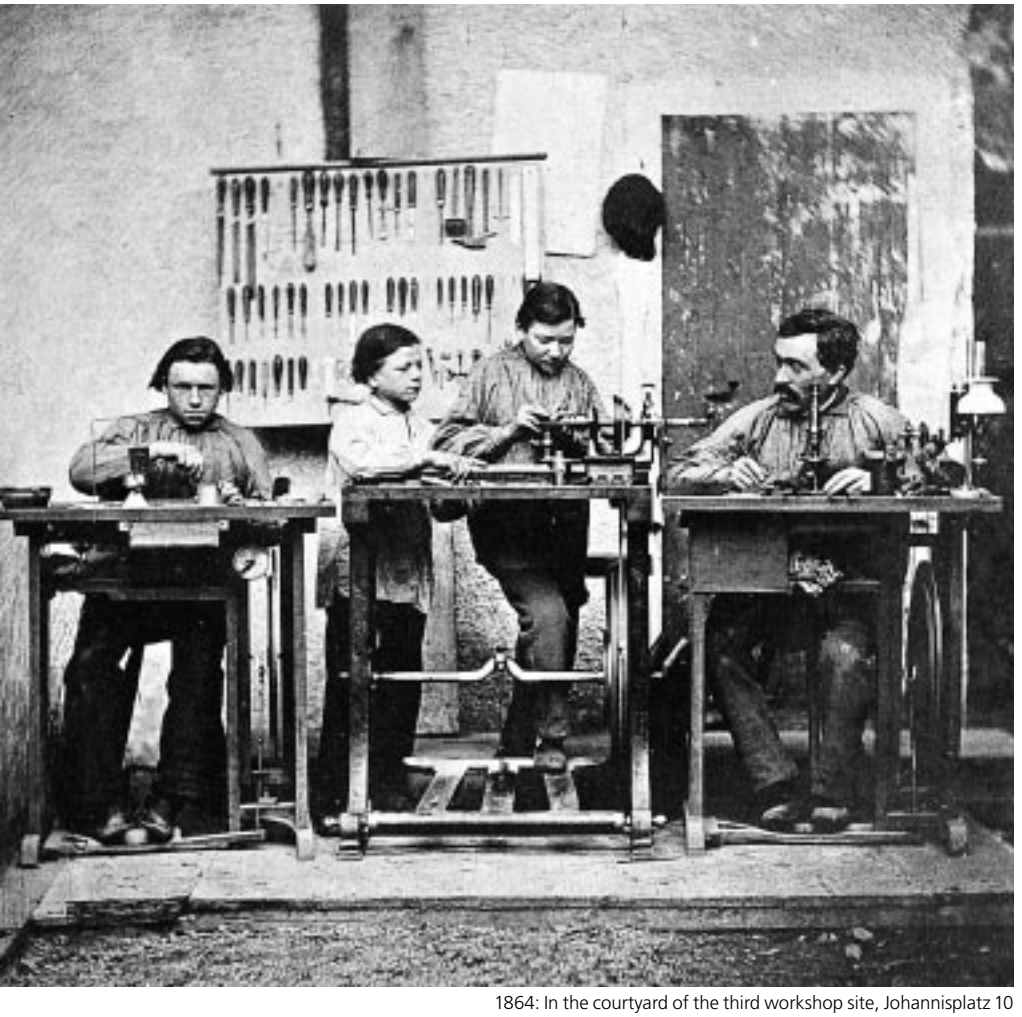


1846: First workshop
Neugasse 7

1847: New premises
Wagnergasse 32

making simple microscopes since the early forties); attendance of lectures at the Jena University (mathematics, experimental physics, anthropology, mineralogy, optics); journeyman's travels for several years; practicals at Professor Schleiden's physiological institute in Jena.

