tions is due to spontaneous formations (the self-made tapestry, autogenesis in development and in evolution)? There is no doubt that self-organizing principles—to which patterns, structures and their changes can be attributed—exist at many spatial and temporal scales and in many different kinds of matter. But the resulting patterns also greatly depend on the inside and outside connections in which constraints, directional information, and energy supply are always at work. These complications are responsible for the great variety within seemingly similar patterns. The situation is comparable to genetic expression. In genes, we have an almost self-made pattern, a high dominance of their influence, but the environment is necessary for their expression and causes the variation.

Symmetry and symmetry breaking are other aspects of pattern formation that require critical evaluation. The concept of symmetry is certainly very useful in modeling and classifying objects and phenomena; it makes processing, calculating and simulating much easier. Although in practice (in reality) symmetry only occurs after very strong averaging or at short moments when fluctuating dynamics pass through equilibrium points, assumptions of symmetry have been enormously helpful in the discovery of general rules and theories. Hypothesized symmetry seems to be an ideal, and even necessary, heuristic tool. But more care should be given to testing the fit of models; in such testing, we are confronted with an ongoing tension between the ideal (the model) and the real (the observed data). Symmetry can also be employed as a potential state, much like maximum entropy, toward which all processes tend but never reach, due to continuous or pulsating energy supplies. (This behavior is exhibited in many of the examples of pattern formation discussed by Ball.)

Investigators adhering to the idea of symmetry are usually satisfied by finding superficial symmetry at a specific level of organization or structure equilibrium or by noticing similarity in many directions. For example, in early embryogenesis (pp. 99–100) the egg is said to have an initial symmetry that is broken during the first division and subsequent development. (The process can be described by the Turing model, which invokes reaction–diffusion instability.) But, in actuality, as demonstrated in the vast amount of literature on this phenomenon, the egg's symmetry is broken from the outset and again at fertilization. These original asymmetries are of critical importance in development; they affect the physical, chemical, and informational interactions among the various well-distinguished parts of the zygote. At best, we might consider symmetry unbroken to a certain degree if we take the potential for mutual interchangeability as a criterion. Yet I would rather say that the tapestry originates by interaction of the parts, each with their own self-formation.

With this remark, I come to a most important implicit contribution of Ball's fine book. Self-organization is a plausible primary candidate for understanding the origin of new forms in a short interval of time. It can produce more—and better than random—variation and mutants on which natural selection can operate. Perhaps mutant forms are products, or by-products, of self-organization. Self-organizing processes also make it easier to explain the development of new emergent structures and the effects of perturbations on entire constructions and patterns. Because small changes can affect an entire tapestry, we arrive at the questions of how to best approach chaos and unpredictability.

The possible importance of self-organization in the generation of variation, one side of the coin of evolution (natural selection being the other), is only one of the many intriguing ideas raised in Ball's discussions. All who wish to understand the repeated appearance of similar patterns and forms will find much of interest in *The Self-Made Tapestry*.

NOTA BENE: PHYSICS

Unmasking Melodious Sounds

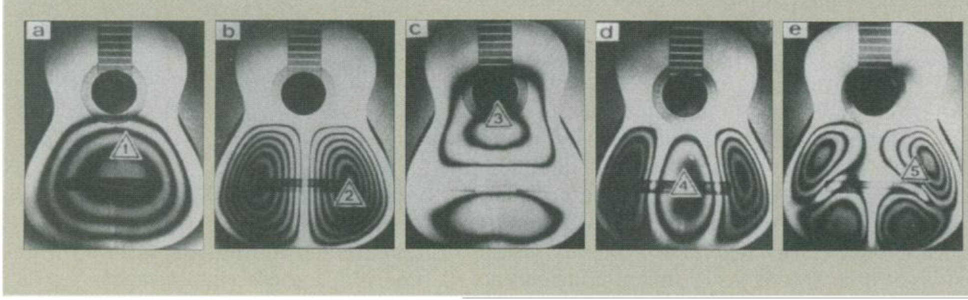
A flute may not sound sweeter just because you know that its notes are produced by the regenerative excitation of a resonant column of air. Nor will a kettledrum seem less imperious just because its vibrations can be reduced to a bunch of Bessel functions. Still, these connections between classical physics and the most sublime of human arts can make each discipline come alive.

The Physics of Musical Instruments
2nd ed.
by Neville H. Fletcher and Thomas D. Rossing
Springer, New York, 1998. 776 pp. $69.95. ISBN 0-387-98374-0.

No comprehensive quantitative analysis of music-making devices existed until Fletcher and Rossing published *The Physics of Musical Instruments* in 1990 (reviewed by D. E. Hall, 21 June 1991, p. 1728). The authors tackled everything from accordions to zithers in a mathematically rigorous way, and they did it with style and clarity. Early chapters presented the basics of vibrating strings, bar, and membranes. Middle sections discussed the specific behavior of sound waves in air—the medium of music. With the fundamentals in hand, Fletcher and Rossing then delved into the detailed physics of each family of instrument, including less familiar ones like Indian tabla drums and Japanese temple bells not usually found in the Western orchestra. As with the guitar vibrations made visible (see figure), each instrument's hidden workings provide insight into its unique sound qualities.

Now with the second edition, this impressive volume has been nicely revised and updated. The changes are less of the radical variety and more along the lines of nipping and tucking, with one exception. An entirely new and needed chapter on the materials of instruments has been added. Musicians have debated for centuries the merits and drawbacks of various substances for instrument building. Woodblocks sound different than cowbells, partly because of shape but also because of the vibrational properties of wood versus metal. But don't older traditional wooden flutes sound "warmer" than modern ones made from cold metals? Yes, but largely because flute design has undergone a radical change from tapered bore to cylindrical bore. Flute players may still argue hotly for their favorite material, but Fletcher and Rossing at least now have added materials science fact to the traditional wisdom of instrument design.

–DAVID VOSS



CREDIT: THE PHYSICS OF MUSICAL INSTRUMENTS, 2ND ED.