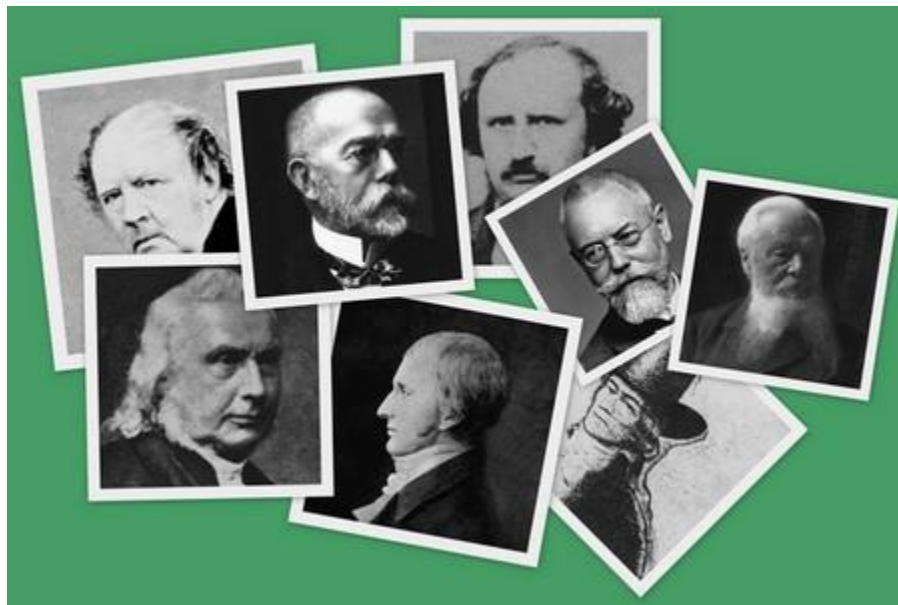


The History of Photomicrography

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The following paper is to some extent a “Leitz-centric” overview of the history of photomicrography.

According to various historical documents, we deduce that **Thomas Wedgwood (1771 – 1805)** is the first who proposed the possibility of photomicrography. In his famous paper “*An Account of a method of copying Paintings upon Glass, and of making Profiles, by the agency of Light upon Nitrate of Silver*” of presumably 1802, published in the Journals of the Royal Institution [1], it states

“In following these processes, I have found that the image of small objects, produced by means of the solar microscope, may be copied without difficulty on prepared paper. This will probably be a useful application of the method; that it may be employed successfully, however, it is necessary that the paper be placed at but a small distance from the lens.”

There is no indication that Wedgwood had ever succeeded in capturing an image through a microscope. In several publications it has been suggested that Wedgwood and **Sir Humphry Davy (1778 – 1829)** attempted such experiments (see [2]). - In its simplest form, photomicrography with a *solar microscope* works as follows: The image of an object that has been illuminated by sunlight and observed through the objective lens of a microscope is projected onto a white screen (e.g. a wall). This projected image is then recorded by a photographic device.

It is said that **William Henry Fox Talbot (1800 – 1877)** created the first photomicrographs using a solar microscope. Since 1834, Talbot used small cameras to record images on paper. All his photomicrographs were at magnifications below 20x. His 1839 image of a transverse section of a stem clearly shows the low magnification he was working with (image available on the Internet). - Worth mentioning is the work by **Rev. Joseph Bancroft Reade (1801 – 1870)** who, according to **William Henry Walmsley (1830 – 1905)**, produced a series of satisfactory photomicrographs in 1837 (see [3]). It is possible that Reade was one of the first persons to successfully record a “fixed” photomicrograph using a solar microscope. However, according to [4], it remains questionable that he had already accomplished this important task before 1839.

Moving forward in time, we want to mention the work by **Alfred François Donné (1801 – 1878)** [5, 6] and **John Benjamin Dancer (1812 – 1887)** [6]. Donné, a French physician, discovered *Trichomonas vaginalis*, a flagellated protozoon, and leukaemia, a cancer of the blood or bone marrow. Donné’s work in photomicrography started around 1840. Using the daguerreotype method (the first publicly announced photographic process), Donné showed his photomicrographs in 1840 to the Academy of Sciences (Paris). Already in 1844, he published the very first atlas of microscopic anatomy. – J. B. Dancer is the inventor of microphotographs, which he sold in form of commercially produced microscope slides. In 1840, he showed for the first time a photomicrograph of a flea at a meeting in Liverpool.

