also the deepest fears of the GAC have been proved illusory. The GAC report is suffused with a feeling of horror of the hydrogen bomb as an open-ended weapon having no limit to its destructive power. It was this open-endedness that was the GAC's primary reason for opposing it. Oppenheimer was particularly oppressed by the nightmare of an undeliverable weapon. Suppose it had turned out, as Oppenheimer feared, that the smallest feasible hydrogen bomb was too heavy to be carried by air. Then the only way to use it would be to put in into a ship or a submarine and detonate it offshore. But then there would be coastal defenses, and the easy response to coastal defenses would be to go further offshore and increase the yield by another factor of ten. Within a few years you would have had ships filled with lithium deuteride, each having an explosive yield in the range of tens of thousands of megatons: in other words, doomsday machines. This was the nightmare that lay behind Oppenheimer's famous remark, "I am not sure the miserable thing will work, nor that it can be gotten to a target except by oxcart."

The reality turned out to be very different from the nightmare. The biggest hydrogen bombs ever built in the United States were those of the first generation, tested in 1954. Since those days the efforts of our designers in Los Alamos and Livermore have been dominated by the belief that small is beautiful. Instead of inventing undeliverable weapons, the designers have tailored their bombs to fit inside smaller and smaller vehicles. In no country have the political authorities shown any desire to build doomsday machines. The hydrogen bomb remains in theory an open-ended weapon, but in practice its destructive power has remained limited to the levels that military men consider reasonable. Our existing weapons are bad enough in all conscience, but they are not significantly worse than they would have been after 30 years of development of fission bombs alone. The step from fission to hydrogen bombs turned out in the end to be not so crucial as it seemed at the time. As Dylan Thomas said in one of the greatest of war poems, "After the first death, there is no other."

York is correct in his assessment that a golden opportunity was missed when Truman rejected the advice of the GAC in 1950. But the importance of this opportunity did not lie in the hydrogen bomb itself. Much more importantly, the GAC report gave Truman an invitation to speak frankly with Stalin and with the people of the world about the great political issues involved in the control of nuclear weapons. If Truman had seized this opportunity whole-heartedly, we could perhaps have begun to halt the nuclear arms race in 1950 instead of in 1970. Whether there was any real hope, with the Korean war about to begin and Stalin far advanced in senile paranoia, is another unanswerable question.

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Vegetation and Culture

Plants, Man and the Land in the Vilcanota Valley of Peru. Daniel W. Gade. Junk, The Hague, 1975. viii, 240 pp., illus. Dfl. 70. Biogeographica, vol. 6.

As in most mountainous areas in the tropics, cultural, natural, and physical interactions in the Andes are complex. The precipitous topography produces many ecological niches; this and the rich flora have allowed the development of a varied, stable, and productive agriculture, with abundant adventives and wild species for minor or supplementary uses. Gade describes the resultant system for a valley that is representative of much of the Andes and yet unique, the "Sacred Valley of the Incas," known for its great terraces and magnificent ruins, especially Machu Picchu. From tundra-like puna, pasture for several cameloids, sheep, and cattle, down past zones of potatoes, maize, *arracacha*, coca, and manioc, to the tropical forest, the landscape of the Vilcanota (or upper Urubamba) Valley is sweeping and varied. The crops, agricultural techniques, and trade patterns reflect a long, complex history.

Agricultural scene in Peru. "This scene is most likely to occur in . . . February. Early potatoes (*maway*) are being harvested under an overcast sky. Meanwhile a dog, two foxes and some birds are menacing the corn crop which is in the 'milk' stage. A woman stands on the field margin and beats a drum to frighten the animals out of the field. Dogs and foxes are still regarded as threats to maize, and [women] and children are still enlisted to frighten pests away. In colonial times a religious rite involved 'excommunicating' pests . . . , but this custom has apparently died out, at least in the Vilcanota Valley." [From *Plants, Man and the Land in the Vilcanota Valley of Peru*]

Half the book is a detailed ethnobotanical description of cultigens and useful nondomesticates. Accounts of the nomenclature, morphology, varieties, and uses of the plants, cultivation techniques, and the geography and history of the region provide a background to discussions of other matters.

Those interested in introducing new specialty crops might find the delicious *llacón* or *oca* as interesting as the important large-kerneled Blanco Imperial or Cuzco maize now popular in the United States. The protein-rich pseudo-cereals *kañiwa* and *kiwicha* might be used elsewhere in the world where dry or cold areas predominate; since in Peru these plants are losing ground to more commercial crops, germ plasm sampling is needed. Perhaps *Jatropha ciliata* or *Hydrocotyle alchemilloides* could prove as useful to pharmacologists as Andean *Cinchona*.

If the productivity of crops in the Andes is to be raised, their variation and ecological potential must be understood. The Andean people's love of color has led to innumerable cultivars of maize, potato, and *oca*. Texture, flavor, and disease resistance affect the acceptance of new potato varieties as much as yield. Several wheat cultivars, adapted to various zones, might be important within one township.

There is considerable discussion of the zonation of the region. Topographical, climatic, vegetational, ethnobotanical, and traditional views are presented, and a variety of terms are used: "Vilcanota gorge," "the zone between 2400 meters and 1500 meters," "the warmer mesothermal zone," "*ceja de la montaña*," "the region of subtropical starch crops," and "*chaupiyunga*" all refer to the same part of the valley. More discussion of the interactions of factors and the establishment of smaller, more inclusive zonal units would have clarified matters. The distributions of crops might have been better presented by zonal diagrams than by the many maps the book includes.

