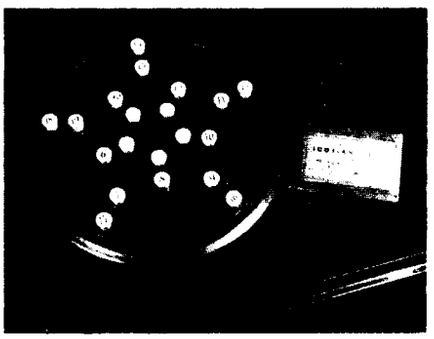
of medals and a locked desk packed with compulsively collected mementos of his unfulfilled love for Catherine Disney Barlow. Powerfully attracted to poetry, intimate of Wordsworth and disciple of Coleridge and through him of Kant, Hamilton was simultaneously an algebraist of extraordinary talent, a professional astronomer with no taste for observation, a Romantic idealist during the decline of Romanticism, and a husband painfully in love with a woman whose forced rejection of his early proposal of marriage nearly led him, and later did lead her, to attempt suicide. He struggled during his 20's to reformulate mechanics by means of his "characteristic function" and during most of his 30's to discover a three-dimensional analogue to ordinary complex numbers. Upon finding his quaternions in 1843, he began a crusade ending only with his death to win for them a place in the mathematics and physics of his day. A decade later he had completed his lengthy *Lectures on Quaternions*, shown fresh from the press to his dying Catherine in the most emotion-charged of their rare meetings. Convinced despite his admittedly weak and outdated knowledge of physics that they would aid physicists, he ironically failed to see that his discovery that new algebras could be created carried no certainty that his algebra was preferable to others that soon appeared. At last he found a single, distant disciple, P. G. Tait, whose efforts he alternately encouraged and retarded. His algebraic books forbiddingly abstruse, his mechanics excessively abstract, he died with the value of his ultimate contribution very much in question. Gradually, however, Hamilton's "ordered couple" justification of complex numbers became classic, his scalar and vector quaternion products were transformed into modern vector analysis, and his characteristic function and wave-particle analogy found fruitful application in quantum physics.

Victorian delicacy and loyalty led Graves to leave only hints of Hamilton's troubles with alcohol, his deteriorating family life and finances, and his involvement with Catherine, which he compulsively confessed to some and desperately hid from others of his contemporaries. With sympathy, sensitivity, and candor Hankins clarifies these matters while simultaneously sorting out the claims made to place Hamilton among the leading figures of his century.

Hankins tells his story in an easy and engaging style; his mastery of detail, everywhere evident, is nowhere burdensome. Frequently it is from the clustering of detail that his vivid portrait of Hamilton emerges, as when he notes that Hamilton "wrote incessantly, usually in notebooks of all sizes and shapes, but also on pieces of loose paper. . . . He wrote on walks, in carriages, during meetings . . . , on his fingernails if no paper was handy, and . . . even on his egg at breakfast" (p. xx). Such sentences suggest as well the difficulties faced by those who have immersed themselves in the sea of papers that inundated Hamilton's library. Graves also went through these, but without Hankins's mathematical sophistication and without the perspective of 20th-century scholarship.



William Rowan Hamilton's Icosian Game, marketed in 1869. Hamilton wrote to John Graves, "I have found that some young persons have been much amused by trying a new mathematical game which the Icosian furnishes, one person sticking five pins in any five consecutive points . . . and the other player then aiming to insert, which by the theory . . . can always be done, fifteen other pins in cyclical succession, so as to cover all the other points, and to end in immediate proximity to the pin wherewith his antagonist had begun. Whatever then may be thought of the utility of these new systems of roots of unity, suggested to me by the study of the ancient solids . . . they will be found to have supplied (a new and innocent) pleasure, not only to algebraists, but even to children." [From *Sir William Rowan Hamilton*; courtesy of Royal Irish Academy]

Definitive no biography can be that takes as its subject a figure so broadly brilliant, so personally complex as Hamilton. Specialists will inevitably dispute some of Hankins's conclusions, but most will probably find, as this reviewer has, that his analyses hold up very well. Some will no doubt wish that more attention had been given to Hamilton's mathematics, his organizational activities, or his literary, philosophical, and religious concerns. This reviewer would have liked more attention to the stabilizing effect of the witty, wise, and constant correspondence of De Morgan, more on Hamilton's apparently not very successful teaching, and more on how Hankins's interpretations differ from those of earlier authors. But few will deny that Hankins has largely succeeded in the immensely difficult task of showing how the different strands of Hamilton's thought interacted. Moreover, future scholars will derive significant benefit from the care with which he has documented his statements.

