occasion newspaper headlines and carry important overtones of international politics.

Confronted with a collection of this nature, the reviewer has much the same task as if he were asked to give critical comment on a bound volume of, say, *Nuclear Science and Engineering*. With such a many-body problem the approach must of necessity be statistical. About 20% of the pages are concerned with the problems of optical and radio tracking of satellites, the determination of orbits from such tracking data, and information on the shape of the earth's gravitational field that can be deduced from the orbits. Reading this portion one is made keenly aware of the Rip-van-Winkle awakening of classical mechanics as an active research subject after its almost century-long slumber. Another 20% of the pages deal with the hardware involved in telemetry and data transmission in general from satellites and rockets. The last third of the book is devoted to the density variation of the atmosphere and what can be deduced about the atmosphere from the "poor-man's space effort" –sounding rockets. In the remaining portion of the volume the papers are devoted to the scientific information gathered by satellites and deep-space probes, ranging from micrometeorites through cloud pictures to cosmic electromagnetic radiation from the ultraviolet to radiowaves. Of particular interest to the reader of this journal is the coherent set of papers dealing with solar flares and associated perturbations in magnetic fields and cosmic radiation. Here a deviation from the statistical treatment is in order to note especially four specific papers. K. E. McCracken from MIT and T. Gold from Cornell have written separate papers on the solar interplanetary magnetic fields that develop during solar flares. Both papers lead to roughly the same picture and both are distinguished by taking pains to be understood by the nonspecialist. R. G. Athay gives an astronomer's view of solar flares and underlines the great difficulties (at least as of April 1961) in the way of predicting the appearance of such flares in advance. Finally, H. Yagoda and collaborators give some details of the vastly increased flux of energetic heavy particles observed in emulsion blocks flown on a satellite during the strong flare of November 12, 1960. Shielding against such storms clearly presents formidable problems.

There is obviously some convenience in having in one location a collection of papers that summarize in effect the current status of a given field. But it is highly questionable whether this convenience outweighs the wide availability and shorter time lag that could come from publication in standard scientific periodicals. The scientific journals should not yet be dismissed as a means of communicating active research work. Is it hopeless to ask conference organizers to take note?

HERBERT GOLDSTEIN
Columbia University
New York, N.Y.

(About the Reviewer: Professor Herbert Goldstein of Columbia University spent the war years in radar research at MIT, following which he wrote his well-known Classical Mechanics. *He joined Nuclear Development Associates in 1960 and was active there in reactor shielding and nuclear cross section calculations. His second book, on shielding, is well known. He was a recipient of an Ernest O. Lawrence Award this year and is a Fellow of ANS.)*

Tritium in the Physical and Biological Sciences. Proceedings published by the International Atomic Energy Agency, Vienna, 1962. Vol. 1, 369 pp. $7.00. Vol. 2, 438 pp. $8.00.

Tritium, the ubiquitous radioisotope of hydrogen, is found in natural water, in meteorites, in interplanetary plasma, and in a host of compounds listed for sale by isotope supply firms. It is at once one of the rarest isotopes in nature and one of the cheapest to produce artificially. Having the softest beta ray, it is also one of the most difficult to detect or measure.

These circumstances help explain the exceptional interest in a single nuclide which brought some 290 scientists from 27 countries to Vienna last year for a symposium on the detection and use of tritium in the physical and biological sciences. The proceedings of the conference have now been published in two paper-backed volumes, containing 67 papers. Four are in French, two in Russian, and 61 in English, but abstracts of each are supplied in English, French, Russian, and Spanish.

Over half of the first volume is devoted to techniques for concentrating and measuring tritium. A most profitable feature of the conference was the commingling of proponents of the various techniques and the opportunity to compare the merits of each in open forum. Five papers described Geiger counter techniques, with which natural tritium was first detected. But the more convenient liquid scintillation method, the subject of eight papers, now surpasses the historic method in sensitivity. Two laboratories reported measuring tritium in water below 1 picocurie/milliliter. Further gains are promised through reducing the background of thermal electrons in photomultiplier tubes, and the phosphorescence of tubes and counting cells. Two papers offer contrasting techniques for counting tritium in biological materials: in one, the tissue is dissolved bodily in an organic base and mixed with the scintillator; in the other, the eluate from a chromatographic column is mixed with scintillator and flows through the cell.

But most natural samples of tritium are too dilute to be counted directly on even the most sensitive counter. Its concentration is commonly enhanced by electrolysis by factors up to 1000. Distillation, gas chromatography, and thermal diffusion have also been successfully employed.

Three papers deal with the utilization of tritium from thermonuclear weapon tests as a global tracer; its distribution in the air, ocean, lakes, rivers, and underground is reported. On a smaller scale, it has been used as a tracer to study seepage from irrigation canals and movement through underground reservoirs. A satellite briefly in orbit collected a surprising quantity of tritium, apparently from a solar flare. Six papers describe studies of isotope effects, the mechanism of reactions, and a microanalysis for amino acids with tritium as a tracer.

The second volume contains two sections on preparing labeled compounds, but is otherwise a comprehensive review of recent biological applications, mostly of interest to physiological chemists.

