subject non-mathematically.

Of the three books, I like *Planet Quest* best. Ken Croswell has everything needed in a great science writer. He knows his subject and understands the joys, difficulties and frustrations of being an astronomer. He has great skill in interviewing the scientific protagonists and drawing from them the details of the excitement and disappointments of their endeavours; many of these interviews are quoted verbatim. And he can tell a superb story, which is compelling and complete. I particularly liked his discussion of the way the media reacted to the 'new planet' news. The book is riveting. And what is more, it has an extensive note and reference section.

Worlds Unnumbered comes a close second. Donald Goldsmith also discusses the new planets revealed in the 1990s but then places them in the wider context of the origin of life, the likelihood of extraterrestrial intelligence, and the perpetual fascination of humanity with unidentified flying objects. He also tries to predict where the subject will be at the end of the next two decades.

The *Quest for Alien Planets* by Paul Halpern is thinner than the other two and more prosaic. Halpern has clearly spent considerable time talking to people and picking up the cut and thrust between the observational astronomers, who are pushing their techniques to the limit, and the theoreticians, who have laboured long and hard to explain how our Solar System formed and are greatly concerned that the new systems have very little in common with the one we live in and clearly had a radically different process of generation. He has produced an engaging tale. He stresses the possible role of planets as the elusive 'dark matter' and also looks to a very distant future when earthlings may have to find somewhere else to live.

It is clear from all these books that we still have a lot of searching to do. Planet hunters will not rest until they have in their sights some more small blue worlds that are warm and wet, and upon whose wind-whipped oceans and verdant forests shines a bright, constant, yellow star like our own. □

David W. Hughes is in the Department of Physics, University of Sheffield, Sheffield S3 7RH, UK.

Life laws

Physical Theory in Biology: Foundations and Explorations
edited by Charles J. Lumsden, Wendy A. Brandts and Lynn E. H. Trainor
World Scientific: 1997. Pp. 486. $85, £59 (hbk); $42, £21 (pbk)

Per Bak

Is biology too difficult for biologists? And what can physics, dealing with the simple and lawful, contribute to biology, which deals with the complex and diverse?

It may not be useful to distil out general laws of structure or behaviour from the phenomena studied by biologists. Nevertheless, in the words of the editors of this book, a marriage is being forged between the two sciences by the information revolution. In 20 essays, some of the foremost practitioners of the enterprise guide us through a cross-section of subjects in which the theory of physics might provide insight into biology.

The essays range from the sound and useful, through the contrived and irrelevant, to the speculative and imaginative. After a philosophical start in which the editors struggle with the meaning and definition of so-called fundamental concepts such as emergence, holism, complexity and computation (not generally important in our simple reductionist science of physics), the book gets up to speed with reviews of specific applications. It goes to show that we learn general principles from specific examples, not vice versa.

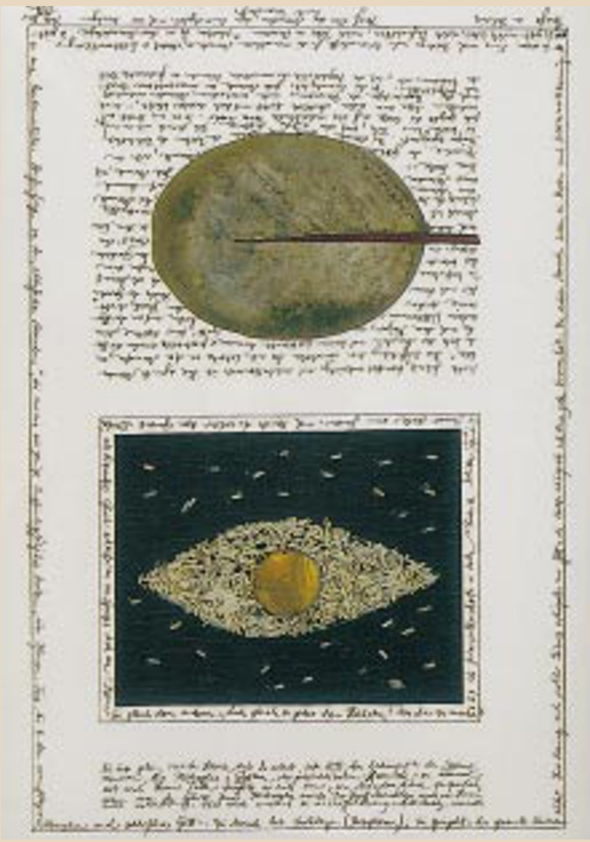
Various authors discuss pattern formation by introducing the 'morphogenetic field'. Patterns as diverse as the intricate surface features of the single-celled *Tetrahymena* and limb generation in the salamander can be described by minimizing an 'energy' function of an appropriately defined morphological field. The theory is rather phenomenological because the microscopic origin is largely unknown.

Goodwin then discusses two methods of deriving shape and form: minimizing an elastic energy function, and studying reaction–diffusion (forest fire) models. The first approach was initiated by D'Arcy Thompson as long ago as 1917, and the second by Alan Turing in 1952. The longevity of the processes is a direct measure of their success. Strikingly complicated forms can arise from very simple equations: the dream of theoretical physics come true! Another success story is the application of statistical mechanics to membranes and bilayers, which is (too) briefly covered by Jones and Tevlin. Here, concepts from theoretical physics are essential for any understanding.