And now: new-made owner of a one-man business. With little money, just the most essential tools, working all on his own in the dim light of an oil-lamp, but, what is more important, full of ideas, energy and determination. He sells eyeglasses, magnifiers and balances, builds and repairs physical and chemical apparatus for the university. The business gets going. In 1847 Zeiss moves his workshop to a bigger site and employs his first apprentice. The same year sees the death of his former master, Dr. Körner, and Zeiss now turns to the subject that has fascinated him ever since his own apprentice years: the making of microscopes.

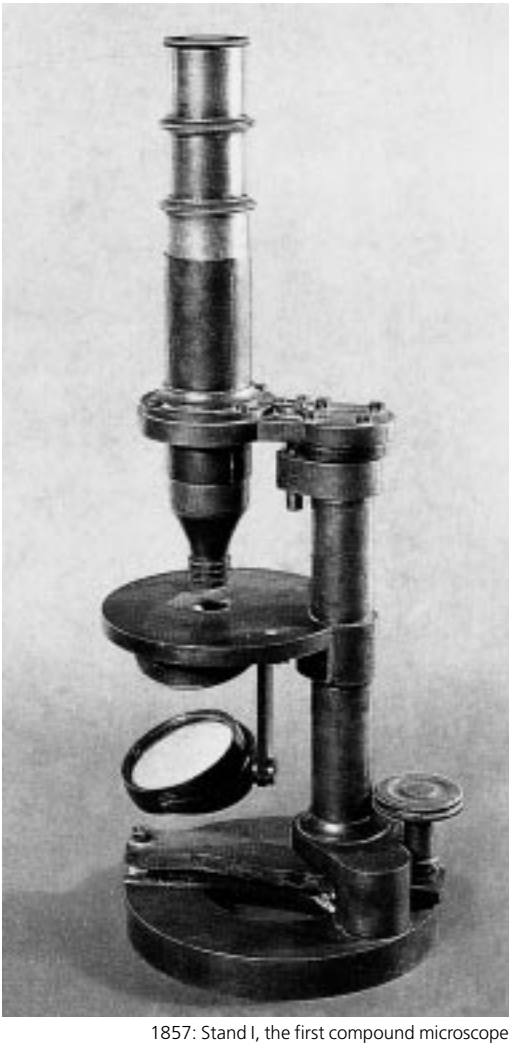


1864: In the courtyard of the third workshop site, Johannisplatz 10

Simple ...

1847: Das erste Mikroskop

compound ...



