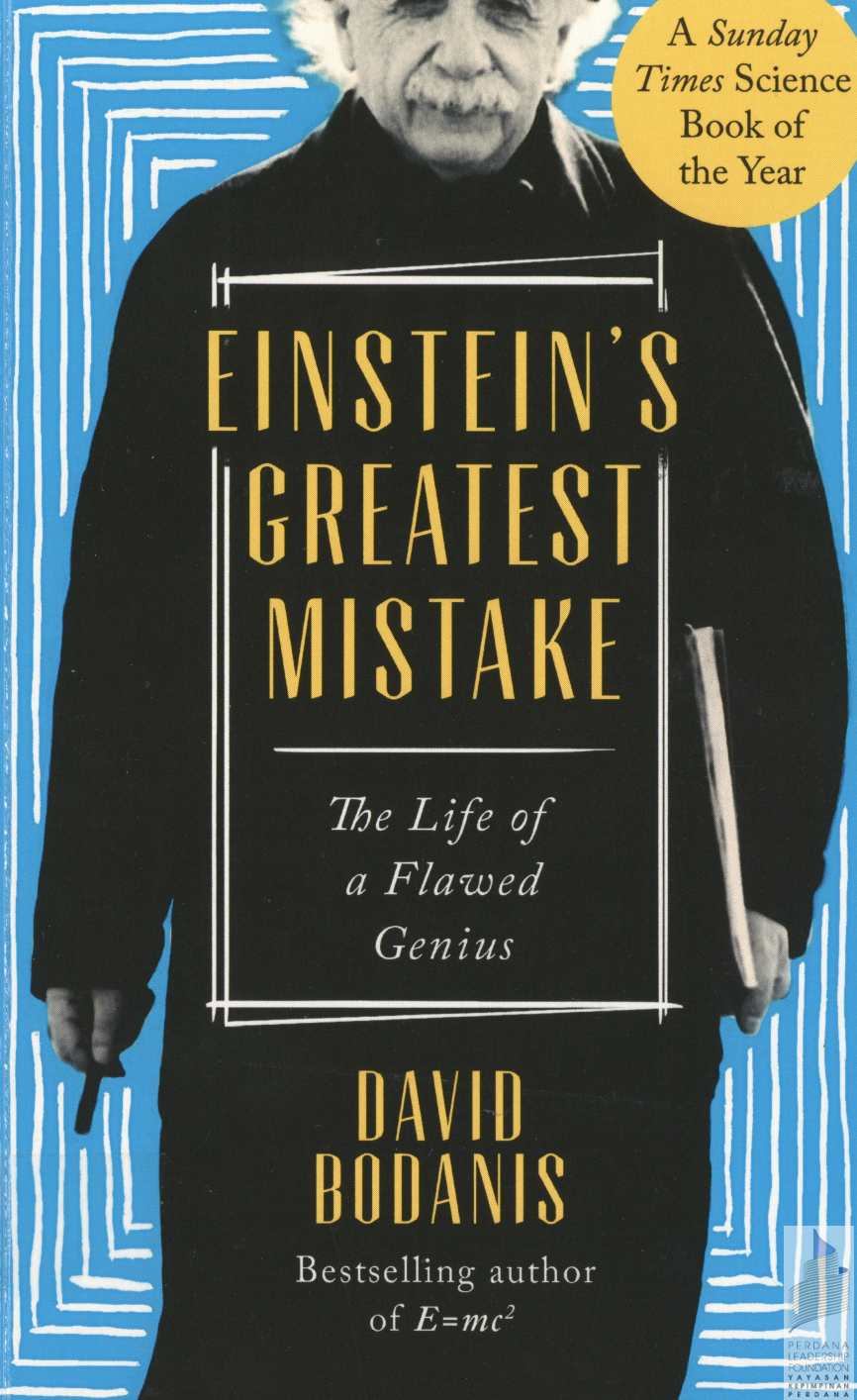

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David Bodanis taught for many years at Oxford University and has written numerous books, including $E=mc^2$, an international bestseller that was translated into two dozen languages and long-listed for the Samuel Johnson Prize. He lives in London.

