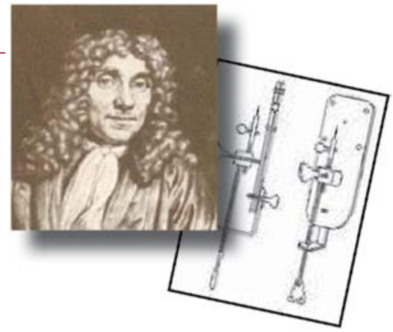
MicroscopyPioneers

Pioneers in Optics: Albert Einstein and Johann Nathanael Lieberkühn



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Albert Einstein
(1879–1955)

Albert Einstein was one of the greatest and most famous scientific minds of the twentieth century. The eminent physicist is best remembered for his theories of relativity, as well as his revolutionary notion concerning the nature of light. However, his innovative ideas were often misunderstood, and he was frequently ridiculed for his vocal involvement in politics and social issues.

Born in Ulm, Germany, on March 14, 1879, Einstein spent his childhood in Munich, where his father owned a small electrochemical factory. Although he did not speak until he was three years old and was a rather poor student at the strict German schools he attended in his youth, Einstein had an innate curiosity. Dismayed by his formal academic curriculum, he concentrated on teaching himself the things he wanted to know, including Euclidean geometry, with which he was familiar by the age of twelve.

In 1895, after the family business had failed, the Einstein household relocated to Milan, Italy. Albert Einstein originally remained in Munich in order to carry on his studies but later joined his relatives, though his education was still incomplete. In Italy, Einstein continued his independent study of mathematics and physics, soon gaining admittance to the prestigious Federal Polytechnic Academy in Zurich, Switzerland. After graduation in 1900, Einstein became a Swiss citizen and found employment as a technical assistant at the government patent office. He married Mileva Maric in 1903, with whom he would later have two sons.

After many years of diligent study, Einstein (and the world) began to see the fruits of his labor in 1905. That year, he received a doctorate from the University of Zurich for a dissertation on the dimensions of molecules. The feat was followed by the publication of four other important examples of his work in the prestigious German journal *Annalen der Physik*. The first, "On the Motion-Required by the Molecular Kinetic Theory of Heat-of Small Particles Suspended in a Stationary Liquid," presented a theoretical explanation of Brownian motion, which was later confirmed by experiment.

The second theoretical paper, "On a Heuristic Viewpoint Concerning the Production and Transformation of Light," would eventually leave a tremendous impression on the field of optics, although it was initially received with skepticism. The work concerned the photoelectric effect, a phenomenon in which charged particles are released from matter when it absorbs radiant energy, such as light. Originally discovered in 1887 by German physicist Heinrich Hertz, aspects of the effect observed by other scientists at the turn of the century could not be explained by traditional physics. Einstein postulated that although light sometimes behaves like a wave, it also consists of discrete packets of energy that he called quanta (now known as photons). The concept was not only central to a more complete understanding of the photoelectric effect, but the behavior of light in general. In his critical essay, Einstein also hypothesized that the energy carried by any light particle is proportional to the frequency of radiation. His landmark ideas were supported experimentally many years later, which helped them to eventually gain broad acceptance.

Still, the most famous of Einstein's publications in 1905 was "On the Electrodynamics of Moving Bodies," which encompassed what was later termed his special theory of relativity. The crux of Einstein's argument was that for all frames of reference, the speed of light is constant and, if all natural laws are the same, then both time and motion are relative to the observer. His fourth paper published in 1905 was a mathematical progression of the theory, which established the equivalence of mass and energy as $E = mc^2$, where c represents the velocity of light, m the mass of a body, and E the resultant energy.

The combined achievements of Einstein in 1905 resulted in his prominence in European scientific circles, even though his worldwide fame was yet to come. He continued working on his theory of relativity, eventually abandoning the patent office to return to teaching, which allowed additional time for research. In 1916, his complete general theory of relativity, which provided an alternative explanation for the variation in the orbital motion of planets previously ascribed to gravity, was published. An implication of the theory, that starlight would bend when in the vicinity of a massive body, was proven three years later during a solar eclipse, resulting in a media frenzy and Einstein's widespread acclaim.

