new-fangled technology that Brinkley took to like an evangelist to television.

It made him a rich man. But as his business grew he got careless, performing operations both before and after happy hour, and fobbing off work to assistants whose medical credentials were even shadier than his own (Brinkley graduated from the improbably named and then unaccredited Eclectic Medical University of Kansas City). "Dozens of patients died over the years, either in the operating room or shortly after their return home," Brock explains. "Many others were permanently maimed."

This attracted the attention of the ambitious medical writer Morris Fishbein, whose career coincided with an attempt by the American Medical Association (AMA) to stamp out charlatanism through accrediting medical colleges and licensing practitioners. Fishbein made his public mark in 1923 when the *Chicago Daily News* sent him to investigate the 'Hot Girl of Escanaba', a woman who suffered from a temperature of 46 °C for two weeks. Fishbein exposed her as a "hysterical malingerer" when he found a flesh-coloured hot-water bottle was used to elevate rectal thermometer readings.

"Along with making him famous as a fraud-buster extraordinaire," Brock notes, "the case fixed him in a role he would revel in for years to come: the face, the popularizer, the lord high priest of the AMA." For the next two decades Fishbein pursued the country's "most daring and dangerous" swindler, as he called Brinkley, until he finally brought him down in a decisive court room confrontation that reads like a Hollywood film script.

Stripped of his licence to practise medicine and embroiled in lawsuits, Brinkley moved to Mexico where he dispensed pseudo-medical twaddle over the airways through a 'border-blasting' radio station that could be heard all the way to Canada. When the Mexican government shut him down in 1941 — in part because of his public sympathies for the Nazis — he was a broken man. "My health is gone. I am ready for the bed and out," he wrote to his wife three days before a heart attack killed him, aged 56.

Fishbein's promotion of science-based medicine was heroic in his day. More than half a century later, medical flimflammery still flourishes on the Internet. Every medical association and journal needs a quackbusting Fishbein on its staff, for without such eternal vigilance, folk medicine will trump scientific medicine in the minds of patients. ■

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Multi-dimensional lives

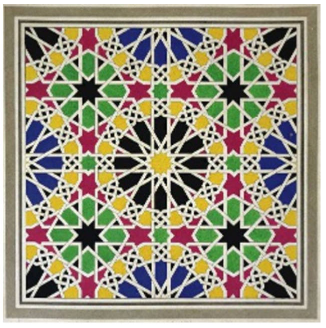
Finding Moonshine: A Mathematician's Journey Through Symmetry
by Marcus du Sautoy
Fourth Estate/Harper: 2008.
400 pp/384 pp. £18.99/$25.95

Mark Ronan

The mathematics of symmetry emerged from the work of Evariste Galois, the young genius who died aged just 20 in 1832 after being shot in a duel. His tragic story, placed in the context of French history and revolution, is retold here in Marcus du Sautoy's follow-up to *The Music of the Primes*. Galois's is a dramatic story of strong egos and lost manuscripts, ending with a letter he wrote the night before he died — perhaps the most famous epistle written by a mathematician.

Galois was working on the solution of equations, a problem first tackled some 4,000 years earlier when the Babylonians created a formula for solving quadratic equations. The subsequent theory was developed by several main characters: the twelfth-century Persian mathematician, astronomer and poet Omar Khayyam; four Italians in the early 1500s; Paolo Ruffini in 1799; and Niels Henrik Abel in 1824, the young Norwegian who showed that most fifth-degree equations and higher cannot be solved in terms of square roots, cube roots and so on.

Some equations of high degree could be solved in this way, but a method was needed to determine which ones they were. Enter Galois. By examining patterns among the solutions and studying the group of symmetries preserving these patterns, he could solve the problem. If the group of symmetries could be deconstructed into cyclic groups, then the solutions could be expressed in terms of roots. Some groups do not admit any deconstruction — they are 'atoms of symmetry' — and Galois found the first ones.



Islamic tile patterns display a multitude of symmetries.

Atoms of symmetry are the basic building-blocks for all finite groups of symmetry, and some of them have applications in modern technology. For example, they can be used to encode digital data such that small transmission errors can be automatically and efficiently corrected. Most symmetry atoms fit into a 'periodic table' where they belong in one of several families whose members enjoy similar properties. There are 26 exceptions. The largest of these is the 'Monster', a vast group of symmetries requiring at least 196,883 dimensions in which to operate. It exhibits numerical patterns similar to those obtained in an important branch of number theory, a connection dubbed 'Moonshine' by John Conway, who was one of the first to investigate it and marvel at its surprising magic.

Moonshine appears at the end of *Finding Moonshine*; the main thrust is elsewhere. Twelve chapters, one for each month of the year, include descriptions of the author's own life and work in the months concerned. Du Sautoy describes how he conducts his own research, interacts with other mathematicians, his family and particularly his son. He points out that mathematicians can be strange people, and pokes playful fun at the idiosyncracies of some of those who worked on the Monster. He is admirably self-deprecating, recounting how on a visit to Japan he annoyed local guests by remarking that the sake was only 30° proof, which is not a prime number, whereupon his host obligingly produced a 43°-proof alternative.

Interesting interludes highlight the elementary aspects of symmetry, including its role in the music of Bach. Du Sautoy also discusses the regular solids (tetrahedron, cube, and so on), teaching us that the Romans were so obsessed with dice games that they carried heavy gaming boards on campaigns, and even used 12-sided dice invented by the Etruscans. He says that Pythagoras learned of the dodecahedron from the Romans while in southern Italy. But hold on — when Pythagoras moved to Croton in Italy in the sixth century BC, Rome was an Etruscan kingdom. The Romans came later. Inaccuracies such as these, the lack of references and the projection of unverified feelings onto historical characters, spoil an otherwise delightful account of the early history (particularly of the sixteenth-century Italians) and the subsequent research on equations. Later material leading to the Monster also contains some factual errors.

The appearance of the Monster near the end is where the mathematics gets most interesting and relevant to more applied areas of science. For example, symmetry atoms are used in physics to create the standard model of the quantum forces, and Moonshine finds a home in string theory.

That said, du Sautoy omits the applications to physics, and sticks with simple symmetries that a reader with no mathematical appreciation will understand. I, meanwhile, share Freeman Dyson's sneaking hope that "some time in the twenty-first century, physicists will stumble upon the Monster group, built in some unsuspected way into the structure of the Universe". ■

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