'Bodanis is a lot like Einstein . . . Both see the fun in physics, both love simplicity and brevity' *The Times*

'A sympathetic appraisal of Einstein's intellectual development' *Nature*

'Like Einstein, he finds fun in physics and understands how to communicate its mystery' *The Times*

Also by David Bodanis

$E=mc^2$: A Biography of the World's Most Famous Equation
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EINSTEIN'S GREATEST MISTAKE

The Life of a Flawed Genius

DAVID BODANIS

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First published in Great Britain in 2016 by Little, Brown
This paperback edition published in 2017 by Abacus

5 7 9 10 8 6 4

A CIP catalogue record for this book
is available from the British Library.

ISBN 978-0-349-14202-9

Printed and bound in Great Britain by
Clays Ltd, Elcograf S.p.A.

Papers used by Abacus are from well-managed forests
and other responsible sources.

Abacus
An imprint of
Little, Brown Book Group
Carmelite House
50 Victoria Embankment
London EC4Y 0DZ

An Hachette UK Company
www.hachette.co.uk

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To my son, Sam

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Einstein walking home in Princeton, 1953

Prologue

PRINCETON, 1953. The tourists generally stayed on the sidewalk across the street from the white clapboard house on Mercer Street. But it was hard to keep down their excitement once they spotted the old man walking slowly back from the university campus, often wearing a long cloth coat and—if the New Jersey wind was especially sharp—a dark knit cap over his famous unruly hair.

The bravest tourists sometimes crossed over to say how much they admired him or to ask for his autograph. Most were tongue-tied or too awed to speak, and kept a respectful distance. For this old man was Albert Einstein, the greatest genius of all time, just yards away from them, his wise, wrinkled face suggesting he'd achieved insights deeper than other humans possibly could.

Einstein was the most famous scientist alive, but despite his celebrity he usually walked alone, or occasionally with one old friend. Although he was feted in public, and still constantly invited to white-tie dinners and even movie openings—Hollywood stars were especially excited to be photographed beside him—working scientists had little to do with him, nor had they for many years.

It wasn't his age that made them treat him this way. The great Danish physicist Niels Bohr was sixty-eight years old to Einstein's seventy-four, but Bohr remained so open to new ideas that bright doctoral students liked nothing more than spending time with him at his intellectually sparkling institute in Copenhagen. Einstein, however, had been isolated from mainstream research for decades. There was polite applause, of course, on the few occasions when he gave a seminar at the Institute for Advanced Study, in its forbidding plot on the edge of the Princeton campus, but it was the applause

one might give an elderly soldier being wheeled out onto a stage. Einstein's peers regarded him as a has-been. Even many of his closest friends no longer took his ideas seriously.

Einstein could sense his isolation. At one time, his house would have been full of colleagues, youthful energy, the buzz of conversation. But lately it had become quiet. His second wife, the ever plumper and ever chattier Elsa, had passed away several years before, as had his beloved younger sister, Maja.

His sister's death especially pained Einstein. Maja and Albert had been constant companions as children back in 1880s Munich, teasing each other and building card castles. If a particularly elaborate castle collapsed in a gust of air, she remembered, her brother would doggedly start building it back up again. "I might not be more skilled than other scientists," he liked to say, "but I have the persistence of a mule."

Einstein had retained his youthful stubbornness, but his health wasn't what it had been. His main room, where he had his books and papers, was upstairs in his Princeton home, down the hall from the bedroom that had been Maja's. At his age, Einstein could climb the stairs only slowly, pausing for breath. But maybe it didn't matter. When he did settle in his study, he would have all the time in the world.

He was the greatest mind of the modern age. How had he ended up so alone?

