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The Optimistic Science of Leibniz

Marc E. Bobro

The philosopher Gottfried Wilhelm Leibniz (1646–1716) is chiefly remembered today, when he is remembered at all, for two reasons. First, he invented the calculus—independently, most scholars now agree, of its other inventor Newton. And second, he authored the provocative statement that this world is "the best of all possible worlds." This claim was famously lampooned in Voltaire's 1759 satire *Candide*, in which the title character, "stunned, stupefied, despairing, bleeding, trembling, said to himself:—If this is the best of all possible worlds, what are the others like?" Leibniz's posthumous reputation, already marred by the accusation he had plagiarized Newton's calculus, never recovered from Voltaire's mockery. Even in his homeland of Germany, the name Leibniz is perhaps more widely known for a beloved butter cookie named after him than for the man himself.

Yet Leibniz is one of the most impressive figures in the history of modern science, mathematics, and philosophy. It seems impossible that one individual could accomplish all that he did. Leibniz worked unflaggingly at whatever task he set himself to, writing copiously on such diverse subjects as politics, theology, mathematics, and physics, and contributing with singular erudition to many other topics, such as chemistry, medicine, astronomy, geology, paleontology, optics, and philology. He was a historian, a poet, a legal theorist, a diplomat, a cryptographer, and a philosopher who thought it possible to reconcile theology with metaphysics and science. A preeminent man of letters, he was also a cosmopolitan writer of letters, exchanging about fifteen thousand of them with more than a thousand correspondents in French, German, and Latin. Physically, Leibniz may have been nothing special—in fact, he was hunched, bow-legged, and nearsighted—but his far-reaching intellect brought him into contact with scholars of the first rank, as well as statesmen, courtiers, and dignitaries around Europe.

The diversity of Leibniz's interests and undertakings is dizzying. How are we to make sense of a man who contributed prominently to so many fields, including both religion and science? In our day, it is common to

Marc E. Bobro *is an assistant professor of philosophy at Santa Barbara City College, and the author of* Self and Substance in Leibniz *(Kluwer, 2004).* *The publication of this essay is supported by a grant from the Religion and Innovation in Human Affairs Program (RIHA) of The Historical Society.*

think especially of religion and science as either pulling in opposing directions in their respective understandings of the world, or as parallel but different domains. How did they hang together for Leibniz?

One of the hallmarks of Leibniz's vast undertakings is that he strove to unify his kaleidoscopic interests into a single whole that deeply integrated faith and science, philosophy and politics, and shaped both his public and private life. This complex effort is difficult to summarize, but Maria Rosa Antognazza, author of an indispensable 2009 intellectual biography of Leibniz, captures its essence about as succinctly as possible when she describes Leibniz's project as an "all-encompassing, systematic plan of development of the whole encyclopaedia of the sciences, to be pursued as a collaborative enterprise publicly supported by an enlightened ruler," the final goal of which was "the improvement of the human condition and thereby the celebration of the glory of God in His creation." The motivating force of Leibniz's life's work was his optimism, which grew out of his philosophical and theological convictions. It is perhaps best understood as the optimism of a scientist who believed not only that science was going to *get* the truth but also that the truth was something worth getting for its practical and moral benefits.

A Life of Ideas and Projects

Gottfried Wilhelm Leibniz was born into an academic family in Leipzig, Saxony, in 1646, two years prior to the Peace of Westphalia that brought to an end the bloody Thirty Years' War. His father was a professor of moral philosophy. His mother was the daughter of a well-known jurist and professor of law, and, after the death of her parents and before her marriage, had been a member of two other academic households: that of a theology professor and then of a law professor.

Leibniz grew up in a conservative area surrounded by strict Lutherans, not only in his immediate and extended families but in Leipzig generally. Antognazza writes that the public practice of both Roman Catholicism and Calvinism was then outlawed in Saxony; even sympathy toward them was looked upon very suspiciously. Such parochialism and dogmatism later came to be a barrier for Leibniz, who, while never rejecting Lutheranism, preferred a much more ecumenical approach to religion, even trying to unify Calvinist and Lutheran denominations as well as Catholics, Protestants, and Greek Orthodox.

Leibniz's ecumenical thinking may have had its origins in his early education. His father died when Leibniz was only six, and at eight years of age he was given access to his father's library. Apart from the Greek and Latin classics, it most likely included books that ran counter to Lutheran theology and thus would normally have been kept from the eyes of a young Saxon. During the day, Leibniz received structured, formal education at one of Saxony's best Latin schools, and self-directed, unstructured education of his father's library in the evenings and weekends.

At fourteen, he enrolled at the University of Leipzig to study philosophy. "I was very young when I began to meditate," he would later write, "and I was not quite fifteen when I strolled for whole days in a grove to take sides between Aristotle and Democritus." Even then, Leibniz was nagged by the tension between the teleological account of nature inherited from Aristotle and engrained in academia, and the new mechanical physics, represented by Galileo and Descartes, that hearkened back to the ancient Greek atomist Democritus. Early in Leibniz's career, mechanism won out and led him to focus on mathematics, but, as we shall see, he later appropriated into his system something akin to the substantial forms of Aristotle.

For reasons not entirely known, Leibniz was denied the doctor's degree of law at Leipzig and left the city, never to live there again. After quickly finishing, defending, and publishing his dissertation at the University of Altdorf at age twenty, he turned down the offer of a professorship, presumably to pursue his independent work of reforming the sciences—a project involving far more than the academy.

