guage shows "a higher plane of thinking, a more rational analysis of situations, than our vaunted English" (p. 85), or "how much more precise and finely elaborated is the system of relationships in many such [preliterate] tongues" (p. 84) have made Whorf vulnerable to those critics who attack the lack of scientific rigor in his methodology. Too, his belief that "it was . . . enlightening to see English from the entirely new angle necessitated in order to translate it into Hopi" (p. 112) sounds suspiciously similar to the old classicist's superstition that everyone should study Latin, for there is no better way to learn English grammar. The two points of view are, perhaps, merely different sides of the same coin.

A more serious criticism of Whorf's methodology, pointed out in Carroll's very fair evaluation, is the undue importance given to translation as an index of the differences between languages. It is surprising, for example, that Whorf considered it so noteworthy that, say, Hopi had only one word where English has three; that there is no one-to-one correspondence between languages is obvious to anyone after his first experience with another language. Differences (or similarities) in the linguistic behavior associated with two events do not necessarily imply corresponding differences (or similarities) in the perception of those events. A number of factors may operate to cause such situations: metaphorical extensions, semantic change, idioms (that is, a case where the meaning of a complex whole cannot be predicted from the meanings of the constituent parts), and so forth. Would anyone, for example, infer that English speakers consider the two events of (i) *dying* and (ii) *hitting a pail with one's foot* as being closely related because they each may be referred to as "kicking the bucket?"

That Whorf's argument suffers from circularity of inferences has been pointed out by his critics. We must observe the linguistic and nonlinguistic events separately before they can be correlated; otherwise, the only evidence for differences in "world-view" turns out to be the linguistic differences. Even assuming that we find a striking difference in language structures, and what seems to be an associated difference in some nonlinguistic behavior, it must be demonstrated (i) how often such co-occurrences might be expected merely by chance, and (ii) what the exact nature of the relationship is. If A and B co-occur, either A causes B, or B causes A, or perhaps some other factor C causes both A and B. To use a trivial example of the relationships between language and culture, it is certainly likely that people who live near the sea and who are engaged primarily in fishing will have a large and precise terminology for things connected with fishing. However, no one would suggest that these people took up fishing because their language had such an appropriate terminology.

Carroll quite rightly points out that regardless of whether the linguistic relativity principle is valid or not, the interest it has aroused should not be allowed to minimize the attempts to search for language universals. Whorf maintains, for example, that such a contrast as that between verb and noun is "meaningless" in some languages—"in Nitinat it seems not to exist" (p. 99). However true this may be, it seems reasonable to assume that language as a form of learned behavior should be subject to the general laws that govern all learned behavior and that there should be some manifestations of these general laws in the forms of "universals."

These remarks are not meant to refute the Whorf hypothesis, but merely to indicate where some refinement is necessary before the hypothesis can be adequately tested. Collection of the data required for investigating the validity of the hypothesis will certainly be fruitful. It is hoped that the appearance of this book will further stimulate research in determining the nontrivial, other-than-chance relationships between language structure and nonlinguistic behavior, perception, cognition, and so forth—research of the nature Carroll himself is engaged in as director of the Southwest Project in Comparative Psycholinguistics.

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Scientific Books, Libraries and Collectors. A study of bibliography and the book trade in relation to science. John L. Thornton and R. I. J. Tully. Library Association, London, 1954. 288 pp. 24s.

In 1949, the senior author, librarian of St. Bartholomew's Hospital Medical College, London, issued *Medical Books, Libraries and Collectors*. He then promised a companion volume, *Scientific Books, Libraries and Collectors*. Now that this work has appeared, it should be welcomed by historians of science, librarians, collectors, and all who are concerned with the growth and development of scientific literature.

Although the book is mainly bibliographic in nature, it has the rare merit of being both readable and interesting. It is not, as the authors point out in their preface, "an exhaustive treatise on the bibliographical aspects of science, but rather an introductory history of the production, distribution and storage of scientific literature from the earliest times. Our aim has been the recording of information accessible only at the expense of much research, rather than the presentation of new material, and our selected bibliography guides readers to sources of additional information."

