and meadows of his native Russia. Nabokov saw his own love of butterflies as a disease that his father before him had contracted from one of his German tutors: "from one of the latter, [my father] caught and passed on to me the *passio et morbus aureliani*."

According to my colleague Igor Emelianov, butterfly collecting was introduced into Russia from Germany by Catherine the Great, and remained a hobby of the aristocratic élite. Similarly, literature such as *The Gift* is hardly for the masses. With its combined textual and lepidopterous obscurities, *The Gift* becomes almost a symbol of the sophistication, decadence and weakness that led to the Bolshevik revolution. This is not to belittle Nabokov; the flaw of élitism demonstrated by *The Gift* is perhaps as threatening to our own technocracy as it was to the Russian aristocracy of 80 years ago.

Still, without the butterflies and the crystalline natural history, Nabokov's novels and poems, especially in their later and lighter English style, would have lacked much of their power. But how good a scientist was he? Nabokov was no dabbler. He discovered new butterfly taxa (he was inordinately proud of 'Nabokov's wood nymph' — *Cyllopsis pyracmon nabokovi*) and wrote systematic treatises in reputable entomology journals. His knowledge of Eurasian and New World butterflies was encyclopaedic and respected. He variously contemplated both a book of the butterflies of Europe and one on the butterflies of North America long before the standard works by Lionel Higgins and Norman Riley (*A Field Guide to the Butterflies of Britain and Europe*, 1970) and Alexander B. Klots (*A Field Guide to the Buterflies of North America*, 1951) were conceived.

Nabokov held some curious views. He hated the name 'red admiral', which his knowledge of early entomological literature enabled him to see was a corruption of the more appealing 'red admirable'. He believed that mimicry between poisonous and nonpoisonous species was too exact to be explained by natural selection, and his systematics papers, with their elaborate and peculiar analyses of spot patterns on the wings of 'blues' (Lycaenidae), were sometimes derided as incomprehensible by other lepidopterists. But in the main, his systematic revisions are still important today. According to the butterfly taxonomist Gerardo Lamas, "had he become a professional lepidopterist, he would have been outstanding, despite his rather odd ideas on mimicry and other evolutionary subjects".

What drove this unique novelist–lepidopterist? *Nabokov's Butterflies* gives clues in a previously unpublished lecture to Russian literature freshmen at Wellesley College: "Whichever subject you have chosen, you must realize that knowledge in it is limitless. And yet there is a semblance of consolation within this dismal state of affairs: in the same way as the whole universe may be completely reciprocated in the structure of an atom, an intelligent and assiduous student may find a small replica of all knowledge in a subject he has chosen for his special research. And if, upon choosing your subject, you *allow* yourself to be lured into the shaded lanes that lead from the main road you have chosen to the lovely and little-known nooks of special knowledge, if you lovingly finger the links of the many chains that connect your subject to the past and the future, and if by luck you hit upon some scrap of knowledge referring to your subject that has not yet become common knowledge, then will you know the true felicity of the great adventure of learning."