Leibniz was highly productive in his early twenties: he served as secretary for the alchemical society of Nuremberg (although the details surrounding this position are unclear); he completed a work on a new method for teaching and learning jurisprudence, devised plans for a vast expansion of an encyclopedia, wrote a work of political science concerning the election of a king of Poland as well as several texts explicating the traditional doctrines of transubstantiation, the Incarnation, the Resurrection, the Trinity, and the soul's immortality. In order to advance his ideas on philosophy and the science of motion, he began a correspondence with the secretary of the Royal Society of London. He also made contact with the Royal Academy of Sciences in Paris; started to work on a calculating machine; concocted a scheme, the Egyptian plan, to persuade Louis XIV of France to mitigate his expansion into Holland and attack Egypt instead; and somehow also found time to serve as secretary, lawyer, librarian, and advisor for the prominent baron who was his patron and friend.

With his patron's assistance, Leibniz was invited to present his Egyptian plan in Paris in 1672. But when Leibniz arrived, England had already pronounced war on Holland, and France was not far behind. Rather than altering the proposal, Leibniz abandoned the project but remained in Paris, ultimately spending four fruitful years there. His acquaintance with and tutelage under the Dutch mathematician and scientist Christiaan Huygens (then in Paris heading the Academy of Sciences) proved to be of special importance; it was under Huygens's guidance that Leibniz visited London to present the Royal Society with a model of a calculating machine capable of addition, subtraction, multiplication, and division. Unfortunately, the machine did not work as well as promised and was not greeted with unanimous approval. Still, the trip to England was a useful one, because Leibniz was able to visit with the experimental chemist Robert Boyle and the mathematician John Pell who directed him to recent work in mathematics that preceded Leibniz's similar work on series of differences, anticipating his later invention of the calculus. Leibniz was also elected a fellow at the Royal Society of London in 1673. After returning to Paris, Leibniz redoubled his efforts in mathematics, studying the works of Pascal and Descartes and other mathematicians, and he refined his calculating machine and introduced his invention of a chronometer.

During his years based in Paris, Leibniz met with many leading European philosophers, theologians, and mathematicians. He desired to remain in Paris under similar conditions to those of Huygens—who was given living quarters and a lifelong pension under the auspices of the Academy of Sciences—but no invitation was extended, presumably because there was a feeling that too many foreigners were already in the Academy. (It was not until 1700 that Leibniz was elected a foreign member.) So it was with some trepidation that the thirty-year-old Leibniz accepted an offer of a post as librarian and court councilor at Hanover from Duke Johann Friedrich.

Hanover would become Leibniz's home for the rest of his life. As best he could, he continued his independent work while fulfilling the duties of his new position. But the duke's successor also tasked him with writing a history of the courtly family line, the Guelph family, a European dynasty reaching back at least six hundred years and with roots in Northern Italy. Always compulsively striving for completeness, Leibniz began with Charlemagne and the origins of the Holy Roman Empire in the eighth century, although even this starting point needed to be prefaced with two treatises, one on the geological history of the earth and of Lower Saxony, and one on the history of the province's inhabitants. The entire project occupied him for nearly thirty years, until the end of his life, by which time he still had not reached his intended endpoint. More than a decade into the project, he lamented in a letter to a friend:

> I cannot tell you how extraordinarily distracted and spread out I am. I am trying to find various things in the archives; I look at old papers and hunt up unpublished documents.... I receive and answer a huge number of letters. At the same time, I have so many mathematical results, philosophical thoughts, and other literary innovations that should not be left to disappear, that I often do not know where to begin.... Thanks to the help of a craftsman whom I have engaged, the calculator with which one can do multiplications up to twelve decimal places is finally ready. A year has gone by; I still have the craftsman with me in order to make more machines of this type, for they are in constant demand.

Fifteen years later, Leibniz wrote with similar regret: "If I were relieved of my historical tasks I would set myself to establishing the elements of general philosophy and natural theology, which comprise what is most important in that philosophy for both theory and practice."

To some extent, Leibniz resented being stuck in Hanover, a provincial city. As he wrote to an English acquaintance: "All that bothers me is that I am not in a great city like Paris or London, where there are plenty of learned men from whom one can benefit and even receive assistance. For many things cannot be accomplished on one's own. But here one scarcely finds anyone to talk to; or rather, in this country it is not regarded as appropriate for a courtier to speak of learned matters."

Still, even while engaged in his historical research, Leibniz managed to get much work done in philosophy, mathematics, and science. And he took advantage of opportunities to travel abroad, most notably on a three-year research trip (1687–1690) to Bavaria, Austria, and Italy. In Florence, he discussed mathematics with Galileo's last pupil, Vincenzo Viviani. Leibniz was especially welcomed in Rome. Besides being given access to the Vatican archives, he frequented the meetings of the Accademia Fisico-Matematica, urged for lifting the Vatican's ban on Copernican astronomy, and was offered the position of custodian of the Vatican library, which he might have accepted had it not come with the condition that he convert to Catholicism. In Vienna, Leibniz earned a hearing with the emperor, Leopold I, and conferred with a leading figure in the attempt to reunify Rome and the Protestant churches.