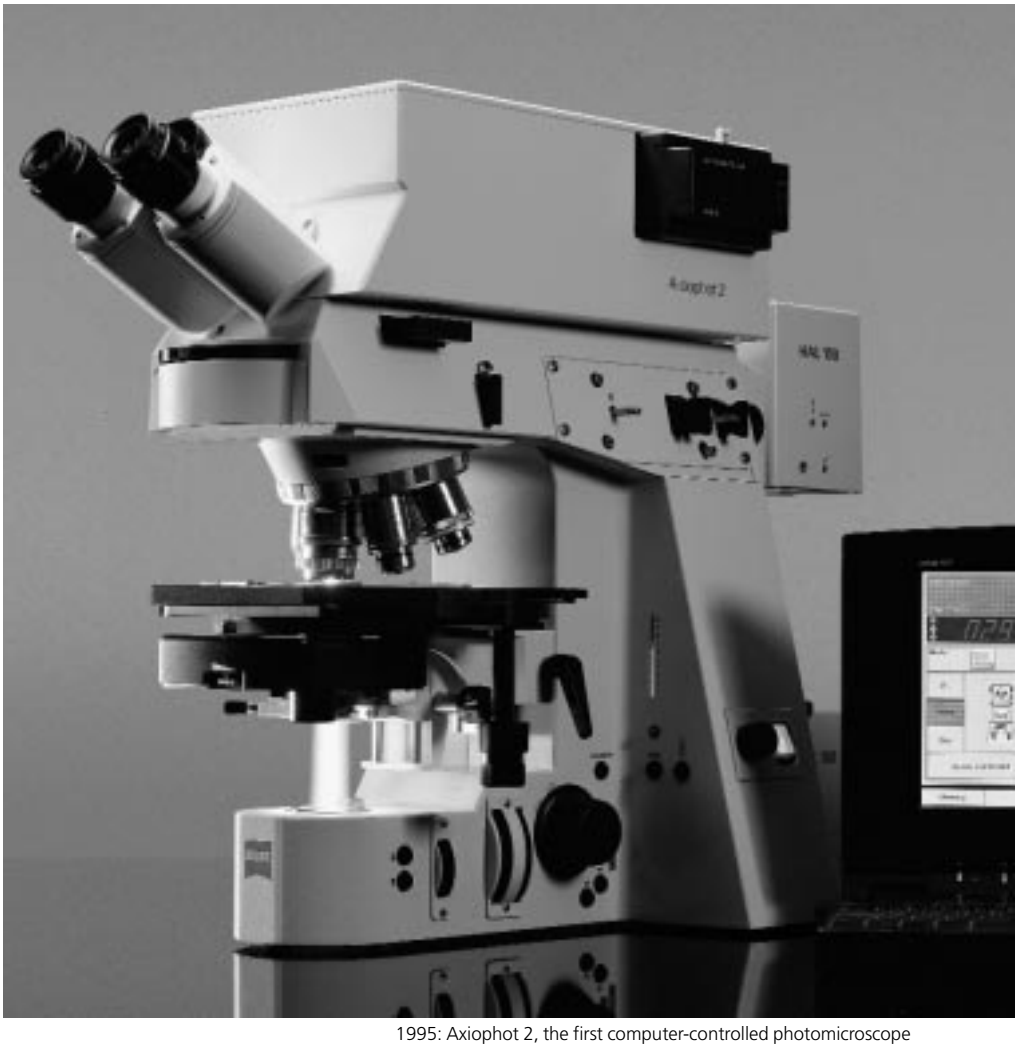
1857: Stand I, the first compound microscope

Microscopes: A Long Story of Success

September 1847: With skill, experience, vigor, and ideas of his own, Carl Zeiss starts making microscopes on his new premises at Wagnergasse 32. These are simple microscopes, consisting of one lens only and intended mainly for dissecting work. During the first year, Zeiss sells as many as 23 of them, an indication that they do well in comparison with other makes. Nevertheless, they undergo many improvements during the following years.

Encouraged by this early success, Carl Zeiss soon sets about a more demanding task – the production of compound microscopes. These consist of two optical elements: an objective and an eyepiece. The first unit of the "Stand I" model goes on sale in 1857.

... excellence from the start



1995: Axiophot 2, the first computer-controlled photomicroscope

Modifications of this, as well as new designs follow. In 1861 Carl Zeiss is awarded a gold medal at the Thuringian Industrial Exhibition, because his compound microscopes are ranked *"among the most excellent instruments made in Germany".* In 1863 Carl Zeiss is appointed supplier to the Grand-Ducal court. Now, after not quite two decades, the flourishing business employs about 20 people.

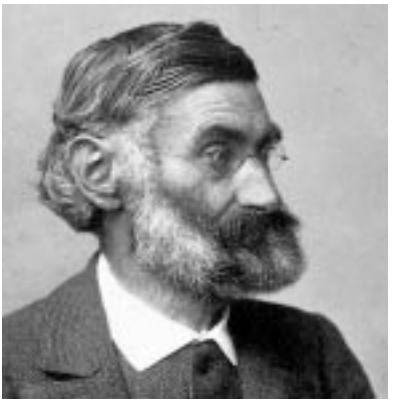
The success of those years is all the more worthy of note as it has been achieved merely by skill and experience, applied to a trial-and-error method of manufacturing instruments whose designs lack a theoretical foundation.

As a man of foresight, Zeiss is well aware of this lack. And he finds something ought to be done about it.

