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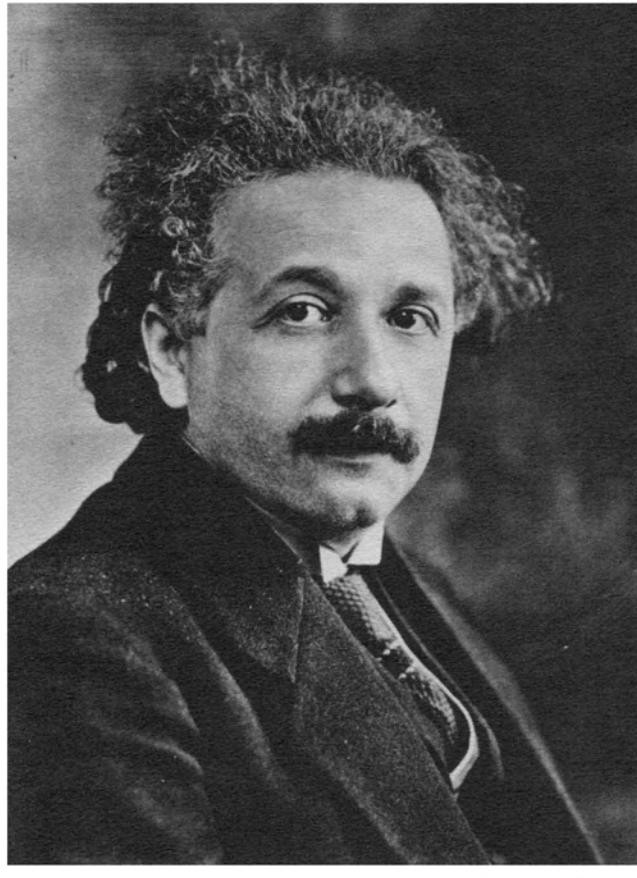
ALBERT EINSTEIN

1879—1955

A Biographical Memoir by

JOHN ARCHIBALD WHEELER

Biographical Memoir



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A. Einstein.

ALBERT EINSTEIN

March 14, 1879—April 18, 1955

BY JOHN ARCHIBALD WHEELER*

ALBERT EINSTEIN was born in Ulm, Germany on March 14, 1879. After education in Germany, Italy, and Switzerland, and professorships in Bern, Zurich, and Prague, he was appointed Director of Kaiser Wilhelm Institute for Physics in Berlin in 1914. He became a professor in the School of Mathematics at the Institute for Advanced Study in Princeton beginning the fall of 1933, became an American citizen in the summer of 1936, and died in Princeton, New Jersey on April 18, 1955. In the Berlin where in 1900 Max Planck discovered the quantum, Einstein fifteen years later explained to us that gravitation is not something foreign and mysterious acting through space, but a manifestation of space geometry itself. He came to understand that the universe does not go on from everlasting to everlasting, but begins with a big bang. Of all the questions with which the great thinkers have occupied themselves in all lands and all centuries, none has ever claimed greater primacy than the origin of the universe, and no contributions to this issue ever made by any man anytime have proved themselves richer in illuminating power than those that Einstein made.

Einstein's 1915 geometrical and still standard theory of

gravity provides a prototype unsurpassed even today for what a physical theory should be and do, but for him it was only an outlying ridge in the arduous climb to a greater goal that he never achieved. Scale the greatest Everest that there is or ever can be, uncover the secret of existence—that was what Einstein struggled for with all the force of his life.

How the mountain peak magnetized his attention he told us over and over. "Out yonder," he wrote, "lies this huge world, which exists independently of us human beings and which stands before us like a great, eternal riddle. . . ."* And again, "The most incomprehensible thing about the world is that it is comprehensible."† And yet again, "All of these endeavors are based on the belief that existence should have a completely harmonious structure. Today we have less ground than ever before for allowing ourselves to be forced away from this wonderful belief."‡

When the climber laboring toward the Everest peak comes to the summit of an intermediate ridge, he stops at the new panorama of beauty for a new fix on the goal of his life and a new charting of the road ahead; but he knows that he is at the beginning, not at the end of his travail. What Einstein did in spacetime physics, in statistical mechanics, and in quantum physics, he viewed as such intermediate ridges, such way stations, such panoramic points for planning further advance, not as achievements in themselves. Those way stations were not his goals. They were not even preplanned means to his goal. They were catch-as-catch-can means to his goal.

