# SAMPLE

## Famous Astronomers: Albert Einstein

Relativity and the Nature of Time

Aira Astralis

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Conclusion

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# Introduction

Albert Einstein was born in Ulm, in the German kingdom of Wurttemberg, on 14 March 1879, and died in Princeton, New Jersey, on 18 April 1955. In the seventy six years between those dates he remade the physicist's picture of space, time, light, gravity, and matter, and he did the largest part of the remaking in a single year, 1905, while working a day job as a patent examiner in Bern, Switzerland. His name became the public's shorthand for genius itself, an honor no scientist before him had quite carried, and his face, the wild white hair and the sad wise eyes, became the most reproduced portrait of a scientist in the history of the medium.

This book tells his life in the pattern the series uses: the events first, then the ideas, then the tests, then the legacy. The events are a story with an unusual shape, because the career splits cleanly into three movements. The first movement is the rise: the restless student, the unemployable graduate, the patent office, and the astonishing four papers of 1905, which taken together opened quantum theory, proved atoms exist, and replaced Newton's space and time. The second act is the triumph: the long construction of general relativity, finished in Berlin in November 1915, and the confirmation by the eclipse of 1919, which made him world famous in a matter of weeks. The third act is the long twilight in Princeton: the flight from Hitler's Germany, the letter to Roosevelt that helped begin the American atomic project, the two great unfinished arguments, against the randomness of quantum mechanics and for a unified theory of everything, and the death with the unfinished equations still on the nightstand.

The ideas deserve their own telling, because they are not difficult in the way legend says, only unfamiliar. Special relativity is the claim that light's speed is the same for every observer and that everything else, length, time, and simultaneity, bends around that fact. General relativity is the claim that gravity is not a force pulling across space but the shape of space itself, curved by the matter it contains. The photoelectric paper is the claim that light arrives in grains, and it seeded the quantum revolution he would later resist. The equivalence of mass and energy, the famous formula, is the claim that matter is congealed energy, a sentence about the physical world that the century's weapons and reactors both proved.

The tests are the reason this is a biography of a scientist rather than a philosopher. Every major claim he made about light, motion, and gravity has been checked, most of them many times over and to fantastic precision, and every check has come back in his favor: the bending of starlight, the advance of Mercury's orbit, the slowing of clocks, the precession of orbiting gyroscopes,

the chirp of colliding black holes recorded a century after his death. The predictions that failed were the ones he wanted most, the static universe held up by his cosmological constant and the unified field theory of his last thirty years, and the honest biography keeps the failures in the ledger beside the triumphs, because he kept them there himself.

He was also a man of the world in a way physicists before him had not been: a pacifist who signed the letter that helped build the atomic bomb and spent his last decade calling for its abolition, a Jew who became the most famous refugee from Nazi persecution and was offered the presidency of Israel, a Swiss citizen who became a German one and then an American one, each time as history pushed him. The chapters that follow keep that life and that work together, on the principle that the series holds for every subject: the science is the discovery, but the person is the story, and Einstein's person, stubborn, funny, musical, generous, and dissatisfied, is as much the subject of this book as his field equations are.

A word on sources is owed before the events begin, because the paper trail here is unusually deep. The Collected Papers of Albert Einstein, the scholarly edition begun in the 1980s, publishes his notebooks, letters, lecture notes, and manuscripts volume by volume, and the volumes for the early years have let historians trace the miracle year's papers to the reading he did in Bern and to the notebooks he filled in Aarau, so that the story told in this chapter is documented to a degree few scientific careers before the twentieth century can match. The letters to Mileva Maric, the correspondence with Marcel Grossmann, the diary of the Italian interlude, and the patent office's own records have all survived, and the biography that follows draws on the record rather than the legend wherever the two disagree, which is often.

