sense of the word is impossible. This being the case the conversation almost always moves immediately to philosophical questions, and one soon no longer knows whether one really holds the position which he is attacking, and whether one really must attack the position he holds. . . .

It is moreover not perfectly easy to be entirely certain how Bohr actually means it, in part because he often speaks in an almost dreamlike, visionary, and really rather unclear way for some minutes at a time, and in part because he is so very considerate and is constantly inhibited by his anxiety that the other person might take his (Bohr's) unreserved expression of his own standpoint as indicating insufficient recognition of the contributions of others—that is, in this case, especially my work.

So much for the tenor of Heisenberg's account. The substance of the conversation which follows is, on the contrary, most likely roughly correct, as far as it goes. In other cases the tenor seems about right, the substance clearly wrong. In most cases it is impossible to tell. Were Heisenberg a novelist his memoirs would perhaps be read as autobiographical novel, presumed to be fiction unless proven to be fact. In that counterfactual case they would be innocuous, and the author would probably even have taken the trouble to correct the English translation. But Heisenberg being a scientist, these memoirs will generally be presumed accurate unless proven otherwise, and so are dangerous.

Finally, a word on ethics and politics. This translation is volume 42 of the series World Perspectives, planned and edited by Ruth Nanda Anshen. In her foreword, mixing 1970 code words—"environment," "planet Earth," "ecological systems"—with the traditional slogans of transcendence—"spirit," "dialectic of polarity," "primordial unitive power," "wholeness, unity, organism," "life itself"—the editor declares her intent to present the intellectual giants of natural science "chastened and humbled," endeavoring to "justify and purify" their scientific achievements by professing them to be intimately connected with "all other knowledge," artistic, intuitive, religious, or whatever. It is disturbing to find some of our most distinguished theoretical physicists as members of the editorial board—Heisenberg is among them—implicitly associating themselves with such fundamentally antiscientific attitudes and empty rhetoric. Whether a "convergence toward human and world unity" is indeed the ineluctable tendency of such slogans no one who recalls their past association with intolerant nationalisms could confidently assert. In fact it was in the Germany of Heisenberg's youth and early manhood that these slogans found their broadest popularity, and were most clearly associated with anticosmopolitanism. Many of the considerations which in these reconstructed conversations take "the whole of mankind" as the reference group or object were at that time doubtless expressed in terms of "Deutschland." And although much that is appalling has been deliberately plastered over, there remain many dicta on political matters which, though not unexpected, are nonetheless chilling.

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Research on Polymers

From Organic Chemistry to Macromolecules. A Scientific Autobiography Based on My Original Papers. HERMANN STAUDINGER. Translated from the German edition (Heidelberg, 1961) by Jerome Fock and Michael Fried. Wiley-Interscience, New York, 1970. xvi, 304 pp., illus. $14.95.

Hermann Staudinger is one of the most important figures in chemistry of this century in that he is among those who are primarily responsible for the concept of the polymer molecule, which can exist as an isolated entity in dilute solutions even if its molecular weight is of the order of 10^6. He was a pioneer in estimating molecular weights of polymers using the simple technique of viscosity measurements, which is still the simplest technique though not an absolute one. His work has therefore had unmeasurable impact on the technology of synthetic rubbers, plastics, and fibers, as well as on the study of biological macromolecules. This book is a scientific biography which summarizes his research contributions in a sequential manner. From it one can obtain the true flavor of scientific discovery, with documentation. Of side interest is the flavor of the personality Staudinger's writing reveals, which is not unlike the generally held conception of a European Geheimrat. He reminisces about the professors who influenced his early career, including Carl Engler, born in 1842. We thus span more than 100 years of chemical tradition. Staudinger won the Nobel Prize in 1953.

Hermann F. Mark has written a brilliant foreword which adds to the value of this interesting book.

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Matters of Concinnity

McGraw-Hill Encyclopedia of Science and Technology. Third edition. McGraw-Hill, New York, 1971. In 15 volumes. Approximately 10,800 pp., illus. $360; to schools, colleges, and public libraries, $295.