To which I am sure they replied, "Will that be in the test, sir?" ■

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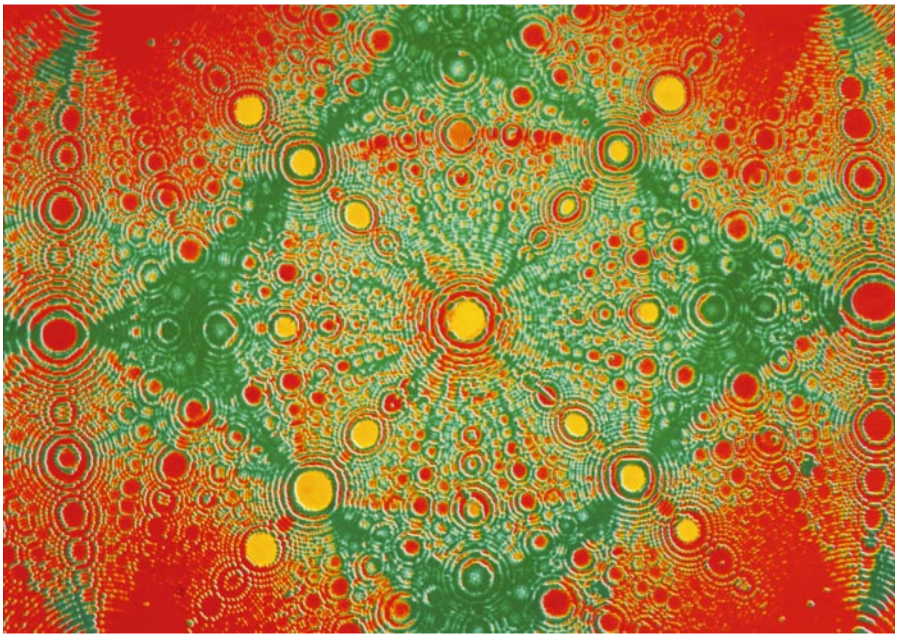
DR ERWIN MUELLER/SPL

Once the ideal of perfect symmetry is abandoned, a deeper understanding may follow.

The bondage of symmetry broken

In Our Own Image: Personal Symmetry in Discovery
by István Hargittai and Magdolna Hargittai
Kluwer Academic/Plenum: 2000. 235 pp. £34.50, $49.95

David Blow

Hermann Weyl's classic book *Symmetry* concentrated on the interplay between the mathematical operation of symmetry, the success of the artist and the satisfaction of the beholder. In delightful contrast, István and Magdolna Hargittai emphasize the deadness of perfect symmetry, citing Pierre Curie's "dissymmetry makes the phenomenon", and Fedorov's "crystallization is death". They follow, in fascinating detail, lines of development where the relaxation of an imposed or imagined symmetry has led to the deepening of scientific insight.

Take for example Johannes Kepler, who tried to link the orbits of the six known planets to the five Archimedean solids: the tetrahedron, cube, octahedron, dodecahedron and icosahedron. He thought that a series of concentric spheres including the orbits of the planets must have some special geometric property. A cube inscribed in the sphere of Saturn's orbit would just contain the sphere for Jupiter. A tetrahedron within that sphere would contain a sphere for Mars. And so on, until Mercury's sphere lay neatly within an octahedron whose apices touched the sphere for Venus. The idea worked pretty well, but did not quite fit the distances Copernicus had calculated between the planets. In trying to eliminate the assumed error, Kepler observed that planetary orbits are not circular but elliptical. He discovered the rules that link these ellipses with the length of time a planet takes to orbit the Sun, rules that Isaac Newton was able to generalize into a law of gravitation. Ideal symmetry was abandoned, leading directly to more profound understanding.

Or consider Jean-Baptiste Biot's discovery in the nineteenth century of optical rotation by organic solutions, exploited by Louis Pasteur. Suggestions of tetrahedral valencies for the carbon atom led Jacobus van't Hoff and Achille le Bel to recognize the possibility of stereoisomers, and chiral chemistry was born. Georges Friedel found that X-ray diffraction properties were centrosymmetric, but Coster, Knol and Prins showed this was not exactly true. Bijvoet exploited these departures from symmetry and used them to confirm the 'Fischer convention' regarding configuration at an asymmetric carbon atom. Under the leadership of Vladimir Prelog and John Cornforth, a complete stereochemistry was built up: a system of classifying molecules as left-handed or right-handed, allowing us to explain the specific way in which enzymes interact with biological molecules and catalyse reactions.

There is always a wonderful interplay between scientific and artistic endeavours. While Buckminster Fuller was learning how to build geodesic domes, in which sheets of equilateral triangles were made to curl up by introducing occasional vertices where only five triangles meet, Aaron Klug and Don Caspar were studying the symmetry of spherical viruses. They found that viruses use just the same principles to build their capsids. But it took almost 30 years to discover that carbon can do the same trick on its own, in the C_{60} form that Harold Kroto named buckminsterfullerene.