The patent office chapter of the story deserves a fuller telling, because the legend compresses it and the years there were the making of everything after. He sat for the examination in 1902, placed second on the list, and was hired in June to examine applications in the electromagnetic field, the very subject of his dissatisfactions; the work's discipline, deciding quickly whether an invention's claims were coherent, trained exactly the muscle his papers would use, the separation of what a claim assumes from what it states; and the office's senior examiner, Friedrich Haller, who ran the room on the principle that the examiner must imagine the inventor's device whole in his head, appears in Einstein's later tributes as the best practical teacher he had.

The salary was modest and the security was total, and the years there, 1902 to 1909, saw the marriage, the children, the miracle year, the doctoral degree, the correspondence with the physicists who were reading him, and the

beginnings of the gravity work, all before the universities would give him a chair; the biography's fair reading is that the office was not a detour from the career but its greenhouse, and the legend's clerk who did physics in the margins is, if anything, an understatement of the arrangement's health.

# Chapter 1: The Discovery of Albert Einstein

The discovery, in the sense this series means it, was not a single event. No telescope found him; no expedition tracked him down. The discovery of Albert Einstein happened when the community of physics, slowly and then very suddenly, realized that a clerk in the Swiss patent office had quietly rebuilt its foundations, and the moment of general recognition, in November 1919, was as close to a worldwide lightning strike as science has ever produced.

The child behind all of it was born to Hermann Einstein and Pauline Koch, a secular Jewish couple of modest means and genuine culture, in an apartment in Ulm on 14 March 1879. The family moved to Munich the following year, and there Hermann and his brother Jakob opened an electrical workshop, later a factory, that made dynamos and lighting equipment. The business gave the boy an early intimacy with electricity and magnetism, the century's newest toys, though the firm itself never flourished for long in any one city.

Two stories from those Munich years became the famous ones, and both happen to be true. He was slow to speak, so slow that the family consulted a doctor, and when he finally talked he had the habit, which he kept for life, of saying his sentences to himself before saying them aloud. And at around five, sick in bed, he was given a compass, and the needle's obedience to an invisible field struck him as the first great mystery of his life: something deeply hidden had to be behind things, he said later, and the compass was where he first felt it. The hidden, once felt, never let him go.

School did not agree with him and he did not agree with school. The Munich gymnasium's drill and rote sat badly on a mind that wanted to follow its own lines, and though he excelled at mathematics his teachers found him insubordinate, one of them famously, and probably apocryphally, assuring him he would never amount to anything. The escape came through the family's finances rather than his own rebellions: in 1894 the Einstein firm lost a bid to light the city of Munich, the factory was sold, and the family moved to Italy, first Milan, then Pavia, leaving the fifteen year old behind in Munich to finish school alone.

He lasted less than a year. In the spring of 1895 he obtained a doctor's note releasing him from the gymnasium, joined his family in Italy, and announced, at sixteen, that he would sit the entrance examination for the Swiss Federal

Polytechnic in Zurich two years early. He took the exam in the autumn of that year and failed it, not in mathematics and physics, where he scored brilliantly, but in the general subjects, languages, history, literature, botany, zoology, that the German gymnasium had not yet ground into him. The principal of the

Zurich school, impressed anyway, advised a year in the cantonal school at Aarau, a teaching culture built on Pestalozzi's ideals of independent thought, and the year at Aarau was one of the happiest of his schooling and produced his first thought about light: what would a beam of light look like if you rode along beside it at the beam's own speed? The question, which the young physics he was taught could not answer, took him ten years to resolve.

The polytechnic took him in 1896, and he spent four unimpressed years there.

He studied what interested him, skipped what did not, borrowed the lecture notes of his classmate Marcel Grossmann to pass examinations he disdained, and fell in love with the only other physics student in his year, a Serbian named Mileva Maric, a soulmate of ideas at a time when few families welcomed the match. He graduated in 1900 with a teaching diploma and a reputation, among his professors, for arrogance. The universities would not have him. For two years he drifted on temporary teaching posts while the friends of Grossmann's father quietly arranged the rescue: in June 1902 the Swiss patent office in Bern took him on as a technical examiner, third class, at a salary of 3,500 francs a year.

