page D-211 "the tropical forest appears to be more tolerant to radiation than temperate forests." My own feeling is that no such sweeping judgments can be proferred on the basis of these pilot experiments, with their obvious differences in treatments and with no replication to estimate the amount of natural variability. The question of how delicate is the balance of nature is obviously not answered in these experiments. The fault lies partly with the design of the experiments, but also is an inevitable consequence of the difficulty in doing field experiments. Experimental sites will be trampled, all difficulties cannot be foreseen, recovery after disturbance takes time. This is why working ecologists are cautious about making pronouncements of the effects of a disturbance of a natural ecosystem.

In the sections dealing with the forest as a system, Odum has tied together many of the findings in the other sections. In addition, he has constructed theoretical models of the whole system using "network diagrams" of power flows and control circuits. Most of the experimental data concern the power flows rather than the control systems. Odum has always used highly original approaches in his work, but his experiment at El Verde, in which he enclosed a whole section of forest in a plastic cylinder 60 feet in diameter and 67 feet high, is undoubtedly his most heroic one to date. The experiment was only partly successful, since some of the upper air was lost in eddies out the open top of the cylinder, but the device still served as a giant respirometer of the lower vegetation and the forest floor. With it, and numerous other ingenious experiments, he and his colleagues have made measurements of the metabolism of a sample of one of the most complex systems in the world.

I found Odum's circuit diagrams difficult to understand. The terms in the glossary of "modules of energy—circuit language" and the illustrative examples on pages A-6 to A-8 are not explained clearly enough to enable me to decipher the diagrams later in the book. A clearer explanation of the symbolism is given in Odum's recent book *Environment, Power, and Society* (Wiley, 1971; reviewed in *Science* 14 May).

Much of the summary chapter is devoted to compiling data on the biomasses of the different components and summarizing the energy and cycling of matter. Animals and microorganisms do not loom large in these power flows; animals weighed less than 0.1 percent of the total biomass. I hope, however, that readers will not be led to the conclusion that the importance of animals in the control circuits is proportional to their weight. Such an impression would be as misleading as evaluating the importance to a heating system of the thermostat by comparing its weight to that of the furnace. As Odum points out (p. I-273), the next urgent need is to study the control system.

Relatively little reference is made to work in rain forests elsewhere; this is understandable, for few other studies have gone beyond measuring biomass. The metabolism of the El Verde forest is compared to that in rain forests in Thailand and Panama and in plantations in Europe and Puerto Rico. It is difficult to decide whether the differences are real or due to differences in techniques or to errors. Whether the findings from El Verde will prove of general applicability only time will tell. The site has a degree of uniqueness, being on an island whose flora and fauna are less diverse than those of the mainland, and in a forest recovering from selective cutting about 25 years prior to the study. But all ecological field studies are site-bound to a degree, as ecologists know to their sorrow.

Within the constraints of my interests, competence, and time, I have not been able to review in any detail some of the chapters on plants, or most of those on animals, microorganisms and fungi, cytological studies, mineral cycling, and forest metabolism. Specialists in these fields will need to judge for themselves; they will undoubtedly find much of interest.

Its weight (10 pounds), thickness (3 inches), and length (1644 pages) make this an extremely unwieldy book to carry or to read, even without attempting to refer from one chapter to another. However, the price would make it a best buy in any consumer index. Although nobody would use it as a handbook in the forest, it will be very useful as a basis for future work in the American tropics, as well as a stimulant to students of tropical forests elsewhere.

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The Future of Deserts

Arid Lands in Transition. Proceedings of a symposium, Tucson, Ariz., June 1969. HAROLD E. DREGNE, Ed. American Association for the Advancement of Science, Washington, D.C., 1970. xiv, 524 pp., illus. $15.75; to members, $13.50. AAAS Publication No. 90.

The purpose of this conference was to contribute to a better understanding of the wise use of arid lands in different parts of the world, under different economic conditions and in countries in different stages of economic development. The papers include contributions from the physical, biological, and social sciences.

Perhaps the most significant feature of the proceedings is the movement toward a consensus by the ecologists and the developers concerning the potential for development and utilization of the world's arid regions. The traditional disagreement, posing man's responsibility for preserving the fragile ecological environment of the arid regions against the urge to make the desert bloom, is not completely absent, but it is considerably muted.

There is considerably greater disagreement regarding the economic welfare of the people who are forced to seek their livelihood in the arid regions. Kelso points out that among the world's arid regions "only the western United States . . . may be said to have escaped fully the restraints of aridity and entered into internally generated economic development," and this escape was possible primarily because the arid areas of the United States are part of the hinterland of a dynamic, urban-industrial economy in which the primary sources of growth lie outside the arid region. Unfortunately there is no easy escape from the lament, expressed by Dregne, "If a nation must be wealthy before it can provide modern services to all members of the rural community, the future is bleak for this and immediately succeeding generations in most of the arid regions." The arid areas of the American west can best be characterized as "low-density urban regions." It is unlikely that dependence on agriculture can be substantially reduced in most arid regions over the next several decades. And it is almost certain that most of the people who earn their livelihood in the arid regions will remain poor.