The range of Hamilton's talents and interests may frighten off biographers, but prospective readers of Hankins's biography should not be intimidated. Hankins has taken pains to ensure that those innocent of Irish politics, Fresnelian optics, Coleridgean philosophy, quaternion and icosian calculi, or the Romantics' ideals of love will not flounder. His expositions of these and other matters are clear, concise, well referenced, and illuminating in themselves.

In the difficult genre of scientific biography, where good books are rare, Hankins's *Hamilton* is excellent. Handsomely printed, generously illustrated, enriched by a useful bibliographical essay and index, this book may be recommended to scholars in a half-dozen disciplines, scientific and humanistic, and to all who enjoy an exciting story well told.

MICHAEL J. CROWE
Program in History and Philosophy of Science, University of Notre Dame, Notre Dame, Indiana 46556

An Italian Mathematician

Peano. Life and Works of Giuseppe Peano. HUBERT C. KENNEDY. Reidel, Boston, 1980 (distributor, Kluwer Boston, Hingham, Mass.). xii, 230 pp. Cloth, $34; paper, $14.95. Studies in the History of Modern Science, vol. 4.

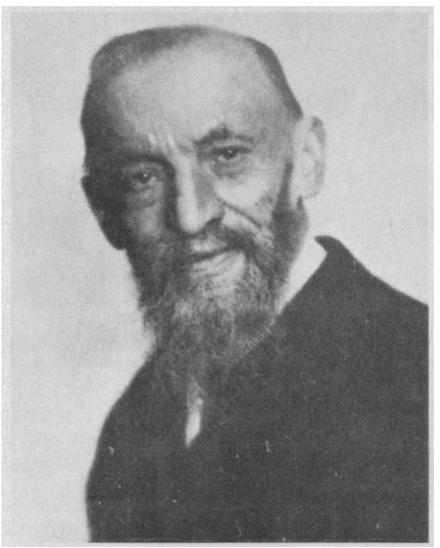
Giuseppe Peano (1858–1932) is well known for his important contributions to mathematical logic, for his famous space-filling curve and his postulates for the natural numbers. In addition to writing numerous articles and books on the calculus, infinitesimal analysis, geometry, and Interlingua, as well as his influential *Formulario Mathematico* (in which he sought to provide a precise symbolic language to express all of the major results of mathematics), he was one of the founders of and major contributors to the *Rivista di Matematica*. Above all it was the special nature of his thought that led Bertrand Russell to praise Peano's "exactness of mind." Although this biography never really attempts to bring the reader very close to that quality of mind responsible for Peano's importance as a mathematician, it does provide, as Kennedy acknowl-

edges, "a strictly chronological account of the life and works of Giuseppe Peano."

Apart from tracing the year-by-year activity of one of Italy's foremost mathematicians, this biography describes Peano's major mathematical and philosophical interests and offers some especially vivid moments that help to reveal aspects of his personality. Of these, the more interesting episodes invariably concern the many rivalries and controversies that enlivened Peano's early career. Especially noteworthy were differences of opinion—or worse, open hostilities—with several of his colleagues in Italy and elsewhere, including his old professor Angelo Genocchi (who was so displeased by Peano's "edition" of his course of lectures on the calculus that he disavowed any connection with it), Corrado Segre (who was greatly offended when Peano pointed out that some of his theorems were incorrect or admitted exceptions, thus beginning the first of ongoing hostilities between Peano and his colleagues at the University of Turin), and Giuseppe Veronese (whose book *Fondamenti di geometria a più dimensioni* was described by Peano as full of "absurdities . . . errors, lack of precision and rigor"). In fact, Kennedy describes Peano's confrontation with Veronese as "strong enough to give rise to histrionics to match Veronese's mother's cousin, the actress Eleonora Duse!" Unfortunately, we are never told what the histrionics were, nor is much detail actually provided as to the substance of the differences between Peano and Veronese (with whom Georg Cantor, creator of transfinite set theory, also had a heated polemic over the issues of infinitesimals).

