longer. The discussions preceding the difficult theorems should be greatly expanded. At least a dozen more examples and counterexamples should be given, motivating the introduction of technical machinery. And many more diagrams could profitably be included. What a great book for students it would then be!

The book contains a few eccentricities: use of "data" as a singular noun; references to "measurements" in general relativity (for example, physical determination of a C^{r+1} atlas!) that would mystify an experimental physicist; and calling the founder of black-hole theory (in an appended translation of his original paper on the subject) by the name Peter Simon Laplace. One is reminded of those famous ghosts of Westminster Abbey: Michel Faraday and Jacques Maxwell.

The book also contains one failure to distinguish between mathematics and physics that is actually serious. This is in the proof of the main theorem of chapter 7, that given a set of Cauchy data on a smooth spacelike hypersurface there exists a unique maximal development therefrom of Einstein's empty-space equations. The proof, essentially due to Choquet-Bruhat and Geroch, makes use of the axiom of choice, in the guise of Zorn's lemma. Now mathematicians may use this axiom if they wish, but it has no place in physics. Physicists are already stretching things, from an operational standpoint, in using the axiom of infinity. It is not a question here of resurrecting an old and out-of-date mathematical controversy. The simple fact is that the axiom of choice never is really needed except when dealing with sets and relations in nonconstructible ways. Many remarkable and beautiful theorems can be proved only with its aid. But its irrelevance to physics should be evident from the fact that its denial, as Paul Cohen has shown us, is equally consistent with the other axioms of set theory. And these other axioms suffice for the construction of the real numbers, Hilbert spaces, C^* algebras, and pseudo-Riemannian manifolds—that is, of all the paraphernalia of theoretical physics.

In "proving" the global Cauchy development theorem with the aid of Zorn's lemma what one is actually doing is assuming that a "choice function" exists for every set of developments extending a given Cauchy development. This, of course, is begging the question. The physicist's job is not done until he can show, by an explicit algorithm or construction, how one could in principle always select a member from every such set of developments. Failing this he has proved nothing.

Happily, every other theorem in the book is as sound as a rock, and students could not ask for better navigators through space-time than Hawking and Ellis.

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Solar Physics

The Quiet Sun. EDWARD G. GIBSON. National Aeronautics and Space Administration, Washington, D.C., 1973 (available from the Superintendent of Documents, Washington, D.C.). xviii, 330 pp., illus. $6.20. NASA SP-303.

This book resulted from the discovery by the author, while training for his role as a Skylab astronaut, that no book or compendium dealing with the physics of the whole sun had been written for over two decades. The title *The Quiet Sun* is used as a device for avoiding detailed discussions of active phenomena, not as an attempt to suggest a sharp distinction between a quiet and an active sun.

The chapter topics follow in an orthodox order. After two chapters dealing with the general characteristics of the sun, they are: "The interior," "The photosphere," "The chromosphere," and "The corona." The subject matter contained under the last three of these headings, however, departs quite strongly from that in earlier books. This difference reflects, in part, new ideas and perspectives. It also indicates a conscious decision to touch only sketchily those topics which have been discussed exhaustively elsewhere and deal critically and in detail with those for which the information has heretofore been scattered through the journals. (The comprehensive discussion of photospheric and chromospheric oscillations is an outstanding example of the latter.) This technique has greatly increased the general usefulness of the work as a starting point for the study of solar physics and makes it an excellent supplement to previous compilations on the sun. It will not replace these compilations, however. A newcomer to the field, impressed by its general excellence and apparent comprehensiveness, might, for example, conclude from it that the optical emission corona has yielded no useful information, even that it can be observed only at an eclipse. He would be unaware that optical monochromatic observations, next to sunspots, constitute the most complete synoptic record that we have of the sun; or that monochromatic photographs still give the most detailed pictures available, prior to Skylab at least, of coronal structure.

A central theme in the book is the idea that many of the phenomena of the solar atmosphere should be explained in terms of small- and larger-scale convective processes made evident by granulations and supergranulations. Another recurring idea is that the appearance of a feature in the chromosphere—whether bright or dark, for example—can be explained only through a nonlocal-thermodynamic-equilibrium computation of how the source function of the line in which the feature is observed varies with distance above the photosphere.

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Geophysics Etc.

Annual Review of Earth and Planetary Sciences. Vol. 1. FRED A. DONATH, FRANCIS G. STEHLI, and GEORGE W. WETHERILL, Eds. Annual Reviews, Palo Alto, Calif., 1973. viii, 350 pp., illus. $12.

Inaugurating a new series, this volume discusses a fascinating array of current problems and shows Annual Reviews' customary high level of editorial and authorial competence. The topics of the 14 papers are: geophysics state of the art (Jeffreys), glacioisostatic rebound (Walcott), the origin of red beds (Van Houten), rock fracture (Mogi), Jupiter's and Saturn's interiors (Hubbard), magnetospheric electrons (Coroniti and Thorne), the origin of mammals (Crompton and Jenkins), subsurface water chemistry (Barnes and Hem), the origin of mineral deposits (Skinner and Barton), earthquake strain release (Kanamori), Cenozoic plankton paleontology (Riedel), rock magnetism (Hargraves and Banerjee), lower-atmosphere electrical balance (Vonnegut), and silicate mineral order-disorder (Burnham).

