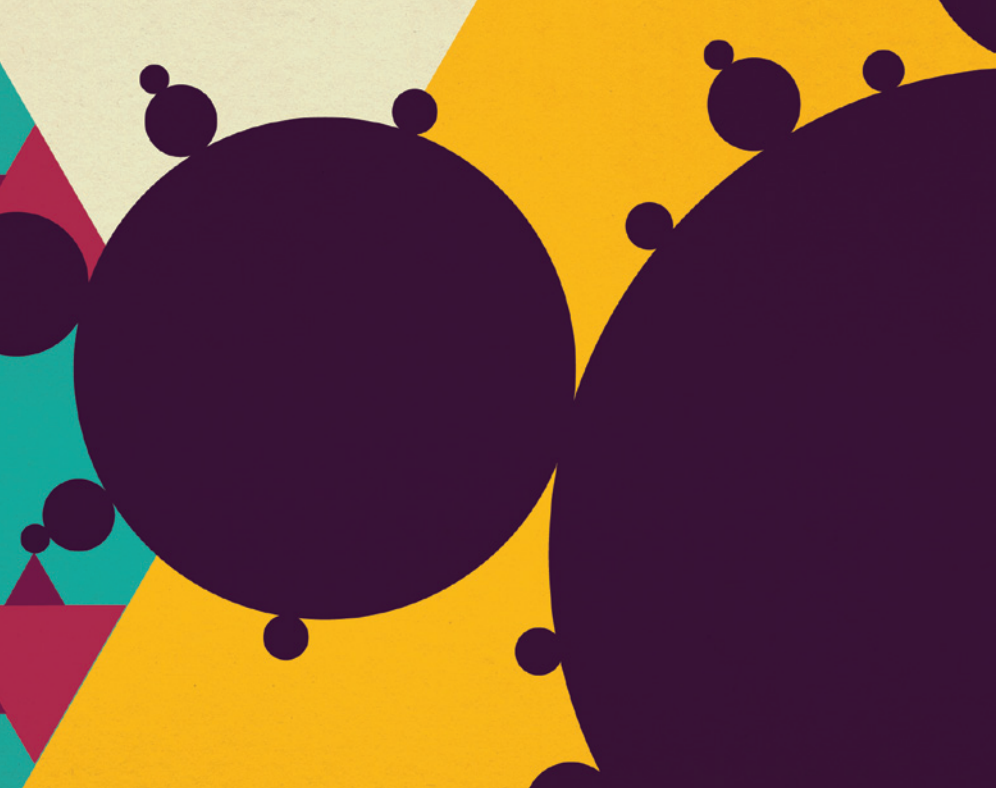


MATHEMATICS

A fractal life

Mark Buchanan enjoys the quirky memoir of a mathematical rebel — the late Benoît Mandelbrot.

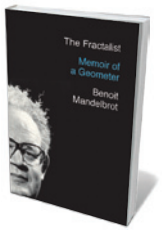
At the start of *The Fractalist* is a photograph dated June 1930. In a Jewish family's apartment in Warsaw, four Polish mathematicians are hosting a meal for an honoured guest — French mathematician Jacques Hadamard. Somewhere in the same house, although not pictured, would have been a six-year-old named Benoît. The family's surname was Mandelbrot.

A hugely productive theorist of geometry and roughness, and the "father of fractals", Benoît Mandelbrot died aged 85 on 14 October 2010. *The Fractalist* is his posthumously published autobiography, polished with help from his former assistant and colleagues.

A collection of poignant vignettes, the memoir paints Mandelbrot as an intellectual individualist who created his own field. He was reputedly a prickly character, self-important and quick to take offence. Traces of his strong opinions come through, but they are overwhelmed by warm and delightful reminiscences of family and colleagues.

Mandelbrot explains that in that 1930 photo are several of the most important people in his life. Key among them is his mathematician uncle, Szolem. The first in the family to attend university, Szolem Mandelbrot had travelled to Paris to study mathematics under Hadamard, and went on to hold the same chair at the Collège de France as Henri Poincaré. He was Mandelbrot's informal mentor, and linked the family to international science.

In 1936, as European civilization began to dissolve, Mandelbrot's "lucid and decisive" parents took the family to Paris to join Szolem. Benoît recalls learning about the history and architecture of the city during long walks. When the war started, the family fled occupied Paris for rural Tulle in the unoccupied Limousin region.