Leibniz's plans for an academy of sciences in his own country came to fruition in 1700, when, using the French Academy as a model, he founded the Berlin Society of Sciences, of which he was to become the first president. Founding such an institution was part of Leibniz's plan to move science out of the academy—the university setting—into the academies—groups of working scientists, many of whom were not employed by universities. However, for its first decade the academy was little more than a name, and once its efforts began in earnest, Leibniz's participation was minimized. (The organization was later called the Prussian Academy of Sciences; its successor in our own day is the Berlin-Brandenburg Academy of Sciences and Humanities.)

Perhaps partly due to his own declining health after the age of fifty, Leibniz proposed a number of improvements for medical practice, including blood and urine tests, transfusions, autopsies, animal experimentation, human experimentation (if it was not dangerous to the subject), study of the spread of disease, regular physical examination (including measurement of a patient's temperature), recording of data about the course of a patient's illness, recording and collecting of all observations to be shared with others, and the establishment of more medical schools—all these as part of a medical system to be supported by the government.

Contributing to each of the physical, life, formal, and applied sciences, Leibniz was truly a polymath. His development of the calculus is his most famous contribution to mathematics. But it is his work in physics that, among his scientific achievements, probably had the most impact, and he developed the calculus principally as a tool to express his physics, with implications, as Antognazza writes, "reaching far beyond mathematics and physics to logic, philosophy, religion, ethics, and politics" to the creation of a mathematically precise language to help resolve disputes of all sorts.

Entire books have been written about the complicated controversy over the invention of the calculus. In the 1670s, Leibniz had seen various mathematical ideas that Newton had circulated but not yet published. Nearly forty years later, after both men had published their versions of the calculus, followers of the Englishman began publicly accusing the German of stealing. Newton had a legion of supporters making the case for his priority while Leibniz stood almost alone. And he grappled with the Newtonians on a wider range of issues as well. Leibniz opposed Newton's views on motion and gravity, and on the nature of space and time. Leibniz founded, in his own words, "a new science of dynamics," that challenged and improved on Newton's understanding of the laws of motion, and he claimed to have been the first to have "explained the notion of force." Some two centuries later, Albert Einstein, commenting on the conflicting views

Newton and Leibniz had on fundamental questions of physics, remarked that Leibniz was groping in the right direction. Einstein wrote in 1954 that Newton's view of space was one of his "greatest achievements" and "in the contemporary state of science, the only possible one, and particularly the only fruitful one," but that Leibniz's resistance to it, while "supported by inadequate arguments," was "intuitively well founded" and "actually justified."

Not only did Leibniz push back against some aspects of the reigning mechanistic physics of his day, he also believed that it was in fact compatible with certain important elements of Aristotelian metaphysics, and he sought to reconcile the two conflicting conceptions of nature that were then as they are now subject to much controversy. One famous synthesis of this kind appears in his late work *Monadology* (1714), wherein Leibniz provided an alternative to the Cartesian dualism of body and mind, which held that the two are separate substances acting on one another. Like Descartes, Leibniz affirmed the reality of mind, but maintained instead that everything—minds and bodies—is composed of immaterial mind-like substances (monads) that, rather than acting on one another, have been placed in pre-established harmony with each other by the Creator.

Although stung by the charges of plagiarism leveled against him, Leibniz responded to the loyal Newtonians with grace and even some generosity. Most notably, his correspondence with Samuel Clarke, which encompassed a host of cosmological and theological issues, was carried out with the utmost politeness and courtesy. This accords with the accounts of Leibniz's exchanges and interactions with others in general, which present an image of a gentle, considerate, kind, and jolly man, eager to smooth over tensions with others and not easily disappointed. But the clash with the Newtonians took a toll on his spirit and greatly diminished his reputation.

Many were the frustrations of Leibniz's final years. In a life overflowing with projects and ideas, he seemed to have little time for close relationships that were more than just epistolary, although he did have a few intimate friendships. Several of his most cherished correspondents were women in high places with whom he shared intellectual interests, but he never married or had children. Most of his patrons and his admirers among the Hanoverian court predeceased him. Age brought nearsightedness, gout, and arthritis. And a political development that could have brought him new opportunities for influence and renown—the ascent in 1714 of his employer, the ruler of Hanover, to the throne of England, becoming George I—brought new humiliation. When the rest of the court left for London, Leibniz was ordered to stay behind and keep working in the relative isolation of Hanover on the family-history project. Leibniz might not have found the London scene very welcoming anyway, given the ascendancy there of Newton and his followers. Meanwhile, a new scientific society in Vienna—one that Leibniz had worked assiduously to establish and that he expected to lead—failed to materialize. Despite ties that he cultivated with the emperor in Vienna and even with Russia's Peter the Great, Leibniz's hopes of ever escaping his historical work in Hanover to assume positions of influence elsewhere dimmed.

During his lifetime and after, speculation ran wild over Leibniz's theological leanings. Some suspected he might have been a deist or an atheist. Neither label is correct. He did not accept the deists' rejection of revelation and mysteries, holding instead that revelation needed not to involve proven contradictions and that mysteries were above reason but not against it. And while he rarely attended church services and took communion irregularly at best, he was far from being an agnostic, and he was certainly not an atheist. But the townspeople and the aristocrats in Hanover looked at him with suspicion, calling him a "Löwenix"—one who "believes nothing." When he died in 1716, rumors circulated that on his deathbed, he spoke of alchemy and refused religious blessings. His funeral was sparsely attended, supposedly due to his reputed agnosticism.