The topics are really too scattered for a single volume. Do the editors seriously think that there are many people working on both mammal taxonomy and the interior of Saturn? If not, why put them in one book? Perhaps the reader should take advantage of Annual Reviews' reprint service rather than spend his money at an efficiency of 1/14 or 2/14. (In fairness, the price of the collection *is* attractive, and the book is a vast improvement over most conference proceedings.)

The reminiscence by Jeffreys, one of the fathers of the field, is stimulating, though one might prefer that such personal reminiscences be collected from a dozen of the eminent fathers of planetary science into one separate volume where attitudes and accounts could be compared (but perhaps such a volume would have a short half-life against spontaneous explosion).

I was struck by the range of problems that we *ought* to be working on, but often can't for lack of adequate funding. Vonnegut, for example, tells us that unintentional artificial weather modifications are going on right now and that we haven't adequately evaluated them! With respect to the subject of my own recent work, Mars, a number of problems were suggested by these papers—for example, red bed formation, possible analogies between isostatic, nonrebound uplifts on Earth and the Tharsis and Elysium volcanic domes on Mars, and the reptile-to-mammal transition (was it due to the same solar-induced climatic shift suggested from Mariner 9 data to have occurred several hundred million years ago on Mars?). Yet while thinking about these matters I learned of the complete inadequacy of the funding available through NASA to follow up the Mariner 9 discoveries. Well, let us hope there is material for volumes 2, 3. . . .

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Atmospheric Processes

Turbulent Diffusion in the Environment. G. T. CSANADY. Reidel, Boston, 1973. x, 248 pp., illus. Paper, $13. Geophysics and Astrophysics Monographs, vol. 3.

The dispersal of pollutants in the environment by turbulent atmospheric or oceanic flow is a matter of great public concern and practical importance; at the same time the theory of turbulent dispersion in even idealized situations is a difficult problem in statistical mechanics. This book steers a middle course between the cookbook approaches that may not be reliable even to within an order of magnitude or two and the more rigorous mathematical approaches that may not be able to give any "answer" at all. The main concern of the book is to develop the simple properties of a dispersing cloud or plume to situations in which a mean shear is present and where buoyancy effects are significant. These, together with questions of relative diffusion and the fluctuation problem, are described in such a manner as to be accessible to a beginning graduate student who knows some fluid mechanics and differential equations; the successes and shortcomings of the theory are illustrated by frequent reference to laboratory and field data.

Not a book for one who wants a quick and easy answer or for one who wishes to understand the latest statistical mechanical analysis, it will, with proper caution, enable the meteorologist or oceanographer to know at least what must be measured and what to do with it in order to estimate dispersion rates in the many and varied situations that he is being called upon to examine.

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Systems under Pressure

Electronic Transitions and the High Pressure Chemistry and Physics of Solids. H. G. DRICKAMER and C. W. FRANK. Chapman and Hall, London, and Halsted (Wiley), New York, 1973. x, 220 pp., illus. $16.50. Studies in Chemical Physics.

Electronic transitions under pressure are a topic of much current interest and include metal-nonmetal transitions of all kinds and transitions involving spin state, valence state, and charge transfer state. Drickamer and his colleagues at the University of Illinois have carried out pioneering studies in recent years in the latter field, using mainly Mössbauer and optical spectroscopy under pressure, and have published a wealth of data on shifts in energy level with pressure and their consequence in a large number of organic and inorganic systems of varying complexity. They developed techniques necessary for extension of such studies to very high pressures, and have established the occurrence of a change of spin state and oxidation state of Fe under pressure in a number of materials. From their results certain generalizations seem apparent, namely: that under pressure a new electronic ground state is established; that, depending on the position of the crystal-field-split levels of the metal ion relative to the ligand levels of the organic molecule, electrons can flow from the former to the latter, or vice versa, causing reversal in the spin or oxidation state; that the equilibrium between these states follows the laws of equilibrium familiar in chemistry; and that the chemical reactivity can be strikingly altered in the new ground state. The book under review is a research monograph embodying mainly this work.

The presentation is slanted toward a chemical physics audience. The theoretical ideas used in the interpretation of the results are dealt with in the first four chapters, which include a brief discussion of the molecular orbital theory, configuration coordinate state diagrams, and the energy of thermal versus optical transitions, as well as a description of continuous electronic transitions modeled on regular solution theory. The experimental techniques are dealt with briefly in chapter 5. The six remaining chapters cover the experimental data and their interpretation. Chapter 7 is a brief discussion of electronic transitions in metals and metal-insulator transitions.

The book should be of interest to both chemists and physicists engaged in theoretical as well as experimental research.

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Drawings and Ideas

An Illustrated History of Brain Function. EDWIN CLARKE and KENNETH DEWHURST. University of California Press, Berkeley, 1973. xiv, 154 pp., illus. $14.

The history of medical illustration is a field that one expects to cut across disciplinary boundaries. Intersecting the history of art and of culture, as well as that of medicine, it should open up resources for interpretation and expansion beyond the traditional view of medical development as a self-contained, progressive accumulation of knowledge. With an acknowledgment of the influence of Robert Herrlinger's masterly work on the history of medical illustration, Clarke and Dewhurst also subscribe to this thesis.