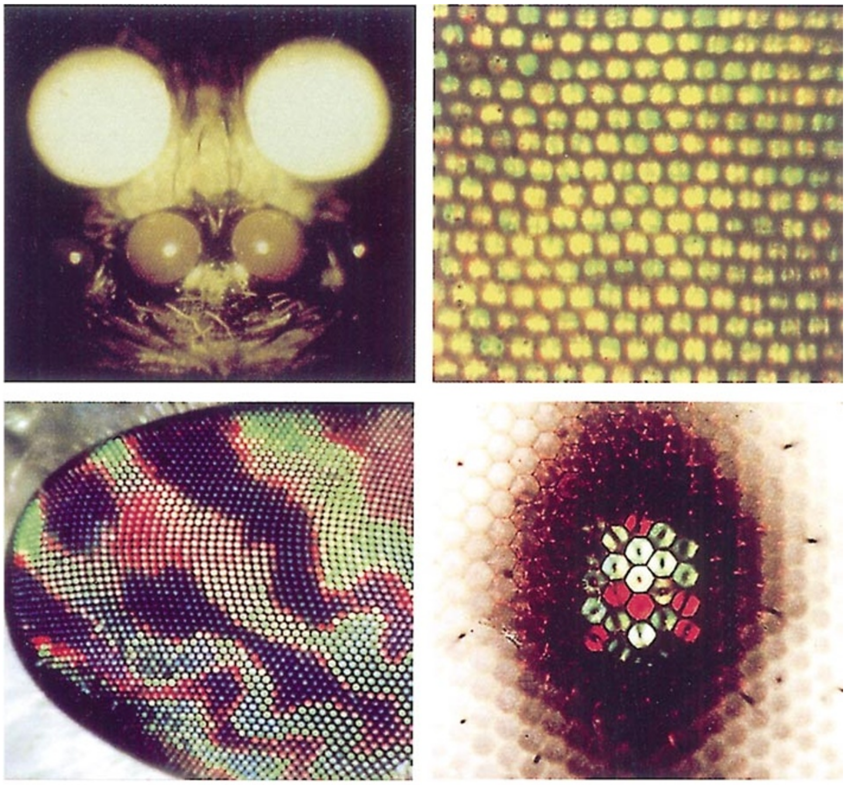


## Visual virtuosity

**The nocturnal wolf spider (top, left; its retina, right) has eight eyes, four of which have a mirror, or tapetum, which reflects light back through the retina. *Animal Eyes* by M. F. Land and D.-E. Nilsson (Oxford University Press, £24.95, $45; pbk) discusses such adaptations and many more, including the visual equipment of the horsefly (below, left) and butterfly (right).**

phenomenon of synchronization.

Synchronization has been on our tongues since the seventeenth century, when Christiaan Huygens first observed the co-ordinated movement of the pendulums in his clocks. Today, understanding synchronization may provide the jackhammer we need to penetrate the walls encircling some of our most difficult scientific challenges.

The authors begin with an engaging history of synchronization that whets the appetite. Of course, this history is reassuringly accompanied by black-and-white photographs of cranky-looking scientists — *de rigueur* for any scientific history.

Next comes my favourite section of the book, the plainly titled "Synchronization". This is written in a way that gives the reader a real understanding of the subject. It leads on to my second-favourite section, the more aggressively titled "What is NOT synchronization" — more scientific books should have a section that clearly spells out misconceptions about their subject.

This attractively laid-out book contains numerous fascinating examples of synchronization culled from the physical and biological sciences. Those that pique the interest include electrical circuits, cardiac pacemakers, menstrual cycles, circadian rhythms and chaotic synchronization. Attractive illustrations tell the story behind each example and demonstrate an important topic to full effect. There is also a section (often neglected by more reality-challenged authors) called "Detecting synchronization in experiments", which explores the consequences of when theory meets experiment. This section alone is worth the price of the book.

One-third of the way into the book, I encountered mathematical equations and, amazingly, was sufficiently motivated and had learnt enough from the previous chapters to begin to establish a meaningful relationship with the increasing complexity. I was rapidly guided through the essentials of the synchronization of driven systems, mutual synchronization, noisy synchronization, oscillatory media, phase synchronization of chaotic systems and globally coupled oscillators. These topics are liberally sprinkled with eclectic and interesting examples and with sufficient references to enable the reader to delve further into relevant questions of synchronization in a variety of fields.