Those who know physicists and mountaineers know the traits they have in common: a "dream-and-drive" spirit, a

* A. Einstein, "Autobiographical Notes," in *Einstein: Philosopher-Scientist*, ed. P. A. Schilpp (Evanston, Ill.: Library of Living Philosophers, 1949), p. 4.

† B. Hoffmann, *Albert Einstein: Creator and Rebel* (New York: Viking, 1972), p. 18.

‡ A. Einstein, *Essays in Science* (New York: Philosophical Library, 1934), p. 114.

bulldog tenacity of purpose, and an openness to try any route to the summit. Who does not know Einstein's definition of a scientist as "an unscrupulous opportunist;"* or his words on another occasion, "But the years of anxious searching in the dark, with their intense longing, their alternations of confidence and exhaustion, and the final emergence into the light—only those who have experienced it can understand that." † For such a man there are not goals. There is only *the* goal, that distant peak.

Who was this climber? How did he come to be bewitched by the mountain? Where did he learn to climb so well? Who were his companions? What were some of his adventures? And how far did he get?

I first saw and heard Einstein in the fall of 1933, shortly after he had come to Princeton to take up his long-term residence there. It was a small, quiet, unpublicized seminar. Unified field theory was to be the topic, it became clear, when Einstein entered the room and began to speak. His English, though a little accented, was beautifully clear and slow. His delivery was spontaneous and serious, with every now and then a touch of humor. I was not familiar with his subject at that time, but I could sense that he had his doubts about the particular version of unified field theory he was then discussing. It was clear on this first encounter that Einstein was following very much his own line, independent of the interest in nuclear physics then at high tide in the United States.

There was one extraordinary feature of Einstein the man I glimpsed that day, and came to see ever more clearly each time I visited his house, climbed to his upstairs study, and we explained to each other what we did not understand. Over

*A. Einstein, "Reply to Criticisms," in *Einstein: Philosopher-Scientist*, ed. P. A. Schilpp (Evanston, Ill.: Library of Living Philosophers, 1949), p. 648.

†M. J. Klein, *Einstein, The Life and Times,* R. W. Clark, book review, *Science,* 174: 1315.

and above his warmth and considerateness, over and above his deep thoughtfulness, I came to see, he had a unique sense of the world of man and nature as one harmonious and someday understandable whole, with all of us feeling our way forward through the darkness together.

Our last time together came twenty-one years later, on April 14, 1954, when Einstein kindly accepted an invitation to speak at my relativity seminar. It was the last talk he ever gave, almost exactly a year before his death. He not only reviewed how he looked at general relativity and how he had come to general relativity, he also spoke as strongly as ever of his discomfort with the probabilistic features that the quantum had brought into the description of nature. "When a person such as a mouse observes the universe," he asked feelingly, "does that change the state of the universe?"* He also commented in the course of the seminar that the laws of physics should be simple. One of us asked, "But what if they are not simple?" "Then I would not be interested in them," † he replied.

How Einstein the boy became Einstein the man is a story told in more than one biography, but nowhere better than in Einstein's own sketch of his life, so well known as to preclude repetition here. Who does not remember him in difficulty in secondary school, antagonized by his teacher's determination to stuff knowledge down his throat, and in turn antagonizing the teacher? Who that takes the fast train from Bern to Zürich does not feel a lift of the heart as he flashes through the little town of Aarau? There, we recall, Einstein was sent to a special school because he could not get along in the ordinary school. There, guided by a wise and kind teacher,

*J. A. Wheeler, "Mercer Street and Other Memories," in *Albert Einstein, His Influence on Physics, Philosophy, and Politics*, ed. P. C. Aichelburg and R. U. Sexl (Braunscheig: Vieweg, 1979), p. 202.

†*Ibid.*, p. 204.

he could work with mechanical devices and magnets as well as books and paper. Einstein was fascinated. He grew. He succeeded in entering the Züricher Polytechnikum. One who was a rector there not long ago told me that during his period of rectorship he had taken the record book from Einstein's year off the shelf. He discovered that Einstein had not been the bottom student, but next to the bottom student. And how had he done in the laboratory? Always behind. He still did not hit it off with his teachers, excellent teachers as he himself said. His professor, Minkowski, later to be one of the warmest defenders of Einstein's ideas, was nevertheless turned off by Einstein the student. Einstein frankly said he disliked lectures and examinations. He liked to read. If one thinks of him as lonesome, one makes a great mistake. He had close colleagues. He talked and walked and walked and talked.