The big targets for physics theorists are biological evolution and the brain. These complex many-body problems might have similarities to problems studied in particle- and solid-state physics. Busch and Trainor review Hopfield-type models of neuronal learning, but I see this as an example of physicists leading a whole field astray. It is hard to imagine a biological foundation for the complicated procedures for updating the synaptic strengths in those models. Nevertheless, the authors give a fair representation of the poor state of the art. They also apply their amusing generalization of the Hopfield neural network model to the organization of ants into eight different categories. This is an example of the way in which similar principles may apply in entirely different areas of science.

Some physical, or rather mathematical, considerations on topics in evolution are

Letters to Leibniz in Berlin



Ruth Tesmar, a German artist and professor of aesthetic practice, is celebrating the legendary letter-writing of the mathematician and rationalist Gottfried Wilhelm Leibniz in an exhibition that opens today at the Berlin–Brandenburg Academy of Sciences in Berlin. She explores the balance between aesthetics and scientific–technical rationalism. "Letters about monads", shown here, represents Leibniz's theory of monads by playing with writing, the traditional means of conveying theories. Tesmar's handwriting frames two images of Leibniz's work, indicating the separation of ideas by boundaries. Rice and a leaf symbolize paper-making materials. "Briefe an Leibniz" runs until the summer.
Alison Abbott *is the senior European correspondent of* Nature.

then reviewed. Evolution on the basis of the statistics of DNA sequences is discussed, and Rowe explains the evolution of evolutionary stable strategies within the framework of game theory. The field of biological physics is vast, and this book barely touches a couple of corners.

The important issue here is not what physics theory has done for biology (which is not very much), but what it can do in the future, and to this end the book does a marvellous job of defining the arena. My own view is that biology is proving to be a goldmine for theoretical physicists at a time when large areas of traditional physics are almost exhausted. Read this book (and others) and get going! □

Per Bak is at the Niels Bohr Institute, Blegdamsvej 17, 2100 Copenhagen, Denmark.

Individual view

Metaphysics and the Origin of Species
by Michael T. Ghiselin
State University of New York Press: 1997. Pp. 377. $24.95, £19.50 (pbk).

Mark Ridley

Michael T. Ghiselin is an idiosyncratic mix of biologist, historian and philosopher. In 1969 he published *The Triumph of the Darwinian Method*, which is still, after 30 years of the Darwin industry, the book I should recommend to a scientific reader who wanted to understand Darwin's thinking. In the early 1980s, assisted by a MacArthur prize, he was one of the biologists who rescued molecular phylogenetics from its 20-year obsession with humans and chimpanzees and redirected it to transform evolutionary biology. But he is probably best known for his campaign, beginning with a paper in 1966, to establish that biological species are, in a philosophical sense, individuals.

It sounds an odd claim, but only because of a pun. As Ghiselin says, "in the usual biological sense, 'individual' is a synonym for 'organism' but the ontological term is a much, much broader one." He does not mean that biological species are organisms (which clearly they are not), but that they are logically — he would say metaphysically — individuals as opposed to classes. Classes are spatiotemporally unrestricted and have defining properties by which you can recognize members, or instances, of the class; individuals are spatiotemporally restricted, non-instantiable (you do not point and say "now there is a particularly fine example of Bill Clinton") and lack defining properties.

For instance, there is a class of all chairs (defined in some suitable way, such as all four-legged furniture that humans use to sit on), and there are individual members of the class. A particular chair has its own history: it is built in a certain place, put in the library, has its arm broken by a student, is stained when a mug of coffee (existentially contrary to library rules) is spilled on it, and is finally destroyed by the gravity of a fat professor. Many scientific classifications do define classes: chemical elements are classes, for example gold consists of all elements with atomic weight 79. But are biological species like the class of chairs, or the particular chair? Most biologists before Ghiselin accepted that each species is a class: thus we speak of a person as being a 'member' of *Homo sapiens*, and species as having 'definitions' drawn up by museum-bench taxonomists.

Ghiselin noticed that, because of evolution, biological species cannot have defining properties. All swans may be white now, but if one mutated to black it would not cease to be a member of the swan species (assuming it could interbreed as normal). A species originates in a speciation event, evolves indefinitely down a lineage, and becomes extinct, analogously to that individual chair. The attributes that a species happens to possess are a contingent matter, like the attributes — the clothes or hairstyle — of a person. Individual attributes may help you to recognize someone at a certain time, but they do not logically define the person, because they can be changed without changing the person into someone else. Linnaean names, like *Homo sapiens*, are therefore proper names. A taxonomic description is logically a diagnosis not a definition.

In *Metaphysics and the Origin of Species* (the title deliberately alludes to the classics of Theodosius Dobzhansky and Ernst Mayr), Ghiselin makes his case fully, from first principles, and defends it against its many critics. In later chapters he explores the implications of the 'individuality thesis' in related topics, such as development and evolution, macroevolution and phylogenetics.

The book is of the kind that narrow-minded laboratory scientists call philosophical and like to ignore. "Why bother to think, when you can do experiments!" (*mutatis mutandis* as biology matures into a descriptive science). There are no experiments in Ghiselin's book, and none of his questions can be answered experimentally. But many scientists and philosophers do like to think about these things. What will they find here?

Critics will find it personal to the point of egocentric ("The possibility that species are processes, rather than wholes composed of organisms, has perhaps never occurred to anyone besides me"), discursive to the point of rambling ("Be that as it may..." is a common paragraph opener), rabbinical about historical texts, and polemical to the point of rude. Supporters will find it stimulating and enjoy the insights across an exceptional range of subjects, they will admire the erudition ("Curiously, the original 'Strickland Code' of zoological nomenclature, to which Darwin

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