The Fractalist: Memoir of a Scientific Maverick
BENOIT MANDELBROT
Pantheon: 2012. 352 pp. $30

Danger was never far away, and in 1943, the family went into hiding and the parents and children split up. Posing as apprentice tool-makers, Benoît and his cousin Leon aroused suspicion and were arrested by the police, who were seeking the culprits of a bombing. Days of anguish followed before a helpful official intervened on their behalf.

Through such kindnesses, and the determination of his parents, Mandelbrot survived the war. Back in Paris, his mathematical skill gained him entrance to the prestigious École Polytechnique. This would have guaranteed him a comfortable career in France, but Mandelbrot never settled for the safe option.

In one vignette, Mandelbrot recalls a "life-altering verbal lashing from Szolem". It was 1952 and Mandelbrot, aged 28, was back in Paris after studying fluid dynamics and aircraft design at the California Institute of Technology in Pasadena. He hadn't chosen a topic for his PhD, and Szolem berated him for excessive book learning and preparation to be a "well-trained monkey".

Szolem suggested pursuing quadratic dynamics, the sometimes complex behaviour of mathematical functions when iterated — plug in a number, take the result and plug that back in again, endlessly. Mandelbrot looked into the topic, then dropped it. But the lashing had an effect. Soon, Szolem pointed Mandelbrot to the linguist George Zipf, who had found a scaling law in the relative frequency of word use that seemed to be universal across languages. "Silly stuff only you can like" was Szolem's view. Benoît, to the alarm of his professors, chose it as his thesis topic — and so set a course to revolutionize science.

Mandelbrot's insight that the apparently random might harbour hidden order broadened over his postdoc positions at the Massachusetts Institute of Technology (MIT) in Cambridge; Princeton University in New

NEW IN PAPERBACK

Highlights from this season's releases

The Red Market: On the Trail of the World's Organ Brokers, Bone Thieves, Blood Farmers, and Child Traffickers
Scott M. Carney (William Morrow, 2012; $14.99)
From illegal adoptions to a bag of tibias used to make flutes on the Indo-Bhutanese border, Scott Carney explores the illegal trade in human bodies and body parts. His investigation into this shadowy realm exposes a system that exploits donors, benefits middlemen and puts a price on our very existence. (See Laura Spinney's review: *Nature* **474,** 156–158; 2011.)

Jersey; and the University of Geneva in Switzerland. In 1958, he began a 35-year career at the IBM Research Center in Yorktown Heights, New York.

His work on market fluctuations in the 1960s could have revolutionized financial economics if the field's equilibrium-focused ideology hadn't pushed it aside for 30 years. Perceiving parallels in everything from fractured surfaces to stock-market movements, Mandelbrot coined the term fractals and did more than anyone to make it possible to talk about natural roughness and disorder in a precise, scientific way.

In 1979, he returned to Szolem's suggestion of quadratic dynamics. Within a year, his explorations of functional iterations led him to discover the Mandelbrot set — an astonishing pattern of infinite richness produced by simple rules. This launched a whole branch of mathematics.

Much of what makes *The Fractalist* fun to read is Mandelbrot's scattered recollection of encounters with luminaries. At MIT he discussed linguistics with the young Noam Chomsky and argued with anthropologist Margaret Mead. Robert Oppenheimer liked his ideas, and Mandelbrot worked with the famed psychologist Jean Piaget in Geneva and computing pioneer John von Neumann at Princeton.

Mandelbrot recalls how after one of his lectures, a famous mathematician objected, saying he had made "absolutely no sense at all". Oppenheimer and von Neumann sprang into action, explaining points that even Mandelbrot hadn't noticed. The meeting, he remembers, "went from abysmally low to unforgettably high". His appreciation of friends, music and quirky mathematics colours every page of *The Fractalist*. Mandelbrot's odd habits explain why he was so original: he avoided work involving direct competition with others, and naturally worked in the gaps between fields, in blind spots.

"A youthful decision set me on a maverick's lonely ride," he writes. "Its consequences took a long time to develop." ■

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MEDICAL HISTORY

Stemming the red tide

Lab luminaries jostle with consumptive cultural icons in a vivid history of tuberculosis, finds **Stefan H. E. Kaufmann**.