No More Trial and Error

1866: The 1000th microscope leaves the Zeiss workshop. Despite all due pride, the principal is preoccupied, has been so for quite some time. He has realized, as nobody before him, that trial and error is insufficient in microscope making. He is convinced that even the most skilled craftsmanship reaches its limits where the perfect form of an optical system has to be found by experimentation rather than by computation. In Zeiss' own words: *"The only remaining function of the working hand should be that of precisely implementing the forms and dimensions of all construction elements as determined by the design computation."*

Optics of calculable, predetermined performance: a demanding task. For some time, Zeiss tries to tackle it himself, in vain. But he does not give up. Then he meets Dr. Ernst Abbe, a physicist and mathematician, 26 years of age, lecturer at Jena's university. Carl Zeiss engages him as a free-lance research worker. Two matching minds join to make possible what nobody has thought of before.



Ernst Abbe

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

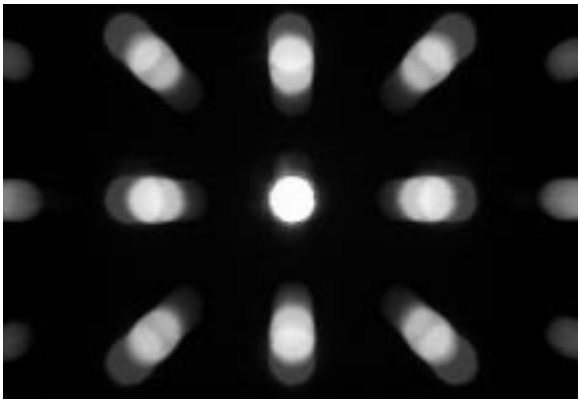
The Formula One of Microscopy

During the ensuing six years, Zeiss and Abbe work intensively to lay the scientific foundations for the design and fabrication of optical systems. The path is arduous, and not without setbacks. A vast scope of theoretical studies and experiments have to be made, testing methods and equipment to be devised. In 1869, a new "illumination apparatus" is designed for use in the studies *("with all parts assembled according to purely theoretical considerations"),* which soon comes into widespread use.

And finally, the breakthrough. In 1872, Ernst Abbe formulates his wave theory of microscopic imaging, and defines what becomes known as the Abbe sine condition. A great year in the history of Zeiss, and in the history of the microscope. Now, for the first time, Zeiss offers a range of 17 microscope objectives (three of them being of the immersion type) designed on the basis of optical research and mathematical operations. In Abbe's words, *"Based on a precise study of the materials used, the designs concerned are specified by computation to the last detail – every curvature, every thickness, every aperture of a lens – so that any groping around"* (Abbe might also have said, any trial and error approach) *"is excluded."*

Abbe's discoveries mark a revolution in microscope design. The new microscopes built in Jena gain the name of Zeiss a worldwide reputation for quality and innovation.

By the way, as far as quality is concerned, Carl Zeiss is a man of principle: With a hammer in his own hands, he smashes many a microscope made in his workshop that fails to satisfy his critical inspection – rather a striking method of quality assurance.



Diffraction experiment

Visible Quality Based on Science

1994: Water-immersion C-apochromat 40x/1.2 with correction collar, mainly for confocal imaging

Abbe's findings are nothing less than the theoretical principles on which microscope objectives can be designed to predetermined performance specifications. They are nothing more either. In many respects, the theory does not materialize – due to lack of proper materials. As demands of microscope users on image quality increase, further progress is impeded because the glass available for lens making just does not have the desired dispersion properties to match improved lens designs. So Zeiss and Abbe, now business partners, face another challenge: the development of new kinds of optical glass satisfying Abbe's specifications. Another challenge, another trailblazing success.

Ingenious Theory, Visionary Practice

Otto Schott
(about 1890)

The Glass

January 4th, 1881: Ernst Abbe meets Otto Schott, a glass chemist aged under 30, who gained a doctorate in Jena in 1875. Abbe urges Schott to collaborate in the development of optical glasses with special properties. A few months later, in his native town of Witten, Schott makes the first melting experiments. In the following year he moves to Jena to work in a glass-making laboratory specially set up for him (the nucleus of what later is to become the Jena glassworks of Schott & Genossen).

