were themselves guilty of using these strategies in the past to further their own economic interests. Until 1891, copyright protection in the United States was restricted to US citizens and, between 1790 and 1836, patents were similarly restricted. The Netherlands and Switzerland also avoided adopting a patent system when industrialists wanted to make use of foreign inventions.

This is not a book for the faint-hearted. General readers may wish to understand why patents and copyright have become prominently linked to such issues as access to medicines in poor countries and the consequences of pirating software and music. But they may become weary as the book traces, often in great detail, how representatives from many industrial, government and other organizations allegedly conspired to manipulate patent and copyright systems to become accomplished operators in the 'knowledge game', to the detriment of the public interest and the developing world.

Those who stay the course will gain a clear insight into why so many non-governmental organizations are furiously lobbying for the removal of TRIPS and for reform of the patent and copyright systems. But they will not discover why many other constituencies, including industry, universities and governments, are broadly in favour of protecting intellectual property. Crucially, evidence of why the patent system has, on balance, almost certainly benefited consumers hardly gets a mention. As a consequence, many of the arguments advanced in the book are seriously flawed.

Neither do the authors get to grips with some of the most important questions in development policy that loom large today: notably, how should the moral and economic responsibility of addressing the burden of disease and food insecurity that affects developing countries be apportioned, and by whom? ■

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Science laws and science lore

Cassell's Laws of Nature: An A–Z of Laws and Principles Governing the Workings of Our Universe/The Nature of Science: An A–Z Guide to the Laws and Principles Governing Our Universe
by James Trefil
Cassell Reference/Houghton Mifflin: 2002/2003. 433 pp. £25/$35

Walter Gratzer

After he pulled off, with his *Brief History of Time*, the biggest publishing coup since the Bible, Stephen Hawking revealed that he owed it all to a sage injunction from the publisher: no equations, for every equation would halve the sales. $E = mc^2$ alone was permitted. James Trefil's text is fairly liberally adorned with equations, but they are more for show than for instruction, because his primary target is the lay audience.

Trefil has assembled a multitude of laws, rules, principles and maxims of science. I had not previously heard of Cope's law — though I am willing to believe that where palaeontologists gather they speak of little else — or Allen's rule, or many of the others that feature in Trefil's 235 short essays. His book is, in truth, an encyclopaedia, encompassing the whole panorama of science, with potted biographies of celebrated protagonists, from Archimedes and William of Occam to the heroes of today.

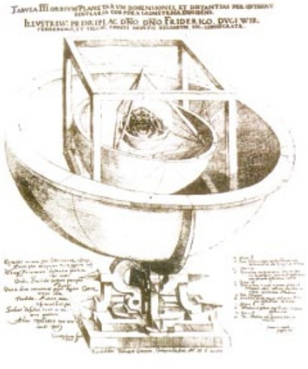
Trefil takes the view that anything too rarified or obscure for the standard textbooks does not warrant inclusion. There is, as he concedes, room for argument around the edges: why, for instance, Graham's law of the diffusion of gases, but not the principles of colligative solution properties, such as Raoult's law? The phase rule is out, as is the Stark effect, but Zeeman is in.

Biology tested pretty well for comprehensiveness. Trefil even finds room for some defunct generalizations, such as the rule that ontogeny recapitulates phylogeny (which he quite properly rejects), yet homeotic genes — among the most important discoveries in twentieth-century biology — are an odd omission.

Still, there is plenty here to nourish all but the most omniscient reader. Trefil writes in an easy, colloquial style, even if some of his analogies are a trifle laboured. His great virtue is that he does not funk the most daunting subjects in the physical sciences; indeed he generally prefaces his expositions with soothing reassurances that the matter is not as difficult as it may seem. For the most part, he adheres to the excellent principle that a little inaccuracy often saves a world of explanation.

In his dissertation on Heisenberg's uncertainty principle, he suggests that if your mind rebels at such an affront to common sense, you should ask yourself: "Why not? How do I know what things are supposed to be like inside the atom? Have I ever been inside an atom?" This strikes me as a mite facile, for the overthrow of determinism did, after all, trouble many of the best minds of the twentieth century. It was Max von Laue and Otto Stern who swore an oath (broken, to be sure) that "if this nonsense of Bohr's turns out in the end to be correct, we will leave physics".

Einstein never renounced his belief that "God does not play dice" (countered more recently by Stephen Hawking, who declared that not only does God play dice, but he sometimes throws them where they can't be found). In cleaving nevertheless to pictorial representations, Trefil chooses to discuss not only atomic physics, but also chemical bonding in terms of the archaic Bohr–Rutherford planetary atom, with



New in paperback

The Evolution Explosion: How Humans Cause Rapid Evolutionary Change
by Stephen R. Palumbi
W. W. Norton: 2002. 288 pp. $14.95, £11.95
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Einstein's Unfinished Symphony: Listening to the Sounds of Space-Time
by Marcia Bartusiak
Berkley: 2003. 272 pp. $14

The Biomechanics of Insect Flight: Form, Function, Evolution
by Robert Dudley
Princeton University Press: 2002. 536 pp. $35, £24.95
"Robert Dudley has written a remarkably comprehensive account of our knowledge of insect flight." R. McNeill Alexander, *Nature* **405,** 17–18 (2000).

