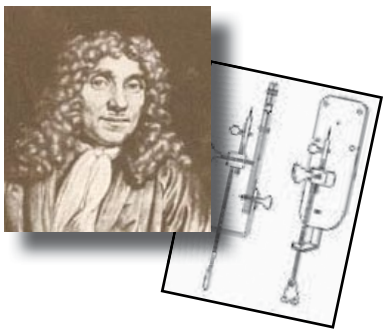
Pioneers in Optics: Zacharias Janssen and Johannes Kepler



Michael W. Davidson
National High Magnetic Field Laboratory, Florida State University, Tallahassee, FL 32306
davidson@magnet.fsu.edu

Zacharias Janssen
(1580-1638)

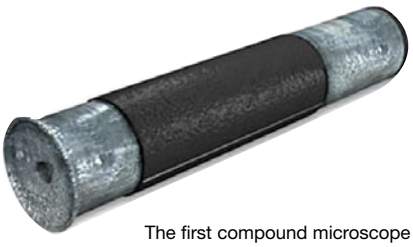
Zacharias Janssen is generally believed to be the inventor the compound microscope. However, because the accomplishment is generally agreed among historians to be dated in the 1590s, most scholars believe that his father, Hans, must have played an important role in the creation of the instrument. The pair worked together as spectacle makers in Middleburg, Holland, not far from Hans Lippershey, another optical scientist who is often alternatively credited with the invention of the microscope.

The Dutch diplomat William Boreel was a longtime acquaintance of Zacharias Janssen who had written to him about the device in letters. Boreel saw the microscope for himself but only years later when it had already fallen into the hands of another family friend, Cornelius Drebbel. When the physician of the French King publicly sought information regarding the origin of the microscope during the 1650s, Boreel responded, relating information about the Janssens and recounting the device they had created and his experience surrounding its use.

The device fashioned by the Janssens, and described by Boreel, rose vertically from a brass tripod shaped like dolphins and was almost two and a half feet long. The main brass tube was only an inch or two in diameter and held an ebony disc at its base and a lens at each end. However, in a Middleburg museum another microscope bears the Janssen name but is of a different design. The museum instrument consists of three tubes, two of which are drawtubes that can slide into the third tube that acts as an outer casing. Lenses at the ends of each drawtube serve as magnifying elements. The lens connected to the eyepiece is bi-convex and the one serving as the objective is plano-convex. Capable of achieving a magnification range between three and nine times the true size of an object, the microscope was apparently built to be used by hand because it has no mounting mechanism.

Though rudimentary when compared with modern models, the Janssen microscope was an important advance from contemporary use of a single lens for magnification purposes. With further developments in microscopy, a formerly unknown and invisible world was to become readily apparent. By the end of the seventeenth century, Robert Hooke had employed his version of the compound microscope to observe organisms, such as fossils, diatoms, and even cells, and Marcello Malpighi had discovered capillaries. Modern compound light microscopes are able to reveal many more wonders because, under optimal conditions, the instruments are capable of ultimate magnifications between 1000 and 2000 times a specimen's true size.

The Janssen Drawtube Microscope. As discussed above, the origin of the light optical microscope is a matter of debate, but most scholars agree that the invention of the compound microscope can be credited to Zacharias Janssen in the late sixteenth century. At that time eyeglasses were beginning to enjoy widespread use and this focused a great deal of attention on optics and lenses. The microscope illustrated in this section was built by Zacharias Janssen, probably with the help of his father Hans, in the year 1595.



The first compound microscope (circa 1595).

Johannes Kepler
(1571-1630)

Johannes Kepler was born on December 27, 1571, in Weilder Stadt, Wurttemburg, in the Holy Roman Empire (now Germany). He was a sickly child with poor parents, but his obvious intelligence earned him a scholarship to the University of Tubingen. At Tubingen, Michael Maestlin, one of the leading astronomers of the day, taught Kepler astronomy. The astronomy of the curriculum was geocentric astronomy in which it was thought that all seven "planets"—Moon, Mercury, Venus, Sun, Mars, Jupiter and Saturn—moved around the Earth. Maestlin chose to teach Kepler even more advanced astronomy by introducing him to the new heliocentric, cosmological system of Copernicus.

Kepler, who was a profoundly religious man, was persuaded by Maestlin to abandon plans for ordination and instead

