Gottfried Wilhelm von Leibniz

Despite never having produced a *magnum opus* to rival René Descartes' *Discours de la méthode* or Isaac Newton's *Principia Mathematica,* **Gottfried Wilhelm von Leibniz** (July 1, 1646 – November 14, 1716) is considered a universal genius and one of the most original thinkers of the early modern period. His major contribution to mathematics was discovering the fundamental principles of infinitesimal calculus, independently of Newton. An individual of extraordinary breadth of knowledge, he made major contributions to optics, mechanics (specially the theory of momentum), statistics, and probability theory and was a pioneer in the use of binary systems and modern symbolic logic.

Leibniz conceived of a universal language and set forth the fundamental concepts of the computer, constructing a calculating machine capable of adding, subtracting, multiplying, dividing, and extracting square roots. He wrote on history, law, linguistics, aesthetics, and political theory. Further he held diplomatic and other posts under various German princes. As librarian to the Elector of Hanover Leibniz more or less invented the modern idea of cataloguing. His philosophy became the foundation of 18th century *Rationalism*, although his approach was markedly less rationalist than that of either Descartes or Spinoza. In 1700, Leibniz helped found the German Academy of Sciences at Berlin and became its first president.

Leibniz was born at Leipzig, Saxony, where his father, Friedrich Leibnütz, was Professor of Moral Philosophy. In his twenties, Leibniz changed the spelling of his name from '-ütz' to 'iz.' A child prodigy, he entered the Nicolai School at Leipzig at the age of seven where he exhibited great mathematical skill. He was an avid reader and spent large periods of time devouring the numerous volumes in his father's library. In his reminiscences he claimed he taught himself Latin by studying an illustrated edition of Livy's history and completed the study of Greek before he was twelve. He then turned his attention to logic and at age 13, unsatisfied with Aristotle's theory of categories, set out to improve upon it. In 1661, Leibniz entered the University of Leipzig to study philosophy and law. He read the works of great thinkers such as Johannes Kepler, Galileo Galilei and Descartes who were fermenting a revolution in both scientific thought and philosophy.

At seventeen Leibniz earned his bachelor's degree, and spent the summer at the nearby University of Jena, where he was introduced to more unorthodox ideas, particularly Erhard Weigel's *Neopythagoreanism*, which taught that Number is the fundamental reality of the universe. Three years later, Leibniz presented himself as a candidate for the degree of doctor of laws at the University of Leipzig. Unfortunately, there were too many doctoral candidates that year and the younger ones, including Leibniz, were told to wait a bit longer. Leibniz suspected a conspiracy engineered by the Dean's wife who he believed urged her husband to argue against awarding him his degree. Disgusted and unwilling to wait, Leibniz left Leipzig, never to return. He moved to Nuremberg, where the University of Altdorf not only accepted his dissertation and conferred his degree, but also offered him a professorship, which he refused. About this time Leibniz developed a lifelong fascination with alchemy. His alleged motivation was scientific, but he did have hopes of making a fortune, fearing only that if gold could be made too cheaply it would lose its value.

Leibniz published an essay on a new method of teaching and learning law, which he dedicated to Johann Philipp von Schönborn, archbishop elector of Mainz. The latter was so impressed that he appointed Leibniz to a post in the diplomatic services. From 1672 to 1676, Leibniz skillfully represented Mainz at the Court of Louis XIV. His assignment was to secretly promote the so-called

Egyptian plan meant to persuade the Sun King to divert his aggression from Europe to the east and against heretics. The years at Paris were the happiest of Leibniz's life. Under the guidance of Christiaan Huygens, he undertook a serious study of mathematics and physics. At this time he also set himself a lifetime goal of finding ways to reconcile the disputed questions between Catholics and Protestants and to reunify Christianity. His diplomatic duties allowed him to travel extensively throughout England, France, Germany, Holland, and Italy, making the acquaintance of Europe's leading scholars. Leibniz was an urbane man of considerable wit and charm. While in Paris he was paid something of a backhanded compliment attributed to either Montesquieu or the Duchess of Orleans:

"It is rare to find learned men who are so clean, do not stink, and have a sense of humor."

When the Elector of Mainz died in 1673, Leibniz was offered the post of Counselor to the Elector of Hanover. He accepted on the condition that he would be allowed to remain in Paris. But in 1676, he was called back to Hanover and assigned the position of librarian, archivist, and court councilor to the Duke of Brunswick-Lüneburg. Leibniz spent the last forty years of his life in the service of several electors of Hanover, grievously missing the centers of culture and learning, He lived a comfortable life in a palatial home and in 1709, he was made a Baron of the Empire. Among the electors he served was the great-grandson of James I of England who as King George I succeeded Queen Anne in 1714. The new monarch did not care for Leibniz and refused to allow his librarian to accompany him to England. Leibniz's duties at the library included the compilation of a complete genealogical survey of the history of the Guelf family from whom the Duke was descended. By the time of his death Leibniz had made it only to the year 1005. He had enough leisure time to pursue his varied interests. Leibniz never married and was plagued by gout and arthritis from age fifty. He died, largely forgotten, with only his secretary as a mourner at his funeral. It is not certain where Leibniz is buried.