The Best of All Possible Worlds

Notwithstanding all his other accomplishments, what Leibniz became most famous for in the popular imagination after his death was his claim that this world was the best of all that are possible. The statement would surely not have become as well known as it did were it not for Voltaire's mockery of it in *Candide*, and one may be inclined to agree with Voltaire that Leibniz's point deserves ridicule. But Leibniz was being neither flippant nor blindly optimistic; rather, his optimism deserves careful analysis, as it helps shed light on his understanding of science and its moral implications.

The statement originates in the only book Leibniz published during his lifetime, a volume that explores the vexing question of how God can be good and just and all-powerful if evil and injustice and suffering exist. (We now call this the problem of "theodicy," after the title Leibniz gave this little volume.) In the book, Leibniz defines "world" as "the whole succession and the whole agglomeration of all existent things, lest it be said that several worlds could have existed in different times and different places. For they must needs be reckoned all together as one world or, if you will, as one Universe." In this world, everything is dependent on something else for its existence—so that in order for the whole world to exist, a first cause must have brought it into being. But an infinite number of worlds were "equally possible," so that in creating this world, the first cause must have been able to consider all other possible worlds. This first cause, being "infinite in all ways"—including in power, wisdom, and goodness—must have chosen the best of all possible worlds.

It is a point of interpretive controversy how close to perfection Leibniz believed the best world comes. While most think that Leibniz considered it to be good in absolute terms, both metaphysically and morally, at least one commentator, Matthew Stewart in *The Courtier and the Heretic* (2006), considers Leibniz to be "in fact one of history's great pessimists," who recognized the vanity of striving for progress in this world that is ultimately indifferent to our desires. Truth—the noble aim of philosophy and the sciences—remained ineffective in politics, and Leibniz understood, according to Stewart, that some measure of deception, both in politics and in theology, seemed necessary for achieving good. If theology demands the conclusion that this is the best of all possible worlds, the harsh reality of political life makes clear that "best" would simply mean that the other worlds would have been even worse than this one. But this cynical view of Leibniz's optimism requires not only an excessively imaginative and tortuous reading of some of his most important works; it would also seem to be undermined by the dedication Leibniz brought to several other efforts, including especially his project to advance all the sciences, which we will return to shortly. A proper understanding of this project reveals that Leibniz's philosophical and theological optimism in fact shaped his vision of advancing the sciences, and that his political and ecumenical work was often aimed at furthering that end.

Leibniz made clear that he did not mean that the best world is composed only of the best parts, just as "the part of a beautiful thing is not always beautiful." While some aspects of the world may not seem good in themselves, they are part of a whole that is better than all the alternatives. No part could in fact have been other than it is, neither better nor worse, since then the world would no longer be as it is, and this world is the best, having been chosen by an infinitely wise God.

For instance, as Leibniz explains, "it is true that one may imagine possible worlds without sin and without unhappiness, and one could make some like Utopian… romances: but these same worlds again would be very inferior to ours in goodness," because humans, being free to act, are able to choose between good or evil, and "there is no rational creature without some organic body, and there is no created spirit entirely detached from matter," subject to pain and decay. To be free and to be both spirit and matter is good, even if this condition allows for evil and unhappiness. For sometimes "an evil brings forth a good," and it is a false maxim "that the happiness of rational creatures is the sole aim of God." God's creation is immense, and human beings make up only a tiny part of it, spatially and temporally; what makes us unhappy may well contribute to the good of the whole or to other creatures. Those who nevertheless criticize God's creation, Leibniz writes in *Theodicy*, should receive the following answer:

> You have known the world only since the day before yesterday, you see scarce farther than your nose, and you carp at the world. Wait until you know more of the world and consider therein especially the parts which present a complete whole (as do organic bodies); and you will find there a contrivance and a beauty transcending all imagination. Let us thence draw conclusions as to the wisdom and the goodness of the author of things, even in things that we know not. We find in the universe some things which are not pleasing to us; but let us be aware that it is not made for us alone. It is nevertheless made for us if we are wise: it will serve us if we use it for our service; we shall be happy in it if we wish to be.

Some have objected that if this is the best possible world then it would already be paradise and there would be no reason to hope for a better world after this, and the grace of God for salvation would be obsolete. But this is to misunderstand Leibniz's position. He strongly affirms the orthodox doctrines that sin is real and that grace is needed for redemption. A given day or age is not necessarily the best possible, nor is our life on earth. While the world as a whole is the best possible, improvement of individual parts is in fact at the heart of Leibniz's concern. In the sciences, in philosophy and theology, and in politics, he always aimed to improve the human condition.

Scientific Optimism

Leibniz seemed confident that science would eventually confirm his optimism. As he wrote in 1686 in his *Discourse on Metaphysics* (published posthumously), "since we have always recognized God's wisdom in the detail of the mechanical structure of some particular bodies, it must also be displayed in the general economy of the world and in the constitution of the laws of nature." More specifically, it is in God's good ends, in the final causes Leibniz desired to preserve in physics, that "we must seek the principle of all existences and laws of nature, because God always intends the best and most perfect." Science—learning about the workings of the universe—can confirm empirically what can be known of God and his actions, thereby making the goodness of God's design more apparent. This kind of optimism in science's ability to reveal the world has at least two salient features: it is forward-looking and it presumes that scientists from all over the globe can resolve their controversies.

