Albert Einstein: His Biography in a Nutshell.

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Albert Einstein was born on March 14, 1879, into a middle-class Jewish family in the Swabian town of Ulm. He only started to talk when he was three years old, but it is a myth that he was a poor student. What did evidence itself from the start was the single-mindedness that became an important characteristic of his later scientific work. He only applied himself when the subject held a strong interest for him. Science was such a preoccupation from early on in his life. When he was only one year old, the Einstein family relocated to Munich, where his father and an uncle went into business together. In his father’s factory, the young Einstein marveled at dynamos and other machinery. Two other events appear to have been crucial in awakening his interest in science. At the age of five, he was deeply impressed when his father showed him a compass. At the age of eleven, he discovered what he later called his “holy geometry book.” Popular science books showed him that the Bible could not literally be true, and his early religious fervor—which he had developed in spite of his parents who were not practicing Jews—gave way to an enthusiasm for science. In high school, the Gymnasium, he did extremely well in physics and mathematics but was undistinguished in subjects that were of no interest to him.

In 1894 his father’s business in Munich failed, and the family went to Italy, leaving Einstein behind to complete his high-school education. Einstein, however, who had little tolerance for the rigid discipline of the Gymnasium, soon dropped out of school and joined his family in Milan. This way, he also avoided being drafted into the German military. After completing his secondary education in Switzerland, he was eventually admitted to the Federal Polytechnic, now the ETH, in Zurich. There he met his first wife Mileva Maric (1875-1948). Einstein frequently skipped class, relying instead on the notes of his classmate Marcel Grossmann (1878-1936), and spent most of his time studying by himself more recent physics than was covered in the university curriculum. He thereby alienated some of his teachers, which was a factor in his failure to find an academic position upon graduation in 1900. In 1902 he finally got a job as a patent examiner third class in Bern. He had become a Swiss national the year before. He and Mileva married in 1903, over the strong objections of his parents. Before they were married, Albert and Mileva had a daughter, Lieserl, who was given up for adoption. No trace of her remains. They had two more children: Hans Albert (1904-1973) and Eduard (1910-1965).

After establishing himself as a serious scholar with several papers on statistical mechanics in *Annalen der Physik*, the leading physics journal of the day, the young patent clerk submitted four ground-breaking papers to this same journal in 1905: one proposing the light-quantum hypothesis, one on Brownian motion that provided crucial evidence for the reality of atoms, one on electrodynamics in moving bodies introducing the special theory of relativity, and a final one on an important consequence of this theory, the inertia of energy or $E = mc^2$. Einstein’s approach in these papers was to work with what he later called “theories of principle.” He started from generalizations supported by a wealth of empirical evidence, even if such generalizations appeared to be contradictory. With uncompromising logic, he then derived the consequences of these generalizations, in the process exposing various preconceived notions as prejudices that had to be cast aside (such as common-sense ideas about simultaneity). Proceeding in a similar vein, Einstein established in 1909 that any satisfactory theory of light must combine aspects of both a wave and a particle theory. This was the very first statement of wave-particle duality.

Einstein presented this result in his first invited lecture as a regular member of the academic community. Earlier in 1909 he had become an associate professor at the University of Zurich. In 1911 he continued his ascent up the academic ladder, becoming a full professor in Prague. A year later he was back in Zurich, this time as a full professor at his alma mater, the ETH. Another year later he was recruited by Max Planck (1858-1947) and Walther Nernst
(1864-1941) to come to Berlin where in early 1914 he became a salaried fellow of the Prussian Academy, a position he would hold until 1933, when the Nazi rise to power forced him to leave Germany permanently. The move to Berlin was the final straw that broke his marriage. Mileva and the couple’s sons returned to Zurich shortly afterward, and Einstein resumed an affair begun in 1912 with his cousin Elsa Einstein-Löwenthal (1876-1936), with whom he would enter into a marriage of convenience in 1919 shortly after his divorce from Mileva was finalized.

Although Planck and others had recognized the importance of special relativity early on, the growing recognition of Einstein’s work by the physics community came mainly from his work on the quantum theory of matter. His quantum theory of light met only with skepticism and strong opposition until the discovery of the Compton effect in 1923. Even the verification by Robert A. Millikan in 1915 of the formula for the photoelectric effect did nothing to change this. When Einstein received the Nobel Prize in Physics in 1921, it was for the formula, not for the light-quantum hypothesis from which the formula had been derived. Einstein’s related work on the specific heat of solids at low temperatures was received much better, especially by Walther Nernst who made the fledgling quantum theory the topic of the first Solvay Congress in 1911. At this meeting, Einstein established himself as the leading thinker in this field.

