Thermodynamics and Society

Entropy. A New World View. Jeremy Rifkin with Ted Howard. Viking, New York, 1980. xiv, 306 pp. $10.95.

In this book Rifkin attempts to use the first and second laws of thermodynamics to expose the weaknesses of the mechanistic world view—the "Newtonian machine paradigm"—that he sees as underlying the rapid consumption of fossil fuels and accessible mineral resources by the technological nations. Those societies have increased the entropy of the earth by converting "available" energy, stored up over millions of years, into "unavailable" energy. They have developed their life-style by exploiting resources of the Third World, whose citizens exist on the edge of survival. This situation cannot continue much longer: already the oil-producing nations have asserted their rights to a fair return, and we can expect similar actions by exporters of other critical resources. In a world armed with nuclear weapons, conflicts over resources could lead to a catastrophic war. Even if wars are avoided, the earth will soon run out of easily recoverable resources. Rifkin feels it is imperative that technological nations develop plans now for a low-consumption, "entropic" society and start moving in that direction before resource wars cause a collapse of society or we are left with insufficient resources to make the transition.

In taking up entropy, Rifkin is like a child with a new toy—he has great fun applying the concept to all aspects of our high-technology society. He starts off well enough with the familiar application of thermodynamics to energy conversion processes and the degradation of concentrated energy sources. He senses that entropy deals with minerals that occur in low concentrations in nature, that is, that one must expend energy to overcome the high entropy of a widely dispersed resource. However, he never makes explicit use of the entropy of mixing. The "expert" whose ideas he draws on, Georgescu-Roegen, suggests in his afterword to the book that thermodynamics deals with energy, but not matter, "because energy, being a homogeneous 'substance,' is analytically far more tractable than heterogeneous matter" and indicates the need for a fourth law that would deal with matter as the first and second laws deal with energy, in apparent ignorance of the fact that scientists have for years dealt successfully with matter by means of the existing laws.

Rifkin evidences further confusion about the applicability of scientific laws. He presents the second law as invalidating Newton's laws and appears not to understand that Newton's laws are quite applicable to objects large enough that quantum effects can be neglected and moving slowly enough to avoid relativistic effects. He views statistical thermodynamics as a plot to overcome the implications of the second law, that is, that the natural tendency of systems with time is toward states of less order. He apparently does not realize that the very foundation of the second law is in the statistical interpretation that, for a system containing a large number of atoms or molecules, the most probable distribution of energies is so highly favored that one can ignore all other distributions, including those that would carry the system backward in time to a more highly ordered state.

The book seems to be presenting an argument against some group, but whom is Rifkin fighting? Presumably those engaged in high-technology work. Yet the scientists and engineers engaged in such work surely understand the second law much better than Rifkin does. Furthermore, most who have given the matter much thought would surely agree that our present use of energy cannot continue far into the future without serious modifications. However, probably few would agree with Rifkin's vision of the future.

Rifkin paints a grim picture of our future, low-entropy life. He discounts nuclear fission as an energy source on the grounds that it is too dangerous and believes that there is no certainty that fusion reactors can be developed. Synfuels and oil shale are viewed (probably correctly) as offering only temporary solutions and as being environmental disasters. He arrives at the usual "soft energy" conclusion that solar energy is the only ultimately satisfactory source. Because of its diffuse nature, he believes solar energy would not be convenient for use in densely populated cities. Thus he envisions a dispersion of the population to small towns and rural areas, with a much larger fraction of the people being engaged in agricultural work. Few aspects of society escape Rifkin's attention: he views even our education and health-care systems as extensions of the Newtonian world machine (making that connection less convincingly than Alvin Toffler does in *The Third Wave*). In the future he envisions, education would place much less emphasis on facts, as excess information accumulates as "dissipated energy"—a form of "social pollution." Instead schools would focus on "processes" and include training in manual skills needed by people who would be largely self-sufficient.

Rifkin rejects virtually every aspect of modern society. Yet, although he is surely right in thinking that we will have to make some major changes in the way things are done, there is no reason all modern developments need be thrown out. Many recent developments, such as silicon chips and fiber optics, use little energy or scarce resources. Rifkin ignores the possibilities for breakthroughs in work on nuclear fusion, photocatalytic decomposition of water, or other energy-related processes that might lead to new energy sources. He also ignores the fact that we are on the threshold of enormous developments in molecular biology whose results we cannot begin to foretell. His approach is more that of an antitechnology "religion" than a careful evaluation of each facet of society to decide which can be retained and which rejected or modified. He has little to say about the population explosion, although, almost as an aside, he notes that the world's population in a low-entropy society would have to be considerably reduced. Curiously, he misses an opportunity to attack the American diet for thermodynamically inefficient consumption of so much food from "consumer" trophic levels.

Rifkin weakens his case with sweeping statements that are not supportable by facts. One example: "In the advanced industrial environment, the chief cause of disease is the dissipated energy created by our energy base of nonrenewable resources." He also asserts that "in 1970 the auto pollution totaled 111 million tons of sulphur oxides." In fact, the total from all anthropogenic sources in the United States was (according to the third annual report [1972] of the Council on Environmental Quality) about 34 million tons, of which about one million came from transportation. Rifkin states that the government acknowledges a direct correlation between the rise in disease since 1950 and pollution from petrochemicals, producing to support this statement a quotation indicating that heart and lung diseases caused 12 percent of U.S. deaths in 1900 but 59 percent in 1976. Of course, most of this increase came about because deaths from other causes were reduced owing to advances in sanitation and medical treatment. As in many instances throughout the book, the reference for his quotation is to a secondary source, here the *Washington Post*, and not to the primary document. Rifkin's funniest error is his comment that the 4000 tons of garbage generated daily in Washington, D.C., would cover the Mall to nearly half the height of the Washington Monument. According to my calculation, this would make the monument about 5 inches tall. These are just a few examples of statements that destroy the book's credibility.