One would expect a world leader in the publication of scientific and technical literature, on issuing a 15-volume encyclopedia covering the area it has staked out, to aim for the production of a modern classic. If this is McGraw-Hill's intent for its *Encyclopedia of Science and Technology*, it has not yet hit the mark. The third edition, issued this year, remains spotty in quality and lacks the overall harmoniousness that would put it in the ranks of the great compendia of knowledge.

The publisher states that this edition is "far more than a thorough updating" of the original 1960 edition and the revised one of 1966. In preparation for the 1971 edition, "each article . . . was carefully evaluated. The great majority were revised and almost 1000 new articles were added" for a total of 7600. Illustrations were replaced or reworked and some 2500 new ones were prepared. Where new material was available, the bibliographies were updated, a special effort being made to include hard-cover material that would be more accessible than periodicals to high school students. The final volume is again an Index, this time with 120,000 entries. The Index volume contains as well a section on scientific notation, and at its end is a topical index which groups the articles according to about a hundred major subject areas of science and technology.

The publisher's preface sets out

various guiding principles. The *Encyclopedia* is conceived as "a work *of*, not *about* science." History, biography, and philosophy are said to be included only as required in the development of the topics covered. (A matching two-volume *Modern Men of Science* is available at extra cost.) Each article is intended to be "understandable to the nonspecialist"; the additional claim is made that "most articles and at least the introductory parts of all are within the comprehension of the interested high school student." Much effort was expended to make certain that the great advances of the past decade were included; awakened concern over population growth and degeneration of the environment has led to the addition of new material. (The publisher produces a yearbook which reviews recent advances in all areas covered by the *Encyclopedia* and gives extended treatment to a few topics of potentially great interest.)

In preparation for writing this review I read the earlier ones (*Science* **133**, 374 [1961] and **152**, 903 [1966]), dealing with the first two editions. I recommend that prospective purchasers (or more realistically, prospective requisitioners) do likewise for two reasons. The earlier reviewers represent quite different professional backgrounds from mine. Certain of their comments, directed to general features of the *Encyclopedia*, still are valid. Further, they made explicit criticisms, and while it is apparent that some of these have led to additions and revisions, it also is true that others have not. I have not attempted to check out all of them.

At the outset of my own remarks I must concur with the earlier reviewers with regard to the usefulness and quality of most of the *Encyclopedia*. It is indeed full of information and contains many carefully written, readable articles. Its format and binding make it comfortable to use. The nonspecialist, and I include here not only the high school student and layman but also the specialist seeking information in a field other than his own, can in general find helpful, authoritative material. In many cases he will be able to trace the pathway, using the many interspersed cross-references, to more detailed and often more analyical aspects of his interest. A good example from physics is the succession of articles starting from the well-constructed bases of "Atomic structure," "Quantum mechanics," and "Quantum theory" which can be followed to late developments in all the branches of contemporary physics. At certain far-out points, for example "Regge pole," one who is not at least a graduate student in physics will probably find himself floundering.

The *Encyclopedia* abounds with articles on engineering and technology, offering extensive clusters on subjects ranging from communication theory, techniques, and devices, design engineering, aeronautics, control systems, and of course computers down to such workaday topics as machine tools, automobile engines, and brakes, all quite up-to-date. Technology, the biological sciences, and the physical sciences seem in good balance.

Browsing through, one runs across pedestrian treatments, typographical errors, transposed figure captions, and minor editorial slips. One wonders, also, why it should be thought helpful to illustrate an article with line drawings of a notebook, a pocketknife, a hand lens, a trowel—all quite ordinary—and thinks how confusing it must be to read in one sentence that quantized vortices and magnetic flux are "one of the latest microscopic quantization effects" and in the next that they are examples of macroscopic quantum systems.

