Introduction

Mathematical Poetry

*Poetry is simply the most beautiful, impressive, and widely effective mode of saying things.*

MATTHEW ARNOLD

Mathematics is a language whose importance I can best explain by starting with a familiar story from the Bible. There was a time, according to the Old Testament, when all the people of the earth spoke in a single tongue. This unified them and facilitated cooperation to such a degree that they undertook a collective project to do the seemingly impossible: They would build a *tower* in the city of Babel that was so high, they could simply climb their way into heaven.

It was an unpardonable act of *hubris*, and God was quick to visit his wrath on the *blithe* sinners. He spared their lives, but not their language: As described in Genesis 11:7, in order to *scuttle* the *blasphemers'* enterprise, all God needed to do was "*confound* their language, that they may not understand one another's speech." Thousands of years later, we are still babbling. According to linguists, there are about 1,500 different languages spoken in the world today. And while no one would suggest that this multiplicity of tongues is the only reason for there being so little unity in the world, it certainly interferes with there being more cooperation.

Nothing reminds us of that inconvenient reality more so than the United Nations. Back in the early 1940s, when it was first being organized, officials proposed that all diplomats be required to speak a single language, a restriction that would both *facilitate* negotiations and symbolize global harmony. But member nations objected — each *loath* to surrender its *linguistic* identity — so a compromise was struck; United Nations ambassadors are now allowed to speak
any one of five languages: Mandarin Chinese, English, Russian, Spanish, or French.

Over the years, there have been no fewer than 300 attempts to invent and promulgate a global language, the most famous being made in 1887 by the Polish oculist L. L. Zamenhof. The artificial language he created is called Esperanto, and today it is spoken by more than 100,000 people in twenty-two countries.

However, as measured by the millions of those who speak it fluently and by the historic consequences of their unified efforts, mathematics is arguably the most successful global language ever spoken. Though it has not enabled us to build a Tower of Babel, it has made possible achievements that once seemed no less impossible: electricity, airplanes, the nuclear bomb, landing a man on the moon, and understanding the nature of life and death. The discovery of the equations that led ultimately to these earthshaking accomplishments are the subject of this book.

In the language of mathematics, equations are like poetry: They state truths with a unique precision, convey volumes of information in rather brief terms, and often are difficult for the uninitiated to comprehend. And just as conventional poetry helps us to see deep within ourselves, mathematical poetry helps us to see far beyond ourselves — if not all the way up to heaven, then at least out to the brink of the visible universe.

In attempting to distinguish between prose and poetry, Robert Frost once suggested that a poem, by definition, is a pithy form of expression that can never be accurately translated. The same can be said about mathematics: It is impossible to understand the true meaning of an equation, or to appreciate its beauty, unless it is read in the delightfully quirky language in which it was penned. That is precisely why I have written this book.

This is not so much an offspring of my last book, Bridges to Infinity: The Human Side of Mathematics, as it is its evolutionary descendant. I wrote Bridges with the intention of giving readers a sense of how mathematicians think and what they think about. I also attempted to describe the language—the numbers, symbols, and logic—that mathematicians use to express themselves. And I did it all without subjecting the reader to a single equation.

It was like sweet-tasting medicine offered to all those who are afflicted with math anxiety, individuals who normally would not have the courage or the curiosity to buy a book on a subject that has consistently frightened them away. In short, Bridges to Infinity was a dose of mathematical literacy designed to go down easily.

Now, emboldened by having -written a successful book that contains no equations, I have dared to go that one step further. In
this book I describe the mathematical origins of certain landmark achievements, equations whose aftereffects have permanently altered our everyday lives.

One might say I am offering the public a stronger dose of numeracy, an opportunity to become comfortably acquainted with five remarkable formulas in their original, undisguised forms. Readers will be able to comprehend or themselves the meaning of the equations, and not just settle for an inevitably imperfect non-mathematical translation of them.

Readers of this book also will discover the way in which each equation was derived. Why is that so important? Because, to paraphrase Robert Louis Stevenson: When traveling to some exotic destination, getting there is half the fun.

I hope that the innumerate browser will not be scared off by I zealously of my effort. Rest assured, though these five equations look abstract, most certainly their consequences are not—and neither are the people associated with them: a sickly, love-starved loner; emotionally abused prodigy from a dysfunctional family; a religious, poverty-stricken illiterate; a soft-spoken widower living I perilous times; and a smart-alecky, high school dropout.