It may be said at once that the authors have succeeded very well in their aim. Although the volume appears to be small, a vast amount of information has been packed into it. There are 12 chapters that include such topics as scientific literature before the invention of printing, scientific incunabula, scientific books of the 16th century, 17th century scientific books, scientific books from 1700–1799, the rise of scientific societies, the growth of scientific periodical literature, scientific bibliographies and bibliographers, private scientific libraries, scientific publishing and bookselling, and scientific libraries of today.

In addition to many bibliographic footnotes, there is a valuable 26-page bibliography and an index.

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Science and Christian Belief. C. A. Coulson. University of North Carolina Press, Chapel Hill, 1955. 127 pp. $2.50.

Coulson is a professor of applied mathematics and an acknowledged authority in several fields of chemistry and physics. He is also a sincere Christian. Therefore, when he undertakes to talk about science and Christian belief, he deserves a respectful hearing from both scientists and churchmen. His book is one of the best discussions of this difficult subject that I have read.

The author's thesis is that science itself is essentially a religious activity. In science, discovery of facts alone is not enough. Facts are all related to each other, and what the scientist especially seeks is to tie them together by unifying concepts. "Scientific truth means coherence in a pattern which is recognized as meaningful." Religion, in the same way, seeks unifying concepts among its own facts and experiences. Both share a common ignorance and a common hope. Furthermore, the underlying assumptions of science are essentially moral and spiritual ones—honesty, integrity, humility, hope, enthusiasm, patience, cooperation with others, and the use of both reason and imagination. Both seek for truth and for order and constancy in nature, but they study different aspects of the truth as one might study different aspects of the complex blueprints for a building. An artist would see in these blueprints something

quite different from what an engineer would find.

It is, therefore, harmful to separate sharply the scientific approach from the religious approach to truth. "Religion is the total response of man to all his environment." The author stresses the importance of "reflection," an attempt to build a full three-dimensional framework of all the reality we encounter in our various experiences. Such reflection will show, he believes, that these experiences provide a conviction of revelation in both science and religion, a sense of unity in nature, and a quality in this unity that is essentially spiritual. This personal and spiritual quality reaches its highest manifestation in Jesus Christ.

Coulson's plea that religion should not be divorced from science but should interpret all our experiences will doubtless meet with much support. It is well, however, for us to remember something which, in my opinion, he does not stress sufficiently—that the approach of science to reality is chiefly through the intellect, while the approach of religion is chiefly through spiritual insight. It is the unwillingness of many men of science to recognize the validity of the latter as an avenue to truth that has been the main cause of the so-called "conflict" between science and religion.

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Ludwig Boltzmann, Mensch, Physiker, Philosoph. Engelbert Broda. Deuticke, Vienna, 1955. viii + 152 pp.

It is 50 years since the tragic end of Boltzmann, one of the greatest physicists of the last century and the founder of the modern theory of statistical physics, but this is the first full-length biography of him. Written by the radiochemist, Broda, the biography is introduced by Hans Thirring, who briefly gives the argument of Boltzmann's explaining heat processes mechanically. The book is divided into four sections.

The section, "Boltzmann the man," not only describes his academic career, which was many sided—he was, in succession, professor of mathematics, of experimental physics, of theoretical physics, and finally of philosophy—but is particularly valuable because, like the whole book, it contains copious quotations from Boltzmann's own writings and statements by former students and friends, and thus it gives a vivid picture of this unique personality.

The second section. "Boltzmann the physicist," is, in my opinion, too brief. However, it gives all the most important discoveries, stressing Boltzmann's outlook on atomistics and mechanics and in particular showing that Boltzmann not only had developed kinetic theory but had also used the kinetic picture in the theory of matter, and in electricity, where he first gave the atomistic explanation for the Hall effect. It was Lorentz who said, "to Boltzmann goes the honor of first having estimated the velocity of electricity in solids."