WARTIME BERLIN, 1915. Einstein had just created a magnificent equation—not his famous $E=mc^2$ that had come ten years earlier, in 1905, but something even more powerful: the equation at the heart of what is called general relativity. It is one of the finest achievements of all time, as great as the works of Bach or Shakespeare. Einstein's 1915 equation had just two central terms, yet it would reveal unimagined features of space and time, explaining why black holes exist, showing how the universe began and how it will likely end, and even laying the foundation for revolutionary

technologies such as GPS navigation. Einstein was overwhelmed by what he had discovered. "My boldest dreams have now come true," he wrote to his best friend that year.

But his dreams were soon interrupted. Two years on, in 1917, he realized that astronomical evidence about the shape of the universe seemed to contradict his general theory of relativity. Unable to account for the discrepancy, he dutifully modified his new equation, putting in an additional term that destroyed its simplicity.

As it turned out, the compromise was only temporary. Some years later, fresh evidence proved that his original and beautiful idea had been correct, and Einstein reinstated his original equation. He called his temporary modification "the greatest blunder of my life," for it had destroyed the beauty of his original, simple 1915 equation. Yet while that modification had been Einstein's first big mistake, his greatest error was still to come.

Einstein felt that he had been wrong to follow such faulty experimental evidence—that he should have simply held his nerve till the astronomers realized they had been mistaken. But from that he drew the additional conclusion that in the most important matters, he never had to follow experimental evidence again. When his critics tried to bring in evidence against his later beliefs, he ignored them, confident that he would be vindicated again.

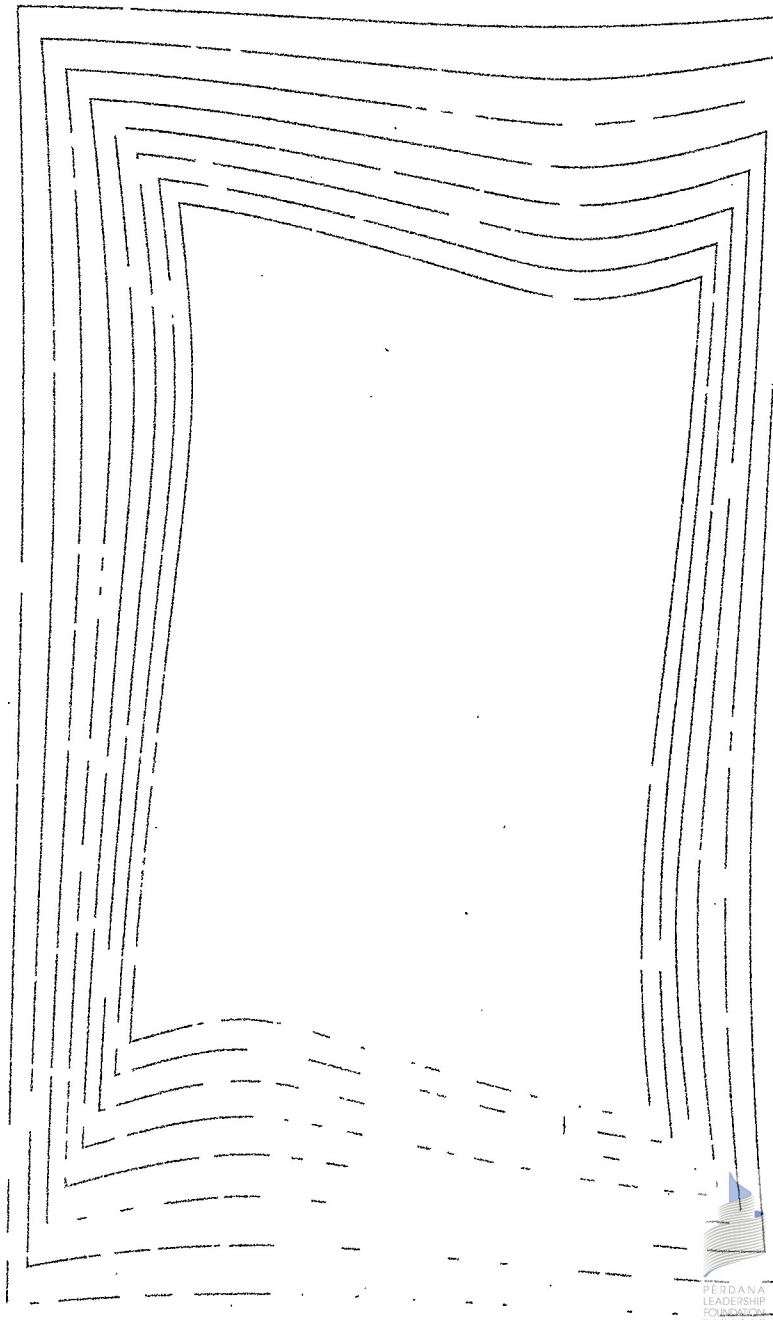
This was a very human response, but it had catastrophic implications. It undermined more and more of what Einstein tried next, especially in the burgeoning study of the ultrasmall, of quantum mechanics. Friends such as Niels Bohr begged him to see reason. They knew that Einstein's exceptional intellect could transform the world yet again, if he only would let himself accept the new findings—valid ones—that a fresh generation of experimentalists were uncovering. But this Einstein could not do.