To Einstein's development, his few close student colleagues meant much; but even more important were the older colleagues he met in books. Among them were Leibniz and Newton, Hume and Kant, Faraday and Helmholtz, Hertz and Maxwell, Kirchhoff and Mach, Boltzmann and Planck. Through their influence, he turned from mathematics to physics, from a subject where there are dismayingly multitudinous directions for dizzy man to choose between, to a subject where this one and only physical world directs our endeavors.

Of all heroes, Spinoza was Einstein's greatest. No one expressed more strongly than he a belief in the harmony, the beauty, and—most of all—the ultimate comprehensibility of nature. In a letter to his old and close friend, Maurice Solovine, Einstein wrote, "I can understand your aversion to the use of the term 'religion' to describe an emotional and psychological attitude which shows itself most clearly in Spinoza. [But] I have not found a better expression than 'religious' for the trust in the rational nature of reality that is, at least to a

certain extent, accessible to human reason."* In later years, Einstein was asked to do a life on Spinoza. He excused himself from writing the biography itself on the ground that it required "exceptional purity, imagination and modesty,"† but he did write the introduction. If it is true, as Thomas Mann tells us, that each one of us models his or her life consciously or unconsciously on someone who has gone before, then who was closer to being role-creator for Einstein than Spinoza?

Search out the simple central principles of this physical world—that was becoming Einstein's goal. But how? Many a man in the street thinks of Einstein as a man who could only make headway in his work by dint of pages of complicated mathematics; the truth is the direct opposite. As Hilbert put it, "Every boy in the streets of our mathematical Göttingen understands more about four-dimensional geometry than Einstein. Yet, despite that, Einstein did the work and not the mathematicians."‡ Time and again, in the photoelectric effect, in relativity, in gravitation, the amateur grasped the simple point that had eluded the expert. Where did Einstein acquire this ability to sift the essential from the non-essential?

The management consultant firm of Booz, Allen & Hamilton, which does so much today to select leaders of great enterprises, has a word of advice: What a young man does and who he works with in his first job has more effect on his future than anything else one can easily analyze. What was Einstein's first job? In the view of many, the position of clerk in the Swiss patent office was no proper job at all, but it was the best job available to anyone with his unpromising university record. He served in the Bern office for seven years, from

*A. Einstein, *Lettres à Maurice Solovine* (Paris: Gauthier-Villars, 1956), p. 102 (January 1, 1956).

†B. Hoffmann, *Albert Einstein: Creator and Rebel* (New York: Viking, 1972), p. 95.

‡P. Frank, *Einstein, Sein Leben und seine Zeit* (München: Paul List Verlag, 1949), p. 335.

June 23, 1902 to July 6, 1909. Every morning he faced his quota of patent applications. Those were the days when a patent application had to be accompanied by a working model. Over and above the applications and the models was the boss, a kind man, a strict man, and a wise man. He gave strict instructions: explain very briefly, if possible in a single sentence, why the device will work or why it won't; why the application should be granted or why it should be denied. Day after day Einstein had to distill the central lesson out of objects of the greatest variety that man has power to invent. Who knows a more marvelous way to acquire a sense of what physics is and how it works? It is no wonder that Einstein always delighted in the machinery of the physical world—from the action of a compass needle to the meandering of a river, and from the perversities of a gyroscope to the drive of Flettner's rotor ship.

Whoever asks how Einstein won his unsurpassed power of expression, let him turn back to the days in the patent office and the boss who, "More severe than my father . . . taught me to express myself correctly."* The writings of Galileo are studied in secondary schools in Italy today, not for their physics, but for their clarity and power of expression. Let the secondary school student of our day take up the writings of Einstein if he would see how to make in the pithiest way a telling point.

From Bern, fate took Einstein to Zurich, to Prague, and then to the Berlin where his genius flowered. Colleagueship never meant more in his life than it did during his 19 years there, and never did he have greater colleagues: Max Planck, James Franck, Walter Nernst, Max von Laue, and others. Colleagueship did not mean chat; it meant serious consulta-

*"Errinerungen an Albert Einstein, 1902–1909," Bureau Fédéral de la Propriété Intellectuelle (Berne, Switzerland), as quoted in: R. W. Clark, *Einstein, The Life and Times* (New York: The World Publishing Co., 1971), p. 75.

tion on troubling issues. No tool of colleagueship was more useful than the seminar. James Franck explained to me the democracy of this trial by jury. The professor, he emphasized, stood on no pinnacle, beyond question by any student. On the contrary, the student had both the right and the obligation to question and to speak up.

