Biographical Encyclopedia of Astronomers

Einstein, Albert

Born Ulm, (Baden-Württemberg), Germany, 14 March 1879

Died Princeton, New Jersey, USA, 18 April 1955

Albert Einstein, who transformed and advanced science as only Isaac Newton and Charles Darwin had done, was the son of Hermann and Pauline (née Koch) Einstein. Einstein's father operated an electrotechnical business, but with limited success. During his lifetime, Einstein published, in addition to several books, over 300 scientific articles, many of which are, to this day, the basis of spectacular new advances

Einstein's contributions spanned a great variety of fields. These include the special relativity theory [SRT] that revised our notions of space and time; brought together under one view electricity, magnetism, and mechanics; dismissed the 19th-century concept of ether; and revealed as a by-product the equivalence of mass and energy ($E=mc^2$). In those first decades of work, Einstein also successfully applied statistical mechanics to explain Brownian motion; proposed a theory that the energy carried by a light wave is quantized ($E = hv$), thereby explaining the photoelectric effect (for which he was awarded the Nobel Prize in Physics in 1922); and made contributions to the quantum theory of specific heats, and the concept of stimulated emission, which became a parent of laser physics

Within months of his birth, Einstein's family had moved from Ulm to Munich. Entering its Luitpold Gymnasium in 1888, he found the school to favor a militaristic style of instruction that he found repugnant. Thus, Einstein resorted to his lifelong passion for self-education. Among those readings that proved influential were, at age 12, a book on Euclidean plane geometry, and popular books on science by Aaron Bernstein and Ludwig Büchner, along with Alexander von Humboldt's *Cosmos*, and (reportedly) Charles Darwin's *Origin of Species*. At age 13 and again at 16, he read Immanuel Kant's *Critique of Pure Reason*. From childhood on, Einstein was exposed to, and became fascinated with, the classics of literature and music

In 1894, though two years younger than the usual age for entry, Einstein tried to be admitted to the Swiss Polytechnic Institute in Zurich. On failing the entrance examinations (although doing well in physics and mathematics), he entered the Cantonal (Secondary) School in Aarau, Switzerland, where the youngster blossomed in a friendly, supportive atmosphere

In 1896, Einstein entered the polytechnic to obtain a diploma for high school teaching, but also took courses on Kant and Goethe. One of his classmates was Mileva Marić, from southern Hungary. An early romance and intellectual kinship resulted in their marriage in January 1903. The couple had two sons, Hans Albert and Eduard, and a somewhat mysterious daughter, born before they were married, who apparently died quite young. Over time, with Einstein's growing fame drawing him away, and Mileva's earlier moodiness reportedly turning into schizophrenia (which also came to afflict her sister and younger son), the marriage dissolved into unhappiness. Their divorce became final in 1919, after which Einstein married his cousin, Elsa Löwenthal

It took Einstein four years (1900–1904) to find a suitable position, that of expert third-class, at the Patent Office in Bern, Switzerland. It has been plausibly argued that his duty of examining applications submitted for electromagnetic engineering devices helped him form critical ideas used in his *special relativity*, one of his several breakthrough publications in the golden year of 1905

Over time, Einstein's extraordinary talent was recognized, and he accepted a series of academic appointments: at Zurich University (1909), at the German University in Prague (1911), at his old Swiss Polytechnic Institute (1912), and at the Friedrich-Wilhelm University in Berlin (1914). Here, Einstein became well established in the Prussian Academy of Sciences. It was his penultimate move in this long series, the final relocation being to the Institute for Advanced Study in Princeton, New Jersey, in October 1933, where he remained until the end. His first visit to the United States took place in 1921, and he returned there for three working visits to the California Institute of Technology. On returning to Europe from the last of these in early 1933, just when Hitler had been allowed to come to power in Germany, Einstein refused to proceed to his home in Berlin. Indeed, he never set foot in Germany again

Starting in 1907 and reaching a climax in 1915/1916, Einstein developed, in intense labor, the general theory of relativity [GRT], which can be considered a reinterpretation of gravitation as the effect of a curvature of spacetime. His long-hoped-for (but never achieved) unified field theory was to encompass the geometrization of electromagnetic fields. Einstein attempted to achieve the stability of a spatially bounded Universe by including a "cosmological constant" (later retracted) and gravitational waves; he also calculated that the gravitational fields of astronomical objects could act as "lenses" to create images of objects located far beyond them. Early successes of the GRT included explaining the degree of deflection of starlight passing close to the Sun (observed in 1919 during a total solar eclipse), the "red shift" of light moving through a gravitational field, and the precession of the perihelion of Mercury During his years at the Institute in Princeton, he and a few collaborators elaborated the GRT, carrying it forward to the next stage of research. During those years, Einstein also worked (in part with Peter Bergmann and Valentine Bargmann) on a generalization of Theodore Kaluza's higher-dimensional unification of electromagnetism with relativity, which later served as an introduction to contemporary investigations in String Theory.

