Reviews

Arthur I Miller

Trafficking in big ideas

Yujin Kim

Enduring appeal
An interactive exhibit based on Conway's "Game of Life".

Genius at Play: the Curious Mind of John Horton Conway
Siobhan Roberts
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480pp

Some minds never cease to fascinate. They soar over difficulties and spot connections between fields that are invisible to others. They traffic in the big ideas. The mind of the mathematician John Horton Conway is an excellent case in point. Conway's biggest idea (at least in the sense of being the most famous) is the "Game of Life", a mathematical grid of cells in which simple rules about when a cell becomes "live" or "dead" can produce a riot of patterns. But Conway's ideas stretch far beyond this one example, and they are the focus of Siobhan Roberts' informative biography *Genius at Play: the Curious Mind of John Horton Conway*.

Born in Liverpool, UK, in 1937, Conway grew up as a typical, socially inept maths nerd. En route to the University of Cambridge though, he realized he could reinvent himself in a way he had only dreamt about, by becoming an extrovert who seemed to spend his time playing board games and card games, tying and untying knots, and messing about with the properties of numbers. He particularly liked tricks such as figuring out the day of someone's birthday years into the future and factoring large numbers in his head; "Gimme a number!" was a typical conversation-starter. Yet he did well enough on Cambridge's Mathematical Tripos to be accepted for postgraduate study, and a story Roberts heard from Conway's PhD adviser, the eminent number theorist Harold Davenport, may explain why. Davenport recalled having two very good students at the same time, Conway and one other. When he gave the other student a problem, the student would return the next day with an excellent solution. Conway, however, would return with a very good solution to a completely different problem. Already, as a student, Conway showed how his mind meandered across the mathematical landscape.

Roberts first met Conway in 2003 at Princeton University, where he had been in the mathematics department since leaving a similar position at Cambridge 17 years earlier. She assumed the role of a sociologist scoping out an exotic, newly discovered tribe, and she describes Conway as "high comedy, in an orbit all his own – prankish, belligerent…he was in good company among artists who matched creativity with promiscuity, intellectual and/or personal – Picasso, for example".

In order to show readers Conway the person as well as Conway the mathematician, Roberts describes his (often unsuccessful) attempts at balancing research, life and amorous escapades. Throughout all of this – as well as two heart attacks, a stroke and bouts of suicidal depression – Conway has persevered, fuelled by his passion for mathematics. As was the case for Einstein, Picasso and many other high-level thinkers, pretty much nothing else mattered. Like them, Conway could work anywhere, at any time. When his office – piled high with papers, books, homemade mathematical models and buried unconsumed food – became impossible to work in (or visit), he fled to the department's common room in both Cambridge and Princeton. He was, in fact, more at home there, among students who, when he appeared, dropped what they were doing to join him in inventing new games and analysing their mathematical properties.

This was how Conway made his most well-known discovery. He came upon the Game of Life after years of studying the patterns that emerge as one places and removes tiles in Go, the Japanese board game. Depending on the pre-set properties of cells in their vicinity, Conway found that initial patterns of cells in the Game of Life change form as they move over an infinitely large grid. "Patterns emerged, seemingly from nowhere," he recalled to Roberts with passion and wonder. In addition to its mesmerizing powers, the Game of Life turned out to have unexpected uses as a tool for exploring the evolution of spiral galaxies; calculating π (which Conway can recite "from memory to 1111-plus digits", he boasted to Roberts); and investigating how ordered systems emerge from complex ones. The game has also been used to examine why, in a multiverse scenario, only certain universes are capable of supporting life due to initial conditions such as their fundamental constants, including the fine-structure constant.

Conway had hit on something universal, yet nowadays his attitude towards his creation is ambivalent at best. "I hate the damned Life game," he told Roberts, an attitude not unlike that of Sergei Rachmaninoff towards his immensely popular prelude in C-sharp minor. What about all their other work, as many great thinkers have complained. Ah, the price of fame.

Conway rates highest his contributions to group theory, and Roberts rightly delves into them in great detail. Like many mathematicians, Conway was attracted to his subject by its beauty, and (again like many mathematicians) what he means by "beauty" is "symmetry". Simply put, groups are a way of representing the symmetries of objects; they are a collection of operations on an object that preserves its original symmetry. A cube, for example, can be reflected or rotated in 48 ways and still look like a cube. The 48 operations of its symmetry group can be enumerated in what mathematicians call a character table. Since the cube is a 3D object, the symmetries that go with a particular operation or number can be visualized. Not so for higher dimensions, where numbers in character tables replace visualizations. Mathematicians read these numbers as they would a novel and are moved by the symmetries they represent.