In the meantime, Einstein also had taken the first steps toward a generalization of special relativity that would at the same time be a new theory of gravity, the general theory of relativity. While special relativity was the work of many, general relativity was essentially the work of Einstein alone. In 1907, still working at the patent office, Einstein had what he later described as “the happiest thought of my life.” He realized that the equality of inertial and gravitational mass indicated that there had to be an intimate connection between inertia and gravity. The equivalence principle, as this connection came to be called, was of great heuristic value in finding the new theory of gravity, which was completed in late November 1915, after a final month of intense work on the problem in war-torn Berlin. Within a year, however, Einstein realized that the theory as it stood still contained remnants of absolute space and absolute motion, two notions he had hoped to banish from physics altogether. The problem was that the theory still needed boundary conditions. In 1917, during the course of a lengthy correspondence with the Dutch astronomer Willem de Sitter, Einstein introduced a static spatially closed model of the universe, thereby obviating the need for boundary conditions. The model was static, and this required the addition of the so-called cosmological constant to his theory. Einstein now believed that this theory satisfied what he dubbed “Mach’s principle”: The geometrical structure of space-time is fully determined by its matter content. De Sitter soon showed that this is not true.

Einstein thereupon lost his enthusiasm for Mach’s principle, a position reinforced by the discovery first of expanding models of the universe and then of empirical evidence that the universe is, in fact, expanding. Einstein’s paper nonetheless launched the field of relativistic cosmology. In these early years of general relativity, he likewise did pioneering work on gravitational waves, gravitational lensing, and singularities.

By 1920 Einstein had redirected his effort to finding a classical field theory along the lines of general relativity unifying the fabric of space-time (responsible for the effects of gravity) and the electromagnetic field. Rather than reducing the structure of space-time to matter, Einstein now hoped to show how matter emerges from this unified field. He would pursue this new line of research until his death in 1955. His approach in this later period is markedly different from the approach he took in his early years. Rather than building on secure empirical foundation, he came to rely more and more on purely mathematical speculation.

Einstein’s hope was that a unified field theory would bring the answer to all the riddles of quantum theory. Before the advent of quantum mechanics in the mid-1920s, Einstein made at least two more fundamental contributions to quantum theory: his radiation theory of 1917, which played an important role in the genesis of quantum mechanics and forms the basis for the laser, and his 1925 work on Bose-Einstein statistics. After that, Einstein’s role became more and more that of a critic of the emerging Copenhagen interpretation of quantum mechanics. His most famous contribution to the discussion of the foundations of quantum mechanics is the 1935 paper coauthored with Boris Podolsky and Nathan Rosen known as the EPR paper.
By this time, Einstein had lost touch with the mainstream of physics and shifted his attention more and more to a mathematical audience. He did not contribute, for instance, to the exciting developments in the 1930s in the area of nuclear physics. It is very telling in this connection that Einstein always stuck to unifying gravity and electromagnetism and never included the nuclear forces that ever more clearly emerged as new types of interactions. For that reason alone, Einstein could never have played a substantial role in the development of nuclear weapons. Much has been made of his letter to President Franklin D. Roosevelt of 1939 warning of the possibility of a German atomic bomb. Work on an American bomb, however, was not begun in earnest until the attack on Pearl Harbor over two years later.

The letter to Roosevelt does provide a good illustration of Einstein’s standing in the scientific community and in society at large. When it was announced in London in 1919 that measurements of the bending of starlight grazing the Sun during a solar eclipse confirmed the predictions of general relativity, Einstein had become an overnight sensation, the world’s first and greatest scientific superstar, whose opinions were sought on all sorts of scientific, political, and moral issues. Einstein, whose political involvement had been tentative up to that point, used his celebrity over the years to support various causes dear to his heart, such as pacifism, Zionism, and disarmament.

The downside of Einstein’s fame was that he became a natural target for anti-Semitic forces in German society in the early 1920s. His theories were denounced as “Jewish physics,” and there were even rumors that his name appeared on lists of people to be assassinated by ultraright-wing elements. Einstein nonetheless stayed in Berlin, mainly out of loyalty to Planck and others in the Berlin physics community. Einstein also felt solidarity with the German people in the face of the harsh conditions in the aftermath of World War I, further exacerbated by the terms of the Versailles Treaty. Einstein used his position to help Germany regain access to the international scientific community after World War I. After the Nazis came to power in 1933, however, he was forced to leave Germany. He accepted a full-time position at the newly established Institute for Advanced Study in Princeton. He became an American citizen in 1940, although retaining his Swiss citizenship. He never set foot on German soil again.

In 1948 Einstein, who had abdominal problems ever since his period of intensive work on general relativity in the mid-1910s, was diagnosed with an aneurysm of the major abdominal aorta. In April 1955 the aneurysm ruptured and Einstein died. The body was cremated but not before both his brain and his eyes were removed during an unauthorized autopsy. On the day that he died, Einstein had asked his secretary for his latest notes on an unfinished project, finding a classical unified field theory for gravity and electromagnetism.

**Bibliography**