Now a celebrity, Einstein began to publicly voice his opinions about world affairs, avidly supporting pacifism and Zionism. His views and his scientific work garnered significant criticism in his German homeland, and Einstein spent an increasing amount of time traveling and lecturing. After a separation and subsequent divorce from his first wife, he married his second cousin, Elsa, who became his traveling companion. In 1921, Einstein traversed the United States for the first time, endeavoring to raise funds for the Palestine Foundation Fund. That same year he was awarded the Nobel Prize in physics for

 doi:10.1017/S1551929514000492

his photoelectric law and theoretical work, although no specific mention was made of the theory of relativity.

Nevertheless, the controversial theory was where Einstein's primary interests were focused, and he spent a great percentage of his remaining years attempting to further broaden the hypothesis to encompass and explain all physical interactions. However, a new field, quantum physics, originally inspired by his work, was leading modern scientific minds in a different direction. Einstein staunchly disagreed with the uncertainty principle that existed at the core of quantum theory, once summing up his position in the statement that "God does not play dice with the world." Similarly, Einstein's colleagues were deprecating of his unified field theory, believing that he was wasting his brilliant mind on a futile quest.

In 1933, Einstein left Germany for the United States. He accepted a professorship at the Institute for Advanced Study in Princeton, New Jersey, and slowly began to renounce his pacifist beliefs in the face of Hitler's rising power. The threat of Nazi Germany to world security was greatly felt by Einstein, and in 1939, he wrote a letter to President Franklin D. Roosevelt expressing the necessity of quick action in atomic bomb research. The letter, produced at the behest of colleagues who believed that Germany was on the verge of such an advance, resulted in the birth of the Manhattan Project and an inexorable connection between Einstein's name and the atomic age. However, Einstein did not take part in any of the atomic research, instead preferring to concentrate on ways that the use of bombs might be avoided in the future, such as the formation of a world government.

His second wife having died in 1936, Einstein spent the rest of his life living alone in New Jersey, concentrating on his work and playing the violin for relaxation. In 1950, he published a new version of the unified field theory, but it was not well received. His health gradually deteriorated over his final years and he passed away in his sleep on April 18, 1955. The following, part of an incomplete statement left on his desk in the hospital where he died, were words that the brilliant, but controversial man lived by:

"What I seek to accomplish is simply to serve with my feeble capacity truth and justice at the risk of pleasing no one."

Johann Nathanael Lieberkühn
(1711–1756)

Johann Nathanael Lieberkühn was a German physician, anatomist, and physicist. He is most widely known for development of the solar microscope, studies of the intestine, and invention of a reflector for improving microscopic viewing of opaque specimens. He was also a member of the mathematics department at the Berlin Academy of Sciences and created a lens that enhanced the use of early portable microscopes for botanical fieldwork.

During his lifetime, normal and pathological anatomies were more established sciences than microscopy. Nevertheless, Lieberkühn's work heavily depended on the microscope. As an anatomist, his research largely focused on the digestive system. The crypts of Lieberkuhn, named in his honor, are the intestinal glands found between the villi that act as a source for digestive enzymes and various hormones. The receptors and carriers necessary for digestion and absorption are contained in the complex network of membranes. Some of Lieberkühn's anatomical specimens have survived for over 250 years. When Catherine the Great acquired them in 1765, she placed them in the Russian Medical Military Academy's Museum of Anatomy, where they remain today.

To aid his anatomical work, Lieberkühn used a simple microscope fitted with a concave mirror or reflector to study injected animal specimens with epi-illumination. The Lieberkuhn reflector, or reflecting speculum, is made of silver or another highly polished metal and increases the amount of light illuminating a specimen. The main advantage of the reflector is that it illuminates an opaque object from almost every azimuth. Although used by many early microscope makers, for most applications the stereomicroscope and modern incident lighting have made the Lieberkuhn device obsolete. Olympus, however, still manufactures Lieberkühn's design as an option for some of its modern microscope models that use 20-millimeter and 38-millimeter macro lenses.

Lieberkühn invented the solar microscope around 1740. Structurally similar to a microscope, in reality it was a projector that required very intense light for good resolution of fine anatomical details. The microscope was designed for showing magnifications of transparent specimens to large audiences, such as an anatomy class. The horizontal instrument was placed at the base of a window along with a mirror that collected and reflected the incident sunlight. A bi-convex lens focused the light rays onto the transparent specimen. The resulting image was enlarged and could be projected a considerable distance from the instrument and object. If sunlight was not accessible, a gas lamp or other light source could alternatively be used with the microscope.

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