 doi: 10.1017/S1551929509991052

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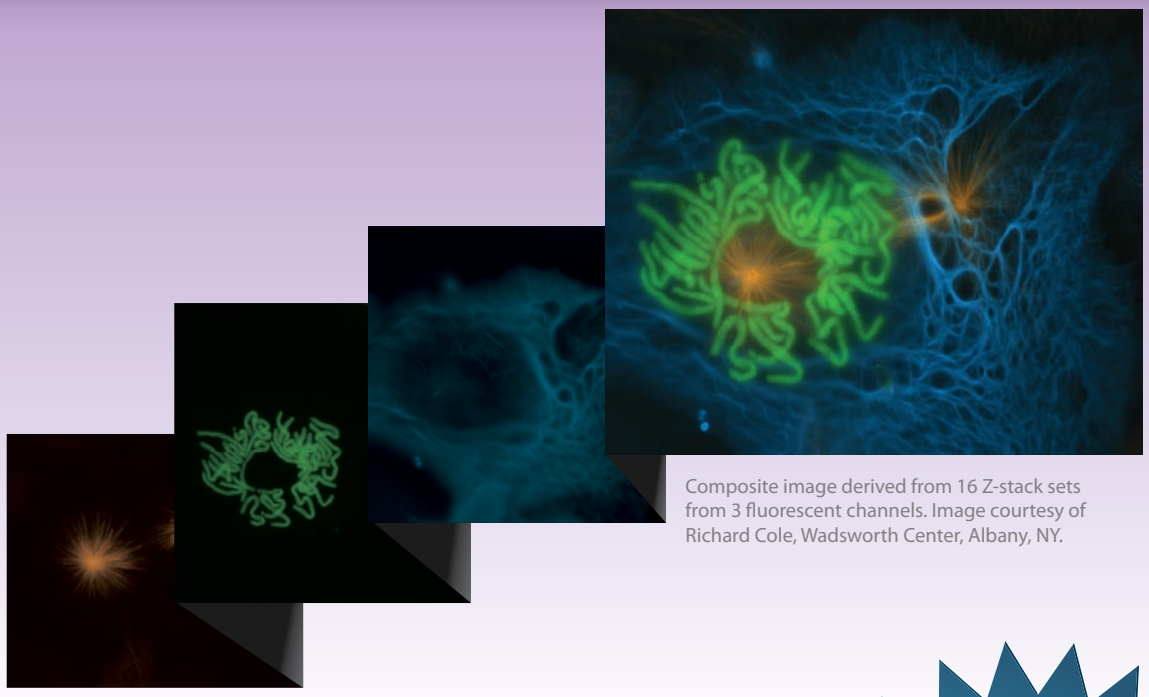

Composite image derived from 16 Z-stack sets from 3 fluorescent channels. Image courtesy of Richard Cole, Wadsworth Center, Albany, NY.

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take up a post teaching mathematics in Graz. In 1596, while at Graz, he wrote the first outspoken defense of the Copernican system, the *Mysterium Cosmographicum*. Religious intolerance increased in the following years and Kepler moved to Prague to work with the renowned Danish astronomer, Tycho Brahe. He inherited Brahe's post as Imperial Mathematician when Brahe died in 1601. Using the precise data that Brahe had collected, Kepler discovered that the orbit of Mars was an ellipse. In 1609, he published *Astronomia Nova* delineating his discoveries, which are now called *Kepler's first two laws of planetary motion*. This work established Kepler as the "father of modern science," documenting how, for the first time, a scientist dealt with a multitude of imperfect data to arrive at a fundamental law of nature. In 1612 Lutherans were forced out of Prague, and Kepler was excommunicated. This caused him much pain, but he was never successful in getting this ban lifted even with his high social standing as Imperial Mathematician.

Kepler moved to Linz, and in 1619 he published *Harmonices Mundi* in which he describes his third law of planetary motion. According to many experts, it was this law—not an apple—that led Newton to his law of gravitation.

In Kepler's book *Astronomia Pars Optica*, for which he earned the title of founder of modern optics, he was the first to discover many of the common theories of optics. He was the first to use a pin hole camera to investigate the formation of pictures, the first to explain the process of vision by refraction within the eye, the first to formulate eyeglass designs for nearsightedness and farsightedness, and the first to explain the use of both eyes for depth perception.

In his book *Dioptrice* (a term coined by Kepler and still used today), he was the first to describe real, virtual, upright, and inverted images and the concept of magnification. He was the first to explain the principles of how a telescope works and the first to discover and describe the properties of total internal reflection.

Kepler died in November of 1630 in Regensburg (now in Germany) after a brief illness. MT

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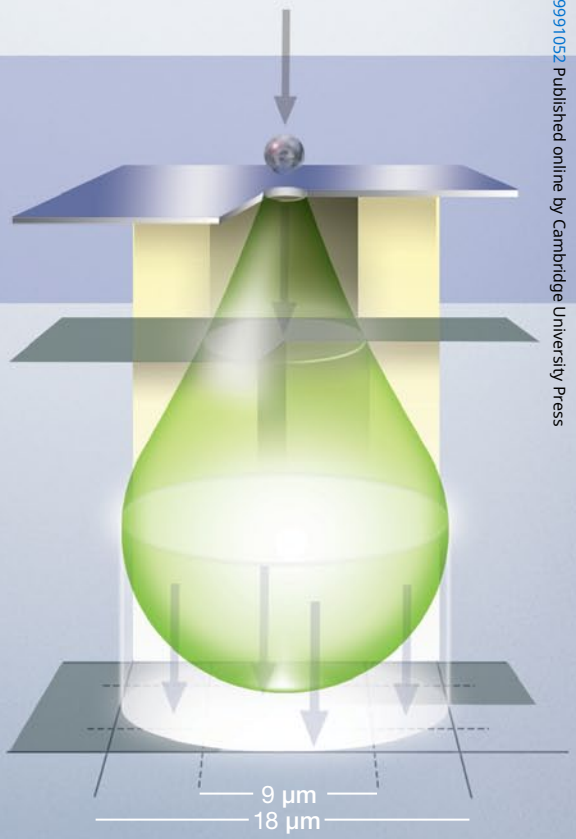

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