If the writing of letters is a test of colleagueship, let no one question Einstein's power to give and to receive. Consider his enormous correspondence. Look at the postcards he sent over the years to the closest in spirit of all his colleagues, Paul Ehrenfest in Leyden. They deal with the issues nearest to his heart at the moment, whether the direction of time in statistical mechanics, or quantum fluctuations in radiation, or a problem of general relativity. Or examine his correspondence with Max Born, or Maurice Solovine, or with everyday people. To a schoolgirl who mentioned among many other things her problems with mathematics, he replied, "Do not worry about your difficulties in mathematics; I can assure you that mine are greater."* Why did Einstein correspond so much with people that you and I would call outsiders? Did he not feel that the amateur brings a freshness of outlook unmatched by the specialist with his narrow view?

The benefits of colleagueship with Einstein I experienced more than once, but never with greater immediate benefit than in statistical mechanics. In a discussion of radiation damping, he referred me to a published dialogue of 1909 between himself and Walter Ritz. The two men agreed to disagree and stated their opposing positions in this single clear sentence: "Ritz treats the limitations to retarded potentials as one of the foundations of the second law of thermodynamics, while Einstein believes that the irreversibility of radiation depends exclusively on considerations of probability."†

*H. Dukas and B. Hoffmann, eds., *Albert Einstein; The Human Side: New Glimpses from His Archives* (Princeton, N.J.: Princeton Univ. Press, 1979), p. 8.

†A. Einstein and W. Ritz, *Physikalisches Zeitschrift,* 10 (1909): 323–34.

In accord with the position of Einstein, Richard Feynman and I found that the one-sidedness in time of radiation reaction can be understood as originating in the one-sidedness in time of the conditions imposed on the far-away absorber particles, and not at all in the elementary law of interaction between particle and particle. I joined the ranks of what I can only call "the worriers"—those like Boltzman, Ehrenfest, and Einstein himself, and many, many others—who ask, why initial conditions? Why not final conditions? Or why not some mixture of the two? And most of all, why thus and such initial conditions and no other? No one who knows of Einstein's lifelong concern with such issues can fail to have a new sense of appreciation on reading his great early papers on statistical mechanics, and not least among them the famous 1905 paper on the theory of the Brownian motion. Surely the perspective he won from these worries will someday help show us the way to Everest.

Best known of Einstein's great trio of 1905 papers, however, is that on special relativity. "Henceforth," as Minkowski put the lesson of Einstein, "space by itself and time by itself, are doomed to fade away into mere shadows, and only a kind of union of the two will preserve an independent reality."* Historians of science can tell us that if Einstein had not come to this version of spacetime it would have been achieved by Lorentz, or Poincaré, or another, who would also have come eventually to that famous equation $E = mc^2$, with all its consequences. But it still comes to us as a miracle that the patent office clerk was the one to deduce this greatest of lessons about spacetime from clues on the surface so innocent as those afforded by electricity and magnetism. Miracle? Would it not have been a greater miracle if anyone but a patent office clerk had discovered relativity? Who else could have distilled this simple central point from all the clutter of

*C. Reid, *Hilbert* (Berlin: Springer, 1970), p. 12.

electromagnetism than someone whose job it was over and over each day to extract simplicity out of complexity?

If others could have given us special relativity, who else but Einstein, sixty-four years ago, could have given us general relativity? Who else knew out of the welter of facts to fasten on that which is absolutely central? Did the central point come to him, as legend has it, from talking to a housepainter who had fallen off a roof and reported feeling weightless during the fall? We all know that he called that 1908 insight the "happiest thought of my life"*—the idea that there is no such thing as gravitation, only free-fall. By thus giving up gravitation, Einstein won back gravitation as a manifestation of a warp in the geometry of space. His 1915 and still standard geometric theory of gravitation can be summarized, we know today, in a single, simple sentence: "Space tells matter how to move and matter tells space how to curve."† Through his insight that there is no such thing as gravity, he had had the creative imagination to bring together two great currents of thought out of the past. Riemann had stressed that geometry is not a God-given perfection, but a part of physics; and Mach had argued that acceleration makes no sense except with respect to frame determined by the other masses in the universe.