The book concludes with one of the best expositions on the synchronization of chaotic systems that I have read. The sections on, for example, phase (and how it is defined) in chaotic systems, the relationships between unstable periodic orbits embedded in chaotic systems and generalizations of synchronization in complex systems (neglected by most standard treatments) are outstanding.

Clearly, the authors of *Synchronization* have pulled off a very difficult trick, that of writing a book that is both a definitive introduction to synchronization for the casual reader and a definitive text for researchers working in a variety of fields. Still, if I might make a suggestion for the second edition of this book — defy tradition and use pictures of smiling scientists! ■

*William Ditto is in the Wallace H. Coulter Department of Biomedical Engineering, Georgia Tech/Emory University, 315 Ferst Drive, IBB 3306, Atlanta, Georgia 30332-0535, USA.*

# Words of climatic wisdom

**The Encyclopaedic Dictionary of Environmental Change**
edited by John A. Matthews *et al.*
*Arnold: 2001. 701 pp. £125*

**Heike Langenberg**

Those who have attempted interdisciplinary collaboration know that one of the highest hurdles to overcome can be language. For example, by 'ventilation' an oceanographer means an influx of water masses rather than anything to do with wind or air. And words such as 'vorticity' are just jargon to non-specialists. These obstacles can make reading literature outside one's own field of research — as well as talking to colleagues from another department — anything from difficult to hazardous.

The problem is well known from the realm of foreign language. With some training in French but no Latin, at the age of about 15 my sister made an educated guess at the translation of Caesar's title *De Bello Gallico* and came up with "The beautiful Gaul". To avoid such potentially embarrassing pitfalls, dictionaries have long served the students of foreign languages. *The Encyclopaedic Dictionary of Environmental Change* aims to support students and researchers of the environmental sciences in much the same way.

But, true to its title, the book is more than just a dictionary. Short paragraphs in understandable language briefly explain the basic concept behind most terms; longer pieces of up to a page are devoted to broader fields such as the "geological record of environmental change". And references, remarkably up to date and citing a good proportion of work from this millennium, help the interested reader to dig deeper than the book can go. Not entirely true to the title, *The*

*Encyclopaedic Dictionary* is devoted far more to environmental science and climate reconstruction than to environmental change, but a certain concession to the vogue of the day does no harm and might increase sales.

Of course, even an encyclopaedic dictionary cannot replace a textbook. So if you are thinking of working in the environmental sciences following a degree in another field (mathematics, in my case), you will still need to work your way through the more involved explanations provided in specialist books.

For example, the explanation of the "Coriolis force" spans only eight lines, and does not go into how it works, why it exists or when it is important. But then, when you read a paper outside your own field of expertise and the words "Coriolis force" pop up, you might not want to know all of this anyway. *The Encyclopaedic Dictionary* does tell you that the Coriolis force deflects air flow to the right in the Northern Hemisphere and to the left in the Southern Hemisphere, and that its magnitude is proportional to the velocity of the air mass and the sine of the latitude. It omits to mention that the same holds for ocean currents, which might have been useful. Nevertheless, the explanation should help you to carry on reading your paper with a good idea of what is meant.

The dictionary emphasizes techniques and methods and contains invaluable accounts of the many ways of constructing past, present and future climates from terrestrial and marine archives as well as from models. Given that most of our knowledge of past climate is based on the interpretation of a wide range of complementary proxies — records such as tree rings — which give indirect information, this is perhaps the most important use of the book. Modellers can learn what speleothems can tell us, and soil scientists obtain an understanding of how foraminifera can record climate.

The coverage seems to be pretty complete; at points, the editors even go a little overboard. For example, 4.5 pages of entries with the prefix "eco" (including "ecofeminism", unknown even to the *Encyclopaedia Britannica*) are not strictly necessary, and instead of three terms starting "geoeco" (geoecology, geoecosphere and geoecosystems), a single one would have been enough. On the other hand, three entries for "hotspot" ("in biodiversity", "in geology" and "in remote sensing") are utterly justified and very useful.

All in all, *The Encyclopaedic Dictionary of Environmental Change* helps to make sense of the babel that can be so characteristic of the literature and conferences in the environmental sciences and gives excellent support when reading across the disciplines. But beware: if, like me, you enjoy following up cross-references, this book may bind your attention longer than you had intended. ■

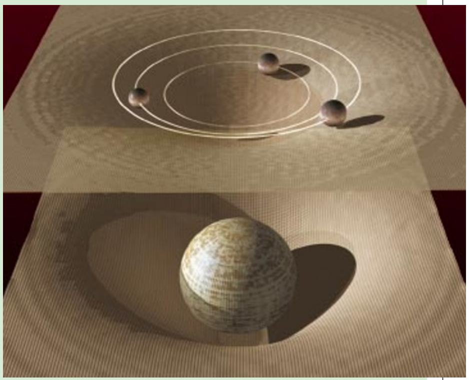
*Heike Langenberg is a physical sciences editor at* Nature.