Roberts tells the saga of how Conway and three collaborators took on the Herculean task of calculating the character tables of a large number of certain basic groups known as finite simple groups. Their result, *The Atlas of Finite Groups*, took 15 years to assemble and instantly became indispensable to group theorists.

Roberts' biography, unflinchingly honest yet entertaining and lively, will be best appreciated by scientists and mathematicians. My main criticism is that it contains many lengthy quotes from Conway (taken from Roberts' interviews) that would have benefitted from more judicious editing. I would also have liked to have learned more about how Conway approaches problems and how he discovers them – in other words, how he thinks. The author tells us that neuroscientists have used functional magnetic resonance imaging to observe Conway's brain while he solves mathematical problems, but she omits any mention of how notoriously untrustworthy this method is.

When Roberts asked Conway what was left to do on the *Atlas*, his reply was emphatic, as if it should have been obvious to everyone. "Lots! Understand it all, for one thing." Among the exceptions to the groups in the *Atlas* is one whose sheer size astonished mathematicians. This group – known as "the Monster" – exists in a space with 196 883 dimensions. Its character table has 194 columns and 194 rows, and the total number of symmetries in it is 54 digits long. "The one thing I want to do before I die is understand WHY the Monster exists," an emotional Conway told Roberts. There is an outside chance that he will get his wish. Not surprisingly, the Monster has connections with other fields in mathematics, such as number theory, and the physicist Freeman Dyson entertains a "sneaking hope [that] 21st century physicists will stumble upon the Monster group." After all, is not mathematics the structure of the universe, as scientists and mathematicians from Plato onwards have speculated?

Arthur I Miller is emeritus professor of history and philosophy of science at University College London, and the author of *Colliding Worlds: How Cutting-Edge Science is Redefining Contemporary Art*, e-mail a.miller@ucl.ac.uk

Between the lines


Robert Sanders/UC Berkeley

Passion for physics Mary Gaillard had to overcome many challenges on her way to becoming a distinguished theoretical physicist.

A survivor's story

The properties of a good memoir are simple, yet elusive: the author needs to have something to say, and they need to be able to say it. In *A Singularly Unfeminine Profession*, the physicist Mary K Gaillard displays both qualities in abundance. As one of the leading theorists of her generation, she was both a participant in and a witness to the events that produced the Standard Model of particle physics. Moreover, as one of the field's very few women, Gaillard has a vitally important story to tell about the swamp of sexism she had to slog through to get there. The book covers her entire career, but it focuses particularly on her time at CERN in the 1960s and 1970s. During this period, Gaillard made her name by predicting (with Ben Lee and Jon Rosner) the mass of the charm quark, but she also faced pervasive discrimination – something that initially surprised her when she arrived in Europe as a PhD student. In the US, she writes, "while many members of the physics community implicitly or explicitly expressed scepticism as to my ultimate survival in the field, there was no question of being refused the chance to try, and judgement on achievement was essentially objective". Not so in 1960s France, where one academic after another declined to serve as her PhD adviser, offering a cavalcade of excuses and putdowns that Gaillard may have forgiven, but certainly hasn't forgotten. Later, as her reputation grew, her position at CERN nevertheless remained irregular and (for the most part) unpaid. Well into the 1990s, she claims, the lab was simply "not ready" to hire a woman as a senior staff scientist. Have things changed? Gaillard agrees that they have – but not uniformly, and not as much as they should.

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Scarce resources

The world's entire supply of platinum, melted down, would barely fill a swimming pool. Other elements are rarer still: all the Earth's promethium, for example, would fit in the palm of a child's hand. These and other exotic denizens of the periodic table are the subject of *Rare: the High-Stakes Race to Satisfy Our Need for the Scarcest Metals on Earth*. In it, science writer Keith Veronese offers an accessible (though US-centric) overview of the key issues surrounding these scarce but industrially important metals. Briefly, mining them is tricky; removing them from conflict-ridden countries is tricky and morally dubious; and recycling them is tricky, messy and energy intensive. But while there's a lot of interesting material in *Rare*, it's seldom explained in much depth, and the number of minor scientific inaccuracies is worryingly high. Ultimately, this is an important topic that deserves a better book.

- 2015 Prometheus Books $25.00hb 270pp