Not all forms of optimism are entirely forward-looking. Some optimists seek to restore a lost Edenic past. Others consider the present to be perfect, ignoring the dark realities of nature and human experience. Leibniz, who is sometimes thought to have held the latter view, actually, as we have just seen, rejected it. Indeed, a simplistic and narrow optimism about the present runs directly counter to scientific endeavor, which seeks truth and creates tools in part precisely because the present world is not as it ought to be. The American intellectual historian Arthur Lovejoy, in the 1927 essay "Optimism and Romanticism," wrote about eighteenth-century optimists—commonly known to hold the view that "this is the best of possible worlds"—that "there was in fact nothing in the optimist's creed which logically required him either to blink or to belittle the facts which we ordinarily call evil."

A forward-looking form of optimism (sometimes termed meliorism, or more rarely, agathism) is the optimism of the working scientist, who is confident that the unknown can be made known. Perhaps possessing this kind of confidence in progressive knowledge is an essential characteristic of the scientist, without which he has little drive or motivation. But this, of course, does not mean that such progress is always linear. The great nineteenth-century German physicist Hermann von Helmholtz compared himself to a mountain climber who, "not knowing the way, ascends slowly and toilsomely and is often compelled to retrace his steps because his progress is blocked; who, sometimes by reasoning and sometimes by accident, hits upon signs of a fresh path, which leads him a little farther." Leibniz used a similar analogy, writing that "we sometimes retrace our footsteps in order to leap forward with greater vigor." He was drawn to the image of the spiral; it represented for him non-linear, yet non-circular progress. A spiral and the words *inclinata resurget* (what declines will rise again) were inscribed on Leibniz's coffin.

Scientific optimism seems also to promise that, given enough time, scientists will arrive at the same answers to the same questions, even if they work independently. In the 1878 essay "How to Make Our Ideas Clear," Charles Sanders Peirce expressed this promise well:

> All the followers of science are fully persuaded that the processes of investigation, if only pushed far enough, will give one certain solution to every question to which they can be applied.... They may at first obtain different results, but, as each perfects his method and his processes, the results are found to move steadily toward a destined center. So with all scientific research. Different minds may set out with the most antagonistic views, but the progress of investigation carries them by a force outside of themselves to one and the same conclusion.... This great law is embodied in the conception of truth and reality.

Today's scientists—more conscious than their forebears of the influence of theoretical commitments on scientific practice—may not be quite as convinced that all disagreements could be resolved simply through perfection of methods and processes. Even Peirce, in a later version of the above essay, tellingly changed "fully persuaded" to "animated to a cheerful hope" and "this great law" to "this great hope." But the original statement certainly captures Leibniz's optimism about science.

Working Together for the Common Good

Leibniz's optimism—that science not only is *able* to discover the world but that it actually *will* continue to advance in this effort *and* will do so for the good of humankind—can be further characterized by pointing to three conditions that Leibniz seems to have had for science and that he sought to meet in his own scientific views and work: science must be progressive without simply overturning the science of the past, it must be collaborative, and it must be conducive to morality.

The first condition is already apparent from what has been said about Leibniz's own approach to science of the past. Leibniz's physics was a blend of the old and the new, seeking to merge Aristotelian teleology—eschewed by others like Bacon, Descartes, and Spinoza—with the new mechanistic understanding of matter. He thought that scientists should see themselves in a kind of ageless dialogue with the great philosophers and scientists who preceded them. They are not to proceed subversively, with the intent to supplant the past.

Leibniz's second condition for scientific progress—collaboration—defined his entire scientific, political, and religious enterprise. Leibniz recognized early on that scientific knowledge is not in the power of one mere mortal, and so desired collaboration among the scientists of different nations. He wanted to merge the academies of France, Italy, and England with the newly formed German academy in order to promote "the universal harmonious relationship of the learned" by supporting education and the sciences, including medicine and the experimental sciences such as physics and astronomy. Leibniz even wanted to include China in this scheme. He had a long-lasting interest in China, although not much was known about it in Leibniz's Europe. But he befriended or read the writings of a number of Catholic missionaries, whose knowledge of China was the best available. In 1716, the last year of his life, Leibniz wrote a lengthy letter to a French correspondent on the subject of Chinese natural theology and on the relation between the binary number system (which he invented) and its use in deciphering one of China's oldest sacred books, the *I Ching*. In another 1716 letter, this time directed to the Russian tsar Peter the Great, Leibniz wrote:

> I wanted to add an extract of Chinese or Cathayan (*Cataisiennes*) letters which clearly prove the good intentions which exist there concerning the sciences and how much Your Majesty would help to unite Europe and China....
>
> It seems that God has decided that science should make a tour of the world and penetrate as far as Scythia, that he has designated Your Majesty to be his instrument for that purpose, while Your Majesty is in a position to draw from Europe on one side and from China on the other what there is of the best, and to perfect the institutions of both these countries by means of wise reforms.

Over a span of thirty years, Leibniz expended much effort in trying to create such collaboration between scientists of various countries. The gadfly Leibniz initiated contact; he sent numerous letters, proposals, and even machines; and he spent considerable time visiting scientists and principalities throughout Germany and in Austria and Italy. This international academy of his devising was intended to cross religious and political divides, involving such disparate institutions and individuals as the English Royal Society, German princes, the king of France, the Holy Roman Emperor, religious orders, the pope, and even the Dutch East India Company. It was also part of Leibniz's ecumenical agenda of reconciling the churches, for he knew that without theological reconciliation there would be little chance of establishing lasting communication and thereby collaboration between scientists of different religious persuasions.