It is unnecessary to recall the three famous early tests of Einstein's geometric theory of gravitation: the bending of light by the sun, the red-shift of light from the sun, and the precession of the orbit of the planet Mercury going around the sun. Neither is it necessary to expound the important insights that have come and continue to come out of general relativity. Einstein showed that the law for the motion of a mass in space and time does not have to be made a separate

*A. Einstein, "The Fundamental Idea of General Relativity in Its Original Form," unpublished essay, 1919 (excerpts, *New York Times*, 28 March 1972), p. L.32.

†J. A. Wheeler, University of Texas, lecture of 2 March 1979.

item in the conceptual structure of physics. Instead, it comes straight out of geometric law as applied to the space immediately surrounding the mass in question. Moreover, the geometry that he had freed from slavery to Euclid, and that he had assigned to carry gravitation force, could throw off its chains, become a free agent, and, under the name of "gravitational radiation," carry energy from place to place over and above any energy carried by electromagnetic waves—an effect for which Joseph H. Taylor, L. A. Fowler, P. M. McCulloch, and their Arecibo Observatory colleagues in December 1978 announced impressive evidence.*

One does not need to go into the theory of gravitationally collapsed objects or the evidence we have today, some impressive, some less convincing, for black holes: one of some ten solar masses in the constellation Cygnus; others in the range of a hundred or a thousand solar masses at the centers of five of the star clusters in our galaxy; one about four million times as massive as the sun at the center of the Milky Way; and one with a mass of about five billion suns in the center of the galaxy M87.

The collapse at the center of a black hole marks a third "gate of time,"† additional to the big bang and the big crunch. Einstein tried to escape all three. Two years after general relativity, Einstein was already applying it to cosmology. He gave reasons to regard the universe as closed and qualitatively similar to a three sphere, the three-dimensional generalization of the surface of a rubber balloon. To his surprise, he found that the universe is dynamic and not static.

Einstein could not accept this result. First, he found fault

*L. A. Fowler, P. M. McCulloch, and J. H. Taylor, "Measurement of General Relativistic Effects in the Binary Pulsar PSR 1913 + 16," *Nature*, 277 (8 February 1979) 437–40.

†J. A. Wheeler, "Genesis and Observership," in *Foundational Problems in the Special Sciences*, ed. R. E. Butts and K. J. Hintikka (Reidel: Dordrecht, 1977), p. 11.

with Alexander Friedmann's mathematics. Then he retracted this criticism, and looked for the fault in his own theory of gravitation. It turned out there was no natural way to change that theory. The arguments of simplicity and correspondence in the appropriate limit with the Newtonian theory of gravitation left no alternative. There being no natural way to change the theory, he looked for the least unnatural way he could find to alter it. He introduced a so-called "cosmological term" with the sole point and purpose to hold the universe static. A decade later, Edwin Hubble, working at Mount Wilson Observatory, gave convincing evidence that the universe is actually expanding. Thereafter, Einstein remarked that the cosmological term "was the biggest blunder of my life."* Today, looking back, we can forgive him his blunder and give him the credit for the theory of gravitation that predicted the expansion. Of all the great predictions that science has ever made over the centuries, each of us has his own list of spectaculars, but among them all was there ever one greater than this, to predict, and predict correctly, and predict against all expectation, a phenomenon so fantastic as the expansion of the universe? When did nature ever grant man greater encouragement to believe he will someday understand the mystery of existence?

Why did Einstein in the beginning reject his own greatest discovery? Why did he feel that the universe should go on from everlasting to everlasting, when to all brought up in the Judeo-Christian tradition an original creation is the natural concept? I am indebted to Professor Hans Küng for suggesting an important influence on Einstein from his hero Spinoza. Why was twenty-four-year-old Spinoza excommunicated in 1656 from the synagogue in Amsterdam? Because he denied the doctrine of an original creation. What was the

*G. Gamow, *My World Line* (New York: Viking, 1970), p. 44.

difficulty with that doctrine? In all that nothingness before creation where could that clock sit that should tell the universe when to come into being!

Today we have a little less difficulty with this point. We do not escape by saying that the universe goes through cycle after cycle of big bang and collapse, world without end. There is not the slightest warrant in general relativity for such a way of speaking. On the contrary, it provides no place whatsoever for a before before the big bang or an after after the big crunch. Quantum theory goes further. It tells us that however permissible it is to speak about space, it is not permissible to speak in other than approximate terms of spacetime. To do so would violate the uncertainty principle—as that principle applies to the dynamics of geometry. No, when it comes to small distances either in the here and the now or in the most extreme stages of gravitational collapse, spacetime loses all meaning, and time itself is not an ultimate category in the description of nature. No one who wrestles with the three gates of time, our greatest heritage of paradox—and of promise—from general relativity can escape the all-pervasive influence of the quantum.

