for a state-run child-rearing service that farmed out children to professional carers, reinforce the fact that Aldous Huxley was only writing what he heard. Alarming though her approach to parenting now sounds, it is shameful that the professional structures of science have hardly made it any easier for mothers some 80 years on.

Wrinch's central problem, it seems, was that, working at a time when most male scientists assumed that women thought differently from them, she seemed to conform to their stereotype: headstrong, strident and reliant on intuition rather than facts. But those complaints could also be made of Wrinch's arch-enemy Pauling: Senechal rightly observes that "Dorothy and Linus were more alike than either of them ever admitted". She sees injustice in the way Pauling's blunders, such as the denial of quasicrystals, were forgiven, whereas Wrinch's were not.

Did sexism play a part here? I think not. Unlike Wrinch, Pauling hit more than enough bullseyes to compensate for his errors. Nonetheless, Senechal's imagined scene of braying men and their snickering wives poring over Pauling's devastating paper has a depressing ring of truth.

Senechal's prose is mannered, but pleasantly so — a welcome alternative to chronological plod. Yet, primarily a mathematician herself, she doesn't always help the reader to understand what Wrinch was trying to do. Her interest in "the arrangement of genes on chromosomes" sounds tantalizingly modern, but it is impossible to figure out what Wrinch understood it to mean. Neither can one easily infer, from Senechal's criticisms of Pauling's attack, that the cyclol theory was way off beam even then. Tanford has pointed out that it predicted protein structures that were "sterically impossible" — the atoms just wouldn't fit (although cyclol rings have now been found in some natural products).

Fundamentally, Wrinch was in love with symmetry — to which the book's title, taken from the 1924 Emily Dickinson poem of the same name, alludes. It was this that drew her to crystallography, and her 1946 book *Fourier Transforms and Structure Factors* is still esteemed by some crystallographers today. But such Platonism can become a false refuge from the messiness of life, both in the biochemical and the personal sense.

It is tremendous that Senechal has excavated this story. She offers a gripping portrait of an era and of a scientist whose complications acquire a tragic glamour. It is a cautionary tale for which we must supply the moral ourselves. ■

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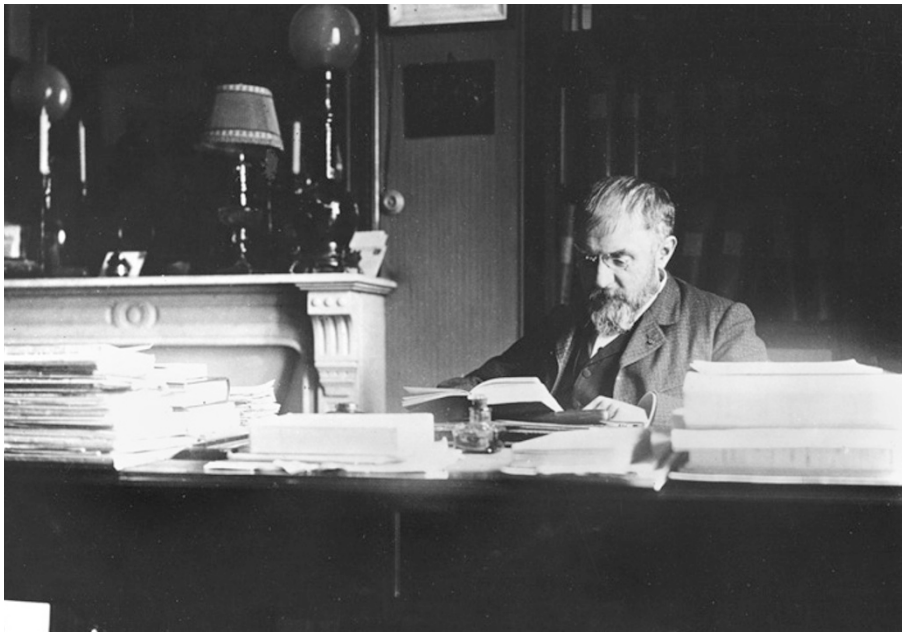


DORNAC (PAUL FRANCOIS ARNOLD CARDON)/ARCHIVES LAROUSSE, PARIS/GIRAUDON/BRIDGEMAN

Henri Poincaré posed a puzzle that remained unsolved for 99 years.