Leibniz believed that progress in scientific knowledge is achieved by a synthesis of different perspectives, none of which is privileged over the others. Such synthesis requires that scientists from different nations, traditions, and languages be able to communicate. This goal motivated Leibniz even from an early age to work on his *characteristica universalis*—a system of symbolic notation "appropriate for expressing all our thoughts as definitely and as exactly as arithmetic expresses numbers or geometric analysis expresses lines," as he explained in his 1677 "Preface to the General Science." This system, the thirty-year-old Leibniz wrote, "will constitute a new language which can be written and spoken; this language will be very difficult to construct, but very easy to learn. It will be quickly accepted by everybody on account of its great utility and its surprising facility, and it will serve wonderfully in communication among various peoples." (One obvious difficulty in constructing this universal formal language was that it required the very type of collaboration it was meant to make possible. Leibniz recognized early on that he could not achieve success in creating such a language without the assistance of many others. Toward the end of his life, he also saw with more than a touch of disappointment that he had not had sufficient time to create this language.)

Contrary to what we might expect, not everyone shares Leibniz's lofty valuation of collaboration among scientists. As the psychiatrist Anthony Storr noted in his 1988 book *Solitude*, some of the world's greatest thinkers, including Newton, Kant, and Wittgenstein, were serious loners. And Galileo criticized the notion that "all the host of good philosophers may be enclosed within four walls. I believe that they fly, and that they fly alone, like eagles, and not in flocks like starlings. It is true that because eagles are rare birds they are little seen and less heard, while birds that fly like starlings fill the sky with shrieks and cries, and wherever they settle befoul the earth beneath them." Similarly, Descartes—in the famous account of his solitary thought experiment in *Discourse on Method*—wrote that "often there is less perfection in works composed of several pieces and made by the hand of diverse masters than in those at which one alone has worked." Indeed, many of Descartes's most important works, in geometry, optics, physics, and philosophy, he composed in seclusion in Holland, where, as he writes in *Discourse on Method*, "I could live as solitary and retired as in the most remote deserts."

Leibniz defended the value of scientific collaboration for two different reasons—one philosophical and one practical and moral. First, Leibniz emphasized that each of us has only limited perception of reality, and any one perceiver can misjudge what he sees. Even a group of observers has only a limited number of perspectives. So if our goal is to gain knowledge—whether it be religious, philosophical, scientific, or moral—we must consider the views of others and overcome our singular points of view. We need to "put us in the place of others and others in our place; the exchange of places in thought." Initially, there will be diversity, disagreement, and uncertainty. But Leibniz was neither a relativist nor a skeptic with regard to the availability of truth; rather, he believed that truth, if sufficiently pursued, eventually prevails in any honest dispute. In the essay "Of the Art of Conference," Michel Montaigne expressed the approach to disagreements that Leibniz sought to overcome: "We only learn to dispute that we may contradict; and so, every one contradicting and being contradicted, it falls out that the fruit of disputation is to lose and annihilate truth." Leibniz believed that to engage others in dialogue only to contradict them is both scientifically disingenuous and a moral failing as a person.

Leibniz's second reason for collaboration is that it is necessary for the moral and medical use of science. Solitary efforts are sometimes fruitful in such areas as metaphysics, mathematics, or theoretical physics, which depend largely on reasoning, because, as Leibniz writes in *Theodicy*, "appearances are often contrary to truth, but our reasoning never is when it proceeds strictly in accordance with the rules of the art of reasoning." But, as Leibniz says elsewhere, "Moral and medical matters; these are the things which ought to be valued above all. For this reason I value microscopy far more than telescopy; and if someone were to find a certain and tested cure of any disease whatsoever, he would in my judgment have accomplished something greater than if he had discovered the quadrature of the circle"—an ancient problem in geometry to which Leibniz himself soon thereafter developed a novel solution using his infinitesimal calculus. Moreover, the collaborative efforts that an international group of scientists can muster for the medical benefit of mankind far exceed the solitary efforts of individuals or of individual nations. Leibniz held that, apart from moral virtue itself, health and social conditions are the greatest contributors to human happiness—certainly more so than most ventures into astronomy, theoretical mathematics, or metaphysics.

This brings us to Leibniz's third condition for scientific progress: it must be morally beneficial. Science should not simply be a truth-seeking or fact-finding enterprise; it is not to be disinterested in its practical use. Neither ought scientists' focus to be on their own society; they should avoid the parochial. Leibniz's aim was that science be cosmopolitan with an eye to universal synthesis. But the ultimate goals of science are to glorify God and to further human happiness, which involves loving mankind by acting charitably.

Leibniz's goal was not modest; it was to synthesize philosophy and science within a Christian moral framework. He saw a logical connection between science and Christian charity. Scientific investigation demonstrates the perfection of the universe and thereby also the perfection of its Creator. The knowledge of perfection produces love, because "one *loves* an object in proportion as one feels its perfections; nothing surpasses the divine perfections. Whence it follows that charity and love of God give the greatest pleasure that can be conceived." And love of God must engender activity in the form of good works; it must lead to charity toward man.

> Our charity is humble and full of moderation, it presumes not to domineer; attentive alike to our own faults and to the talents of others, we are inclined to criticize our own actions and to excuse and vindicate those of others. We must work out our own perfection and do wrong to no man. There is no piety where there is not charity; and without being kindly and beneficent one cannot show sincere religion.