The most successful papers in the

volume are those that draw on an author's depth of research and experience. The paper by Le Houerou, "North Africa: past, present, future," is an outstanding example. Most of the authors, either by choice or by assignment, restrict themselves to rather general literature surveys. Interdisciplinary communication is reflected only at the most superficial level. Most of the papers contribute little in the way of new knowledge or insight and are valuable primarily for their extensive literature citations. In a few cases even this symbol of scholarship is lacking.

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Environmental Physiology

Biology of Intertidal Animals. R. C. NEWELL. Elsevier, New York, 1970. viii, 556 pp., illus. $23.75.

The simplest animals face the same array of basic problems in making a living as the most complex, and the sapient. The right kind of food in sufficient amount, an adequate supply of water and oxygen, protection from enemies and adversities of the physical environment, and a suitable mate are important requisites of species throughout the animal kingdom. Richard Newell's general view of the biology of the animals dwelling between high and low tide lines on the shore is that their physiological responses to the chemical and physical stresses of their environments largely determine where they will occur. The title of this book is thus to be construed narrowly. The dust jacket and preface describe its intent more aptly: to account for the distribution of intertidal invertebrates in physiological terms. The author devotes little attention to the biology of intertidal animal assemblages or communities.

The major sections of the book treat the establishment and maintenance of intertidal zonation patterns, feeding mechanisms, respiratory adaptations, and thermal stress and desiccation. These chapters are detailed and up-to-date reviews stressing the present state of knowledge and well documented with tables and graphs redrawn from original sources for increased clarity. The coverage is taxonomically wide but geographically restricted largely to the British Isles; however, many of the genera mentioned are also found along North American shores.

About 40 percent of the text is devoted to problems of respiration in the intertidal zone. Environmental factors affecting respiration are categorized as controlling, or setting boundaries of tolerance, and limiting, or actually determining metabolic rate at a given time. This section is lucid and informative, in part because the author's own research contributions have clarified some of the factors affecting the rate of oxygen consumption by intertidal invertebrates. Clarity is perhaps also facilitated here because the environmental requisite of all animals is identical—molecular oxygen. The other major topic covered, feeding mechanisms, is more challenging to present, because the energy sources of animals are packaged in a wide variety of complex molecular configurations, and the diets of all species differ: it is easier to describe utilization of the services of a gas pump than of a supermarket.

In the section on responses to thermal stress, Newell ranges to molecular levels of organization in seeking to explain mechanisms of acclimation and the well-documented fact that active rates of metabolism are dependent on temperature whereas resting and maintenance rates are constant over the broad temperature spans characteristic of the intertidal zone. Here important unanswered questions are clarified, and hypotheses based on knowledge of isoenzyme production at different temperatures in fishes are proposed as relevant to intertidal invertebrates.

By treating species of animals as independent entities and taking a reductionist or analytical approach, the author is able to concentrate on evaluating the environmental physiology of individual organisms, and the coverage is intensive but selective. Newell believes that to account for the distribution of intertidal animals in physiological terms is "by no means an easy task"; I believe it is impossible. One must consider that factors dependent on the presence of other organisms (of the same or different species) in the community may also be important determinants of distribution patterns, and these are either omitted or given only brief mention. Chief among the missing are predation and competition (the important studies of J. H. Connell in Scotland a decade ago are not cited), reproductive strategies and tactics, and defensive mechanisms against predation.

Selectivity of topics, absence of these more synthetic aspects of the ecology of intertidal invertebrates, and limited summarization and generalization detract from the book's desirability as an undergraduate text. For the topics covered, it will serve admirably as a reference, lucidly reviewing and guiding the reader to the relevant primary literature, including several recent important and unpublished London Ph.D. dissertations dealing, for example, with the biotic requirements of high tidepool organisms, effects of tidal level and temperature on activity, and a model of the settling behavior of free-swimming larvae.

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Inactive States

Dormancy and Survival. Symposium No. 23 of the Society for Experimental Biology, Norwich, England, Sept. 1968. Published for the Company of Biologists by Academic Press, New York, 1969. viii, 598 pp., illus. $15.

The speakers at the symposium of which this book is the proceedings included bacteriologists, protozoologists, botanists, entomologists, and mammalian physiologists. One might wonder how the convenor and editor could possibly organize the thinking of such a variety of scientists so that they could come out with an organized unit deserving the name "symposium." The types of dormancy even within the mammal group are diverse (there are at least four distinct types), so that it would seem difficult to compare "hibernation" in a bacterial spore and a mammal. The audience for the symposium should expect each of the 22 articles to include consideration of most of the following questions: (i) Does dormancy in the various groups of plants and animals show a central theme or common element? (ii) What induces dormancy? (iii) What keeps the flicker of life in protoplasm during dormancy? (iv) What initiates break from dormancy to growth? (v) What are the evolutionary meaning and ecological implication of the dormancy of the particular organism under discussion?

When I began to read the articles, I was reminded of a famous artist who