Boltzmann's most important contribution was the formulation of the H-theorem that leads to the relation between entropy and probability, which according to Planck is written in the simple equation, $S = k \ln P$, where S is the entropy, k the Boltzmann constant, and P the probability. It is this equation that has been put on Boltzmann's tombstone. To this generation, Boltzmann is best known for these theoretical investigations. E. Mach called him an experimenter of unsurpassed technique, and it was Boltzmann who investigated the dielectric constant and its relation to the refractive index (Maxwell relation), who measured the force on a dielectric sphere in an electric field, and who also determined the wavelength of Hertzian waves (microwaves) with an interferometer.

The third section is "Boltzmann the philosopher." Boltzmann was unfortunate in that most of his contemporaries, particularly the natural philosophers as represented by Ostwald and Mach, did not believe in the reality of atoms. His polemic arguments against their criticism took a great deal of his time and to a certain extent colors his philosophical lectures, which are discussed in some detail in this book.

Boltzmann was of an artistic and sensitive nature but full of humor. Californians then and now will be delighted with his statement in one of the *Popular Lectures,* "The trip of a German professor to Eldorado." In describing the trip to California, he calls it something "quite exquisite" and says, "A trip to California is Champagne Veuve Cliquot and oysters." Not many physicists will say what he says in the preface to his *Popular Lectures,* which he dedicated to the memory of the great German poet, Friedrich Schiller. He said, "This dedication is no empty phrase. Through Schiller I am what I am at the present time. Without him a man with the same type of beard or nose could exist, but never myself. There is only a second one who had a similar influence on me and that is Beethoven."

It is characteristic for this outlook that in his *Popular Lectures* the names of Beethoven, Schiller, Mozart and some other artists appear frequently and that he is full of the enthusiasm of an artist who is taken with the beauty of the physical theory in very much the same way as Einstein himself, who was profoundly influenced by Boltzmann's writing.

The final section summarizes briefly Boltzmann's importance for modern physics. The book is well worth reading as an introduction both to Boltzmann's personality and to his outlook on physical theories and philosophy.

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Physical Sciences

Relativity: the Special Theory. J. L. Synge. North Holland, Amsterdam; Interscience, New York, 1956. xvi + 450 pp. $10.50.

J. L. Synge of the Dublin Institute for Advanced Studies is well known as a competent mathematician who is also an excellent writer of texts on an intermediate level. Readers of his mechanics text will find the present book on relativity on a substantially more demanding level, but written with the charm that makes reading a pleasure and that is a substantial help over the rough spots.

The subject matter of this book covers the geometry of the Minkowski manifold perhaps more comprehensively than would be necessary for a presentation of of the special theory alone. This excess mathematical baggage is, however, well justified for anyone who contemplates going on at some later date to a study of the general theory of relativity. Because Synge is by inclination a mathematician rather than a physicist, he begins not with a discussion of the physical reasons leading to the replacement of the Newtonian by the Minkowskian continuum but rather with a semipostulational discussion of the logical possibilities. As the discussion progresses, physical and observational arguments are given their due attention as well. The discussion of the mathematical and the kinetic aspects of the Minkowski space and the Lorentz transformations occupies roughly the first third of the book.

Next the author proceeds to what is usually called relativistic mechanics. It is well known that relativistic mechanics cannot properly cover as much ground as does Newtonian mechanics, because of the incompatibility of the Lorentz transformation with action-at-a-distance. Relativistic mechanics concerns itself, accordingly, with action at infinitesimal distances—that is, with collisions between mass points and with the laws of fluid dynamics. There is no attempt to cover relativistic quantum mechanics (that is, the theory of a single Dirac particle). The Compton effect is treated (as it can be done very adequately) as the collision between a classical point electron and a classical photon—that is, a particle of zero rest mass. Synge even treats pair creation and pair annihilation purely classically. It is comforting to see how much information can be obtained even in this simplified approach. Mechanics comprises the second third of the book.