Tuberculosis has killed more people than all wars combined, and was a leading cause of death in many Western megacities as recently as the 1950s. Historically, tuberculosis (TB) was hothoused in overcrowded European and US cities: at the start of the twentieth century in New York and Berlin, it killed 40% of people aged 25–40. Yet TB was in decline until the late twentieth century, when the HIV/AIDS epidemic in sub-Saharan Africa triggered a resurgence. Now, it is the number one cause of death among people with HIV, and the incidence of multi-drug-resistant strains is rising.

But the story goes beyond the medical. TB's long history, wide spread and lethality irrevocably link it to social and cultural history, as Helen Bynum reveals in her gripping history of the disease and its impacts, *Spitting Blood*.

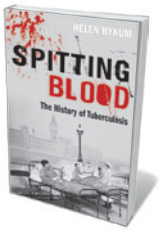
Bynum kicks off with the case of George Orwell, which encapsulates the progression of TB and its impact on culture. In 1949, when Orwell published *Nineteen Eighty-Four*, he was in the late stages of the disease, which arguably influenced his novel's dystopian tone; he died a year later. Bynum goes on to expertly turn the many facets of TB to the light, from biology to medicine and socio-economics. She ends with a brief account of why it has not been eradicated.

TB is caused by *Mycobacterium tuberculosis*, a bacterium that probably evolved from an environmental microbe to a human pathogen. The signs of 'consumption' or phthisis — pulmonary TB, triggered by aerosol infection of the lung — are coughing and spitting of blood. Before the nineteenth century, another common form was scrofulosis, in which the lymph nodes became pus-filled and ulcerated. It usually arises from ingesting bacteria, so the increasing eradication of bovine TB and the sterilization of milk have radically reduced its incidence. Pott's disease, a third, rare form, affects the bones.

Phthisis and scrofulosis were known in antiquity. But it was not until the late Renaissance that anatomists came to recognize TB lesions, and spotted similarities between the manifestations of the disease.

TB began to gain cultural cachet as artists succumbed. The death at 25 of English Romantic poet John Keats (a trained surgeon) did much to glamorize the disease. In Rome in 1820, Keats "vomited near two cupfuls of blood"; he died a few months later. Anne Brontë and, possibly, her sister Emily succumbed at 29 and 30. Consumption became linked to the punishment and redemption of a bohemian life, as with the courtesan Violetta in Giuseppe Verdi's 1853 opera *La Traviata*.

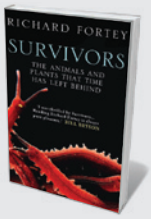
Meanwhile, as Bynum shows, the medical disease began to emerge, and "consumption became tuberculosis". Louis Pasteur provided the first evidence that microbes caused certain diseases. Robert Koch showed that TB was infectious, and demonstrated that a single pathogen was responsible for its different forms. At the time, clinicians tried to treat the disease using the 'pneumothorax' method, collapsing the lung by inserting needles into the pleural cavity, in the hope that pressure on the lung would lead to a cure. But the unveiling of TB as a bacteriological disease paved the way for effective drugs, diagnostics and a vaccine.



Spitting Blood: The History of Tuberculosis
HELEN BYNUM
Oxford Univ. Press: 2012. 352 pp. £16.99, $34.95

In the second half of the nineteenth century, efforts to control public spitting began. Dispensaries were set up, then sanatoriums for the rich, the first in Germany in the 1860s. Working-class sanatoriums emerged courtesy ▶

Knocking on Heaven's Door
Lisa Randall (Ecco, 2012; $16.99)
What can CERN's Large Hadron Collider (LHC) reveal about the make-up of the Universe? Particle physicist Lisa Randall explains, alternating details of the LHC's inner workings with more general musings on the philosophy of science. (See Joseph Silk's review: *Nature* **477,** 30–31; 2011.)



Survivors: The Animals and Plants that Time Has Left Behind
Richard Fortey (Harper, 2012; £9.99)
Palaeontologist Richard Fortey narrates the history of life by looking not to the long-extinct, but to organisms that have survived, almost unchanged, for millions of years. These survivors, he says, speak to us of pivotal evolutionary events.