He had a few private moments of doubt but suppressed them. In his theory of 1915, he had revealed the underlying structure of our universe, and he had been right when everyone else had been wrong. He wasn't going to be misled again.

That conviction is what isolated him from the new generation's exciting work in quantum mechanics and destroyed his reputation among serious scientists; that is what left him so alone in his Mercer Street study.

How that happened—how genius reaches its peak and how it fades; how we deal with failure and with aging; how we lose the habit of trust and whether we can get it back—are the topics of this book. So, too, are Einstein's ideas themselves—right and wrong—and the steps by which he arrived at them. In that sense, this is a double biography: it's the story of a fallible genius, but also the story of his mistakes—how they began, grew, and locked in so deeply that even a man as wise as Einstein was unable to work himself free.

Genius and hubris, triumph and failure, can be inextricable. Einstein's 1915 equation, and the theory it undergirded, was perhaps the greatest feat of his life, yet it also sowed the seeds for his most astonishing failure. And to understand what Einstein did achieve in 1915, and how he went wrong, it's necessary to go even further back in time—to Einstein's earliest years, and the mysteries that intrigued him even then.



Part I

ORIGINS OF GENIUS

Einstein at university, around 1900

ONE

Victorian Childhood

TWO GREAT CONCEPTS dominated European science in 1879, the year of Einstein's birth, and they would provide the context for much of his greatest work. The first was the recognition that the forces that made the world's great industrial civilization function—the firing of coal in huge steam trains; the explosion of gunpowder in the warship turrets that kept subjugated peoples under control; even the faint pulses of electricity in the undersea cables that carried telegraphic messages around the world—were all but different manifestations of one fundamental entity, called energy. This was one of the central scientific ideas of the Victorian era.

Late Victorian scientists knew that energy behaves according to certain immutable principles. Miners could hack coal out of the ground, and technicians could feed gases from baking that coal into pressurized tubes that powered the streetlamps of London. But if something went wrong and the gas exploded, the energy of the resulting explosion—the energy of the flying shards of glass, plus the acoustic energy in the booming air and even any potential energy in errant fragments of metal from a streetlamp flung onto the rooftops nearby—would be exactly the same as the energy inherent in the gas itself. And if one fragment of streetlamp metal then fell to

the pavement, the sound and energy of it hitting the ground, plus the energy of the gusts of wind as the fragment plummeted, would be exactly equal to the energy that had lifted it up in the first place.