Each story is told in five parts. The Prologue recounts some dramatic incident in the main character’s life that helps set the tone for what is to follow. Then come three acts, which I refer to as Veni, Vidi, Vici. These are Latin words for “I came, I saw, I conquered,” a statement Caesar reportedly made after vanquishing the Asian king Pharnaces. Veni is where I explain how the main character—the scientist—comes to his mysterious subject; Vidi explains historically how that subject came to appear so enigmatic; Vici explains how the scientist manages to conquer the mystery, resulting in a historic equation. Finally, the Epilogue describes how that equation goes on to reshape our lives forever.

In preparing to write this book, I selected five equations from among dozens of serious contenders, solely for the degree to which they ultimately changed our world. Now, however, I see that the stories attached to them combine fortuitously to give the reader a rather seamless chronicle of science and society from the seventeenth century to the present.

As it turns out, that is a crucial period in history. Scientifically, it ranges from the beginning of the so-called Scientific Revolution through the Ages of Reason, Enlightenment, Ideology, and Analysis, during which science demystified each one of the five ancient elements: Earth, Water, Fire, Air, and Ether.

In that critical period of time, furthermore, we see: God being
forever banished from science, science replacing astrology as our principal way of predicting the future, science becoming a paying profession, and science grappling with the ultra-mysterious issues of life and death and of space and time.

In these five stories, from the time when an introspective young Isaac Newton sits serenely beneath a fruit tree to when an inguissitive young Albert Einstein nearly kills himself scaling the Swiss Alps, we see science wending its way from the famous apple to the infamous A-bomb. Which is to say, we see science going from being a source of light and hope to its also becoming a source of darkness and dread.

Writers before me have chronicled the lives of some of these five scientists—all too often in frightfully long biographies. And writers before me have reconstructed the pedigree of some of these intellectual innovations back to the beginning of recorded history. But they have never focused their roving attentions on the small number of mathematical equations that have influenced our existence in such profound and intimate ways.

The exception is Albert Einstein's famous energy equation \( E = mc^2 \), which many people already know is somehow responsible for the nuclear bomb. But for all its notoriety, even this nefarious little equation remains in the minds of most people scarcely more than a mysterious icon, as familiar yet inexplicable as Procter & Gamble's corporate logo.

What exactly do the letters \( E, m, \) and \( c \) stand for? Why is the \( c \) squared? And what does it mean for the \( E \) to be equated with the \( m \times c^2 \)? The reader will learn the surprising answers in "Curiosity Killed the Lights."

The other chapters deal with scientists less well known than Einstein but who are no less important to the history of our civilization. "Between a Rock and a Hard Life," for example, concerns the Swiss physicist Daniel Bernoulli and his hydrodynamic equation \( P + p \times \frac{1}{2} v^2 = \text{CONSTANT} \), which led ultimately to the modern airplane. "Class Act" is about the British chemist Michael Faraday and his electromagnetic equation \( \Delta x E = \frac{-\delta B}{\delta t} \), which ultimately led to electricity.

"Apples and Oranges" tells the story of the British natural philosopher Isaac Newton and his gravitational equation \( F = G \frac{M}{d^2} \)—which led not to any specific invention but to an epic event: landing a man on the moon.

Finally, "An Unprofitable Experience" is about the mathematical physicist Rudolf Julius Emmanuel Clausius thermodynamic equation (or more accurately, his thermodynamic inequality) \( \Delta S_{\text{universe}} > 0 \). It led neither to a historic invention or event but to a
startling realization: Contrary to popular being alive is unnatural; in fact, all life exists in defiance of, conformity with, the most fundamental law of the universe.

In my last book, *Bridges to Infinity*, I suggested that the human imagination was actually a sixth sense used to comprehend truths that have always existed. Like stars in the firmament, these *verities* are out there somewhere just waiting for our extrasensory imagination to spot them. Furthermore, I proposed that the *mathematical* imagination was especially *prescient* at *discerning* these *incorporeal* truths, and I cited numerous examples as evidence.

In this book, too, readers will see dramatic *corroboration* for the theory that mathematics is an exceptionally super-sensitive see eye dog. Otherwise, how can we begin to account for the *unerring prowess* and tenacity with which these five mathematicians able to pick up the scent, as it were, and zero in on their respective equations?

While the equations represent the *discernment* of eternal universal truths, however, the manner in which they are written strictly, *provincially* human. That is what makes them so much like poems, wonderfully artful attempts to make infinite realities comprehensible to *finite* beings.

The scientists in this book, therefore, are not merely intellect *explorers*; they are extraordinary artists who have mastered the extensive vocabulary and complex grammar of the mathematical language. They are the Whitmans, Shakespeares, and Shelleys of the *quantitative* world. And their *legacy* is five of the greatest poems ever inspired by the human imagination.