# Science in culture

## Godwin's galaxies

**The illustrations in Stephen Hawking's *The Universe in a Nutshell***

*Martin Kemp*



**Brane new worlds: Godwin's depiction of two adjacent brane worlds, one of them our own.**

MALCOLM GODWIN

Illustrations accompanying popular science are rapidly becoming a genre of art in their own right. The most valiantly ingenious are those in books by theoretical physicists and mathematicians who take us on dizzying voyages through multi-dimensional space. The classic dilemma of how to represent figures of more than three dimensions on a flat surface remains the greatest technical challenge, allied to the task of visualizing the kinds of space that evolution has ill-equipped us to 'see'.

The latest contender in the quest to portray the strange world of theoretical physics is the artist, illustrator and author Malcolm Godwin, whose works are included in such prestigious collections as the Museum of Modern Art in New York and the Tate Gallery in London. Until the 1970s he worked as a sculptor, using translucent materials to explore the representation of complex spaces. As an author–illustrator, he has been responsible for books such as *Who are You? 101 Ways of Seeing Yourself* (Carroll & Brown, 2001), *The Lucid Dreamer* (Simon & Schuster, 1994) and *Angels: An Endangered Species* (Simon & Schuster, 1990).

Having collaborated with Stephen Hawking on *The Illustrated Brief History of Time* (Bantam, 1996), he has now provided the extraordinary suites of images for Hawking's *The Universe in a Nutshell* (Bantam, 2001). Although credited in person only at the very end of the 'Picture Acknowledgements', his depictions occupy at least as much space as Hawking's text, and bear a very substantial part of its communicative burden.

Hawking began by signalling where he thought illustrations should be provided, initially envisaging many more than could eventually be included. Godwin, for his part, provided twice as many as were eventually used, and each design was either accepted, returned for revision or rejected by the author.

The range of illustrative techniques is remarkable. There are photographs and images of people, literal depictions, mnemonic representations of objects (such as clocks and guns), poetic evocations of concepts, suggestive analogies and metaphors, representations of two- and three-dimensional space, and illusionist tricks to conjure up visions of multi-dimensional space, as well as the diagrams, graphs and formulae expected in a physics book. Conventional figures are hugely outweighed by those that use visual evocation to depict concepts that cannot be represented in a direct manner.

Not the least of the problems is the disjunction between the language of theoretical physics and that of the illustrator. This applies literally, in that a term such as 'axis' has a different meaning for an artist than for a theoretical physicist studying black holes. It also applies more broadly to the way that physicists exploit a quasi-diagrammatic and mathematical language that is internal, part of their own conceptual world. Indeed, Hawking does not demand that his mathematical models correspond to physical reality as experienced in any obvious sense. As a self-declared positivist, the existence of extra dimensions has meaning for him only insofar as the mathematical models of $n$-dimensional space serve as good descriptions of the Universe.

An excellent example of how Godwin has responded to something that cannot be envisaged as straightforwardly 'real' is his illustration of the influence of one 'brane world' on another. In brane theory, largely the creation of Hawking's colleague Paul Townsend, a brane (as analogous to 'membrane') is defined as an object that has a variety of dimensions. Thus, a $p$-brane possesses length in $p$ dimensions, whereas a 1-brane is a string, a 2-brane is a membrane, and so on.

The illustration evocatively shows two adjacent 'brane worlds', our own and another. The nearby brane world is not visible from ours because light is trapped within the dimensions of each brane. However, gravitational forces are envisaged as operating across the gap, and the existence of the mass of the nearby 'shadow brane' can only be detected through its gravitational effect on the behaviour of objects in our own Galaxy. The orbital paths of our stars are thus literally overshadowed by sources that are irredeemably dark to us.

The reader, perhaps struggling to understand when told how brane theory is part of M-theory, might turn to the glossary. This duly informs us that M-theory "unites all five string theories, as well as supergravity, within a single theoretical framework, but which is not fully understood". A tough job indeed for the illustrator. ■

*Martin Kemp is in the Department of the History of Art, University of Oxford, Oxford OX1 2BE, UK.*