Our next stop is the work of pharmacist **F. Meyer** (or F. Mayer) of Frankfurt (Germany) and the work of **Joseph von Gerlach (1820 – 1896)** [6]. Around 1852, Meyer developed a very fine apparatus for photomicrography (see Fig. 1). This vertical setup is truly a remarkable achievement. It offers the stability necessary to produce photomicrographs and can be considered the first incarnation of a professional setup. - Gerlach is often considered to be one of the first physicians to use photomicrography for medical research although his work is preceded by the research of Donné. In 1863, Gerlach published a book entitled “Die Photographie als Hilfsmittel mikroskopischer Forschung” (Verlag von Wilhelm Engelmann, Leipzig). This publication is the first textbook on

photomicrography in Germany. In his book, Gerlach mentions **Christian Joseph Berres (1796 – 1844)**, a professor in Anatomy (Vienna), who created photomicrographs with a solar microscope already in 1839. According to Gerlach, Berres fixed his photomicrographs using the daguerreotype method. - Gerlach's vertical photomicroscope was rather modest and certainly not suitable for high magnification work (see **Fig. 1**). According to page 344 of [6], he soon switched to a stand similar to the one developed by Meyer.

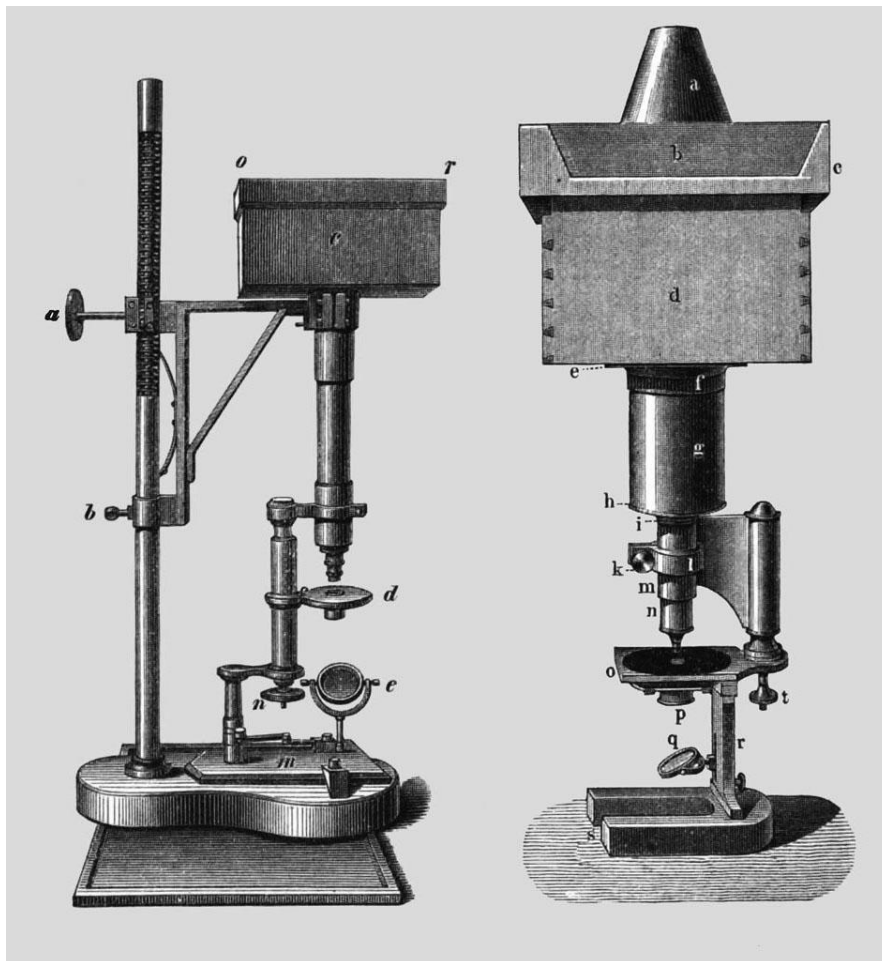


Fig. 1: Photomicroscope by Meyer ~1852 (left) and photomicroscope by Gerlach 1863 (right). While the implementation by Meyer is a good setup for photomicrography (see page 343 and 344 of [6]), the apparatus by Gerlach is very simple and does not provide enough stability for vibration-free work at higher magnification.

