Henri Poincaré: The Ninth Bruce Medalist

Joseph S. Tenn
Sonoma State University

Jules Henri Poincaré
29 April 1854 - 17 July 1912
1911 Bruce Medalist

Photograph courtesy of the Yerkes Observatory, University of Chicago.

Henri Poincaré is considered one of the greatest mathematicians of all time. Like Carl Gauss and Isaac Newton, he developed much of his mathematics in order to apply it in problems of astronomy and physics. He published more than five hundred research articles and thirty books, some still in print after ninety years. He was elected to the French Academy for his literary achievements, and his writings on the philosophy of science are still discussed.

Astronomers awarded him the Bruce Medal, and numerous others as well, for his work in celestial mechanics. They did so even though Poincaré and his followers had, according to celestial mechanician Ernest W. Brown, "less interest in the phenomena than in the mathematical processes which are used by the student of the phenomena. They do not expect to examine or predict physical events but rather to take up the special classes of functions, differential equations or series which have been used by astronomers or physicists, to examine their properties, the validity of the arguments and the limitations which must be placed on the results."

Jules Henri Poincaré was born into a distinguished family of scholars and statesmen in Nancy, in the French province of Lorraine. His father was a professor of medicine; a first cousin became prime minister and president of France. Weakened by a childhood bout with diphtheria, Henri was tutored at home until he was eight, when he entered school and immediately became the top student, winning prizes first in history and geography and later in mathematics. In the lycée he won renown for not taking notes, an unheard of practice. He had no concern about recalling proofs of theorems; he could always construct his own.

Yet he could not draw. Only his outstanding mathematical ability gained him admission to l'École Polytechnique after he scored zero in drawing on the entrance examinations. Poor eyesight probably contributed to this failing. Some have claimed that Poincaré's lack of drawing ability is what led him to investigate properties of curves and figures that are unchanged by stretching or distortion. In any case he is considered the founder of the branch of mathematics now called algebraic topology.

From the Polytechnique he went to the School of Mines, where he was made an engineer in 1879, the same year he submitted his doctoral dissertation in mathematics to the University of Paris.

Poincaré first gained fame in his mid-twenties, when, as an instructor at Caen, he published important discoveries in the theory of functions of a complex variable. With characteristic generosity he named the new functions *Fuchsian* and *Kleinian* after the German mathematicians who had indicated the possibility of such work. This seemed particularly magnanimous considering that at sixteen Poincaré had assisted his father in treating the victims of the

German army when it overran Lorraine in the Franco-Prussian War.

From the age of twenty-seven until his death at fifty-eight Poincaré was a professor at the University of Paris, where he held chairs of physical and experimental mechanics, mathematical physics, calculus of probabilities, mathematical astronomy, and celestial mechanics. He also taught general astronomy at the Polytechnique and theoretical electricity at the National School of Posts and Telegraphs.

Each year he lectured on a different subject, and his students' lecture notes became books — on capillarity, elasticity, Newtonian potential, vortices, the propagation of heat, thermodynamics, light, electric oscillations, electricity and optics, electromagnetic waves, mathematical electricity, kinematics, equilibrium of fluid masses, celestial mechanics, general astronomy, and probability!

It was said that he knew at least the results and methods of all of the physical sciences. He gave useful advice to Henri Becquerel when the latter was discovering radioactivity, and in 1904 Poincaré almost developed the special theory of relativity. Citing the importance of the Michelson-Morley experiment which had failed to detect the absolute motion of the Earth, Poincaré treated the Lorentz contraction, variation of mass with velocity, the speed of light as an unsurpassable limit, and the problem of comparing clocks by exchanging light signals. But he was too conservative to give up the ether, however, or to reject Newton's law of motion, so Einstein gets the credit for discovering relativity the following year (probably without knowing of Poincaré's work).

Nevertheless, Poincaré's major achievements were in mathematics, where he is considered the last person to have made contributions to every branch of the subject, both pure and applied. He worked on the theory of functions, algebra, number theory, and the foundations of mathematics, and he introduced deep connections between differential equations and topology.

He did extensive research in celestial mechanics, where he was concerned with the long-standing problem of the stability of the solar system. Could the system continue forever, or would small perturbations of orbits caused by the planets' gravitational effects on each other eventually lead one to be expelled or to fall into the Sun? A specific case is the famous three-body problem of the Sun, Earth, and Moon. After G.W. Hill introduced periodic solutions, Poincaré found whole families of them and discovered their importance in leading to solutions of other hitherto unsolvable problems.

Poincaré's outstanding essay on the three-body problem won a prize offered by King Oscar of Sweden in 1889. He introduced the important concept that almost any system will return arbitrarily close to its initial state after a sufficiently long time, now known as the "Poincaré time." Some one hundred of his papers on the rigorous treatment of celestial mechanics were combined into an influential three-volume book, *The New Methods of Celestial Mechanics.*

Poincaré also investigated tides and rotating fluids held together by their own gravity, simple models for the formation of stars and planets. He discovered a family of pear-shaped figures, which he thought might break up into double stars or planet/satellite pairs. The work was considered important at the time, but after Poincaré's death it was found that these figures are always unstable.

According to his biographer, Ernest Lebon, Poincaré divided mathematicians into two groups: those who liked to generalize, building a huge pyramid of knowledge from which they could see far, and those who preferred the details and wanted perfection, who were more like artists than poets. He himself was in the first group, always going from the particular to the general, often opening up new fields of inquiry, and depending on others to flesh out the details. In his proofs he sought elegance and the greatest possible rigor, for harmony, symmetry, and balance gave him esthetic pleasure.

This was a man to whom esthetic pleasure was all-important. He claimed:

> *The scientist does not study nature because it is useful; he studies it because he delights in it, and he delights in it because it is beautiful. If nature were not beautiful, it would not be worth knowing, and life would not be worth living. . . .*
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> *And it is because simplicity, because grandeur, is beautiful that we preferably seek simple facts, sublime facts, that we delight now to follow the majestic course of the stars, . . .*

Poincaré wrote extensively for the public. His description of how a mathematician makes a discovery, first presented as a lecture to the Psychological Society in Paris, is justifiably celebrated.[1] He described working long and hard on a problem, apparently making no headway, and then having the solution suddenly pop into his head as he stepped aboard a bus. Collections of his essays, such as *Science and Method* and *Science and Hypothesis*, have gone through many printings in many languages, and some of his ideas on the philosophy of science were discussed in scholarly journals in 1989 and 1990.

Poincaré believed that the only true science was disinterested science. If it were only for immediate applications, it would be not science but "cooking". He believed that a sincere love of science procured moral advantages: the passion which inspired the scientist was a love of truth; this must carry over into a love of moral truth as well.

He played an active role at the University and in the broader world, presiding over the French mathematical, physical, and astronomical societies, as well as the Bureau of Longitudes and several other national and international organizations. No observer, he declined to be director of the Paris Observatory.

Poincaré was apparently devoted to his wife and four children. He had a great appreciation for the arts and for nature. Nature was for him "an incomparable work of art of which the beauty came from the contrast between the variety of appearances and the profound unity of the underlying realities."

By the end of his life Poincaré had received every honor, prize, and medal available to a mathematician or astronomer, and he had also received fifty-one nominations for the Nobel prize in physics (a fact only recently made public). According to the worshipful Lebon, Poincaré accepted all the honors in part for the glory of France: "He had the soul of a patriot." ■

1. Reprinted in volume 4 of *The World of Mathematics*, edited by James R. Newman and available in numerous editions.