With his work on or correspondence about wind propellers, water pumps, desalinization, lamps, clocks, calculating machines, submarines, steam engines, mining, and many other technical and engineering ideas, Leibniz was an early promoter of what we now call applied science. He was also invested in public policy, especially its role in advancing medicine. He implored medical doctors to ground their theories in observation and experiment, the need for which became even more pressing with the advent of the microscope. To further public health, he advocated a medical administrative authority and state support of medical science and the education of physicians based on the premise that human life "should never be subject to the marketplace," for it is a "sacred thing."

Leibniz chastised certain Christian millenarian sects for doing nothing to improve the world and instead trying to escape it. Not only did they fail to strive for an understanding of nature in scientific terms, they also did not possess the Christian virtue of charity, he thought. He also criticized the Quietists for failing to act charitably, preferring instead only to meditate. The virtuous person, Leibniz wrote, "directs all one's intentions to the common good, which is no other than the glory of God. Thus one finds that there is no greater individual interest than to espouse that of the community, and one gains satisfaction for oneself by taking pleasure in the acquisition of true benefits for men."

Faith and science, for Leibniz, must therefore work in concord. As he did in many ways throughout his career, Leibniz sought to find points of harmony between forces that during his time had grown apart. As the divide between faith and reason widened, various thinkers began to popularize controversial positions that troubled Leibniz. On one side was Spinoza's rigorous determinism that obliterated the notion of a personal God over and above nature and that largely identified the laws of nature with divine activity. On the other side was the fideism of Pascal and Pierre Bayle, the view that faith is independent of, and possibly even in conflict with, reason.

Leibniz refuted both of these positions, and his *Theodicy* was in large part a response to them, particularly to fideism. Faith in a perfectly just, wise, and powerful God is rational, he maintained. Reason is not "the opinions and discourses of men, nor even the habit they have formed of judging things according to the usual course of Nature, but rather the inviolable linking together of truths." Truth, including the truths of religion, can therefore never be contrary to reason, even if reason cannot fully comprehend all these truths, and "when an objection is put forward against some truth, it is always possible to answer it satisfactorily." Certainly, he argues, "one must always yield to proofs," and "it is wrong and fruitless to try to weaken opponents' proofs, under the pretext that they are only objections." Leibniz maintained that no demonstrations have been offered to render faith irrational.

An Active and Good God

Leibniz's hope that science would be conducive to the advancement of human health and well-being as well as Christian charity also meant that he found harmful certain scientific theories that did not meet these goals. Today's discussions about the dangers of science often focus on its double-edged nature—science's capacity to cause harm even as it does great good. Leibniz, by contrast, seemed unconcerned about the potential misapplication or abuse of scientific knowledge. Perhaps he was not farsighted enough. But this is not to say that he altogether ignored the potential for moral harm from scientific knowledge, for he was in fact worried about *faulty* science—that is, sloppy scientific investigation that would result in false and dangerous views, both religious and moral. Proper science, for Leibniz, would correspond with true religious and moral views.

Although Leibniz himself was not very pious, he was greatly concerned with religious decline and with scientific views that he thought could further it. He thought, for instance, that the new physics propounded by Newton and his followers might contribute to the "decay" of "natural religion" in England, as he put it in his famous correspondence with the Newtonian Samuel Clarke.

According to the Newtonians, all physical phenomena could in theory be explained by the interaction of invisible atoms moving about a vacuum according to predetermined laws of motion. One of these laws was gravitational interaction between bodies, which, in the Newtonian view, was a universal force governing bodies without intervening physical contact between them. For Leibniz, this account of gravity to explain the inner workings of the universe seemed much like a miraculous force; the Newtonian universe, he argued, was akin to a mechanical watch that must be wound up continually by the Creator in order to keep its parts moving:

> Sir Isaac Newton, and his followers, have also a very odd opinion concerning the work of God. According to their doctrine, God Almighty wants to wind up his watch from time to time: otherwise it would cease to move. He had not, it seems, sufficient foresight to make it a perpetual motion. Nay, the machine of God's making, is so imperfect, according to these gentlemen; that he is obliged to clean it now and then by an extraordinary concourse, and even to mend it, as a clockmaker mends his work....

The problem with the Newtonian picture, according to Leibniz, is not, as a contemporary reader might assume, that God becomes a detached watchmaker, indifferent to the details of his creation. Rather, according to Leibniz, Newton's watchmaker-God is *too* directly involved in his creation because his creation is imperfect. And an imperfect creation implies an imperfect God. In other words, Newton's vision, Leibniz criticized, was of an intrinsically imperfect creation that needed miraculous intervention in order to be maintained. This is not the awesome, harmonious creation that a God worthy of worship would create, Leibniz thought. What is so great about an architect and carpenter who designs and builds a house that requires continual repair?

By contrast, Leibniz held that the most perfect universe possible would be one in which the interaction of created things occurred entirely by natural causes, without a force that seemed unnatural. Though not completely self-sufficient, such a universe would at least not require continual miraculous intervention to make up for its inherent deficiencies. Leibniz writes, "when God works miracles, he does not do it in order to supply the wants of nature, but those of grace. Whoever thinks otherwise, must needs have a very mean notion of the wisdom and power of God." The Newtonian clockwork universe is thus unworthy of God.