Spinoza's influence on his thinking about cosmology Einstein could shake off—but not Spinoza's deterministic outlook. Proposition XXIX in *The Ethics* of Spinoza states: "Nothing in the universe is contingent, but all things are conditioned to exist and operate in a particular manner by the necessity of divine nature."* Einstein accepted determinism in his mind, his heart, his very bones.

Who then was first clearly to recognize that the real world, and the world of the quantum, is a world of chance and unpredictability? Einstein himself!

Why did Einstein, who in the beginning with Max Planck

* B. Spinoza, *Die Ethik*, Part One, Proposition XXIX (Hamburg: F. Meiner, 1955).

and Niels Bohr had done so much to give quantum physics to the world, in the end stand out so strongly and so lonesomely against the central point? What other explanation is there than this "set" he had received from Spinoza?

The early quantum work of Bohr and Einstein is almost a duet. Einstein, 1905: The energy of light is carried from place to place as quanta of energy, accidental in time and space in their arrival. Bohr, 1913: The atom is characterized by stationary states, and the difference in energy between one and another is given off in a light quantum. Einstein, 1916: The processes of light emission and light absorption are governed by the laws of chance, but satisfy the principle of detailed balance. Bohr, 1927: Complementarity prevents a detailed description in space and time of what goes on in the act of emission. Here Bohr and Einstein parted company. Einstein spoke against Einstein. The Einstein who in 1915 said there was no escape from the laws of chance was insisting by 1916, as he did all the rest of his life, against the evidence and against the views of his greatest colleagues, that "God does not [play] dice."*

If an army is being defeated it can still, by a sufficiently skillful rear-guard action, have an important influence on the outcome. No one who in all the great history of the quantum contested with Niels Bohr did more to sharpen and strengthen Bohr's position than Einstein. Never in recent centuries was there a dialogue between two greater men over a longer period on a deeper issue at a higher level of colleagueship, nor a nobler theme for playwright, poet, or artist. From their earliest encounter, Einstein liked Bohr, writing him on May 2, 1920, "I am studying your great works—and when I get stuck anywhere—now have the pleasure of seeing your friendly young face before me smiling and explain-

*A. Einstein, *Albert Einstein und Max Born, Briefwechsel, 1916–1955, Kommentiert von Max Born* (München: Nymphenburg, 1969), pp. 129–30.

ing."* Bohr viewed Einstein with admiration and warm regard. Let him who will read Bohr's account of the famous dialogue, even today unsurpassed for its comprehensive articulation of the central issues. Who knows what the quantum means who does not know the friendly but deadly serious battles fought and won on the double-slit experiment, on the possibilities for weighing a photon, on the Einstein-Podolsky-Rosen experiment, and on the danger associated with unguarded use of the word "reality"? To help to clarify the issues brought up in the later years of the great dialogue, Bohr found himself forced to introduce the word "phenomenon" † to describe an elementary quantum process "brought to a close by an irreversible act of amplification." ‡ Thanks to that word, brought in to withstand the criticism of Einstein, we have learned in our own time to state the central lesson of the quantum in a single simple sentence, "No elementary phenomenon is a phenomenon until it is an observed phenomenon." §

How could the correctness of quantum theory be by now so widely accepted, and its decisive point so well perceived, if there had been no great figure, no Einstein, to draw the embers of unease together in a single flame and thereby drive Bohr to that fuller formulation of the central lesson which he at last achieved?

If the quantum and the gates of time are the strongest features of this strange universe, and if they shall prove in time to come the doorways to that deeper view for which

* Letter to N. Bohr, 2 May 1920.

† N. Bohr, "Discussion with Einstein on Epistemological Problems in Atomic Physics," in *Einstein: Philosopher-Scientist*, ed. P. A. Schilpp (Evanston, Ill.: Library of Living Philosophers, 1949), p. 238.

‡ N. Bohr, *Atomic Physics and Human Knowledge* (New York: Wiley, 1958), p. 73, 88.

§ J. A. Wheeler, "Frontiers of Time," in *Rendicotti della Scuola Internazionale di Fisica "Enrico Fermi,"* LXXII Corso, Problems in the Foundations of Physics, ed. N. Toraldo di Francia and Bas van Fraassen (Amsterdam: North-Holland, 1979), pp. 395–497.