Nearly one-third of this book, especially the later portions devoted to Peano's life after the congresses for philosophers and mathematicians held in Paris in 1900 (chapters 15 through 25), concerns Peano's interests in the Interlingua movements dedicated to the creation and adoption of an international language. In fact, for a brief introduction to the ups and downs of the most influential of these movements, including Volapük, Idiom Neutral, Esperanto, Ido, Ro, and Peano's own favorite, *Latino sine flexione*, Kennedy's book serves as an informative guide.

Peano includes one photograph of Peano and three appendixes, which provide short biographical sketches of 14 of Peano's professors, including one who was canonized in 1971 (Francesco Faà di Bruno), a list of students making up the



Giuseppe Peano

"School of Peano" that identifies those who were also Peano's assistants at the University of Turin, where he taught for his entire professional career, and a list of papers by other authors presented by Peano to the Academy of Sciences of Turin between 1892 (when he was elected to membership) and 1932. There is also a comprehensive list of the publications of Peano, which goes beyond the list of 231 items published in volume 1 of Ugo Cassina's edition of Peano's *Opere Scelte* by 45 entries, the majority of which are reviews and published letters to editors, replies to questions, and short biographies. The indexes are made the more useful by the inclusion of an index to the publications of Peano as mentioned or discussed in the course of the book.

Peano is a study many will find useful, not for its explication of Peano's mathematics or even of his philosophy, but largely for its success in painting the day-to-day life and changing influences and interests of one of the last century's great contributors to mathematical logic and international languages. Particularly interesting is the last chapter, "Summing up" (pp. 172–175), in which the author suggests that Peano lived too long, that his significant contributions to mathematics and logic were all made before 1900; consequently, he should be seen as a great figure of the last century, but not of this one. Further contributing to Peano's neglect, suggests Kennedy, were strong anti-Peano forces at the University of Turin, as well as Peano's preferences for immediate results, his editorial interests in the *Rivista* and *Formulario* projects, and the later almost exclusive devotion he gave to the cause of Interlingua. Ultimately, this book succeeds in providing the first comprehensive account of Peano's life available in any language, including Italian.

JOSEPH W. DAUBEN
Department of History, Lehman College, and *Graduate Center, City University of New York, Bronx, New York 10468*

Argumentation Examined

Galileo and the Art of Reasoning. Rhetorical Foundations of Logic and Scientific Method. MAURICE A. FINOCCHIARO. Reidel, Boston, 1980 (distributor, Kluwer Boston, Hingham, Mass.), xx, 482 pp. Cloth, $42; paper, $21. Boston Studies in the Philosophy of Science, vol. 61.

When Galileo published his *Dialogue on the Two Chief World Systems* in 1632, the debate on the heliocentric theory had been going on for almost a century. Copernicans and Anti-Copernicans could cite the same arguments, ostensibly based on direct observations and experiments, to demonstrate the validity of their diametrically opposed views. The crucial factor in the disagreement over how the empirical data should be interpreted was the a priori constructions of both parties. Far from being decisive, the variously interpreted experiments merely mirrored the entrenched positions of their proponents. This situation was changed when Galileo's telescopic discovery of the rugged surface of the moon made the already dubious division between moon and earth even less plausible, and the fact that Jupiter orbited with no fewer than four satellites provided a reply to those who asked how the earth could rush through space without losing its moon. But a mere looking-glass could not dispel a theory about the structure of the world, and the Aristotelians had to be shown that their world view was wrong! To achieve this Galileo had recourse to a fictitious dialogue between Salviati, a militant Copernican, Simplicio, an avowed defender of geocentrism, and Sagredo, an intelligent layman already half converted to the new astronomy. They are presented as having gathered at Sagredo's palace in Venice for four days to discuss the arguments for and against the motion of the earth. In the First Day, the Aristotelians' radical division between terrestrial and celestial phenomena is revealed as gratuitous. In the Second and Third Days, the arguments against the diurnal and annual revolu-