He called the patent office his worldly cloister and meant it as praise. The work was steady, honest, and finite, judging the correctness of electromagnetic patents for a morning's six hours, and it left his evenings and his Sundays his own. Around a table at the Odeon cafe, with a circle of friends he grandly called the Olympia Academy, he read philosophers and argued physics over coffee and sausage, and out of that reading, Mach and Hume and Poincare among them, came the habit of doubting the things nobody doubted: absolute time, absolute space, the simultaneity of distant events.

In 1903 he married Maric, over both families' objections, and their first child, a daughter born before the marriage, vanished into the historical record with a cruelness the biographers have never repaired: born in 1902, mentioned in letters, never mentioned again. A son, Hans Albert, arrived in 1904. The young family was poor, the office work was full time, and none of it showed in what came next, which is the closest thing the history of physics has to a miracle in a small calendar. In the year 1905, from a cramped Bern flat and a patent desk, a twenty six year old examiner with no academic post, no laboratory, and no students published the papers that remade physics: March brought the light quantum and the photoelectric effect, April and May brought a new way of counting atoms from Brownian motion, June brought special relativity, and

September brought the consequence that the world knows as the equivalence of mass and energy.

The miracle year's papers took years to be absorbed, and the offices that should have claimed him were slow to move. The University of Bern gave him a lecturer's post, unpaid, in 1907; he became a professor at Zurich in 1909, at Prague in 1911, back at the polytechnic in 1912; and through those years, while the world of physics was still digesting 1905, he was already at work on the much harder problem, gravity, which would become general relativity and is the subject of the chapters ahead. The discovery of Einstein by the world came later still, in 1919, when an eclipse, an English expedition, and a headline in London all happened at once; that part of the story belongs to the chapter on his theory's first test.

A note on notation, offered because the reader will meet the formula in several places ahead. The equivalence of mass and energy is written with three symbols, and the middle one is a speed: the energy in a body, at rest, equals its mass multiplied by that speed twice over. The speed in question is light's, three hundred thousand kilometers a second in round figures, and multiplying by it twice is what makes the number so ferocious, since the arithmetic squares an already enormous quantity. A thimble of water, fully converted, would run a large city for a week; the Sun performs the conversion on four million tons of itself every second, which is the burning the nineteenth century could not explain and the twentieth could.

The formula's fame has outgrown its context, and the context is the fairer reading: it was an afterthought to special relativity, a small paper of three pages in the autumn of 1905, whose point was deeper than its arithmetic, that mass is not a thing beside energy but a measure of it.

One idea from the margins of his work belongs in this chapter's set, because it has grown since he wrote it and shows his nose for the important. In 1917, in the cosmology paper, he also introduced the first modern treatment of a universe governed by dynamics, and the cosmology seeded the modern discipline the earlier chapters have named; but the margins entry is the stimulated emission paper's twin contribution, the recognition that the quantum description of a gas of photons would need a statistics of its own, which the Bose work of 1924 completed. The margins entry matters because it shows the method: wherever a question stood at the edge of what the theory could describe, he walked into the edge and marked it, and the marking is why so much of the modern subject is built on his footprints, at the borders he drew.

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# ABOUT THE AUTHOR

Aira Astralis is a science writer specializing in astronomy and space exploration. Her work spans the full breadth of humanity's relationship with the cosmos -- from the earliest naked-eye observations to the engineering marvels of modern space missions.

Her books are built on a foundation of primary sources: peer-reviewed research, mission archives, and direct engagement with the scientific community. She writes for readers who want to understand not just what we know about the universe, but how we came to know it.

She believes that the most important frontier is not out there but in the gap between what scientists discover and what the public understands. Her books exist to close that gap.