How representative is the Vilcanota Valley? Every valley and region in the

Andes has unique traits. Inca terraces, Blanco Imperial maize, and consumption of *achira* tubers may be more important in the "Sacred Valley" than anywhere else. However, the situation there predominantly parallels what I saw in the upper Huallaga and Marañón valleys in central Peru. The description this study provides of a part of Andean ethnobotany and cultural geography is good, and it should be widely used.

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Adaptations of Plants

Photosynthesis and Productivity in Different Environments. Papers from a meeting, Aberystwyth, Wales, 1973. J. P. COOPER, Ed. Cambridge University Press, New York, 1975. xxiv, 716 pp., illus. $65. International Biological Programme 3.

Diversity is the major strength of this volume, which summarizes a decade of work on photosynthesis, primarily at the whole plant, plant community, or ecosystem level. It consists of 35 chapters by 49 authors, and it assembles up-to-date information on the comparative productivity and physiology of plants in a wide range of environments. The book will have its greatest value as a reference work providing quantitative information on primary production in such diverse environments as agricultural fields, rain forests, deserts, and the seas and on the factors that affect the rate of primary production in these environments.

Troughton reviews the remarkable knowledge acquired during the past decade concerning the C_4 pathway for carbon fixation in photosynthesis and the physiology and leaf anatomy that are related to this unique adaptation. His review is important because of the relationship of the C_4 system to plant productivity and adaptation. Loomis and Gerakis discuss the role of the C_3 and C_4 pathways in plant productivity. They report that when growing at low latitudes C_4 species are the world's most productive plants. At high latitudes, however, C_3 species have greater productivity. Loomis and Gerakis's analysis of the relationship of leaf area index, leaf angle, and light to maximum crop productivity is done well. They point out that a high leaf angle is of value only when the soil is covered with a dense canopy of leaves. Their analysis clears up some of the confusion over the relationship of plant productivity to the leaf area index, and they give examples of an optimum-type response, a plateau-type response, and the response typical of some of the highly productive C_4 species, in which productivity continues to increase with increasing leaf area to indices as high as 20.

During the last decade, it has been shown that water controls the rate of photosynthesis not only through stomatal closure but also by directly affecting the biochemical processes. Slavik discusses this work and points out that the relative importance of stomatal processes and direct biochemical effects of water in controlling CO_2 uptake depends on the environmental conditions, the water stress within the plant, and the species of plant.

A much greater understanding of the effect of temperature on photosynthesis has also been obtained in recent years. It is now known that the upper limits of temperatures at which photosynthesis is possible vary from 35°C to more than 60°C, depending on the species. Likewise, species differ markedly in their ability to perform photosynthesis at low temperatures. Some species are sensitive to mere chilling, whereas in others photosynthesis proceeds until the leaf tissue actually freezes. Although the reasons for these differences in sensitivity to temperature are not yet understood, it is clear that during evolution remarkable differences in ability to tolerate extremes of temperature have developed. This suggests that man may be able to alter the temperature sensitivity of a given species markedly once an understanding of the mechanisms of tolerance is attained.

The role of radiant energy in terrestrial and aquatic communities is discussed at some length in the book. The greatest value of the chapters on that subject is to bring the reader up to date on the gradual progress that has been made during the past decade and to increase his understanding of the role of light in communities of plants with different leaf structures.

A large section of the book is devoted to primary productivity in various environments. These chapters, on the whole, are done well, and they pull together information that will be useful to the ecologist or agricultural researcher. Finally, the possibility of enhancing photosynthetic productivity is evaluated in the light of major research efforts during the past decade on the alteration of photosynthesis through genetic manipulations. Although the practical results of those efforts are not impressive, the groundwork has been laid for a significant accomplishment in the years ahead.

In his introduction, the editor writes: "The present volume sets out to provide a comparative survey of the photosynthetic activity of different ecosystems, both terrestrial and aquatic, including an examination of the physiological basis of such activity and its possible modification by management and breeding." Many of the reviews tend to be weighted with citations of the author's own work to the exclusion of other work that might (or should) have been cited, but because the authors represent many of the world's prominent laboratories where the physiology and ecology of plant productivity are being investigated, the volume comes nearer to reaching the editor's stated goal than anything yet published on photosynthesis.

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Photochemistry

Excited States in Organic Chemistry. J. A. BARLTROP and J. D. COYLE. Wiley, New York, 1975. xii, 376 pp., illus. $39.50.

A number of books in organic photochemistry appeared about a half decade after the field began to undergo exponential growth about 1960. These are generally quite good but are now ten years old. Thus the timing of Barltrop and Coyle's book is right.

The book covers the literature and the theory of photochemistry. The first two chapters cover the basic principles of light absorption, multiplicity, excited states and properties, types of transition, and modes of formation of excited species. A third chapter deals with photophysical processes such as fluorescence, radiationless decay, and Franck-Condon effects—thus emphasizing time-dependent behavior—and a fourth considers quenching processes such as energy transfer, heavy atom quenching, and electron transfer. Chapter 5 discusses different methods of deriving photochemical reaction mechanisms. Chapter 6 deals with the concepts of reaction allowedness and forbiddenness. A seventh chapter considers mechanisms of carbonyl chromophore reactions, chapter 8 turns to carbon-to-carbon π-bond chromophore transformations, and chapter 9 treats aromatic photochemistry. Chapters 10 and 11 concern themselves with nitrogen-containing molecules and saturated species, respectively. A useful brief appendix on group theory is included.

The book is quite well done. Writing such a book is a challenge, because pho-