Einstein searched, mankind will forever remember with gratitude his absolutely decisive involvement with both.

No one who is a professor and receives his support from the larger community can rightly be unmindful of his obligations to it. He must speak to the higher values of all insofar as he is qualified and able to do so. Burden though it was for Einstein to take on this extra duty, he did it to the best of his ability. What he defended were no whims, no lightly held fancies, but goals he held and deeply desired for the world. If in this undertaking he had some of the character of an Old Testament prophet, he also had all of the eloquence. Statements from Einstein created an audience, and the audience created the pressure for more statements. What is long, Einstein felt, is lost. Pith and pungency were the points of his pronouncements. Who does not know the causes for which he stood! Whoever admires greatness, let him read Einstein's words about the goals and the greatness of recently departed colleagues, as well as heroes out of the deeper past. For social justice and social responsibility, Einstein spoke up time and again: "A hundred times every day I remind myself that my inner and outer life are based on the labors of other men, living and dead, and that I must exert myself in order to give in the same measure as I have received and am still receiving."* He stressed the necessity of a political system that does not rely on coercion if people are to contribute all that lies in them to achieve.

He expressed admiration for the system of social care, going back to Bismarck, that makes provision for the individual in case of illness or need. Living through the tragedy of two world wars, he protested many times about the wastefulness of war: lives lost, hatred engendered, and values per-

* A. Einstein, *Mein Weltbild*, trans. A. Harris, in *The World As I See It* (New York: Philosophical Library, 1949), p. 90.

verted; but when it came to a choice between war or freedom and justice, he spoke for freedom and justice. He refused the invitation to become the first president of Israel, but he worked after that declination as effectively as before for the welfare of a unique community, remarking, "The pursuit of knowledge for its own sake, an almost fanatical love of justice and the desire for personal independence—these are the features of the Jewish tradition which make me thank my stars that I belong to it."*

Things did not go in the world as Einstein had hoped. Things did not go in physics as he had desired. Determinism stood in ruins. His search for a unified geometric theory of all the forces of nature came to nothing—though today, with a new and wider concept of what geometry is, in the sense of a so-called "gauge theory," marvelous new progress is now being made toward his dream of unification. He left us in general relativity with an ideal for a physical theory that has never been surpassed. He showed a unique talent for finding the central point in every subject to which his philosophical antecedents gave right of entry. He did as much as any man who ever lived to make us face up to the central mysteries of this strange world.

Einstein worked with all his force to the very end. In his last days he had a tired face. Everything that he had to give he had given for his causes, and among them that greatest of causes, the goal toward which he had climbed so high, that snowy peak whose light today shines brighter than ever: "A completely harmonious account of existence."†

As we look up at the distant intervening craggy slope, we are amazed suddenly to make out the faint sound of a high far-off violin. Then out of the valley behind and below us

*Ibid., p. 1.

†A. Einstein, *Essays in Science* (New York: Philosophical Library, 1934), p. 114.

comes an answering burst of song, young voices all. They chorus of the loftiness of the peak, the danger of the climb, and the greatness of the climber, the man of peace with the white hair. He no longer belongs to any one country, any one group, any one age, we hear them singing, but to all friends of the future. Least of all, they tell us, does Einstein anymore belong to Einstein. He belongs to the world.

BIBLIOGRAPHY

A Bibliographical Checklist and Index, compiled by Nell Bonie, Monique Russ, and Dan H. Lawrence. New York: Readex Microprint Corp., 1960. 34 pp.

This bibliography has been emended and updated by Helen Dukas as part of the not yet published work of the ongoing Einstein papers project at the Institute for Advanced Study, Princeton, New Jersey, 08540. The 34-page length of this bibliography and its availability in leading libraries makes it appropriate, in the case of Einstein, to replace the bibliography customarily at the end of the usual memorial by a list of some of the more important writings *about* him. Princeton University Press, on February 22, 1971, signed an agreement with the Estate of Albert Einstein, Otto Nathan and Helen Dukas, trustees, for the preparation of an authorized annotated scholarly edition of the papers of Albert Einstein, the preparation of which is, however, expected to require some years. In the meantime, reference can be made to the unauthorized Russian four-volume series, *Sobranie Nauchnykh Trudov*.

Einstein, The Life and Times, by Ronald W. Clarke. New York: The World Publishing Co., 1971. xv + 719, with index.

