Henri Poincaré, a scientific biography; by Jeremy Gray, Princeton University Press, 2012, xiii + 592 pp. £24.95

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One of the problems of the history of science is that historians usually do not know much about science, most scientists are not sufficiently aware of the many links and connections in history. However, for a biography of Henri Poincaré (1854-1912), this is to some extent not a serious issue as he was one of the most inventive, versatile and productive scientists of all time. So, necessarily, any biography of him has to be restricted in scope, one can describe him as a physicist, as a mathematician, as an influential figure in public discourse in France around 1900 (see [3]), or as a philosopher. In this biography, the emphasis is on the scientific achievements of Poincaré, put in an appropriate historical context. So there are only a few pages in this book about his life and personal relationships; the discussion of his work is organised in eleven chapters on specific topics like topology or the philosophy of science, followed by technical appendixes, references, name and subject indexes.

Before 2012, the centenary of his decease, there existed only a few, rather sketchy biographies of Poincaré. The most interesting older one is by Paul Appell [1], renowned scientist and lifelong friend. The biography under review, and also [2], points out how many important, even fundamental results by Poincaré were forgotten or ascribed to other scientists. This is in itself an interesting topic for the sociology of science. How to explain this? Shortly after this death, the First World War broke out, interrupting life in general and also daily university activities; after 1920, the style of doing mathematics changed abruptly under the influence of the Göttingen school (David Hilbert) and the Bourbaki movement in France. Mathematical physics was changed dramatically by relativity and quantum theory. The Italian mathematician Vito Volterra described Henri Poincaré as "an impressionist among the mathematicians", an adequate description but not one to make his writings popular among young and upcoming scientists. But there is an important second aspect. Henri Poincaré's papers were often so deep and far-reaching that it took many decennia for people to understand their meaning. A few examples. He developed single-handedly algebraic topology, his philosophy of science papers (conventionalism) are still of great value. He introduced the fundamental concept of qualitative changes in dynamical systems (bifurcations), linked differential equations with geometry and topology, and, most surprisingly, gave a detailed description of the dynamics of homoclinic and heteroclinic chaos. It took more that sixty years to absorb this information about chaos, I know of no other reference showing insight in these chaos ideas before 1960.

The eleven chapters by Gray on various topics can be read nearly independently as essays on Henri Poincaré's work. All of them are of interest but most valuable are the chapters involving complex function theory, group theory, mathematical physics and the foundations of science. The chapters on dynamical systems and celestial mechanics are not the most successful ones. In chapter four, Poincaré's work on plane differential equations is discussed as an introduction to the three-body problem. This topic, however, was developed by Poincaré in his thesis where it is related to solutions of first order partial differential equations. Some of the new concepts there are the algebroid functions

and the relation between the analysis of differential equations and geometry. The story of Poincaré's error in his first submission for the Prize Essay for the Swedish King Oscar II has been told by a number of authors, but rarely correctly. As Gray notes, Poincaré made the error correction himself, but omits that the original submission contains so many novel ideas and results that this should have been sufficient in itself to get the nomination. The famous 'Méthodes Nouvelles de la Mécanique Célèste' gets four pages which is not much, considering that its stature can be compared with Descartes' 'Discourse on the Method' and Newton's 'Principia'.

Leaving this criticism aside, we note that there are many beautiful chapters. Chapters six and seven contain important material on mathematical physics in the context of the discussions in the beginning of the last century of the work of Maxwell, Lorentz, Einstein and other contemporaries. I have not seen such a useful description before; most scientists, in particular physicists, are not aware of Poincaré's part in these discussions.

Another fascinating chapter (nr 11) concerns the philosophy of science. Most of Poincaré's articles on this topic are included in his philosophical essay books where he develops his conventionalism in mathematics and physics. This takes a fundamentally different form in each of these fields. In mathematics one has the freedom to build a theoretical structure as long as it contains no internal contradictions and it is logically sound. Each of these structures has its own conventions. The conventionalism of physics is different as it is based on convenient hypotheses that are used to make predictions. Questions about "reality as it really is behind the phenomena" make no sense according to Poincaré. In the later development of structural realism by several authors, these ideas have been usefully incorporated.

Poincaré's work is fully alive in science today. This biography is one of the first thorough introductions to his work, it should get the attention of mathematicians, natural scientists and philosophers.

References

[1] Henri Poincaré, by Paul Appell; Plon, 1925.

[2] Henri Poincaré, impatient genius, by Ferdinand Verhulst; Springer, 2012.

[3] Henri Poincaré: a biography through the daily papers, by Jean-Marc Ginoux; World Scientific, 2012 (French orig. Ellipses, 2012).

Ferdinand Verhulst
University of Utrecht, Mathematisch Instituut,
PO Box 80.010, 3508 TA Utrecht, The Netherlands
f.verhulst@uu.nl