the molecular phylogenetic discoveries on which the future of evolutionary biology will be built.

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Solid Flows

Granular Matter. An Interdisciplinary Approach. ANITA MEHTA, Ed. Springer-Verlag, New York, 1994. xii, 306 pp., illus. $89 or DM 158.

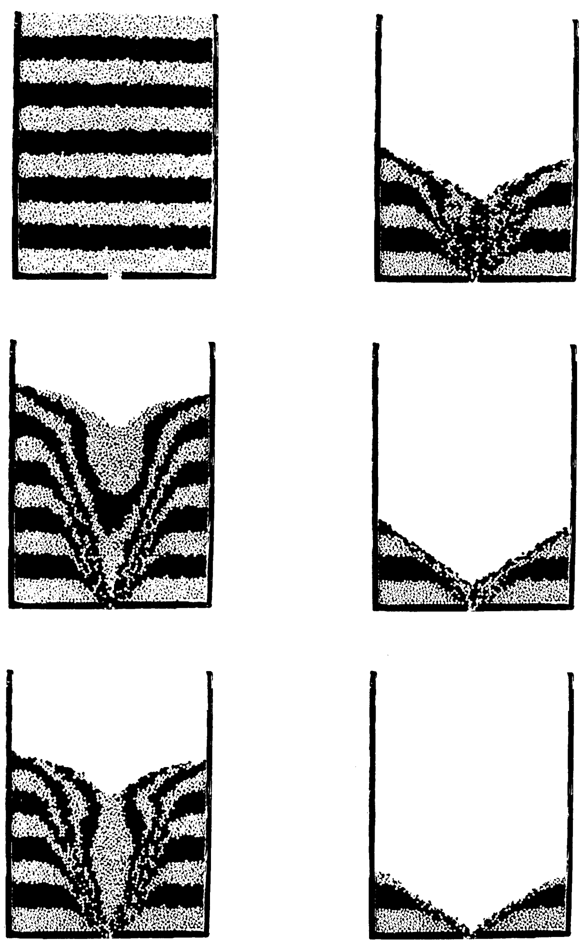
Disorder and Granular Media. D. BIDEAU and A. HANSEN, Eds. North-Holland (Elsevier), New York, 1993. xxiv, 323 pp., illus. Paper, $80. Random Materials and Processes.

Practically everyone is aware that salt, pepper, soil, sand, a collection of marbles, and many other materials composed of discrete solid particles can be made to flow in a way that is reminiscent of the flow of fluids. The abundance of such media, also known as granular materials, and the economic importance of coal, cereals, pills, and other granular materials are undeniable, and the dynamics of solid pollutants is of environmental concern. Collections of solid particles cannot always be considered as granular materials but should be referred to as suspensions when the ambient fluid is of dynamical importance.

Naturally, a rich engineering literature is devoted to the statics and dynamics of this class of materials. The increased use of coal as an energy source in power plants and the need to develop reliable models for its behavior in static and fluidized cases have significantly encouraged research in this area. Though the study of granular matter is not limited to "applied" science—astrophysicists have studied the dynamics of interstellar dust and rocks (in part in order to understand some properties of Saturn's rings)—the physics community on the whole had not devoted much attention to the interesting and unique phenomena characterizing these materials prior to the work on the effect of "self-organized criticality" by Bak, Tang, and Wiesenfeld. As Mehta discusses in the opening chapter of *Granular Matter*, this work, while presenting a highly oversimplified model of a sandpile (the demonstration Bak *et al.* used), has attracted the attention of physicists to granular materials. It is rather curious that some physicists were interested in this field a long time ago: work on the stability of piles composed of granular materials, such as sandpiles, dates back to Coulomb (the very same Coulomb who was responsible for the formulation of the law of electrostatic interactions) in 1776, and the idea of dilatancy, that is, that a granular medium must dilate as it is set into motion, was published by Hagen in 1852 and by Reynolds in 1885.