Several years later, in 1868, **Berthold Adolf Benecke (1843 – 1886)** published a more advanced book on this topic under exactly the same title as Gerlach's work (Friedrich Vieweg & Sohn, Braunschweig). Benecke's book is essentially a translation of the work by **Albert Moitessier (1833 – 1889)** (*La photographie appliquée aux recherches micrographiques*, Paris, 1866) with additional comments. Also in 1868, **Oscar Reichardt** and **Carl Stürenberg** published their book "*Lehrbuch der Mikroskopischen Photographie*" (Verlag von Quandt & Händel, Leipzig), which describes methods of illumination that do not require direct sunlight. Benecke's work and the book by Reichardt and Stürenberg are considered the first truly useful introductions into photomicrography, while the latter one was the more practical introduction for scientists working in this field.

An excellent improvement of an apparatus for photomicrography was made by **Gustav Theodor Fritsch (1838 – 1927)** ([7] and [8]). One of his main contributions was to separate the various parts such as camera, microscope stand and illumination device (see **Fig. 2**). **Robert Koch (1843 – 1910)**, who contacted Fritsch in 1876, used the

horizontal apparatus by Fritsch for creating his very successful photomicrographs of bacteria [9]. Around 1880, Fritsch made some important improvements to his setup, which he henceforth called photomicrographic universal apparatus (mikrophotographischer Universalapparat). The company Seibert and Kraft in Wetzlar sold this newly improved photomicroscope, which could be used in horizontal and vertical position. Several years later, Zeiss further improved Fritsch's setup and, besides other improvements, added a vibration-free connection between camera and microscope through an upper and lower light excluding collar. This new connector was soon adopted by Leitz for their photomicroscopes.

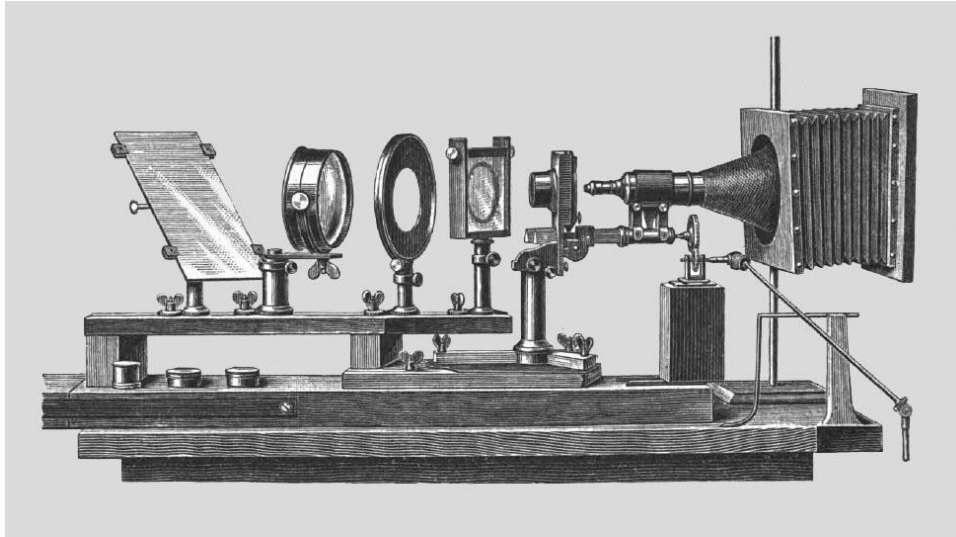


Fig. 2: Photomicrographic horizontal camera by Gustav T. Fritsch. Robert Koch used such a setup for his work in bacteriology.

While Robert Koch's first photomicrographs of bacteria were done with a vertical setup, Koch soon realized that a horizontal arrangement offered much greater stability at very high magnifications. It is therefore not difficult to understand why most microscope makers at the turn of the 20th century offered horizontal photomicrography systems (see **Fig. 3**). At the same time, Zeiss and Leitz worked on improving the stability of their vertical incarnations. Eventually, the vertical design was commonly accepted as the most practical photomicrography setup.