Clarke responded by saying that Leibniz's God is, for all intents and purposes, an absent creator—an intelligence beyond the world that cannot act within the world except by a miracle. A world that is a perfectly self-sufficient mechanism, Clarke charged, would need no attention, conservation, or intervention. But this reveals a misunderstanding of Leibniz: "I do not say, the material world is a machine, or watch, that goes without God's interposition." For Leibniz, the created world does indeed need continual divine concurrence: all things are created and sustained by God's activity. But Leibniz's point was that it doesn't require fixing; God doesn't need to intervene to mend it.

Unlike the human watchmaker, God not only *creates* a machine, he creates a *perfect* machine. God's creation is a "watch, that goes without wanting to be mended by him." But such perfection is possible because "God has foreseen every thing; he has provided a remedy for every thing beforehand." Thus Leibniz's God is greater than all artists or workmen not only because of his power to create, but also because of his infinite wisdom. "The bare production of every thing, would indeed show the *power* of God; but it would not sufficiently show his *wisdom*," Leibniz writes.

Leibniz charges the Newtonians with assuming, on the contrary, that God's "excellency" is "only on the account of power." They thus come dangerously close to a voluntaristic view of God—that is, a view that emphasizes God's will above his reason and goodness. According to this understanding, sometimes attributed to Descartes, God's actions are good only because he wills them. According to Leibniz, however, God's power must be inseparable from his essential wisdom and goodness. Though free, Leibniz's God wills a rational, harmonious, and beautiful universe because of his divine nature. Perfection prevails not because of divine will alone, but because of divine wisdom and goodness.

But Leibniz was not concerned merely with defending a particular view of God. Just as Leibniz rejected a voluntaristic notion of God in his correspondence with the Newtonians and in his *Theodicy*, he also denounced voluntaristic views of the rights of kings. In the unfinished manuscript "Meditation on the Common Concept of Justice," he argued, largely against Hobbes, that both divine justice and human justice are intrinsically bound to goodness and reason. Might does not make right; rather, a king's right to rule is inseparable from his moral responsibility of charity. Indeed, "justice is nothing else than the charity of the wise" and "conforms to the will of a sage whose wisdom is infinite and whose power is proportioned to it."

Leibniz was especially concerned about the French "Sun King," Louis XIV, who ruled for a remarkable seventy-two years, virtually throughout Leibniz's entire life, and through his aggressive expansionist foreign policy frequently threatened order in Europe. In a 1683 political satire, *Mars Christianissimus* (*Most Christian War-God*), Leibniz mocked the twisted logic and poor scriptural defense of the king's persistent aggression.

The distinct feature of Leibniz's work that becomes apparent here is that all these disciplines—science, philosophy, theology, politics—are intertwined, informing each other and together shaping Leibniz's aim of seeing science flourish for the human good under the guidance of a wise and benevolent ruler.

The Unfinished System

Leibniz's current reputation as a great early-modern scientist and major Enlightenment philosopher has been slow in coming. While highly respected by many of his contemporaries, including by the leading scientific societies, by other philosophers, and by the many men and women with whom he corresponded, much of his scientific and philosophical work did not retain the wide attention of scholars after his death. Most of what he wrote was in personal letters. Only the *Theodicy* was widely read, but its subject matter was narrow compared to the immense breadth of Leibniz's work. The bitter dispute with Newton and the Royal Society over the discovery of the calculus and Voltaire's derision of Leibnizian optimism in *Candide* tarnished his reputation. And even when Leibniz's name was later uttered in praise, it was often because he was considered the main influence on the German mathematician and philosopher Christian Wolff (1679–1754) who had tasked himself with systematizing Leibniz's work. Today, however, Leibniz is recognized universally to have been a much greater thinker than Wolff.

The transition from wide disregard to deep respect in Leibniz's reputation as a philosopher and scientist coincided—and is still ongoing—with the slow cataloguing and dissemination of his vast number of writings. The first complete publication of Leibniz's collected writings and letters, which, when finished, will take up eight multi-volume series, is currently still in process as a collaborative project of four German institutions. Collecting and organizing Leibniz's work in various other incomplete publications has increasingly enabled scholars to see that Leibniz's spontaneity, easily distracted intellect, and interest in so many subjects were not the earmarks of a dilettante but the wellsprings of profound, if incomplete, philosophy and science. It was philosophy and science not only in the purely speculative realm but often with a view toward practical use, specifically toward human well-being. As Antognazza writes, "for all the heights of his logical, mathematical, and metaphysical thinking, Leibniz kept his feet sufficiently firmly on the ground to understand that political stability, health, and social security contributed more to the happiness of human beings than many elevated meditations."

Furthermore, his religious convictions were not a mere appendage to otherwise secular, scientific thought. Neither, as Antognazza writes at the end of her biography, was Leibniz's "acceptance of Christianity…duplicitous lip service paid to powerful patrons"; it was "inextricably interwoven with his philosophical doctrines and his practical endeavors." It was front and center to his entire work, shaping his theoretical and his applied science, his politics, and his grand project of unifying scientists from diverse political and religious backgrounds into academies that would advance Christian charity. His optimism that this project would indeed come to fruition and that over time science would reveal the perfections of nature and its Creator is best characterized as a belief that scientific knowledge and its moral use would grow out of philosophical and theological convictions about the goodness of the world. It is striking to consider how similar and yet how alien that optimism is to the optimism of today's scientists.