Ten papers deal with preparative methods including radiation labeling, catalytic exchange, recoil labeling, chemical synthesis as well as biosynthesis. The difficulties of radiochemical purification, especially with radiation labeling, were touched on by the authors but were more adequatees brought out in the discussions. This example illustratly the

high value of the printed discussion throughout both volumes. Three papers describe problems associated with the use of labeled substances in biological studies. Instability of the label and isotope effects are not new to biological workers, but the problems are more acute with tritium than any other tracer.

The last two-thirds of the volume is devoted to biological uses. These include radiation effects and metabolic studies of nucleosides, hormones, and vitamins in normal and pathological conditions.

By means of labeled thymidine which is taken up in the nuclear components of the cells and by virtue of the very short range of tritium beta rays, radiation damage can be highly localized and studied separately from general radiation effects. Three papers reported such studies on plant roots, bacteria, and malignant tissues.

Eighteen papers were devoted to cellular metabolism studies, mostly involving tritiated thymidine and concerned with DNA synthesis. Autoradiography is used in this work more frequently than counting techniques. The small beta-ray range enhances the definition obtained by the film technique. An outstanding paper revealed the origin and fate of inflammatory cells evoked by antigenic reactions. In addition, a thorough discussion of radioautographic procedures was included. Other papers not involving DNA were concerned with the metabolism of cholesterol and thyroid and adrenal hormones.

These volumes give a comprehensive picture of present-day tritium techniques and accomplishments. No matter what field he works in, the investigator who uses tritium will find useful information and references here. Much of the material has been published in specialized journals, but no one's reading is likely to be so omnivorous as to have included it all. If the sections on labeling compounds had been put in Volume I, most nonbiologists could have done without Volume II; as it is, we expect that most readers will want both volumes. The IAEA staff is to be commended for a useful service, well done.

D. E. Hull
B. A. Fries
California Research Corporation
Richmond, California

(About the reviewers: D. E. Hull is a Senior Research Associate and B. A. Fries a Research Associate at California Research Corporation, where they have collaborated for fifteen years in developing applications of radioactivity in the petroleum industry. Hull was at Minnesota, Columbia, and Oak Ridge before going to his present position, while Fries was at Chicago, Oak Ridge, and Hanford. Their experience in radioactivity goes back to their Ph.D. theses. Hull received his degree in physical chemistry in 1935; Fries in physiology in 1941, both at the University of California.)

Physics of Fast and Intermediate Reactors, Volume II. Proceedings of a Seminar, Vienna, 1961. Published by International Atomic Energy Agency. 407 pp. $9.00.

Anyone interested in fast and intermediate reactors is certainly going to want to study this volume for himself, for there is a great deal of valuable material in it.

The editors have divided it into sections on (1) calculation methods, (2) effects of cross section errors, (3) reactivity effects, (4) long term effects, and (5) reactor concept studies. The emphasis of a large part of this work is the comparison of various calculations with each other and of assumed cross section sets with each other. Without disparaging the work reported on, one would still like to see more included on comparison of theory against experiment.

The contents are briefly as follows:

Section 1. This part starts with a review by Marchuk of some of the methods used by the Russians in analyzing reactors. These include multigroup, P_n, and S_n methods which are more or less familiar to most people; however, they appear to go farther with the analytical attack in many instances before putting the problems on the computer. A great deal of use is made of adjoint solutions. It would have been an editorial kindness to provide translations of this and other Russian papers.

Moinereau and Solanes, and Pendlebury and Underhill discuss the influence on computed results of changing integration step sizes, order of the approximation to the angular flux, transport approximation, and two- vs. one-dimensional calculations. These subjects are not entirely new, but it is helpful to have this material presented with the care and organization shown here.

Zelazny and Kuszell's analytic treatment of the multigroup transport theory points toward useful results, but it would be more useful and convincing to see some applications here. Haggblom's multigroup analysis of the reactivity effect of an air gap appears to be an improvement, but it appears that the problem is not closed yet.

Section 2. Effects of cross section errors on multiplication and breeding ratio are discussed by Moinereau and Solanes, Pendlebury, and Moorehead. It would have been interesting if these authors had had the opportunity to add material for inclusion in this volume comparing their results where possible. Whether or not the estimates of the influence of errors in the various cross sections will be instrumental in getting better cross section measurements, they are of considerable use, as Pendlebury shows, in adjustment of cross section sets to fit families of critical experiments.

Sections 3 and 4. Bhide and Hummel find that use of improved cross sections for sodium, steel, and oxygen obtained from a very fine-structured multigroup calculation gives a more positive sodium coefficient. Yiftah likewise finds the sodium coefficient to be more positive when higher plutonium isotopes are present in the reactor, and at the same time he discusses the effect of these higher isotopes on critical mass and breeding ratio for a number of reactor systems.

Okrent's very comprehensive paper presents material on most of the topics already mentioned as well as information on the approach to equilibrium of isotopic content in long burnups, fission products, influence of recycle and cross section uncertainties, on sodium coefficient, and much more; and the results are related in a fashion particularly easy to follow.

In a study of long burnup Ott and Jansen find the time variations of isotopic composition of reactors under two possible schemes of fuel recycling. The steady state compositions and breeding gains are also given.

Soodak's calculations of reactivity effects of hydrogen addition are interesting both for their bearing on reactor safety and for the physical insight this work gives into the interplay among leakage, absorption, and alpha variation over wide spectrum variations.

Other subjects covered in these sections are poison