However valid criticisms of this kind are, such faults seem trivial in comparison with structural features of the *Encyclopedia* which I find very troublesome. Possibly in pursuit of its intent to be "of science," the *Encyclopedia* treats certain subjects in a highly fragmented manner which has produced serious inconsistencies and which decidedly impairs its usefulness. To illustrate this criticism I cite some examples drawn from the physical sciences.

The first example is the treatment of the concept "heat." This term is fundamental to nearly all science and is likely to be of concern to the general reader. Without attempting to exhaust the possibilities, I found the following four definitions of it. Under "Heat":

> . . . all energy while in transit, but unassociated with matter, [is] either heat or work. Heat is that form of energy in transit due to a temperature difference . . .

Under "Heat transfer":

> Heat, a form of kinetic energy, . . .

Under "Thermodynamic principles":

> . . . change in state of a system can be effected by either supplying work to the system . . . or by contacting the system through a conducting wall with a higher temperature system. The latter *method* . . . is termed heat . . . [emphasis added].

Under "Thermodynamics, chemical":

> . . . a quantity Q [defined] such that Eq. (2) holds [Eq. (2) is the first law of thermodynamics.]

What understanding can be gained from these by someone who stumbles across more than one of them and is not already versed in thermodynamics?

I will not list all the cross-references given in these articles, but will mention that "Heat" refers only to "Internal energy," "British thermal unit," and "Calorie"; whereas "Thermodynamic principles" and "Thermodynamics, chemical," both expounding the basic ideas of thermodynamics and separated in volume 13 by one article, make no reference to each other. The article separating them, "Thermodynamic processes," refers to neither of its neighbors. Why is there no "Thermodynamics" itself, which after all is the commonly used term? Indeed why, if "Thermodynamics, chemical" appears, does neither "Thermodynamics, physical" nor "Thermodynamics, engineering"? These plaints might not be dismissed as nitpicking by a student trying to orient himself in the jumble; certainly the inconsistencies and errors in the definition of "heat" are inexcusable.

The second example involves the term "resonance." This term pervades physics, appearing in all its limbs, branches, and twigs; it has great importance for chemistry and engineering as well. The Index gives 93 entries commencing with it or a close derivative, many of them referring to more than one article. Imagine the interested high school student assigned a paper on "resonance." He finds well over 93 places to look but not one reference suggesting an unqualified, general description. I looked at more than half a dozen of the most likely and found no hint anywhere of the ubiquitousness of the concept, no general treatment. Of course, the list of 93 entries is itself a powerful hint, but what a pedantic observation this is! Cross-indexing ties the entries together, but with widely varying degrees of relevance and generality. Let me push this example a bit further. "Resonance frequency," "resonant angular frequency," and "resonant frequency" appear in the Index separated by many interposed entries. A total of eight locations are cited for the three. These essentially synonymous terms almost certainly were used by individual authors out of habit, taste, background, or what have you, and the indexing procedure picked them out as unrelated

topics. A formula for the frequency is given in some locations, whereas the term is used only discursively in others; the Index does not discriminate. "Resonance tank circuit" (in volume 13) and "Resonance, electric (tank)" (in volume 4) are separated in the Index by nearly two columns of entries. I am willing to believe that out of all of this richness of detail our student could put together an impressive report provided he is unusually persistent as well as interested. I'm more willing to believe that he would soon wander off the track, bemused by the other fascinating articles turned up as he bats from one volume to another. Perhaps it's better this way.

The Index gives some 300 entries beginning with the word "nuclear." Under "nuclear engineering" appear dozens of topics including "background count," "barn," "Geiger-Müller counter," "multipole radiation." Under "nuclear physics" are listed only seven citations, but none of the above—although they and perhaps half of the 300 are in fact topics of nuclear physics. The history of our understanding of the nucleus is treated in the article "Nuclear chemistry"! I'm not a nuclear physicist commenting out of pique; it just seems unnecessary that the organization of the material should obscure its origin and nature.