To Rifkin's credit, unlike many advocates of solar energy, he warns that society may be quite different with solar energy as a major source. The transition to a solar-energy–based society will be painful, perhaps revolutionary. Costs will be enormous and it cannot be done quickly. He makes the interesting point that 75 percent of the buildings that will exist in the United States in the year 2000 have already been built, so most would have to be retrofitted for solar energy. On the other hand, life in the "entropic" society would not have to be as dull, almost medieval, as Rifkin pictures it, as we could retain computers, communications, and other features of society that use little energy or resources.

This is a very disappointing book. Thermodynamics, and the second law in particular, can be used quite effectively in dealing with many problems of our society and has been by several authors, notably Alvin Weinberg, Stephen Berry, and Barry Commoner. There is a need for continued efforts to awaken citizens, politicians, and scientists to the need for changes in our uses of energy and other resources. But bringing about such changes will require careful, quantitative evaluation of the alternatives that a simplistic antitechnology approach does not provide.

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Behavioral Ecology

Behavioral Mechanisms in Ecology. DOUGLASS H. MORSE. Harvard University Press, Cambridge, Mass., 1980. xii, 384 pp., illus. $25.

During the last decade behavioral ecology has emerged as an exciting field of study, so named because the way in which behavior contributes to survival and reproduction depends on an animal's ecology, the food it eats, its predators, the architecture of its habitat, and so on. Present methods of field observation and experiments are really just extensions of the descriptive approach to behavior of the early naturalists and the studies by Tinbergen and others of animals in their natural environment. The recent excitement has arisen from advances in theory, particularly the development of optimality theory and ideas about the evolution of social behavior, together with the realization that it is possible to test precise, quantitative predictions about animal behavior in the field. We can now attempt to explain why it is often male fish but female mammals who exhibit parental care, why in ant societies there is more cooperation between sisters than between brothers, and why the male dungfly copulates for 41 minutes.

Morse provides a useful textbook reviewing the field, particularly foraging and antipredator behavior, habitat selection, competition for resources (mates and territories), and social groups. The book is attractively produced and well written, but, for me, it does not convey the excitement of behavioral ecology because the examples of behavior discussed are not related in any critical way to evolutionary or ecological theory. For example, in the chapter on food selection the results of several patch-choice experiments are described, but there are no details of the underlying theory (marginal value theorem); in the section on communal breeding there are only brief discussions of the concepts of kin selection, inclusive fitness, and coefficients of relatedness; data to test a threshold model of territoriality are given, but the model is not described so we do not know its assumptions or predictions; several examples of individual differences in competitive behavior within a population are given but no theory of alternative strategies.

Of course, there is always the danger of becoming carried away by theoretical arguments. A few years ago, if we saw an animal behaving in a way different from the majority of the species we would probably have said it was abnormal; now we are perhaps too quick to label anything different as a "strategy." However, I think this book goes to the opposite extreme; unless there is some critical presentation of theory it will be difficult for the student reader to understand exactly why the observations are interesting.

In the final chapter, Morse gives a sensible list of future directions for the subject. Since the book went to press (it covers the literature up to 1978), several of these ideas have already been explored, such as quantification of the genetic payoffs from helping versus breeding in communally breeding groups and consideration of goals other than energy maximization in foraging models. However, Morse is surely right in emphasizing that many of the data are weak, even on fundamental problems like the costs and benefits of group living. Perhaps it is up to the fieldworkers to make sure that the theoreticians restrain their models by anchors firmly embedded in natural history. If so, then it is the theoreticians who would profit most by reading this book.

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Stellar Oscillations

Nonradial and Nonlinear Stellar Pulsation. Proceedings of a workshop, Tucson, Ariz., Mar. 1979. H. A. HILL and W. A. DZIEMBOWSKI, Eds. Springer-Verlag, New York, 1980. viii, 498 pp., illus. Paper, $33.60. Lecture Notes in Physics, vol. 125.

The sun is now being welcomed back into astronomy after a considerable interval of neglect by most astrophysicists. This is an exciting time for solar physics, and a principal cause of the excitement is the recent observation of solar pulsations with periods ranging from a few minutes up to 2 hours 40 minutes. In these proceedings the observational evidence for and theoretical implications of solar oscillations are enriched by discussions of oscillations in other kinds of stars.

Much of the interest in and excitement surrounding the study of solar oscillations is due to the possibility of learning through them about the interior regions of the sun that are not accessible to direct observation. This is now of particular interest because the flux of solar neutrinos observed in a lead mine in South Dakota is less by a factor of 3 than had been predicted from standard solar models, calling into question our understanding of solar (and stellar) structure. A recent flurry of interest in a solution to this problem related to a finite mass of the neutrino seems now to be dying down.

A mode of solar oscillation in which the entire visible solar disk or a large fraction thereof is moving in phase has a period equal to twice the time required for a sound-like wave to travel from the solar core to the surface. Studies of this wave give information about the density and temperature of the solar interior. Another type of wave having many nodes on the solar surface gives information about the outer layer of the sun. The solar rotation produces a splitting of this mode so that it is possible to measure the