to solve them using standard dynamics. Einstein took a clue from the second law of thermodynamics instead. Although the second law can give lots of detailed results, it can also serve as a higher-level 'judgement machine', telling you whether an entire type of activity is allowable or not. The result, of course, was the postulates of special relativity.

### Relax in your own way

Physics is hard, and relaxation is crucial. Max Planck and Werner Heisenberg played the piano at near concert-level. They loved immersing themselves in music, not just for its beauty, but because it suggested the underlying truths that were still waiting to be discovered. Religion has been a deep source for many others — such as Abdus Salam and Faraday — and there are also a few who've taken the Schrödinger approach. Erwin Schrödinger had a tolerant wife, a charming manner and as many affairs as Wolfgang Pauli had tantrums. This presented problems in Anglo-Saxon countries. As the biographer Walter Moore put it: "It was bad enough [for Schrödinger] to have one wife at Oxford — to have two was unspeakable."

Most frequently, though, it's simply conversation: honest, quick-firing conversation with the handful of friends who can lift you to a higher level. This insight is what William Cropper has provided, in a book that has such excellent biographical information, mixed in with fully accurate science, that it can serve both as a good guide for top secondary-school students or beginning university students, and as a wise collation of advice and experience for working physicists at all levels beyond. ■

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# Costs and benefits of inflicting pain

**Defending Animal Rights**
by Tom Regan
*University of Illinois Press: 2001. 224 pp. $24.95, £18.50*

**Why Animal Experimentation Matters: The Use of Animals in Medical Research**
edited by Ellen Frankel Paul & Jeffrey Paul
*Transaction Publishers: 2001. $49.95 (hbk), $24.95 (pbk)*

**William H. Shaw**

In *Defending Animal Rights*, Tom Regan maintains that animal experimentation is immoral and should be halted. The ideas and arguments of philosophers such as Regan have helped to galvanize the animal-rights movement. But although the regulation of animal research has increased, extremists still express their dissatisfaction with it by harassing scientists, vandalizing laboratories and releasing test animals from their cages.

The contributors to *Why Animal Experimentation Matters*, by contrast, deplore animal activism and reject the idea of animal rights. Its editors do not strive for balance, but seek to show that animal experimentation is vitally important to human welfare and therefore morally permissible. Most of the essays are by scientists who argue that animal experimentation has contributed crucially to medical and scientific progress, and offers our best hope for understanding and combating many deadly or incapacitating diseases. But lists of scientific breakthroughs resulting from animal testing and experimentation will not assuage those critics, including some scientists, who believe that the overall benefits of animal experimentation are exaggerated.

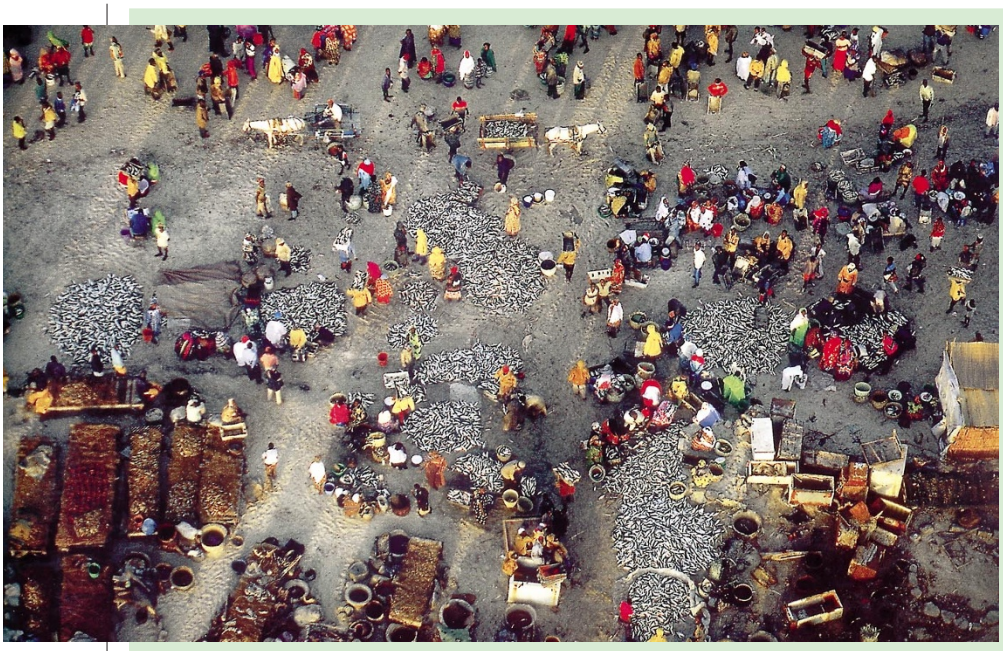
Some of the authors in *Why Animal Experimentation Matters* worry that excessive concern for animal welfare can hamper research, and they write as if there have never been needless or abusive experiments on animals. These days, Institutional Animal Care and Use Committees (legally mandated in the United States) typically urge experimenters to 'replace' animal experimentation with other research methods where possible, to 'reduce' the number of animals used, and to 'refine' the research so as to minimize pain and suffering (the 3R approach). Experimenters are also encouraged to substitute lower animals for higher ones. Has such regulatory control eliminated genuine evils? Has it retarded scientific progress? This book neglects such questions.