MATHEMATICS

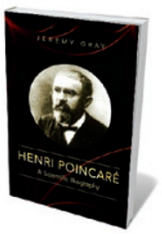
Poet of the infinite

George Szpiro celebrates a biography of the multifaceted mathematician, physicist and philosopher Henri Poincaré.

Were it not for the Poincaré conjecture, it is doubtful whether many non-mathematicians today would know of Henri Poincaré. His vexed question in topology was solved only in 2003 — nearly a century after it was published and some years after its conqueror, Russian mathematician Grigori Perelman, began to unpick it. Perelman has vanished from public view. Poincaré remains a household name.

He was hardly unknown in his day. As John Gray recounts in his masterly *Henri Poincaré: A Scientific Biography*, Poincaré was one of France's great intellectuals in the late nineteenth and early twentieth centuries. When he died at just 58 in 1912, the French Minister of Education called him "a kind of poet of the infinite, a kind of bard of science", and his funeral cortège was a veritable who's who of the world's intellectual elite.

Poincaré was also a prodigiously versatile thinker. A brilliant mathematician, equalled in his time only by David Hilbert in Göttingen, Germany, Poincaré was also rightly considered a physicist and philosopher of science of the first order. Gray encapsulates Poincaré's multiple dimensions; his intellectual biography is both a tour de force and a triumph of readability. He leads us through Poincaré's life, and the vast array of subjects he touched on, covering practically the entire corpus of what interested mathematicians and physicists at the turn of the twentieth century — from topology and algebraic geometry to Lie groups.



Henri Poincaré: A Scientific Biography
JEREMY GRAY
Princeton Univ. Press: 2012. 616 pp. $35

The field that Poincaré spawned is algebraic topology, which explores surfaces in higher-dimensional spaces using techniques from abstract algebra, the discipline concerned with mathematical structures. And, within topology, he formulated his conjecture.

Poincaré in fact posed a version of the conjecture four years before the one for which he is remembered: a theorem he decided to publish to "avoid making this work too prolonged", as he put it, with the promise of a proof to follow. Instead, he proved himself wrong by providing a counterexample. In 1904 he was much more cautious, and published the puzzle as a question. In essence, he asked whether a three-dimensional surface is equivalent to a three-dimensional sphere if rubber bands, wound around it, can be contracted, lasso-like, to a single point. He

ends with the ominous words, "However, this question would carry us too far."

Mathematicians laboured over the problem for 99 years. Most tried to solve it in the affirmative; some attempted to find counter-examples. It was left to Perelman to prove that the answer to Poincaré's question was "Yes" — after which he refused both the US$1-million Millennium Prize from the Clay Mathematics Institute and the Fields Medal.

Like many, Gray wonders why the Nobel Prize in Physics was never awarded to Poincaré for his work in, say, electromagnetism, optics or thermodynamics. As Gray tells us, Poincaré was ahead of Albert Einstein in speculating about a truly relativistic theory of gravity. Quoting Maurice de Broglie, who pioneered X-ray spectroscopy, Gray writes that the reason Poincaré did not take the decisive steps that Einstein did may have been his "too hypercritical turn of mind, due perhaps to his having first been a pure mathematician." Another reason that Poincaré did not win the prize, Gray suggests, was that he was a theorist in mathematical physics, and Nobel prizes at the time were awarded mainly for experimental discoveries. After all, even Einstein was awarded the Nobel prize only in 1921 — for the discovery of the law of the photoelectric effect.

It would be petty to find faults in a work of this calibre, but some reference to Louis Bachelier would have been welcome. He was the visionary of the Black–Scholes options pricing formula of modern financial theory — which gives the correct price of financial derivatives — and one of Poincaré's handful of doctoral students. And the bibliography seems to have omitted Perelman's postings to the Internet.