Newcomers to the field of granular materials have not been able to find basic textbooks on the subject, and even review articles on the statics or dynamics of granular matter were next to nonexistent up to a few years ago. The appearance of two new books on granular materials is thus very welcome. Neither is a textbook, but both are written for nonspecialists (particularly physicists). They can be useful to specialists as well, since they cover a larger variety of topics than can be in the area of specialization of a single person. Some related subjects, such as suspensions and colloidal suspensions, are reviewed in them as well. The editors of both books have clearly attempted to achieve a balance among theory, experiment, and simulations.

Bideau and Hansen's *Disorder and Granular Media* seems to cater more to the interests of physicists and applied mathematicians in presenting an extended exposition of the properties of disk and sphere (two- and three-dimensional) packings. This information is of course useful to applied physicists or engineers, but it is not central to their interests. Other papers in the book describe deposition models and the dynamics of porous media as well as the dynamics of dense suspensions, all of which are closely related to granular materials and thus topics with which researchers in the field need to be familiar. The engineer will find in this book a clear exposition and applications of some important concepts and theories, such as scaling and percolation theory, which have been thoroughly studied by physicists and applied mathematicians. The physicist will find in this book some good introductory expositions of topics in the field.



"Emptying of nearly spherical particles from a rectangular two-dimensional hopper." [From S. B. Savage's paper in *Disorder and Granular Media*]

Granular Matter, in addition to the contribution by the editor in which the nature of "real sandpiles" is explained and contrasted with the toy sandpiles that some physicists have been playing with, includes an interesting attempt by Edwards to define a thermodynamic theory of powders. Papers characterizing the mixing and segregation of granular materials as well as expositions of continuum mechanical and micromechanical descriptions make contact with important applications, while providing good introductions to the subject.

One of the important topics that is not covered in either book (though it is referenced in both) is that of rapid granular flows and the kinetic theoretical approach to this problem. This subfield has been of much interest to engineers and of less to physicists.

The presentation in both books is very clear, and the extensive (and up-to-date) lists of references are very useful. Both books make it perfectly clear that granular materials exhibit a large number of interesting and unusual rheological properties, that the physics of these materials is unique and challenging, that many of their features are poorly understood, and that the range of applicability of the concept of a granular material is very wide indeed. Some of the modern experimental techniques and numerical methods that are presented in the books should be of interest to both specialists and nonspecialists.

The practical importance of this field as well as many problems baffling the engineering community are exposed.

All in all these books not only are sources of information but whet the appetite of the reader for contributing to this challenging field. They not only fill an important gap in the scientific literature, they help carry the message of the emergence of a new and exciting interdisciplinary scientific interest that has grown out of a time-honored but relatively narrow discipline.

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Vignettes: Homely Experiments

Just think of the shape taken by water as it flows down the plug-hole of the bath—a distinctive spiral vortex, either clockwise or counterclockwise. And don't believe anyone who tells you that it flows one way in the Northern Hemisphere and the other in the Southern. Do the experiment yourself: keep track of several spiral exits from your bath and you will find that the water goes either way, depending on the movements you produce in the water as you step out of the bath. And by simply swirling the water the other way, you can reverse whichever spiral first forms. The Coriolis force that is related to the rotation of the earth is very weak, and you need special conditions to see its effects on liquid flow patterns. Only if there is no other stronger influence to initiate a vortex will the Coriolis force break the symmetry of water flow and induce a clockwise spiral in the Northern Hemisphere and counterclockwise in the Southern.

—*Brian Goodwin*, in *How the Leopard Changed Its Spots: The Evolution of Complexity* (Scribner)

The upper arm has three degrees of freedom at the shoulder, which is a ball-joint. If you start with your right arm hanging by your side, you can raise it in a straight line either forwards or to the side, making two degrees of freedom. To assure yourself there is a third, raise your arm level with the shoulder and pointing straight ahead, with the index finger extended. Now bend the elbow till your index finger points straight up. Finally, without further bending of the elbow and keeping the upper arm still pointing straight forward from the shoulder, rotate the forearm anticlockwise until the index finger points to the left.