Nearest Star: The Surprising Science of Our Sun
by Leon Golub & Jay M. Pasachoff
Harvard University Press: 2003. 267 pp. $16.95, £11.50, E16.95

only the sketchiest allusion to atomic orbitals. The problem remains that, as one physicist has put it, we have no words for the quantum world.

Trefil is a physics professor who served time as a high-energy physicist, and his entries in the physical sciences are accordingly the most authoritative. There are some curious errors nevertheless: what, for instance, is the Rydberg constant doing in the Clausius–Clapeyron equation? Was this introduced (in place of the gas constant) by the errant hand of a copy-editor? The shear elastic modulus is wrongly defined, the description of Oersted's famous experiment misses the point, and the section on spectroscopy recognizes only the electronic sort, with not a mention of vibrational, nuclear magnetic or electron-spin-resonance spectra.

The biological topics are for the most part clearly laid out, but again they are not altogether devoid of errors. Most are trivial, but blue-eyed children are not born to brown-eyed parents, nor does a B-cell display many kinds of antibody on its surface; the experiments of Miller and Urey and their successors on the origins of life have never given rise to anything that can decently be called a protein or a lipid; bacteriophages do not all contain DNA, nor, when they do, is it necessarily stitched into the host genome; and there are 20 protein amino acids.

The material is abundantly cross-referenced, yet there is a good deal of repetition. A few entries, says Trefil, are "just plain fun"; so there is the 'beauty criterion', Occam's razor and Murphy's law (although without the various well-known corollaries — when you want to do something, there is always something else you have to do first, and so on). Fermat's last theorem surfaces, presumably because it has of late entered into public consciousness (as reflected by the graffito in the New York subway: "I have a beautiful proof of this theorem but can't give it here because my train is coming").

This is a handsomely produced and stylishly illustrated volume, and should make a helpful and attractive basic reference source. I am now better informed on several topics of which I knew little before for having read it. So more power to Trefil for a brave and largely successful effort. ■

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Mergers and acquisitions

Darwin's Blind Spot: Evolution Beyond Natural Selection
by Frank Ryan
Houghton Mifflin/Texere: 2002/2003. 320 pp. $25/£18.99

Steven A. Frank

Photosynthesis arose in several independent bacterial lineages. Traditional evolutionary analysis would suggest that photosynthetic biochemistry originated independently in each of the separate lines of descent. However, recent genomic comparisons between five groups of photosynthetic bacteria show that there has been widespread horizontal gene transfer. Several bacterial groups acquired key components of photosynthesis by getting genes from other lineages.

The plant *Dichanthelium lanuginosum* grows in geothermal soils that get very warm. Like nearly all land plants, *Dichanthelium* has symbiotic fungi. These fungi enhance the growth of *Dichanthelium* at temperatures below 40 °C but are essential above 40 °C; plants without symbiotic fungi die at higher temperatures. So colonization of geothermal soils by *Dichanthelium* requires symbiosis.

Retrotransposons make up about 38% of mouse and human genomes. Those transposons presumably invaded ancestral genomes by retroviral infection. It is not yet clear whether retrotransposon DNA contributes significantly to host characters. However, the origin of some important host characters will probably be traced to this vast genomic component descended from viral genes.

According to *Darwin's Blind Spot*, if you are shocked by these observations, you are a true darwinian; if not, you are a radical symbiologist. Frank Ryan's darwinians believe that evolutionary change can arise only by descent with modification within clearly defined lineages. The radical symbiologists believe that major evolutionary innovation often arises by the joining of genetic information from different lineages.

The three observations on symbiosis quoted above come not from Ryan's book, but from a few recent issues of *Science* and *Nature* that I happened to read last night. Must we conclude that these journals have abandoned traditional darwinism and quietly gone radical?

Ryan has built an exciting story of heroic outsiders and fierce conflict over the nature of evolutionary innovation. There were indeed mighty battles over the origin of mitochondria and the eukaryotic cell, but they ended decades ago. Now everyone accepts that mitochondria descended from an independent bacterial lineage, and that the eukaryotic cell has symbiotic origins.

I agree with Ryan that mainstream evolutionary biologists still often fail to consider symbiosis as a plausible hypothesis to explain puzzling characters. But this failure does not arise from deep convictions about the nature of evolution. Rather, the mainstream comes round to a new way of thinking only after the evidence has piled up. Genomics will help greatly here because it allows us to trace the evolutionary history of lineages and untangle the complex web of descent.

Studies of symbiosis will surely lead to great progress in understanding ecological interactions and evolutionary history. On this most important point, Ryan is right. So why is it necessary to have heroes and villains, and to portray mainstream science as hopelessly conservative and plainly wrong?

Sales. Ryan is a successful author who

J. BURGESS/SPL

On the move: the broken, variable colour of dahlias is caused by transposons, or 'jumping genes'.