The series of experiments consumes lots of effort, time and money. The success more than justifies every bit of it. A vision becomes true when Zeiss, in 1886, markets the first lot of an entirely new type of microscope objectives: apochromates. Made in different varieties as dry, water immersion and homogeneous immersion objectives, and used together with so-called compensating eyepieces, they provide images free from color distortions throughout the image field, *"without their design having to be more intricate".* This even applies to apochromates of relatively high aperture.

Together with Abbe's wave theory and sine condition, the new glass types provide the basis for practically any modern high-performance optics.

A note on the enterprise in between: In 1886, the year of the glass breakthrough, Zeiss employs 250 workmen and turns out the 10,000th microscope.

During this period of breakthrough and upswing, the founder and prime mover of the enterprise leaves his comrades-in-arms: Carl Zeiss dies on December 3, 1888.

The Light

August Köhler

The scientific theory is there, and so are proper glasses. But there is yet another factor to be mastered before best results can be achieved in microscopy: Illumination.

Enter Professor August Köhler. In 1893, at the age of 27, he reports on an illumination method he has devised for photomicrography. Known as Köhler illumination, this elaborate method makes it possible for microscopists to use the full resolving power of Abbe's objectives.

It cannot be a mere coincidence: Köhler joins Zeiss, contributes his illumination system, and later is put in charge of microscope development.

To this very day, no other illumination method beats Köhler for optimum results in microscopy.

The Goal

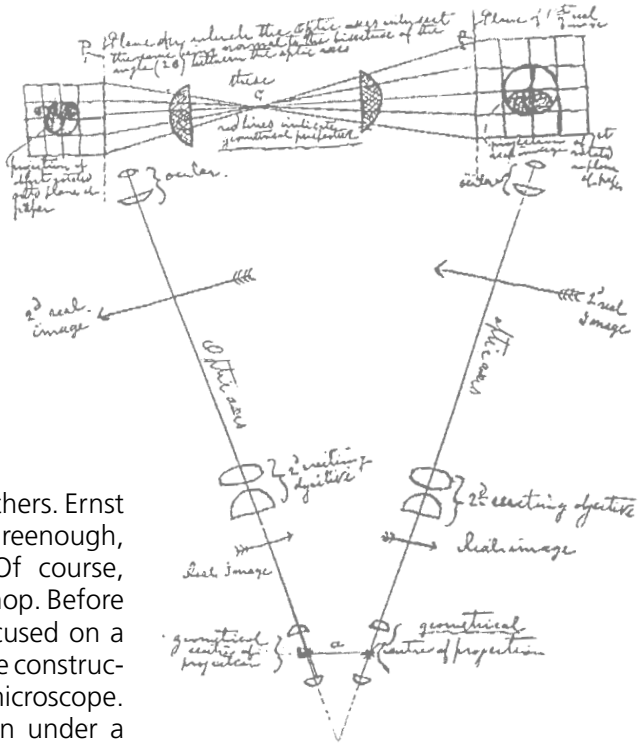
1996: Metaphase chromosomes, double fluorescence, laser scan microscope LSM 410 invert

Maja Günthert, ETH Zürich

The death of Carl Zeiss is a grievous loss. In honor of the name of his friend and partner, Ernst Abbe in 1889 establishes the Carl Zeiss Foundation, and in 1891 transfers to it his shares in the Optical Workshop and the Schott Glassworks, together with those of Roderich, son of Carl Zeiss, and co-partner since 1881.

Onwards Forever

As much as they miss Carl Zeiss, both as an initiator and a friend, his collaborators carry on the business in his spirit. The last decade of the 19th century is paved with milestones – inventions and design innovations that already look forward past the turn of the century: Metallographic microscopes, anastigmatic photolenses, binocular microscopes with image-reversing prisms, to name but a few. And then a push forward that is out of the ordinary, even for an enterprise as extraordinary as Zeiss.



