by the KGB), the tensions within dissident circles, Sakharov's seven-year internal exile, the demoralizing KGB thefts of four successive drafts of his memoirs (which Lourie would eventually translate and on which he draws on copiously here), and the summons from Gorbachev 21 months into *perestroika* to return to Moscow. "He was a move in Gorbachev's game," Lourie writes, "a bishop brought in at a sudden diagonal." Though intrigued by string theory, Sakharov had long since ceased doing science systematically. He emerged, hesitantly, as the leader of a democratic opposition. He died in 1989, while executing a government commission to write a new Soviet constitution. The Soviet Union died two years later, and so did the impressive edifice of Soviet science, which collapsed along with the state that had engendered, nurtured, and harassed it.

**BOOKS: PLANETARY SCIENCE**

# Travelers in Space and Time

**Monica Grady**

**Stable shield.** This 47.4-kg iron meteorite from Cabin Creek, Arkansas, was shaped by ablation after drag forces oriented it with respect to its direction of motion.

**Meteorites**
**A Journey Through Space and Time**
***by Alex Bevan and John de Laeter***
Smithsonian Institution Press, Washington, DC, and University of New South Wales Press, Sydney, Australia, 2002. $35.95, £27.50, A$59.95. ISBN 1-58834-021-X.

**The Cambridge Encyclopedia of Meteorites**
***by O. Richard Norton***
Cambridge University Press, New York, 2002. 374 pp. $50. ISBN 0-521-62143-7.

It has been argued that meteoritics, the science of meteorites, was born at the turn of the 19th century: Ernst F. F. Chladni published the first textbook on meteorites in 1794. In 1801, Giuseppe Piazzi discovered the first asteroid, Ceres, and the next year Edward C. Howard published the first chemical analysis of stony meteorites. Two hundred years later, we are in the middle of a golden age of meteorite study. Once considered rare curiosities and regarded with veneration or superstitious dread, meteorites are now recognized as natural objects lingering from the earliest period of solar system formation. Meteorites are true time travelers, carrying within themselves evidence of over 4.56 billion years of evolution.

Meteorites span a range in composition and texture from unmelted, primitive stony objects to highly differentiated irons. They provide probes for tracing the origin and evolution of the dust from which the solar system aggregated and for studying processes of planetary formation. Most meteorites are fragments from asteroids, but rare lunar and martian meteorites yield information on their parent bodies that complements data obtained from space missions. With sophisticated instrumentation, we can investigate submicrometer-sized presolar grains, which emanated from stars whose life cycles were completed before that of the sun had commenced. The material needed to carry out these various studies falls randomly and unpredictably all over Earth's surface. Until approximately 30 years ago, the recovery of new meteorites was a matter of chance and only about 2000 meteorites had been recognized. (Fewer than 12 per year if one takes the date of Howard's analysis as a starting point.) Today, however, over 30,000 meteorites are known; the annual acquisition of specimens has increased by nearly three orders of magnitude through the efforts of teams of collectors who have returned meteorites preserved in hot and cold deserts. Almost every collecting trip turns up unusual meteorites and increases the diversity of material available for study.

Along with the rapid increase in the number of recovered meteorites, there has been a concomitant increase in the number of meteorite collectors and dealers. This has led to an enhanced interest in planetary sciences in general and meteorites in particular. There is, more than ever before, an extensive market for nonspecialist texts describing the nature and significance of meteorites. The two most recent entrants in this field are very different in style, although their contents necessarily overlap a great deal.

Alex Bevan, a mineralogy curator at the Western Australian Museum in Perth, and John de Laeter, an emeritus professor of physics at Curtin University in Perth, offer *Meteorites: A Journey Through Space and Time*. Billed as "written for people who are not scientists," the book is structured as a series of 14 self-contained essays that covers all aspects of meteoritics. The text is straightforward and well illustrated, and the book more than fulfills its promise to explain the nature and significance of meteorites. The authors avoid the traditional approach to meteoritics, in which specimens are described in terms of their classification and properties; instead, the chapters are more process-orientated. Through detailed but clear treatments of planetary formation and differentiation, meteorites are placed firmly within the context of the solar system's evolution. Bevan and de Laeter also provide a fascinating historical overview of pre–19th century beliefs about meteorites. My principal disappointment in this otherwise excellent book is that enlargement of a few of the digital images has left them pixelated, reducing the sharpness and clarity of the textures shown. Notwithstanding this shortcoming, the authors have chosen a rich variety of illustrations with which to enhance their text. I would recommend their book to nonspecialists fascinated by meteorites and interested in what can be learned from them.

In contrast to Bevan and de Laeter's book, the grandly titled *Cambridge Encyclopedia of Meteorites* by O. Richard Norton, an astronomer and former director of the University of Arizona's Flandrau Planetarium, is something of a disappointment. Few specialists would claim to have the breadth and depth of knowledge required to write a complete encyclopedia on a subject, especially a work that aims to "act as a reference source for students, teachers and scientists." And this is where Norton's