This is a convenient reference for one seeking a year-to-year chronology of the events, great and small, in Einstein's life.

Albert Einstein; the Human Side: New Glimpses from his Archives, translated and edited by Banesh Hoffmann and Helen Dukas. Princeton Univ. Press, 1979. 167 pp.

Contains many hitherto unpublished letters that Einstein, in reply to everyday people, wrote with no thought of publication in mind. They illuminate the wider outlooks and concerns of Einstein, the man.

Albert Einstein, Creator and Rebel, by Banesh Hoffmann with the collaboration of Helen Dukas. New York: Viking, 1972. xv + 272, with index.

This is a brief biography by one who worked with him as an assistant in 1936 and 1937, who understands and describes Einstein's achievements in clear, simple terms.

Einstein, His Life and Times, by Philipp Frank, translated from a German manuscript by George Rosen, edited and revised by Shuichi Kusaka. New York: Alfred Knopf, 1947. xxiii + 298, with index.

This is written by one who knew Einstein well, in 1912 became Einstein's successor as professor of theoretical physics at the University of Prague, and kept contact after he became professor of physics at Harvard University in 1940.

Albert Einstein: Philosopher-Scientist, edited by Paul Arthur Schilpp. Evanston, Ill.: Library of Living Philosophers, 1949. xvi + 781, with index, subsequently made available in a paperback edition by Schilpp.

This book begins with "Autobiographical Notes" by Einstein himself in facing pages of English and German. It tells much about the motivations of childhood and youth, as well as later years. It contains commentaries on Einstein's work by such colleagues as Arnold Sommerfeld, Louis de Broglie, H. P. Robertson, Wolfgang Pauli, Max Born, Max von Laue and Kurt Godel. Niels Bohr's contribution, "Discussion with Einstein on Epistemological Problems in Atomic Physics," is a so far unrivaled account not only of the great dialogue, but also of the role of measurement in quantum mechanics. More on the dialogue will be found in *The Philosophy of Quantum Mechanics* by Max Jammer (John Wiley, New York, 1974, xii + 536), especially chapter 5, "The Bohr-Einstein Debate."

Einstein, by Jeremy Bernstein, edited by Frank Kermode. New York: Viking, 1973. xii + 241. Appeared originally in the pages of *The New Yorker*.

Albert Einstein, by Carl Seelig. München, Germany: Europa Verlag, 1960. 446 pp.

Described by Thomas Mann, Einstein's Princeton neighbor during World War II, as "an important contribution to the biography of a world genius on whose shadowy [tastende] beginning he throws new light."

Einstein—Letters à Maurice Solovine. Paris: Gauthier-Villars, 1956. 140 pp.

Maurice Solovine was a close friend of Einstein in his early scientific life.

Letters on Wave Mechanics: Schrödinger, Planck, Einstein, Lorentz, edited by K. Przibram, translation and introduction by Martin J. Klein. New York: Philosophical Library, 1967. xv + 75.

Contains, on pages 23–40, the Einstein-Schrödinger correspondence dealing with the issues raised by quantum mechanics about the nature of "reality."

Einstein to Ehrenfest Postcards, sent over the years 1915 to 1933 to Einstein's closest scientific colleague, and given by Mrs. Ehrenfest to John Archibald Wheeler, September, 1956, and deposited by him in the Einstein Archives like many other Einstein writings, to wait for the definitive publication of his works to see the light of day.

Albert Einstein—Arnold Sommerfeld Briefwechsel, von Armin Hermann herausgegeben und kommentiert. Basel, Germany: Schwabe, 1978. 126 pp.

Correspondence (1912 to 1949) between two outstanding, but very different physicists, beginning with relativity, but then turning to quantum theory and mirroring the physics of the times.

Albert Einstein—Hedwig und Max Born, Briefwechsel, 1916–1955, kommentiert von Max Born, Geleitwort von Bertrand Russell, Vorwort von Werner Heisenberg. München: Nymphenburger Verlagshandlung, 1969, 330 pages; translated by Irene Born as *The Born-Einstein Letters: the Correspondence Between Albert Einstein and Max and Hedwig Born, 1916–1955*, (New York: Walker, 1971, xi + 240).

Deals with issues human as well as scientific. C. P. Snow remarked of this book in the *Financial Times* of London, "nothing I have said ought to prevent anyone, however illiterate scientifically, from getting hold of these Born-Einstein letters . . . . there is nothing quite like this correspondence of theirs."