The realization that energy cannot be created or destroyed, only transformed, seemed simple, but it contained extraordinary implications. When, for instance, one of Queen Victoria's servants opened the door of her carriage as it arrived at Buckingham Palace in central London, the energy that had been in his shoulder began to leave it . . . while exactly the same amount of energy appeared in the swinging motion of the ornate carriage door and the ever so slightly raised temperature of the friction-grinding hinge on which it turned. When the monarch stepped down to the ground, the kinetic energy that had existed in her descending form was transferred to the earth beneath her feet, leaving her stationary, but making our planet tremble in its orbit around the sun.

All types of energy are connected; all types of energy are neatly balanced. This simple truth became known as the law of the conservation of energy and was widely accepted by the mid-nineteenth century. Victorian confidence in religion had been bruised when Charles Darwin showed that a traditional God wasn't needed to create the living species on our planet. But this vision of an unchanging total energy was a consoling alternative. The way energy was so magically balanced seemed to be proof that some divine hand had touched our world and was still active among us.

By the time energy conservation was understood, Europe's scientists were well acquainted with the second great idea that dominated nineteenth-century physics: matter never entirely disappears either. In the Great Fire of London back in 1666, for example, Europe's largest city had been attacked by flames exploding from the tar and wood of the bakery where it began; roaring from one wooden housetop to another; pouring out vast volumes of acrid smoke; turning homes, offices, stables, and even plague-carrying rats into hot ash.

No one in the 1600s could have seen that as anything more than

rampant chaos, but by 1800, a century before Einstein, scientists realized that if someone had been able to weigh absolutely everything in London before the flames began—all the wooden floorboards in all the houses; all the bricks and furnishings; all the beer kegs and even the scurrying rats—and then, with an even greater effort, had been able to measure all the smoke and ash and crumbling brick produced by the fire, it would come out that the weight of the two was, precisely, the same.

This principle became known as the conservation of matter and had been getting ever clearer from the late eighteenth century. Different terms have been used for this idea at different times, but the gist has always been the same: Burn wood in a fireplace, and you'll end up with ashes and smoke. But if you were somehow able to put a huge impermeable bag over the chimney and any drafty windows, and then you could measure all the smoke you captured plus all the ash—and take into account the oxygen pulled in from the air during the burning—you would find that the total weight was again exactly, precisely, the same as the weight of the firewood. Matter can change shape, turning from wood into ash, but in our universe it will never, ever disappear.

Those two ideas—the conservation of matter and the conservation of energy—would be central to the education and spectacular achievements of the young Einstein.

WHEN EINSTEIN HAD BEEN BORN, in 1879, in the German city of Ulm, some seventy-five miles from Munich, his family was just a few generations removed from the life of the medieval Jewish ghetto. To many Christian Germans of the nineteenth century, the Jews in their midst were strange, possibly subhuman, interlopers. To the Jews, however, virtually all of whom were Orthodox, it was the world outside their community that was threatening and disturbing, and never more so than when Christianity itself began to weaken, for that lowered the boundaries between the two religions. This let ideas of the eighteenth-century Enlightenment—

'With delightful simplicity, Bodanis distils the great man into a compound consisting of "genius and hubris, triumph and failure" . . . Bodanis is a lot like Einstein – minus the great mistake. Both see fun in physics, both love simplicity and brevity. In this book, theories of the universe morph into theories of life. Bodanis shows "how genius reaches its peak and how it fades; how we deal with failure and with ageing; how we lose the habit of trust"'

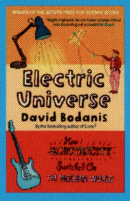
The Times

Widely considered the greatest genius of all time, Albert Einstein revolutionised our understanding of the cosmos and helped to lead us into the atomic age. Yet in the final decades of his life he was also ignored by most working scientists, his ideas opposed by even his closest friends.

An intimate and enlightening biography of the celebrated physicist, *Einstein's Greatest Mistake* reveals how much we owe Einstein today – and how much more he might have achieved if not for his all-too-human flaws.

'This perceptive biography shows how a genius fell out of favour with the scientific world'

Sunday Times



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Cover photograph: Camera Press Design: Jack Smyth – LBBG