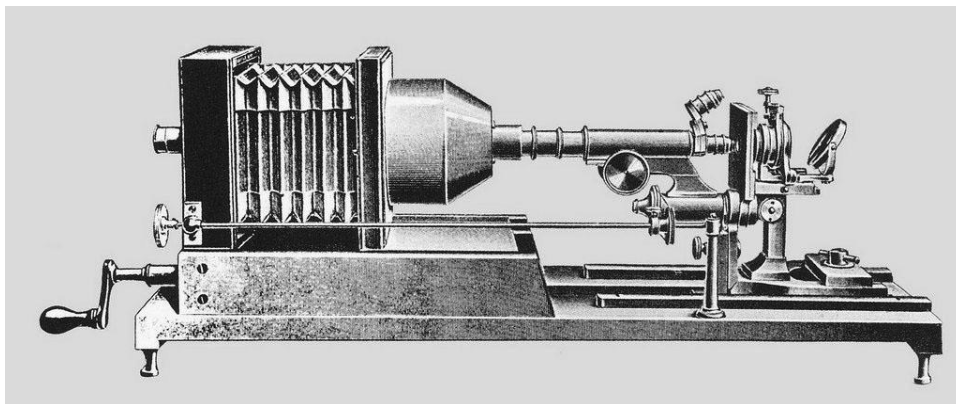


Fig. 3: Large photomicrographic horizontal camera by Leitz (1883). This type of horizontal arrangement was preferred for high magnification work until the late 1920s.

In 1893, **August Köhler (1866 – 1948)** published an important article about an improved illumination technique for photomicrography [10]. Today, we refer to this type of illumination as "Köhler Illumination". - Already in 1904, Köhler observed fluorescence using short wavelengths. This work led four years later to the introduction of

the first fluorescence microscope and opened new possibilities for creating photomicrographs of fluorescent signals. Before the invention of the fluorescence microscope, ultraviolet radiation was used to increase the resolution but not to intentionally excite fluorophores. - The first photomicrographs with long-wavelength radiation appear to have been made by Köhler around 1912-13 [11]. He used the Wratten Process Panchromatic Plates, which were limited to about 710nm (deep red). Soon after Köhler's discovery, photomicrography was used to explore signals in the Infrared (IR) spectrum.

It is interesting to look at the development of various photomicroscopes made by Leitz. Already in 1886, Leitz built its first vertical photomicrography setup according to suggestions by **Ludwig Leitz (1867 - 1898)** (see **Fig. 4**). This important development eventually culminated around 1933 in the introduction of the famous Leitz Panphot microscope. The Panphot is an excellent universal stand for photomicrography. This vertical, optical bench is equipped with a powerful illumination system and some of the finest mechanical controls. The version from the 1930s was very similar to the one shown in **Fig. 5** except for the viewing body. The first Panphot microscopes sold with an inclined monocular tube instead of the trinocular tube.

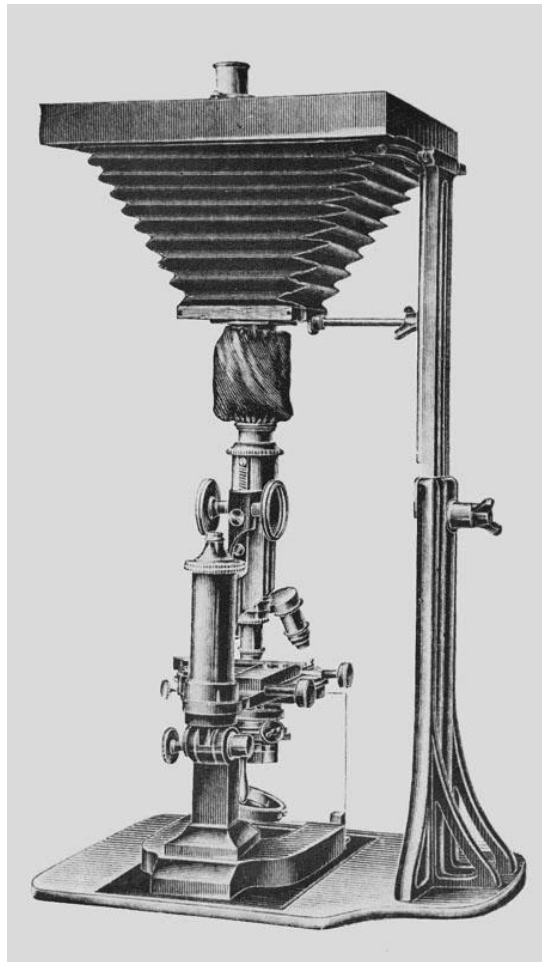


Fig. 4: Vertical photomicrography setup by Leitz (1886) using a rigid stand to support the camera. This stand can be used with most microscopes.

