Science in the USSR is neither all destroyed nor progressing by leaps and bounds. The situation is more complex than this. In some respects, science enjoys unprecedented opportunities. On the other hand, there is the cancer of Lysenko, which has been nurtured by those in power in blissful ignorance of the fact that he is the most efficient wrecker ever to afflict their biology and agriculture. Furthermore, the situation is fluid, and the future, possibly a very near future, may bring changes and surprises which the author is wise not to attempt to predict.

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Climatic Change: Evidence, Causes, and Effects. Harlow Shapley, Ed. Harvard Univ. Press, Cambridge, Mass., 1953. 318 pp. Illus. + plates. $6.

The title of this volume suggests a meteorological discussion, but only three of its 22 chapters are devoted to meteorology as such. Instead, numerous ramifications of climatic changes, their causes and effects, are discussed. Here one finds such varied topics as radiocarbon dating, tree-ring studies, soil geology, analysis of lake sediments, Pleistocene glaciation, and the relationship of climate to human racial characteristics. Two chapters give excellent and concise summaries of the paleontological and paleobotanical evidence for changes of climate. It would be difficult to imagine a wider assortment of scientific fields, all directly connected with a single main theme.

An introductory chapter by Dr. Shapley includes speculations on the possibilities of life under climatic conditions of other planets. The other 21 authors include meteorologists and climatologists, an anthropologist, several astronomers, a paleontologist, two botanists, a zoologist, and several geologists. The majority are on the Harvard and Yale university staffs. The coordination of chapters is good on the whole, for each author treats a well-defined area that fits into a planned sequence. The lack of a general index is somewhat inconvenient.

Much space is devoted to the problem of the Pleistocene glaciations. The great question of how the vicious circle can start is only slightly less difficult than its logical sequel: once an ice age is established, how can it ever end? Ice begets more ice, as C. E. P. Brooks pointed out some years ago, and some drastic change is required to remove it, once it has taken hold.

Substantial progress has been made since Croll offered his precessional hypothesis, which has been revived more recently in a more precise form by Milankovich. The evidence now seems rather clearly opposed to all such purely geometric astronomical explanations. At best, they can probably account only for minor waves superimposed on the main trend (for example, the variations in the varves of the Green River formation of Eocene age). The geologically rapid alternation of glacial and interglacial episodes is fatal to hypotheses that rely chiefly on elevation of the continents and mountain building. Still, the reviewer finds it hard to avoid the compulsion in the circumstances that two tremendous glaciations (Permocarboniferous and Pleistocene) each followed a few million years after a tremendous orogeny. (Extensive pre-Cambrian glaciations cannot yet contribute clear evidence on this point, owing to difficulties of correlation). It seems at least probable that elevation plays a part in setting the stage.

A recurring theme is the recognition that ice ages represent an accentuation and equatorward shift of climatic zones. It is significant that postglacial times have witnessed cycles that differ only in their shorter periods and lesser amplitudes. All other agencies having failed, the basic cause of world-wide climatic change is considered to be probably solar variation. The naive idea that less radiation would bring an ice age has long been abandoned. Greater radiation is required to increase evaporation and precipitation. But Miss Bell presents the hypothesis in a new form, according to which the earth, especially the oceans, must have been precooled by a cooling of the sun, after which increased activity brought on extensive snowfall. This seems to be the most promising idea yet proposed. Other suggestions concerning effects of solar corpuscular radiation can best be evaluated after we have more definite information. At present we can only regard them as hopeful speculations.

Two decades ago the authors of such a book would probably have felt obliged to refute the hypothesis of continental drift. In this volume it is dismissed quite casually, when mentioned at all. The strongest point in its favor is the Permocarboniferous ice age in and near the tropics, which remains the greatest of all geologic climatic enigmas.

Climatic Change states a problem and discusses its present status but only suggests possible directions in which the solution may lie. There is much in the book that is new and original, to which a brief review cannot do justice. It is well written, far above the "popular" level, and is stimulating and highly informative reading for the scientist or scholar who is not a specialist in climatology.

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Astronomy and Mathematics

Dialogue on the Great World Systems. Galileo Galilei. In the Salusbury translation. Revised and annotated by Giorgio de Santillana. Univ. Chicago Press, Chicago; Cambridge Univ. Press, London, 1953. 506 pp. Illus. $12.50.

Dialogue Concerning the Two Chief World Systems—Ptolemaic & Copernican. Galileo Galilei. Translated by Stillman Drake, foreword by Albert Einstein. Univ. California Press, Berkeley, 1953. 496 pp. Illus. $10.

Galileo's monumental defense of the Copernican system, the *Dialogue on the Two Principal World Systems,* has been virtually inaccessible in English since the Great Fire of London destroyed most copies of Thomas Salusbury's 17th-century translation. Until 1953 the fire damage was not repaired. Most English and American readers have known Galileo only through his *Discourses on Two New Sciences.* Now two English editions appear simultaneously: one, a brilliant revision of Salusbury's clumsy and inaccurate translation; the other, a completely fresh translation from the Italian original. Both are admirably clear and faithful versions of one of the few readable classics in the literature of science.