As a final example I cite the articles named after the principal areas of science and technology—"Botany," "Engineering," "Physics," and so on. These vary greatly in length and approach, from nine pages for "Ecology" to four sentences for "Zoology." In the three-page "Chemistry" article appears another historical summary of events and people associated with the development of the concepts of the atom and the nucleus, a description of the literature of chemistry, and a discussion of employment prospects for chemists. The "Mathematics" article gives, in five pages, a very nice account of the structure and aims of its fields. One page is given to a survey of the development of astronomy and its branches. Why could there not have been some common purpose and format for these key articles?

One is left with the impression that in its fine structure the *Encyclopedia* is for the most part well done; all of the thousands of assigned places in the organization chart have been filled. Editing, however, seems to have been carried out only on an intradisciplinary, article-by-article basis. Judging from my samples and the comments of the earlier reviewers, it would appear that no editor read a manuscript in juxtaposition with others treating related or analogous material, no editor used a wide-angle lens. The indexing appears to have been accomplished in a mechanical fashion; it suffers from a kind of aimlessness and inattention to overall considerations. Of course an encyclopedia is not a textbook, to be organized according to some author's conception of a logical or pedagogically sound treatment. Neither is it a dictionary, organized solely according to our peculiar notion of an alphabet. It must follow the alphabetical sequence in order to be universally useful, but, unlike a dictionary, it can have an overall harmony and its organization is a matter of discretion. There is freedom that can be exploited poorly or well by the editorial staff.

The 11th edition of the *Encyclopaedia Britannica* contains a long editorial introduction which discusses in several places the relationship between its editorial staff and the individual contributors. The editor-in-chief quotes as his guiding principle a statement from his predecessor of the 9th edition, "No effort has been spared on the part of the editorial staff to secure the accuracy and sufficiency of every contribution, and to prevent those repetitions and inconcinnities which necessarily occur where each contributor is absolutely and solely responsible for the articles which bear his name." The *Encyclopedia of Science and Technology* begins with a brief preface by its publisher, who makes no such claim. Well-executed in many of its parts, thorough in its coverage, and valuable as it stands, it will not reach excellence until he can do so.

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Prehistory of the Midwest

Pleistocene and Recent Environments of the Central Great Plains. A symposium, Lawrence, Kans., Oct. 1968. WAKEFIELD DORT, JR., and J. KNOX JONES, JR., Eds. University Press of Kansas, Lawrence, 1970. xii, 434 pp., illus. $25. University of Kansas Department of Geology Special Publication 3.

The grassy plains of North America's heartland form an enormous, seemingly monotonous province that has been commonly accepted as a legacy of geologic time. Indeed, even thoughtful observers since the time of F. E. Clements half a century ago have regarded these vast grasslands as the consequence of a dry climate, maintained by the uninhibited impact of strong winds. Forces opposing these uniformitarian concepts, however, claiming that the apparent permanence of the grasslands is misleading and that these plains were even forested in many places during the Pleistocene Epoch, have been slowly gathering strength, especially in the last decade. To assess various reports of intelligence, the contributors to this book and many of their colleagues closed ranks and held a symposium. Quite obviously, they were in virtual agreement, having mustered material from a variety of sources, including some understanding of physical features, matters of archeology, and new results from botany, together with some truly synoptic work in zoology and zoogeography. These subjects were analyzed both in the perspective of the fossil record and in the immediacy of the present.

With all this ammunition, and with the leading generals in charge, this resulting symposium volume is a frontal attack on the idea of permanent grasslands on the Great Plains—and much more. Several of the generals loom as heroic figures. Even so, this written history of the assault shows a lack of coordination and a raggedness of effort. The editors as organizers of the symposium did not make the ground rules clear enough, and the necessary matters of present-day geography, regional geology, climate, phytogeography, and so on are left out. Worse, an observer trying to piece the action together has a hard time because he is never given the plan of battle. For my part, I had to discover the supporting tactics by a careful reading of the whole book, because the editors provided no substantive introduction, no summary of the outcome, and no index