Biology on the global scale

All of the Earth's systems — including life — are intimately connected.

The Earth's Biosphere: Evolution, Dynamics, and Change
by Vaclav Smil
MIT Press: 2002. 360 pp. $32.95, £21.95

Peter Westbroek


GETTY IMAGES

Tree of life: tropical forests support biodiversity by providing habitats for a huge range of insect species.

No object in the Solar System is more enigmatic than our own familiar planet. At least four of its attributes stand out as unique, as far as we know. The slow mill of tectonics pumps the rocks around from the deep Earth to the surface and back; two-thirds of the planet is covered with liquid water; the atmospheric composition is far removed from thermodynamic equilibrium; and, most stunning of all, there is abundant life — a biosphere. We feel that these remarkable attributes are intimately connected, but are poorly informed about these relations and by what principles the system evolved. Earth dynamics, in particular the role of life, is hot stuff at present, Earth system science and geobiology being examples of new disciplines specifically concerned with this problem. So Vaclav Smil's overview of what we know about the biosphere is timely.

To those reading *Nature* today, it may come as a surprise that only a few decades ago Earth dynamics was overwhelmingly considered as resulting from purely physicochemical interactions. Even Edward Suess, who coined the term 'biosphere' in 1875, thought of life as basically independent of the rest of the planet. In retrospect, it seems as though the geologists first had to settle the more basic aspects of their subject before they could concentrate on the intricacies of geobiology.

This may explain why the Russian scientist Vladimir I. Vernadsky, who had already set the stage for modern geobiology in the first half of the twentieth century, could be ignored for so long in the Anglo-Saxon part of the world. It is one of the great merits of Smil's book that it puts this record straight. The volume opens with a vivid description of Vernadsky's eventful life and career, stressing the enormous achievements of this great scientist. *The Earth's Biosphere* may be read as an update of Vernadsky's key book *The Biosphere*, which only appeared in English as recently as 1998 (Copernicus Books, translated by D. B. Langmuir).

The subject is immense, encompassing the present state of life and its environment, as well as the history of the system over almost 4 billion years. To deal with a field of this complexity, two options are open. One can either try to organize the different aspects around a single vantage point, or just give a kaleidoscopic description of the state of our knowledge. The first approach has the advantage of coherence and perspective. Things fall into place and there is an argument that one can agree with or not. James Lovelock's book on Gaia (*The Ages of Gaia: A Biography of Our Living Earth*, Norton, 1988) is an example. It is easily accessible even to a lay audience and, although the message has been criticized, the book has sparked a vivid interest in a systems approach to the Earth and to global geobiological feedbacks.

Another example is S. A. L. M. Kooijman's *Dynamic Energy and Mass Budgets in Biological Systems* (Cambridge University Press, 2000; 2nd edition), which presents a theory of biological organization at the level of the individual organism. Based on a very limited set of assumptions, this theory has a high predictive value and covers an amazing variety of natural phenomena. The ambition is to extend the organismal models to the molecular, ecological and eventually global levels of organization.

Smil's book is closer to the descriptive end of the scale. It covers almost the full range of relevant subjects, while many of the actual relationships between them remain open-ended. Discussions of the physical aspects of the system include the generation and output of energy by the Sun, plate tectonics, oceanic and atmospheric current systems and global climate. Biological subjects include molecular processes, organismal biology, ecology and global phenomena. Thus there are passages on basic molecular-biological concepts and the origin of life, metabolic pathways, microbial ecology, and biogeochemical cycling. The global dimension includes discussions on the deep hot biosphere and biospheric mass and productivity. The book ends with the impact of civilization on the biosphere.

The above is only a selection, and the whole text becomes a bit of a pot-pourri. I feel that this not only reflects the author's jumpy mind, but also the state of the art. Nevertheless, the book offers updated reviews of many of these subjects, and most of its statements are well documented by the long list of references. This by itself is a major achievement, for which all those interested in the biosphere should be grateful.

In addition to presenting the broad overview, Smil indulges in a wealth of salient and often entertaining details. Did you know that a sperm whale can dive more than 2,000 metres deep, holding its breath for over an hour? Or that in 1973 a jet collided with a huge vulture at an altitude of over 11,000 metres? The book is replete with such *petites histoires*. These are welcome, of course, but point to a lack of organization underlying Smil's less systematic approach. At times I felt somewhat overwhelmed by the abundance of facts, observations, theories and details. This impression was strengthened by the uneven style of writing. Some parts read like a newspaper, whereas others are in the dry style of professional reviews. I recommend several rounds of rigorous reorganization before the next edition goes into print.

With the present focus on Earth system science and geobiology, there is a pressing need for good introductory textbooks. Although I do not think that Smil's volume is sufficiently systematic to qualify for a first students' introduction to this burgeoning field, it will certainly be of great use to a more advanced audience with a general curiosity in biospheric matters. Smil conveys the thrill of exploring the unknown planet we inhabit. His enthusiasm and the broadness of his interest are infectious. ■

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Putting scientists in the picture

Envisioning Science: The Design and Craft of the Science Image
by Felice Frankel
MIT Press: 2002. 335 pp. $55, £36.50

Dee Breger

Newspaper mogul William Randolph Hearst had it right when he wrote: "The illustrations are a detail, though a very important one. Illustrations embellish a page; illustrations attract the eye and… materially aid the comprehension of an unaccustomed reader." Hearst was referring to artists' illustrations of newspaper stories in the late nineteenth century, but his insight was prescient about today's photography. He was later an avid photographer, so he would surely have been delighted at the burgeoning of photographic techniques that has occurred since the simple optics of his day. Technological developments have led to the atomic, microscopic, macroscopic and galactic scales of contemporary science images.