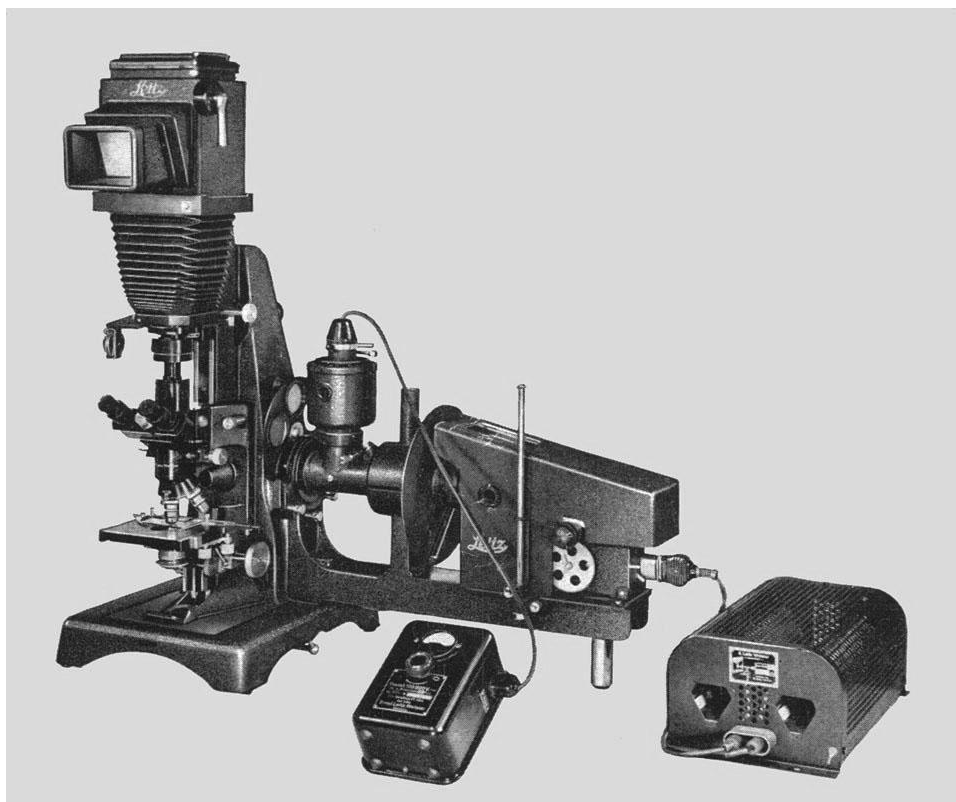


Fig. 5: Leitz Panphot from 1953. The Panphot was the first truly universal stand for photomicrography.

In 1937, Leitz introduced its flagship microscope system, the Leitz Ortholux. Around the same time, Leitz offered a straight photographic tube (O) and a combination vertical photographic and inclined monocular tube (FP) for the Ortholux. With these viewing heads and the introduction of the Leitz Aristophot stand (1941), the Ortholux established itself quickly as an excellent choice for photomicrography. About 1953, the Leitz trinocular tube (FS) was introduced, which became the de facto standard for most microscopists interested in photomicrography (see **Fig. 6**). Of course, other microscope makers (such as Zeiss) went through a similar development.

Over the following decades, photomicrography quickly reached a very sophisticated level as film emulsions, illumination techniques, light detectors, and the correction of image flatness improved. The Leitz Orthoplan (shown on the right in **Fig. 6**) is an excellent example of having accomplished all necessary requirements for the highest quality work in photomicrography.