The Third Dimension

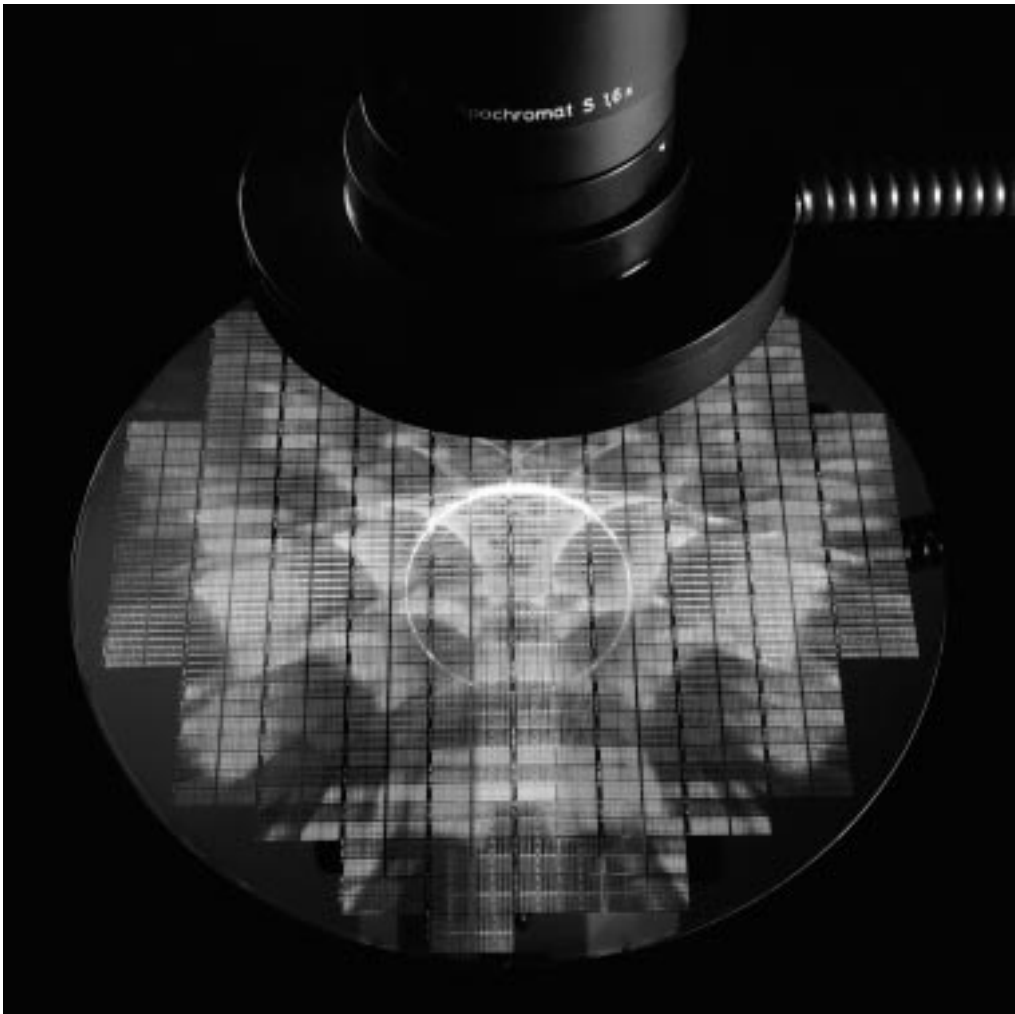
1896 is not a year as others. Ernst Abbe meets Horatio S. Greenough, an American biologist. Of course, they cannot help talking shop. Before long, the discussion is focused on a seemingly utopian idea: the construction of a stereoscopic microscope. Utopian? The idea is born under a lucky star. The American visitor draws a promising sketch on a sheet of paper. That's it. Around the turn of the year, Greenough's invention has taken shape as a Zeiss product: the first stereomicroscope ever.

1897: Greenough stereomicroscope

Success in 3D

1993: Stemi 2000

And More To Come ...



1995: Stemi SV 11 Apo