Leibniz is believed to have first investigated the idea of the differential calculus in 1673. His interests may have been aroused the previous year while visiting England where he might have learned that Newton had invented his method of fluxions. By 1675 Leibniz had fairly well developed his independent theory although he never published his complete findings. He confined himself to writing short articles and piecemeal explanations of his discoveries in letters to other mathematicians. In 1684 Leibniz published "Nova methodus pro maximis et minimis itemque tangentibus, qua nec fractas, nec irrationales quantitates moratur, et singulare pro illis calculi genus" ("A new method for Maxima and Minima, and also for Tangents, which is neither impeded by fractional nor irrational Quantities, and a remarkable Type of Calculus for them") in *Acta Eruditorum*, the journal of the learned society Akademie der Wissenschaften, founded by Leibniz, its president for life. In his paper, he introduced the familiar "*d*" notation, still in use today. He gave formulas $dxy = x\,dy + y\,dx$, $d(x/y) = (y\,dx - x\,dy)/y^2$, and $dx^n = nx^{n-1}dx$ for products, quotients, and powers. He gave no proofs of the formulas, prompting Jacob Bernoulli to describe the work as "an enigma rather than an explanation."

Two years later, Leibniz published a paper dealing with the integral calculus. It contained the first use of the $\int$ notation for integration, and emphasized the inverse relationship between differentiation and integration in the fundamental theorem of calculus. It is significant to the later priority controversy over the invention of calculus that Leibniz's published work was so sketchy and, although Newton invented the fluxional calculus in 1671 and shared it with his pupils and others through letters, he delayed publishing his work until 1687. Each genius, working independently, made incredible discoveries about the tremendous tool that is calculus.

Leibniz's primary contributions to the calculus are: (1) a convenient notation; (2) definite rules of procedure that he called algorithms; (3) recognition that quadratures (i.e., the process of finding a square equal in area to the area of a given region) constitute only a special application of integration, or what he called it at the time, the inverse of the method of tangents; and (4) representation of transcendental functions by means of differential equations. Leibniz's notation was superior to Newton's and, with the exception of Great Britain, was soon universally adopted.

Early on there was no controversy over who deserved credit for inventing calculus. In the first edition of the *Principia* Newton acknowledged that Leibniz had found a similar method of the differential calculus. Following a bitter quarrel between adherents of the two concerning priority in the discovery of calculus, the reference to Leibniz's work was excised from the third edition published in 1726. From 1684 to 1699 no suggestion was made that Leibniz was not the inventor of his own particular differential calculus. Then the proud Newton learned that in Holland calculus was regarded as the discovery of Leibniz. In 1699, an obscure Swiss mathematician, Nicolas Fatio de Duillier, implied in a paper to the Royal Society that Leibniz had gotten his ideas of the calculus from Newton. Many believe that this attack was instigated by Newton.

Outraged, Leibniz insisted in an article in the *Acta Eruditorum* that he was entitled to priority of publication. Things might have cooled down had not an unfavorable review of Newton's first published account of fluxions appeared in the *Acta Eruditorum* in 1705, probably written by Leibniz. The review contained a remark that John Keill, Savilian Professor of Astronomy at Oxford, considered an accusation of plagiarism against Newton. Keill fanned the flames by accusing Leibniz of having published Newton's work as his own. Leibniz protested against the charges of plagiarism to the Royal Society, of which he was a member and of which Newton had been president since 1703. Newton could have defused the controversy at this point by merely repeating his acknowledgment of Leibniz's work, but he said nothing.

The Society appointed a committee to investigate the matter. As it consisted of friends and supporters of Newton its conclusion is not surprising, "The *differential method* is one and the same with the *method of fluxions*, excepting the name and mode of notation…." The findings were based on the claim that Leibniz was privy to correspondence concerning Newton's work. It has subsequently been shown that Leibniz never saw these documents. The report was published in full in the *Transactions of the Royal Society* in 1715, the year before Leibniz's death. Sir David Brewster in his *Life of Newton* states that almost the entire manuscript of the report was in the handwriting of the Society's president, Isaac Newton.

It has been said that the reason that academic arguments are so vicious is because they are over such trivial matters. Neither Newton nor Leibniz would have acknowledged that their argument was over trivialities. Throughout the 17th century, the most fruitful work and original research were not carried out at universities, but by talented amateurs, sometimes called *virtuosi*, that is, those endowed with special genius. There was little cooperative research and considerable competition and jealousies developed among these intellectual heroes. The controversy between the two geniuses did not end with Leibniz's death. According to Stephen W. Hawking in *A Brief History of Time*, following the death of Leibniz, Newton declared that he took great satisfaction in "breaking Leibniz's heart." If that doesn't sound worthy of the "Man of the Millennium" it is necessary to factor in that Newton took criticism very badly, responding furiously. He sought revenge for slights real or imagined.

Although Leibniz spent much of his life attempting to organize knowledge, he left no systematic or complete statement of his thinking, writing only many separate essays. Of his many writings on philosophy only his *Theodicy* was published during his lifetime. In it Leibniz expressed an optimistic faith in reason, which became an important text of the Enlightenment. He believed that the world is fundamentally harmonious and good, being composed of *monads*, infinitely small units devoid of all extension and endowed with activity. Each monad is self-contained and indivisible but acts in harmony with every other, forming an ascending hierarchy culminating in God who ordained the world's harmony.

In Voltaire's *Candide,* Leibniz is satirized as Candide's teacher Dr. Pangloss, who often tells his pupil, "This world is the best of all possible worlds." Among Leibniz's most important posthumously published philosophical works are: *Discourse on Metaphysics, The New System of Nature, Monadology*, and *New Essays Concerning Human Understanding*, which was a criticism of John Locke's *An Essay Concerning Human Understanding*.

Quotation of the Day: "In symbols one observes an advantage in discovery which is greatest when they express the exact nature of a thing briefly and, as it were, picture it; then indeed the labor of thought is wonderfully diminished." – Gottfried Wilhelm von Leibniz