On the whole, however, this book is an achievement in its own right. Gray keeps the tone light and embeds each of the equations in explanatory text.

Fortunately, Gray also tells it like it was, warts and all. Poincaré's work could contain errors, and often lacked rigour. Aside from his initial, incorrect attempt at his conjecture, his first stab at a prize question — posed to honour the 60th birthday of Sweden's King Oscar II — contained a serious flaw. All copies of the journal that published it were pulped. But most of Poincaré's fumbles are there for all to see; and by studying such blunders, we may observe the meanderings of science as it advances by trial and error. Presenting only the finished product, as Isaac Newton did when he concealed his discovery of calculus, does injustice to the scientific process. ■

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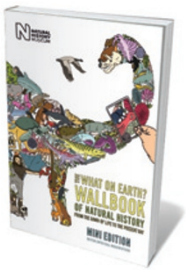
Children's edition

Books in brief

Lift-the-Flap Questions and Answers
Katie Daynes and Marie-Eve Tremblay USBORNE *14 pp. £9.99 (2012). Age 3+*
This interactive board book by Katie Daynes is food for enquiring minds, answering questions from 'How deep is the sea?' to 'What makes a car go?' and the age-old 'Why do I have to go to sleep?' Questions are divided into types — How? What? Why? — and each has a flap to lift to solve the mystery. Marie-Eve Tremblay's quirky cut-out illustrations give this the feel of a scrapbook, packed with drawings and detail. Simple and accessible, it could prove a boon to a parent asked for an early-morning explanation of how fish breathe.



The What on Earth? Wallbook of Natural History: From the Dawn of Life to the Present Day (MINI EDITION)
Christopher Lloyd and Andy Forshaw NATURAL HISTORY MUSEUM *16 pp. £6.99 (2012). Age 5+*
Christopher Lloyd shows that Earth's entire history can be folded down to the size of a postcard. Once the timeline is unfurled, Andy Forshaw's 1,000-plus illustrations capture key events. On a backdrop divided into land, sea and sky, life forms from single-celled organisms to humans appear according to where they live and when they evolved, in a harmonious interplay of large evolutionary concepts and detailed examples.

How We Make Stuff: The Story Behind Our Everyday Things
Christiane Dorion and Beverley Young TEMPLAR *18 pp. £14.99 (2012). Age 7+*
The latest in the *How It Works* series traces the journey that natural resources take as they are transformed into food, clothes, phones and 'things'. By revealing, say, that a cheeseburger can involve combined efforts from four continents, Christiane Dorion and Beverley Young could inspire thinking about the planetary impact of our need for stuff. The tabs, flaps and fold-out sections tell the stories of particular items; one of the most interesting is an interactive mix-and-match game to create an environmentally friendly outfit.

Deadly! The Truth About the Most Dangerous Creatures on Earth
Nicola Davies and Neal Layton WALKER *64 pp. £9.99 (2012). Age 8+*
Zoologist Nicola Davies takes a spin on the hilarious side of death in a book that reveals the ingenious methods animals use to kill each other. The comedy comes from Neal Layton's cartoons, which deploy exaggerated expressions and amusing speech bubbles to puncture the killer beasts' fearsomeness. Davies' text goes into gruesome detail to describe killer whales' team hunts, the 'death roll' performed by crocodiles and much more. She also raises challenging and important concepts, such as the value of predators to biodiversity and the danger of humans viewing them simply as threats.

Eve & Adam: And Girl Creates Boy
Michael Grant and Katherine Applegate EGMONT *320 pp. £6.99 (2012). Age: 12+*
Teen meets gene in this creation myth for the modern age. Evening Spiker's billionaire-geneticist mother gives her a computer program and a challenge: design the perfect boy. But it soon becomes clear that the project extends beyond the computer screen — Adam can become real. This portrayal of a world in which humans have "taken the reins of evolution" is unsettling, but at its heart lies a touching exploration of love and why perfect isn't always good enough.