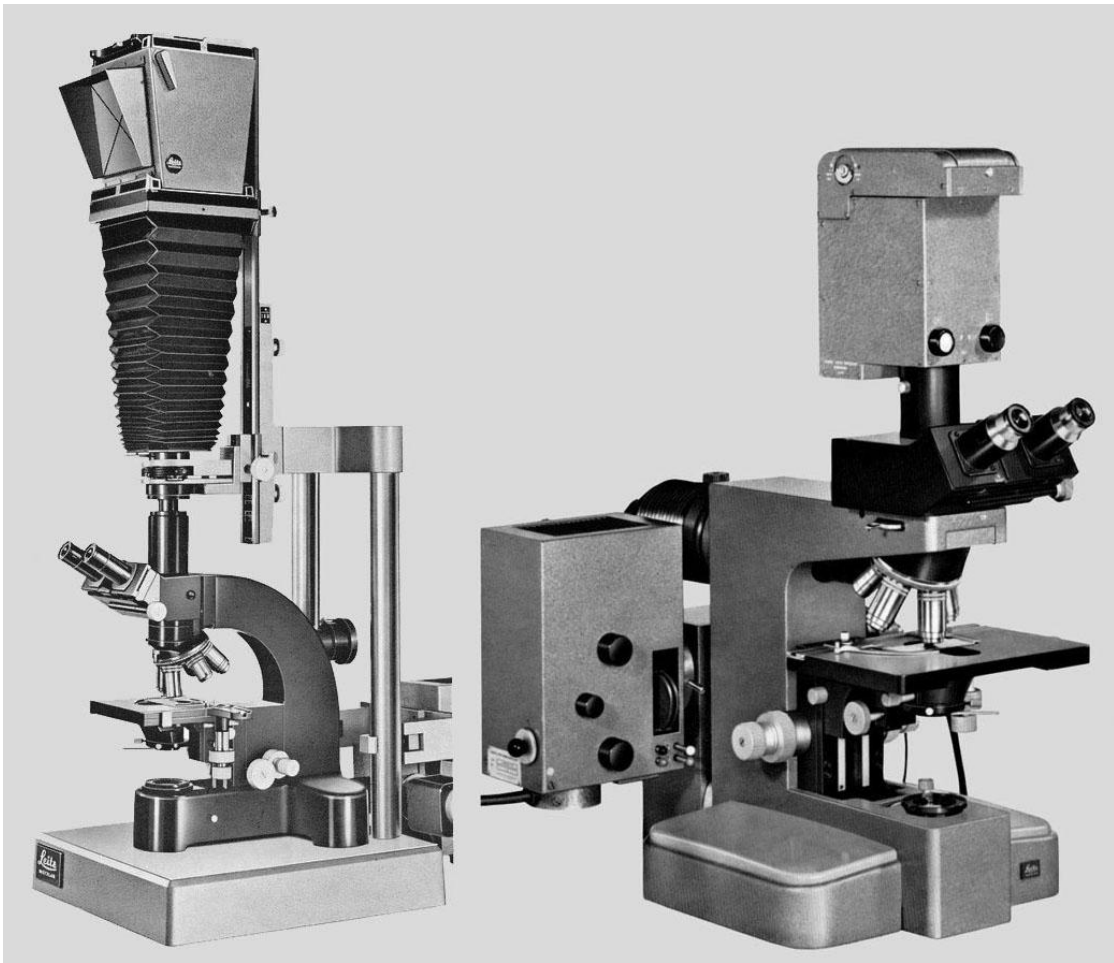


Fig. 6: On left: Leitz Ortholux with Leitz Aristophot stand (~1964). The Aristophot was one of the most successful stands for photomicrography. The Leitz Aristophot stand was first introduced in 1941. – On right: Leitz Orthoplan with Leitz Orthomat camera (~1965). In the 1960s, the Orthomat was one of the best fully automatic microscope cameras for 35mm photomicrography.

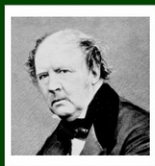
The older publications about photomicrography, such as Walmsley [3], Neuhauss [7], Hind [12], Sternberg [13], and Shillaber [14], are freely available in electronic form [15]. In this historical context, we also want to mention the books by Loveland [16] and Lawson [17].

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Tom Wedgwood
(1771-1805)



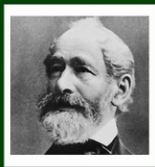
William Henry Fox
Talbot (1800-1877)



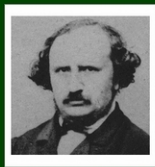
Joseph Bancroft
Reade (1801-1870)



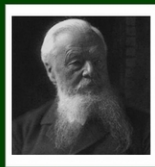
Alfred Donné
(1801-1878)



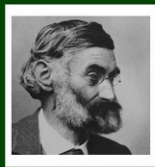
Carl Zeiss
(1816-1888)



Josef von Gerlach
(1820-1896)



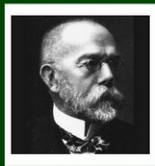
Gustav Theodor
Fritsch (1838-1927)



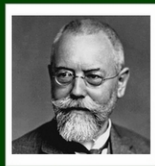
Ernst Abbe
(1840-1905)



Ernst Leitz I
(1843-1920)



Robert Koch
(1843-1910)



August Köhler
(1866-1948)



Ludwig Leitz
(1867-1898)