Two takes on a master of mathematics, physics, and the written word

Henri Poincaré
A Scientific Biography

Jeremy Gray
Princeton U. Press, 2013. $35.00
(608 pp.). ISBN 978-0-691-15271-4

Henri Poincaré
Impatient Genius

Ferdinand Verhulst
Springer, 2012. $49.95 (271 pp.).
ISBN 978-1-4614-2406-2

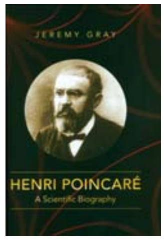
Reviewed by Julio M. Ottino

Writing a comprehensive biography of Jules Henri Poincaré is a most difficult task. Two books that tackle the subject are *Henri Poincaré: A Scientific Biography* by Jeremy Gray and *Henri Poincaré: Impatient Genius* by Ferdinand Verhulst. Gray is a professor of the history of mathematics at the Open University based in the UK; Verhulst is a professor of mathematics at the University of Utrecht in the Netherlands. He notes in his preface—and I agree—that it is impossible to do justice to Poincaré in one monograph.

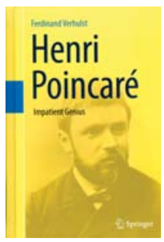
The "last of the universalists" is what Eric Bell called Poincaré in the 1937 history, *Men of Mathematics*. But Poincaré was not only one of the greatest mathematicians; he was a polymath. He contributed fundamental insights to mathematics, physics, astronomy, and philosophy. Poincaré was an essayist who made deep incursions into the psychology of creativity; he was fascinated by how ideas emerged and believed that the unconscious played a central role. He was also an influential intellectual. His book *La science et l'hypothèse* (*Science and Hypothesis*, 1904) was required reading for any cultured person, especially in France. Some of his books are still in print after 100 years.

What's more, Poincaré was a member of the European establishment, a symbol of European culture and tradition. Twice, in 1886 and in 1900, he was president of the Mathematical Society of France. He was elected to the French Academy for his literary achievements. He became director of that preeminent French literary academy, and he also served as president of France's Academy of Sciences—an unmatched combination. At one point he held five professorships, and he collected honorary degrees from the universities of Oxford and Cambridge, among others.

How can one book possibly do justice to a life full of such diverse excellence? Perhaps by answering two questions: What can we learn about Poincaré as a person, and how can we learn some of the technical details of what he did? The biographies by Gray and Verhulst attempt to tackle both. In that regard, the books are similar. They are also similar in that their first parts deal generally with Poincaré's life, and then they address his technical work. But in their detailed construction and their focus, they are somewhat different.



As to the first question, Poincaré had a shining public persona, but it is hard to get insights into his personal life. Both books cover his work habits, which we know about because he told us in some of his writings and also because he consented to psychological examinations. He had no confidants, and he had perhaps three students in total; Louis Bachelier, seen now as the founder of financial mathematics, is the most famous.



As to the second question, both books cover a broad range of topics, including rotating fluid masses and a special emphasis on the three-body problem, a fascinating story with myriad political nuances. In general, both bios can be read at two technical levels: curious "amateur scientist" at one, technically proficient mathematician, physicist, or philosophy of science enthusiast at the other.

Stylistically I found Gray's chapters to be more like essays that can be read independently of each other. At roughly 600 pages, *Scientific Biography* gets more into the complexity of the man, whereas *Impatient Genius*, nearly 60% shorter, has genealogical trees, mini-bios of relevant people, and anecdotes, and it presents examples in a somewhat distracting chapter-within-a-chapter construction.

Each book brings a viewpoint. In Gray's book, Poincaré is "a man with a coherent view about the nature of knowledge," the rare creative person who both trusts his intuition and can speak intelligently about it. In Verhulst's, the theme is impatience. We are told that Poincaré was uninterested in correcting proofs, that he worked quickly, and that his manuscripts had hardly a line crossed out. Based on his schedule, however, he did not look like a man in a rush: He worked from 10 in the morning to 12 noon and from 5 to 7 in the evening. His mind was surely always on—he wrote on how ideas came to him in periods of idleness—but he made a point of saying he disconnected himself completely while on holidays.

Poincaré's name has carried to our time. Both books get into what is now known as the Poincaré–Birkhoff theorem, a special case conjectured by Poincaré in 1912 from consideration of the three-body problem; George Birkhoff proved it in 1913. That one was easy. But the so-called Poincaré conjecture, also mentioned in both books, was for a long time one of the most important open questions in topology. It was finally proved by Grigori Perelman in 2003, roughly a century after Poincaré proposed it. Poincaré was recognized for contributions to the three-body problem and to our understanding of the stability of the solar system, work that was improperly recognized in his lifetime for its broader implications. Yet, his "failure to solve the [three-body] problem"—connected to the identification of homoclinic intersections—is why he is considered the father of chaos.

Although creativity is often associated with art, Poincaré was not artistic, at least in the conventional sense. On the entrance examination for the École Polytechnique, he scored a zero in drawing. I found it amazing that someone who developed the qualitative theory of

Julio M. Ottino is the Distinguished Robert R. McCormick Institute Professor and the Walter P. Murphy Professor of chemical and biological engineering at Northwestern University in Evanston, Illinois. His research includes theoretical and experimental connections among chaos, fluid mixing, and granular dynamics.

differential equations and other concepts that are typically explained or aided by pictures could not draw.

