preface, the editors state that the emphasis of the first international symposium has been placed on background information from the various fields that bear on the biological control of soil microorganisms. We may very well be just at the beginning of a new era of soil microbiology-microecology, and this book may be its catalyst. More than 3200 references are cited, and, for this reason alone, the book should remain a standard reference to this important field of biology that affects the world food situation, influences the world population, and, in turn, has a direct bearing on world politics.

The book holds the reader's attention from the electron microphotograph of the surface of a root hair, which shows attached bacteria, and the first figure, which shows the growth of fungus mycelium in the cortex of a rootlet of plant material from the Carboniferous Period of the Paleozoic, to the end of the book, which discusses the planning for another symposium, on the same subject, to be held in 5 years.

Instead of a random arrangement of papers, the book is divided into parts that deal with soil microorganisms; soil environment; the plant root and the rhizosphere; pathogenesis and resistance; the mechanisms of antagonism; the soil inoculum; and interaction between soil, microorganisms, and the plant. Several of the authors have provided sections that outline work that needs to be done. Most of the numerous illustrations, tables, and graphs are original. In view of the number of authors who submitted papers, the illustrations are surprisingly excellent throughout. Because the book contains so much data on a diversity of topics, it needs an extensive index; this need is admirably fulfilled in a 34-page index of topics, names, and titles.

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Paleobotany: Tenth Pacific Science Conference

Ancient Pacific Floras: The Pollen Story. Lucy M. Cranwell, Ed. University of Hawaii Press, Honolulu, 1964. x + 115 pp. Illus. Paper, $3.50.

The 14 papers and abstracts presented in this slim volume derive from a symposium of the Tenth Pacific Science Congress, held in Honolulu in 1961. A stated aim of the work is that it should be understandable to the general reader. To that end, the editor's foreword explains the role of pollen and spores in the life cycles of plants, defines some terms, and traces the historical development of Pacific palynology. Additional introductory comments from the veteran paleobotanist R. W. Chaney stress the importance of pollen studies in evaluating and extending earlier phytogeographical and paleoecological inferences based primarily on leaf impressions. In view of the fact that some of the papers contain previously unpublished technical data, the goal of general readability seems fairly well achieved. This is done through the use of excellent illustrations, by avoiding involved nomenclatural discussions and keeping technical descriptions to a minimum, by the authors' emphasis on subjects of broad interest —ancient climates, plant geography, the age of the angiosperms—and by the lively writing of Lucy Cranwell's own papers (in which she deals with microfossils of remote Rapa Island and possible Antarctic origin of the southern beeches). The brevity of some of the offerings makes the work attractive as a "sampler," but one regrets that the Russian contributors, E. V. Koreneva and E. D. Zaklinskaya, submitted only abstracts; an expanded review of pertinent Soviet palynological investigations would have been a valuable inclusion.

The volume lacks topical unity. B. E. Balme reviews Australian pre-Tertiary microfloras, and C. J. Heusser compares postglacial climatic changes in South America with those of other continents. Other contributors (S. Tokunaga, J. Ueno, Jane Gray, J. Muller, and Isabel Cookson) discuss very diverse aspects of Tertiary research. In view of the increasing worldwide interest in pollen and spores, the editor's expressed hope for future Pacific Science symposia to treat more specific palynological themes will probably be realized. Let us also hope that in the future the publishers of such symposia will not take three years to bring the results to print.

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Three-Dimensional Drawings

The Architecture of Molecules. Linus Pauling and Roger Hayward. Freeman, San Francisco, Calif., 1964. Unpaged. Plates. $10.

This book is intended to provide the reader with a feeling for the three-dimensional structures of molecules. It consists of 57 colored drawings of atomic and molecular structures, each with a short caption. The drawings range from pictures of the regular polyhedra to illustrations of such complex molecules as the Prussian blue crystal, the polyoma virus (actually the DNA of the virus), and a portion of myoglobin. They are done with great skill, and some are truly things of wonder and beauty, representing three-dimensional structures about as closely as can be achieved in two dimensions. One wonders, though, whether an entire page is required for some drawings. For example, the plates depicting polyhedra could very well have been inserted into corners of later drawings. Conversely, one would like to see aromatic rings and a discussion of the π electrons. Also, a picture of purine-pyrimidine base pairing and nucleic acid structure would seem valuable, even though they are all too often mentioned nowadays. Again, one might wish that the central structural feature of a complex molecule such as the alpha helix (Fig. 50) was more clearly distinguished from the surrounding hydrogen bonds. This is very nicely achieved for the structure of silk (Fig. 48). The structure of the unit cube of diamond (Fig. 15) could be explained more clearly with an additional sketch in the figure.