The scientists writing in *Why Animal Experimentation Matters* believe that humans matter more than animals do, but their moral arguments are often superficial. Placing emphasis on the benefits we would lose if we gave up animal research does not prove that animals have no moral rights or that their interests are inherently less valuable than our own. Neither our superior cognitive abilities nor the fact that animals treat one another badly settles the question of our duties to them. And one reads with embarrassment two evolutionary biologists decrying animal rights as a "maladaptive philosophy" because it fails to promote the interests of our species, and debunking animal advocates as "adaptively unfit" because they tend to be childless (based on a survey of participants in a 1990 rally).

By contrast, the philosophers contributing to the book grasp the deeper, thorny ethical issues. And, unlike the scientists, they don't mind raising problems for the home team. Thus, Baruch Brody proposes a thought

## Rare and unusual

**The Usambara three-horned chameleon (*Chamaeleo deremensis*) from Tanzania becomes spotted with black when irritated. It is one of the 420 or so reptiles illustrated in *A Field Guide to the Reptiles of East Africa* by Stephen Sprawls *et al.* (Natural World, £29.95).**



## Around the world in 365 days

**The vivid colours of a fish market in Saint-Louise, Senegal, one of Yann Arthus-Bertrand's photographs in *The Earth from the Air: 365 Days* (Thames & Hudson, £24.95). His powerful images on many different scales range from the polar wastes to the tropics, giving a new view of natural and human landscapes — from the 'stone forest' of Madagascar to the Rio slums.**

experiment that forcefully challenges the assumption that animal pain is intrinsically less important than human pain, and R. G. Frey argues that the same reasoning that justifies experimenting on animals (which he supports) also justifies experimenting on members of our own species.

Regan, on the other hand, is an abolitionist. He does not want to regulate or reform animal experimentation, but to end it altogether. He rejects the utilitarian approach of philosopher Peter Singer. Singer believes that animal testing and experimentation are wrong because the price paid by the animals outweighs the likely benefits to humans. Singer does not contend that animal lives are equal in value to our own or that they have rights. What he does say is that, to act morally, humans must take animal interests into account, giving those interests as much weight as the equivalent interests of humans.

Regan faults utilitarianism for permitting us to sacrifice the interests of some for the benefit of others and, more specifically, for failing to rule out animal experimentation in principle. He believes that some animals are the "subject of a life". By this he means that they "bring the mystery of a unified psychological presence to the world". These animals desire, remember, feel emotion and act intentionally. Taken together, such capacities mean that their lives have innate value. In kantian terminology, these animals are ends in themselves — just as humans are — and, accordingly, they have a right to life, liberty and bodily integrity. More generally, they have a right to be treated with respect.

If all subjects of a life have these basic rights, and if, as Regan believes, many non-humans are subjects of a life, then experimenting on these animals is morally impermissible. To point to the costs of forgoing such experimentation, as *Why Animal Experimentation Matters* does, misses the point. But is Regan's reasoning sound? Regan argued his case at length in his 1983 book, *The Case for Animal Rights* (University of California Press). In several of the essays collected in *Defending Animals Rights*, he restates his position and addresses his critics. But the philosophical debate is bound to rage on. ■

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# Biotechnology retrospective

**The Green Phoenix: A History of Genetically Modified Plants**
by Paul F. Lurquin
*Columbia University Press: 2001. 240 pp. $50, £33.50 (hbk), $25, £17 (pbk)*

**F. C. Botha**

Ask any student of biotechnology today when the first foreign DNA was transferred to plants, and the answer will invariably be 1984. Very few will recall that it all started with the innovative and tenacious work in Lucien Ledoux's laboratory in Belgium in the late 1960s. And it would be interesting to know how many plant molecular biologists have read the two pioneering publications of Ledoux and Huart, which claimed to report the integration of foreign DNA into the genome of barley. Paul Lurquin's book appropriately reminds us of the major difference between the theory of the scientific method and the way it translates into practice. Certainly, it is not as simple as formulating a hypothesis and then automatically verifying it. All those many failures — and often erroneous interpretations — are seldom told to newcomers to the field.

In the late 1960s, the concept of horizontal DNA transfer — the transfer of genes between species — was inconceivable, as this violated the accepted idea of slow, mutation-driven evolution constrained by sexual barriers. Without good models or detection systems, the early pioneers in this field had to persuade a highly sceptical scientific community of the merits of their hypotheses. It is almost unimaginable that they had to rely on a very basic technique, density centrifugation, to demonstrate gene transfer in plants. Today's students have the benefit of sensitive modern techniques, and yet often fail to obtain good evidence for the stable integration of foreign DNA into plant genomes. They will certainly appreciate the enormous task that early researchers faced in convincing others of this phenomenon.

In the very early days of plant genetic engineering, the small flowering plant *Arabidopsis* was already the laboratory workhorse for the Ledoux team. In 1974, they stated that they had achieved the successful complementation (restoration to normal function) of a vitamin B1 mutation by the transference of genetic material from bacteria. In the same period, D. Hess in Germany claimed to have engineered a change in flower colour through horizontal gene transfer. Both pieces of research were heavily criticized and their accuracy was questioned. But a major turning point came with the discovery in Germany and the USA that genes from the bacterium *Agrobacterium* can transfer naturally to plants. The book accurately describes the very rapid developments that followed this discovery, culminating in the conclusive demonstration of horizontal gene transfer to plants in 1984.

Looking back at the turbulent first two decades of plant genetic engineering, it is difficult to understand how the researchers involved persisted with their ideas. It is inspiring to read how a few individuals, driven by curiosity and faced with strong opposition and criticism, eventually had such a huge impact on science. Yet again, this history illustrates how major breakthroughs, with enormous potential applications and