Meanwhile, despite Leonhard Euler's proof that five-fold lattice symmetry could not exist, Roger Penrose showed how a flat surface could be covered with tiles based on the pentagon angles 72° and 144°. Alan Mackay found that such tilings, although lacking complete symmetry, create a diffraction pattern with five-fold symmetry. This ultimately led the International Union of Crystallography to refine its definition of a crystal.

These are just a few morsels from the lavish feast offered by *In our Own Image*. Another tells how the symmetry between matter and antimatter, envisaged by Paul Dirac, had to be relaxed when Chin-Shiun Wu's experiment demonstrated the lack of mirror symmetry in the decay of ^{60}Co gamma radiation in 1956. Curie's observation that lack of symmetry creates a phenomenon came into its own, and in the work of Abdus Salam, Steven Weinberg, Leon Lederman and others this relaxation allowed the rules of modern physics to be rewritten.

The story is fascinatingly instructive, and displays scintillating gems of scientific thought. Written by avid collectors of oral history, the book includes lengthy quotations from interviews with contemporary scientists, some evidently published here for the first time. These quotations bring the story to life, and generate insights that could not be gained from reading the scientific literature.

The book is not, however, an historical work. It lacks the completeness and thoroughness that a professional historian should provide. Its contents are to some extent dictated by the authors' idiosyncrasies. I was thrilled by unfamiliar quotations from Lucretius and Thomas Mann, but surprised at no mention of D'Arcy Thompson's *On Growth and Form* (Cambridge University Press, 1917). In discussion of the handedness of the Universe, it seems a pity to pass over S. F. Mason's assertion that, because of the electroweak forces, D-sugars and L-amino acids are more stable than their enantiomorphs, or mirror-image forms.

Each chapter is dedicated to an iconic figure of science and art, and contains a series of linked short essays. Like the faces of a polyhedron, the subject matter of one essay fits closely to several others, and the authors have personally chosen a structure that is fascinatingly non-symmetrical. ■

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Expanding horizons

The Accelerating Universe: Infinite Expansion, the Cosmological Constant, and the Beauty of the Cosmos
by Mario Livio
Wiley: 2000. 274 pp. $27.95, £18.50

Francesco Bertola

The 18 December 1998 issue of *Science* awarded its accolade of "Breakthrough of the Year" to an astronomical discovery. The magazine's definition of a breakthrough is an event that profoundly changes the practice or interpretation of science. Indeed, if this astronomical discovery is completely and fully verified, it will constitute one of the major advances in cosmology of the last decades of the twentieth century.

A few years ago, two teams of astronomers — the Supernova Cosmology Project led by Saul Perlmutter of the Lawrence Berkeley National Laboratory, and the High-Z Supernova Search Team led by Brian Schmidt of Mount Stromlo and Siding Springs Observatories — undertook an observational project to generate the Hubble diagram, a plot of redshift against inferred distance, for distant galaxies with ages roughly half that of the Universe. They used type Ia supernovae as standard candles — whose distance can be calculated by comparing their brightness with an assumed absolute luminosity — taking advantage of the fact that supernovae are highly luminous and can be detected at enormous distances from the Earth.

The results of this work, presented in 1998, indicate that our Universe will expand for ever. In fact, the Hubble diagram for type Ia supernovae clearly suggests that the Universe's expansion proceeds at increasingly higher speeds. In other words, the Universe is accelerating. The long-debated question about the future of the Universe, whether the expansion will slow and end in a collapse or whether it will continue for ever, may have finally been answered. The consequences of this discovery are enormous, suggesting that our Universe is dominated by a 'dark' energy characterized by negative pressure that causes the acceleration. It marks a return to the cosmological constant, first introduced by Einstein, but always distasteful to the developers of cosmological models.

The title of Mario Livio's book points directly to this new discovery about the Universe. He provides a detailed account of the facts that led to this extraordinary result, presenting them within the broader framework of modern cosmology, and explaining even complex concepts clearly. Of course, as head of the Science Division at the Space Telescope

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Cosmological constant: our obsession with the ways of the Universe remains unchanging.