The book is "planned especially for young people who are beginning to develop an interest in science." I agree that it indeed serves admirably to introduce young people to a most vital area. Ability to visualize the three-dimensional structures of molecules, including their angles, distances, and charges, is extremely important today in the sciences of chemistry and biology. Recent developments in molecular biology have underscored this to such an extent that it scarcely needs further statement. Conventional two-dimensional representations of molecules do not provide even approximately adequate pictures of what molecules really look like. This inadequacy is intensified by the persistence in textbooks of old-fashioned formulas such as linear structures for sugars, rectangular rings for purines and pyrimidines, and un-ionized formulas. Ideally, when students first study molecules, they should make three-dimensional models of them. But such models cannot easily be made for the more complex molecules, nor are their fine points always evident; here *The Architecture of Molecules* fills an important role. It is entirely fitting that Linus Pauling, one of the earliest and foremost advocates of the importance of molecular architecture in chemistry and biology, should produce the present text.

One can safely predict that every reader will disagree in part with the selection of molecules. However, in general, they well illustrate the main points of molecular structure. One might take exception to some discussions. In Figure 17, the reason why free rotation cannot occur in the ethane molecule is not made at all clear by the ball and stick illustration. Would not a representation showing a van der Waal's type structure, as in Figure 10, be much more appropriate? In Figure 9, where the halogen molecules are illustrated, a text relating the drawing to the periodic table and electron shells would make the relation between these members of the same family more apparent. To compensate for these less striking texts, some discussions are indeed remarkable. Probably every reader will discover new insights into the structures of molecules when he reads the book and examines its pictures.

Some great insights and a tremendous amount of hard work are summarized in the final simplicity of this volume. Anyone who is interested in the structure of matter should read through this book.

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A "Three Plus One" Dimensional Treatment

The Special Theory of Relativity. David Bohm. Benjamin, New York, 1965. xvi + 236 pp. Illus. Paper, $3.95; cloth, $7.

It is admittedly difficult nowadays, in an exposition of special relativity, to find something new to say. David Bohm has solved the problem by adding a 45-page appendix in which he describes the views of J. Paiget on the development of our "common notions" of the external world in infants and children and the views of J. G. Gibson and others on the nature of perception. The upshot is the conclusion that "Science may then be regarded as a means of establishing new kinds of contacts with the world, in new domains, in new levels, with the aid of different instruments, etc."

The first 184 pages of Bohm's work are divided into 31 brief chapters in which special relativity is developed by the historical method. Pre-Einsteinian notions of relativity, the Michelson-Morley experiment, the Lorentz theory of the electron, and the hypothesis of the aether lead up to a demonstration of the inherent ambiguity in the meanings of space and time measurements. Einstein's views are then explained together with the new interpretation of the Lorentz transformation. This transformation, however, is not derived formally from Einstein's ideas: reliance is placed on a piecemeal demonstration after the fashion of Lorentz. Applications of special relativity include discussions of the decay of mesons, the Doppler effect, and momentum and mass. The equivalence of mass and energy is interpreted in terms of the notions of the "energy of inward movement" and the "energy of outward movement." Bohm is thus led to the conclusion that elementary particles will have to be understood "as structures arising in relatively invariant patterns of movement occurring at a still lower level than that of these particles." Other mathematical developments are the "K calculus" which is essentially based on E. A. Milne's interpretation of the Lorentz transformation, although Bohm appears to be unaware of the fact. He also ventures cautiously onto the space-time continuum and its interpretation by means of the diagram in which one coordinate is the time and the other, space. This "Minkowski diagram" is discussed at length, and the conclusion is that it is "a kind of map of the events in the world . . . but which is not itself the world as it actually is." I should have thought that this statement was self-evident a priori. The twin paradox is also described under the usual assumption that clocks measure proper time.

The treatment throughout is "three plus one" dimensional, very little use being made of four-dimensional ideas. For example, it is never made clear that the energy and momentum of a particle are components of a single four-vector. Bohm also writes as if the principle of special relativity demanded the invariance of mathematical form in the basic equations of mathematical physics. If this were so, an investigator would be debarred from using spherical polar coordinates, instead of the usual rectangular ones, in treating the motion of a particle in special relativity. He frequently suggests that a coordinate system, accelerated relative to a Lorentz frame, is possible only in the domain of general relativity. A four-dimensional point of view would show him that this need not be so. When Maxwell's equations, for example, are expressed as four-dimensional tensor equations, they can be transformed mathematically to an accelerated system without violating the principle of special relativity. In abandoning the assumption that space-time is flat, general relativity does much more than employ accelerated frames. Incidentally, the statements on page 101, which imply that the law of gravitation, like the laws of electromagnetism, can be thrown into a Lorentz invariant form, are entirely misleading. Bohm also has his own version of Newton's second law of motion for a particle (pp. 81 and 100); he adds the condition that the mass of the particle must be constant with time. If this were so, it would be impossible to set up a Newtonian equation for the motion of a rocket. In chapter 23 it is implied that the notion of "mass" ceases to be difficult after a person has reached the age of 4. I do not know what experience Bohm may have had in teaching University students, or whether he has ever tried to explain "weightlessness" to a newspaperman. Too often I have found that "mass" is inextricably confused with "weight." The idea of mass is one of the hardest departures from the common-sense view of the world that has to be made if mechanics is to be understood. My own experience during the process of learning physics leads me to question Bohm's implicit assumption that the world of common-sense, with which we become familiar in childhood, is a guide to the basic ideas of physics. Learning physics seems to me to imply much "unlearning" of common-sense notions.

The exposition is marred by many