. . . The shoulder is indeed a remarkably mobile joint, and only excellent design is able to give such a variety of motions through such large angles, while retaining strength and small size. It is not surprising that it dislocates from time to time.

—*Michael French*, in *Invention and Evolution: Design in Nature and Engineering* (second edition; Cambridge University Press)

Molecular Conformations

Stereochemistry of Organic Compounds. ERNEST L. ELIEL and SAMUEL H. WILEN, with a chapter by Lewis N. Mander. Wiley, New York, 1994. xviii, 1267 pp., illus. $75 or £57.

Science historians may record that the last half of the 20th century was organic chemistry's "era of stereochemistry." Fittingly, the era began with Barton's pioneering *Experientia* paper (1950) that pointed out the profound significance of the chair conformation of cyclohexane and the far-ranging consequences of the difference between "axial" and "equatorial" substituents and with the first experimental determination of absolute configuration of an organic molecule, sodium rubidium (+)-tartrate, by Bijvoet in 1951. These two developments, one dealing with dynamic and the other with static stereochemistry, were followed shortly by seminal publications from Cram (1952), Prelog (1953), and Dauben (1956) on the stereochemical outcome of additions to the faces of prochiral carbonyl groups and from Zimmerman (1957) on the preferred conformation of the transition state for reaction of an enolate with an aldehyde. At the same time, the now-standard system for stereochemical nomenclature was being formulated (Cahn and Ingold, 1951) and perfected (Cahn, Ingold, and Prelog, 1956). These important developments during the 1950s set the stage for an explosion of activity in many different aspects of stereochemistry, which continues until the present time.

During this period of exponential growth, two of the most influential stereochemical textbooks were Ernest Eliel's *Stereochemistry of Carbon Compounds* (McGraw-Hill, 1962) and the Eliel-Allinger-Angyal-Morrison book *Conformational Analysis* (Wiley, 1965). Generations of chemistry students (the author included) "cut their stereochemical teeth" on these important texts. Now comes the long-awaited update, *Stereochemistry of Organic Compounds* authored by Eliel and Samuel Wilen, with a significant chapter on stereo- selective synthesis by Lewis Mander. In 14 chapters spread over 1267 pages, the authors have distilled the essence of a large field.

Stereochemistry of Organic Compounds does an excellent job of surveying the subject at a level appropriate for a chemistry graduate student and will no doubt become a standard resource for chemistry teachers at all levels. The book covers all of the standard topics that one would expect to find in a comprehensive discussion of stereochemistry, such as symmetry elements and symmetry point groups, methods for the determination and notation of absolute configuration, properties of stereoisomers, separation of stereoisomers, and chiroptical properties. In addition, there are detailed synopses of less common aspects of stereochemistry. For example, chapter 6, "Properties of stereoisomers. Stereoisomer discrimination," is a well-crafted discussion of "the physical properties of enantiomer pairs and methods for the determination of enantiomer composition." This chapter includes a succinct definition of "homochiral" and "heterochiral," words coined by Lord Kelvin in 1904 and much misused in the recent chemical literature. It also includes cogent discussions of such interesting topics as biodiscrimination and origins of enantiomeric homogeneity in nature.

One of the most useful sections of the book is Mander's 156-page chapter 12, an excellent précis of the burgeoning field of stereoselective synthesis. Here the reader will find a well-organized summary of diastereoselective synthesis, enantioselective synthesis, and double stereodifferentiation. All of the important synthetic reactions are treated, with ample discussion of modern mechanistic rationale as applied to stereoselectivity. This chapter alone could form the syllabus for a modern graduate course in stereocontrolled synthesis.

The final chapter, "Chirality in molecules devoid of chiral centers," provides