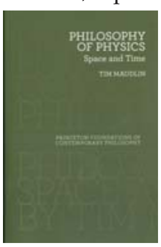
There are more connections with art and aesthetics worth mentioning. Poincaré's thinking was especially close to a surrealist's. Psychologist Édouard Toulouse wrote that Poincaré's thought "was spontaneous, little conscious, more like dreaming than rational, seeming most suited to works of pure imagination." It is well documented that Poincaré's *Science and Hypothesis* inspired Pablo Picasso and Marcel Duchamp, two of the most influential 20th-century artists.

The aesthetics connection is with elegant writing. Poincaré's obituary in *Nature* said that "passion for scientific truth did not suffice for him, he loved literary beauty. . . . He knew that the French language is itself a country, and, against every perilous invasion, this soldier of sound speech stood firmly at the frontier." Coming from an English publication, that was high praise indeed.

Philosophy of Physics
Space and Time

Tim Maudlin
Princeton U. Press, 2012. $29.95
(183 pp.). ISBN 978-0-691-14309-5

An understanding of the nature of space and time is central to both philosophy and physics. Tim Maudlin, a professor of philosophy at New York University, is well qualified to review theories of space and time from both perspectives, and he is successful in doing so in this concise and highly engaging book.



In *Philosophy of Physics: Space and Time*, Maudlin begins with a discussion of Isaac Newton's view of absolute space and time, including an interesting analysis of the Leibniz–Clarke correspondence, wherein Gottfried Leibniz attacked the notion of absolute space and Samuel Clarke defended it. Maudlin then explains the changes to the Newtonian view of space and time needed to incorporate Galilean relativity's demand that absolute velocities have no meaning. Then he presents special relativity from a fully geometrical point of view. Maudlin concludes with a discussion of general relativity, but the presentation is extremely cursory and the choice of topics within general relativity is quite desultory. It is therefore hard to see how a reader who is not already deeply familiar with general relativity will be able to follow the discussion in a serious and meaningful way.

The main strength of the book is its presentation of special relativity, which is done without ever introducing a Lorentz transformation. Maudlin explains very clearly why commonly made statements like "time slows down for moving observers" are utterly nonsensical. His discussion of the twin paradox is excellent, and it corrects many of the wrong and confusing statements that have been made previously by a number of distinguished people. There also are several worked examples that concretely illustrate how calculations can be done in special relativity by direct use of the spacetime interval rather than via Lorentz transformations.

However, there is one significant flaw in Maudlin's presentation. In chapter 4, the first of the two chapters dedicated to special relativity, he introduces a "clock hypothesis," and constructs global inertial coordinates using the idealized clocks he thereby introduces. The fact that the coordinate speed of light is one light-minute per minute is then a tautology. But in chapter 5, Maudlin tries to explain that there is, in fact, a nontautological meaning to the statement that the speed of light is "constant in all frames." To do so, he introduces the notion of (approximately) rigid rods as *physical systems* and then asserts that such rods would undergo a *physical* Lorentz contraction. By introducing the notion of physical Lorentz contraction, Maudlin edges backwards toward exactly the same type of confusing presentation of special relativity that he rightly criticizes in chapter 4. There is no justification for treating clocks and rods asymmetrically, so if it is appropriate to say that physical rods undergo a physical Lorentz contraction, then it must be equally appropriate to say that physical clocks undergo a "physical time dilation." And that concession leads one back toward the usual discussions of the twin paradox that Maudlin demolishes in chapter 4.

It would be much better if Maudlin consistently stuck to the view that all of the structure of space and time in special relativity is described by the topological and differential properties of events together with the spacetime metric. Only that structure enters the laws of physics governing the dynamical behavior of matter and fields in spacetime, so the dynamical behavior of physical systems directly reflects the properties of the spacetime metric. The physical manifestations of the spacetime metric may then be nicely elucidated by stating how idealized clocks and rods would behave. (However, since rigidity cannot be maintained for general, noninertial motions, it is much more awkward to formulate a "rod hypothesis" than a "clock hypothesis," since one would have to use arbitrarily short rods in such a formulation.) Of course, both real clocks and real rods are governed by the laws of physics for the matter of which they are composed. But one can make real clocks and rods that closely approximate the idealizations if the motion considered is not too extreme, so it is fine to base a discussion on idealized clocks and rods.

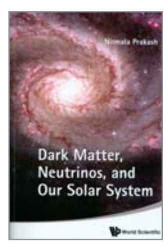
My expectation is that a perceptive reader will feel highly enlightened by the clear explanations in chapter 4, which uses clocks as idealized objects, but will likely feel uneasy after reading chapter 5, in which rods are introduced only as physical objects. Despite the above criticism, I would highly recommend *Philosophy of Physics* to anyone who wants to get a deeper historical and philosophical perspective on the nature of space and time, as well as to any physics student who has been confused by the twin paradox.

Robert M. Wald
University of Chicago
Chicago, Illinois

Dark Matter, Neutrinos, and Our Solar System

Nirmala Prakash
World Scientific, 2013. $77.00
(676 pp.). ISBN 978-981-4304-53-5

I appreciate the book *Dark Matter, Neutrinos, and Our Solar System*, by Nirmala Prakash. This work is quite unconventional in many aspects; actually, its style resembles a large edited scrapbook in which an amazing bunch of subjects have been recorded for further thought. The author´s preface actually states something like this; the result is quite eclectic in breadth and in its attempt to intermingle the many subjects.



The first chapter, which discusses the advent of dark matter, is supposed to motivate the rest of the book. That approach sounds promising, but I found the presentation to be sketchy. The