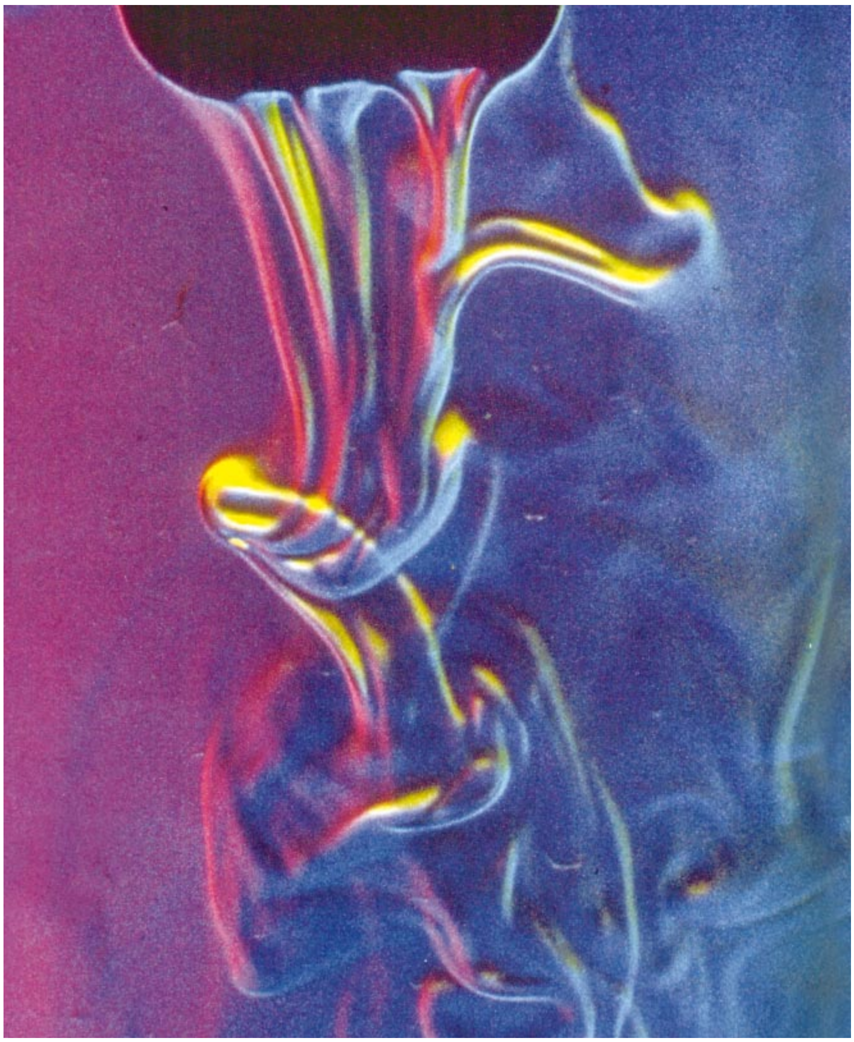
Even mediocre pictures can briefly attract the eye, if that's all we want from them. Better, though, is to enhance the viewer's comprehension by elevating images to media quality with the application of techniques used by professional artists and photographers. How to bring these techniques to the research community? Enter Felice Frankel and her exceptional manual, *Envisioning Science*.

Frankel, a photographer at the Massachusetts Institute of Technology, is a leader in the growing movement to enhance the quality of technical images from science and engineering. Her goal in this meticulously organized book is to help readers create "an image that communicates your work more effectively to both colleagues and the general public". These are two distinct audiences, but Frankel's mission suggests that they don't necessarily require divergent approaches. A high-quality, technically and aesthetically proficient image is always an effective vehicle for transmitting information. A poorly lit or composed photo can convey less information than intended, and one that includes distracting extraneous details can obscure the message as well. These are especially important considerations for interdisciplinary communication.

The use of stimulating images attracts the often science-shy public as nothing else can; accompanying textual information is then more likely to be absorbed in a fluid, agreeable way. And, as Frankel points out, public interest creates a supportive climate for research. For all these reasons, universities have begun to recognize and invest in the powers of higher-quality scientific imagery.

Written in a conversational tone, *Envisioning Science* is primarily a comprehensive lab manual for the optimum photography of research samples. Covering both film-based and digital techniques, it is also a generous reference book for photographic facts and resources, and includes exercises, a bibliography and two useful indexes. But it is also an art book in the sense that it is a beautifully designed array of arresting images (nearly all the author's). And it is a science guidebook in that the images chosen to illustrate the points under consideration derive from many disciplines and tell diverse stories.

An introductory section sets the stage for the core of the book: chapters that present concise, easy-to-assimilate descriptions of equipment and methods, copiously illustrated with comparative or before-and-after photographs. The initial chapter on the basics of picture-making includes data on sample preparation, composition, lighting, exposure and depth of field. Subsequent chapters tailor these topics to the photography of small samples 4–10 cm in size, and for using a stereomicroscope to document samples ranging from 50 μm to 4 mm. A chapter on compound microscopes (for samples down to 1 μm) includes a section on biological fluorescence microscopy. The final



K. VANDIVER

Swirl of colour: ice can be seen melting in water by photographing gradients in the refractive index.