Book Reviews

Works intended for notice in this column should be sent direct to the Book-Review Editor (R. F. Bryan, Department of Chemistry, University of Virginia, McCormick Road, Charlottesville, Virginia 22901, USA). As far as practicable, books will be reviewed in a country different from that of publication.

Acta Cryst. (1999). B**55**, 810

The self-made tapestry: Pattern formation in nature. By PHILIP BALL. New York: Oxford University Press, 1999. Pp. vi +287. Price $37.50. ISBN 0-19-850244-3.

Similar patterns appear spontaneously in quite different natural settings: Mineral dendrites, electric discharge fracture patterns, forked lightning, branches of a tree, river systems and their tributaries all have something in common, once it is pointed out to us. And what about the patterns that appear in living organisms? The zebra's stripes, the spiral arrangement of florets on a sunflower head, the ornate lattices of polygons on radiolarian exoskeletons? These too are products of self-organization and, along with innumerable other examples, both from the animate and inanimate worlds, are discussed in Philip Ball's excellent book, mostly in the context of related patterns and theoretical models. Some of the explanations are by no means simple, but the reader who has difficulty following them will still be fascinated by the illustrations – I counted more than 300, including 24 spectacular pictures in colour. Ball provides recipes for several do-it-yourself chemical and physical experiments leading to pattern production, for example, oscillating chemical reactions, Liesegang bands, and Bénard convection cells. I confess I did not test them.

Many of the important concepts behind present day theories and models of self-organising systems have been developed during the past half-century or so. They were unheard of when I was a student: fractals, diffusion limited aggregation (DLA for short), chaos theory, strange attractors, symmetry breaking. Others were perhaps known to us by name, but we were unaware that they had anything to do with pattern formation: energy dissipation, Fibonacci series. Thus, although Ball's book can be considered as a kind of up-to-date sequel to D'Arcy Thompson's classic *On Growth and Form*, first published in 1917, with which it partly overlaps in coverage, the developments in molecular biology, physics and mathematics since then have led to radically new ways of thinking about (and talking about) self-assembling structures. Among these developments may be mentioned, in particular, Prigogine's non-equilibrium thermodynamics, Turing's model of autocatalytic chemical reaction-diffusion systems and, perhaps more than anything else, the ongoing dizzying advances in computational power and availability. For only through computers did it emerge how chaotic dynamics can produce complex but repeatable symmetric patterns when some operation is iterated many million times. At least, the appearance of self-organizing patterns (as in the Belousov-Zhabotinsky reaction or Bénard convection cells) is no longer to be regarded as mysterious. Ball explains how such patterns may arise spontaneously in homogeneous media when the driving force away from equilibrium is increased. They can be maintained as long as the system is driven away from equilibrium, but only as long as the driving force is not too great. In other words, patterns appear when forces are strong enough to banish uniformity, but not strong enough to induce chaos.

Ball has not much to say about crystal structures as self-organizing patterns of molecules, apart from a mention of Johannes Kepler's inspired explanation of the hexagonal symmetry of snowflakes in terms of close packing of spheres. This was probably the first attempt to explain an observed property of matter in terms of an underlying pattern of unseen particles. An alternative point of view, charmingly cited by Ball, comes from the ancient Chinese scholar T'ang Chin: 'Since Six is the true number of Water, when water congeals into flowers they must be six-pointed'. It is indeed remarkable that, following Kepler, so many of the early arguments for the atomic nature of matter came from speculations about the origin of regularities observed in the shapes of crystals, not only snowflakes. Nor has Ball anything to say about the crystallization process, surely one of the most striking examples of spontaneous self-assembly at the molecular level. But this is a minor lack in a book that treats so many other other topics.

A more serious flaw, in my opinion, comes from the author's aim to eschew mathematical equations and chemical formulas. For example, the Laplace equation, relating the pressure inside and outside a bubble to its radius is expressed as: 'The pressure inside the bubble is greater than that outside the bubble by an amount that is proportional to the inverse of the bubble's radius'. Absolutely correct, but most people, I imagine, would get the point more easily from an equation. Or what is one to make out of: 'cAMP (a signalling molecule) is made from a molecule called adenosine triphosphate (ATP) in a reaction catalysed by an enzyme called adenylate cyclase...'? It was probably not easy for Ball to imagine his ideal reader, infinitely curious about how patterns arise in nature, able to follow Ball's descriptions and explanations, yet lacking the most rudimentary education in chemistry, physics, biology and mathematics? The book is an ambitious and mostly successful attempt to introduce this ideal reader to the present state of knowledge and understanding of spontaneous pattern formation.

JACK D. DUNITZ

Organic Chemistry Laboratory,
Swiss Federal Institute of Technology,
ETH-Zentrum, CH-8092 Zurich,
Switzerland