Einstein responded to these (and later) successes with inner self-confidence and outward expressions of humorous self-derogation. He once said his greatest gift was his stubbornness and his ability to remain intrigued by questions that only children might ask. His personal behavior and opinions often alarmed his more conventional colleagues, for he had "Bohemian" tendencies in demeanor and clothing, urged pacifism during World War I, and worked strenuously on behalf of arms control after World War II. Einstein expounded against nationalism and undemocratic, hierarchical rules; he made no secret of his Jewish heritage and his support for Zionism (provided it accommodated the Arabs in Palestine). He opposed religious establishments in favor of a personal "cosmic religion," in the spirit of Baruch Spinoza. In 1952, Einstein felt compelled to decline the offer of the presidency of the State of Israel, feeling that he lacked the leadership qualities needed for the task.

Some of these traits, when added to his exceptional scientific standing, conveyed on him a kind of charisma that still holds sway, although Einstein himself never understood it. It made him the target of attacks by anti-Semites and other enemies from 1920 onward (even threatening his life in 1922), but, on the other hand, flooded him with adoring or opportunistic appeals. A famous example of the latter occurred when three of his colleagues persuaded Einstein to sign the letter of 2 August 1939, warning President Franklin Delano Roosevelt of the danger that the Germans, then about to begin World War II, might construct atomic weapons (as they attempted to do before the Allies).

What might have been the sources of Einstein's extraordinary imaginative powers? A reasonable, though all-too-brief, answer might begin by noting that each of his three main papers of 1905—on the quantized notion of light, on explaining Brownian motion, and on what Einstein modestly called a "modification of the teachings of space and time" (i.e., SRT)—

seems to be written on completely different topics. Yet, closer study shows that they all stemmed from one preoccupation, namely, with fluctuation phenomena; moreover, they have the same general style and components

Contrary to one of the popular images of how scientists work, Einstein did not begin with some "crisis" brought about by puzzling over new experimental facts (nor, contrary to opinions in textbooks, a seminal influence of the failure of the Michelson-Morley experiment). Rather, his dissatisfaction was focused on an asymmetry, or lack of generality, in the then-current theory that others might dismiss as merely aesthetic in nature. He proposed one or two principles, analogous to the axioms of Euclid, and then showed how consequences drawn from them would remove his dissatisfaction. At the end of each early paper, there was a brief and seemingly offhand proposal for experiments that might bear out the predictions of Einstein's theory

For example, Einstein's paper on the quantum nature of light was motivated by noting an obvious point: that the energy of a palpable body is concentrated and not infinitely divisible. But why should atomicity not apply to both matter and light energy? Here, one glimpses Einstein's fundamental, primary motivation in scientific work, announced in a 1901 letter to Marcel Grossmann: "It is a wonderful feeling to recognize the unity of a complex of appearances which, to direct sense experience, seem to be separate things." All of his 1905 papers endeavored to bring together and unify apparent opposites, removing the illusory barriers between them. Similarly, Einstein's GRT and attempted unified field theory arose from his dissatisfaction with his SRT, because the latter excluded gravity and therefore seemed to him to require extension. As he once put it, he was driven by the "need to generalize."

These observations intersect, finally, with Einstein's often-expressed interest in a guiding, practical philosophy of science. A key part of this approach was his recognition that a researcher initially cannot work "without any preconceived opinion." He referred to these preconceptions as "categories" or schemes of thought, the selection of which is, in principle, entirely open to us, and whose qualification can only be judged by the degree to which its use contributes to making the totality of the content of consciousness "intelligible." Einstein clearly interpreted such categories in a non-Kantian sense, i.e., as freely chosen. Like other major scientists, his loyalty to and use of presuppositions, to which I refer as themata, were powerful motivations and guides

Among the themes prominent in Einstein's theory constructions were the following: primacy of formal (rather than materialistic) explanation; unity (or unification, preferably on a cosmological scale); logical parsimony and necessity; symmetry; simplicity; completeness; continuity; constancy and invariance; and causality. In contrast, the quantum mechanics of Niels Bohr's school, with its concepts of fundamental probabilism and indeterminacy, rather than (classical) causality and completeness, was abhorrent to him, and largely explains the unresolved controversy between Einstein and Bohr

Of Einstein's thematic presuppositions, the one that guided him most to success, but also to his failure to achieve a unified field theory, was the concept of *Einheit* (unity), or, as he once put it, a longing to behold the preestablished harmony that would lift one from the harshness and dreariness of everyday life. Here one glimpses why Einstein and his search, even if uncomprehended in detail by lay people, continues to be an icon for them.

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