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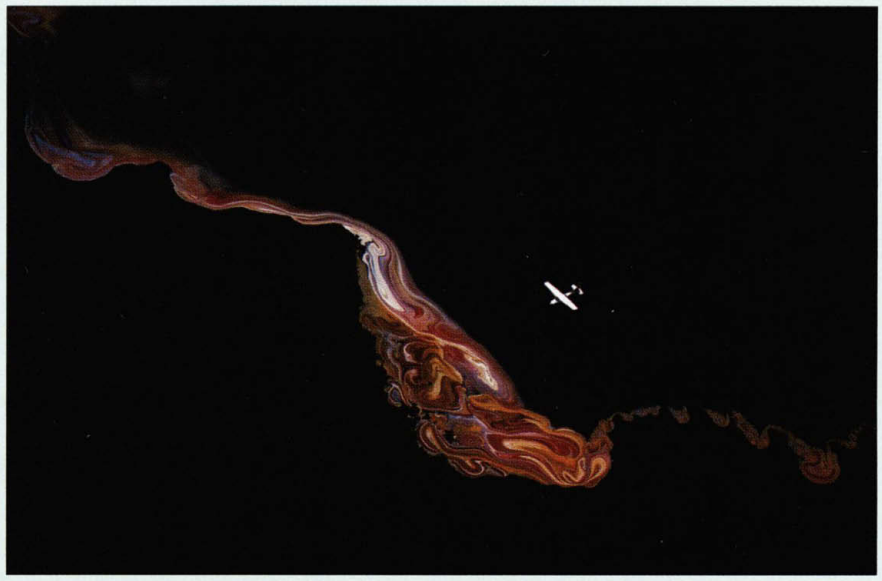
text falls short of what might be expected of an encyclopedia—the author's lack of expertise in several aspects of meteoritics has resulted in errors. The straightforward text takes the traditional approach of systematically describing stones, stony-irons, and iron meteorites in terms of their classification and properties. The book is not the sort that a nonspecialist would read in order to learn about meteorites; it is much too technical for that. However, it is beautifully and lavishly illustrated with many pictures of meteorites in thin section as well as of hand specimens. These images should help the work fulfill another of its goals, providing a "guide to assist searchers in the field to recognize the many classes of meteorites."

Meteoritics has come a long way in the 208 years since Chladni's publication. Bevan and de Laeter devote their final chapter to looking to the future, in which they consider missions to Mars, comets, and asteroids, along with efforts to retrieve interstellar dust. Much remains for the next 200 years; we are still looking for meteorites that are indubitably from Mercury, Venus, a cometary nucleus, and a Kuiper belt object. Part of the excitement of meteoritics is knowing that any of these extraterrestrial rocks might already be here on Earth, just waiting to be found, identified, and written about. In their different ways, both of these books convey the message that meteoritics is a fast-moving field, one in which we still have much to learn.



CREDIT: YANN ARTHUS-BERTRAND/ALTITUDE AGENCY, PARIS

**BROWSINGS**

**Earth from Above.** Revised and Expanded Edition. *Yann Arthus-Bertrand.* Abrams, New York, 2002. 462 pp. $45.00. ISBN 0-8109-3495-7. **Earth From Above.** An exhibit at Millennium Park, Chicago, IL, through 30 September 2002.

With a helicopter as his preferred tripod, Arthus-Bertrand specializes in composing images on the fly. Ranging from an intimate glimpse at a worker resting on cotton in the Côte d'Ivoire to a spectacular panorama of the Himalayan crest, the 190 photographs in this oversize volume capture the beauty of natural landscapes and human settlements alike. Many depict strikingly abstract patterns, such as these formed by crystallized salts on the surface of Kenya's Lake Magadi (above). Arthus-Bertrand's project was supported by UNESCO, and the book includes 14 new short essays on our beleaguered world and steps towards an "eco-economy." The exhibit, with 120 large (1.2 m by 1.8 m) prints, opened in Paris in May 2000 and has appeared in 40 cities and 15 countries.



PERSPECTIVES: GENOMICS

# Vertebrate Genomes Compared

**S. Blair Hedges and Sudhir Kumar**

It takes two of anything to make a comparison. With the publication of the draft genome sequence of the tiger pufferfish (*Fugu rubripes*) by Aparicio *et al.* on page 1301 of this issue (*1*), we are now able to compare the genomes of two vertebrates. Measuring 365 million base pairs in length, the *Fugu* genome is only one-ninth the size of the human genome (*2*) yet contains approximately the same number of genes. Shorter introns and a smaller amount of repetitive DNA in the pufferfish genome account for this difference. Its unusually small genome size, combined with a faster method of sequencing (whole-genome shotgun), has yielded a much lower price tag—a mere $12 million compared with the hundreds of millions of dollars spent on sequencing the human genome. The primary incentive for sequencing this and other vertebrate genomes lies in better identification and characterization of human genes and their regulatory elements, especially those that are mutated in human diseases. For example, nearly 1000 putative human genes have been discovered by comparing the *Fugu* and human genomes (*1*). Beyond biomedical applications, the extent of conservation and divergence among the pufferfish and human genomes will shed light on the underlying evolutionary and genetic mechanisms that shape them.

The tiger pufferfish is a good example of how the concept of "model organism" has changed. Growing up to 70 cm in length, it is a relatively large marine fish known for its taste, not a laboratory workhorse like the fly or mouse. It was introduced as a "genomic model" organism (*3*) specifically because of its compact genome, permitting efficient comparison with the human genome. Other genomic models include human parasites, such as *Plasmodium* and *Trypanosoma*, and species of interest to agriculture, such as rice and corn. *Fugu*'s relative, the spotted green pufferfish (*Tetraodon nigroviridis*), is a much smaller (up to 17 cm in length) freshwater species with a similarly small genome, and is more accessible to experimental research requiring laboratory breeding. The *Tetraodon* genome, one of at least 18 vertebrate genomes being sequenced, is almost complete (see the figure).

A major motivation behind genome-sequencing projects is to generate a better

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