The Galileo who emerges from the *Dialogues on the World Systems* is a less familiar scientific type than the Galileo of the *Two New Sciences.* The latter appears as a theoretical engineer, concerned with a limited range of practical terrestrial problems; he can be drawn as the "first modern scientist," the man who destroyed medieval science at a stroke by insisting upon the supreme authority of observation and who founded modern science by the experimental solution of its first fundamental problems. The author of the *Dialogues* will not conform to this mold. He is a speculative Renaissance cosmologist who, with unrivaled virtuosity, will turn every observation and trick of dialectic to the documentation of his vision of the universe as uniform and homogeneous. His first concern is to banish from cosmology the primitive perception, dominant in most ancient and medieval science, which divides the universe into two intrinsically disparate portions: the corruptible and chaotic earth, and the eternal and regular heavens.

The vision of the uniformity of matter and laws ties the *Dialogues* together and is the key to much of its substance and originality. Galileo is the first scientist to fruitfully apply celestial observation to the discovery of terrestrial laws. The eternal regularity of the heavens demands that the celestial bodies move naturally in circles; the universe would dissolve, says Galileo, if natural (inertial) motions were linear. To this point, he is a good Aristotelian. But for Galileo the same natural motions must be exemplified on earth. It is only a naive trust in uninterpreted sense-data that misled Aristotle to assert that the unconstrained motions of terrestrial bodies were straight. In fact, Galileo says at one point, the stone that appears to fall straight along the side of a vertical tower with steadily increasing velocity is really governed by the same law of uniform circular motion as the planets. It really moves uniformly in a semicircle from the top of the tower to the center of the earth, but the earth's diurnal rotation keeps the tower aligned with it throughout the fall. These ideas are not Newton's laws, but they are Newton's vision. The celestial moon and the terrestrial apple display identical aspects of nature's fundamental regularity.

To many readers, the most startling characteristic of the *Dialogues* will be the attitude displayed toward exact observation. The book is filled with an unparalled wealth of qualitative observation, brilliantly interpreted to demonstrate Galileo's predetermined theorems. Galileo is a master of the simple demonstration technique; there is nothing to be observed in nature so trivial that he cannot turn it to account. And this is a key novelty of his work. But he does use nature to demonstrate, not to derive, and he does not hesitate to suppress troublesome details again and again. The pendulum, whose circular motion is for Galileo the key to so many of nature's regularities, is for him absolutely isochronous. He has watched, he says, two bobs on strings of the same length swing back and forth, remaining together: one had a small amplitude, the other swung through nearly 180° of arc. More essential suppressions occur in the discussions of astronomy. Galileo restricts himself entirely to a simplified version of the Copernican system, a version that could satisfy no astronomer, including Copernicus, because it was unable to account for the observed planetary motions as well as Ptolemy's system did. But Galileo's faith in the geometric simplicity of natural law was stronger than his faith in quantitative observation, and the astronomers' fuller quantitative version of the Copernican system, with its epicycles and eccentrics, would not conform to Galileo's system of circular inertia.

The Galileo of the *Dialogues* is a far more complex figure than the more familiar Galileo of the *The Two Sciences,* and the *Dialogues* is a correspondingly richer and more rewarding book. The unfamiliar facets of Renaissance scientific thought which emerge in this book are ingredients essential to an understanding of the intricate fabrication linking the critical and analytic science of the later Middle Ages to the more empirical and mathematical Newtonian science of the later 17th century. Either of these new editions will illuminate the sources of Newtonian science. Perhaps the Chicago edition, with a more readable format and with fuller and more perceptive notes, will facilitate more penetrating insights.

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Principles of Numerical Analysis. Alston S. Householder. McGraw-Hill, New York–London, 1953. 274 pp. $6.

During the past few years, the number of people working in the field of numerical analysis has increased sharply. This increase is due to the growing use of applied mathematics in the research laboratories of industry, government, and universities. It is also due to the introduction of new instruments for computing, namely, electronic digital computers. These factors have led to a development of the field and a need for books that treat the subject as it is used today. *Principles of Numerical Analysis* treats many topics not adequately covered by the classical textbooks on the subject.

The book begins with a chapter on computation and a discussion of errors. The remainder of the book is concerned with a mathematical analysis of the general classes of problems met in performing calculations. First, there is a discussion of linear algebraic equations, which, as the author notes, are used extensively in almost every calculation. Differential equations, integral equations, and many other problems can be reduced to sets of linear algebraic equations for calculational purposes. Next, nonlinear equations are discussed, followed by a chapter on eigenvalue problems. Other chapters treat interpolation, general methods of numerical integration, and differentiation. The final chapter presents a brief discussion of the Monte-Carlo method.

This book presents a good discussion of errors in calculation. Errors, the changes in the results owing to the finite number of digits used and owing to the representation of a continuous problem by a discrete problem, are distinguished from blunders, actual mistakes in calculation.

The mathematical aspect of numerical analysis is the principal topic of the book. The author attempts to give the reader some insight into the mathematical problems involved in carrying out numerical calculations. This subject has been neglected in most preceding textbooks, and its emphasis here points out the increasing mathematical interest in calculational methods.

It would be desirable to see more examples of calculations in a book of this type. The important problem of stability of numerical calculations is neglected, and there is no explicit treatment of the numerical solution of differential equations. The use of the new computing tool, electronic digital computers, is not discussed. These omissions suggest that there is a need for another book that would be concerned with them.

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Astronomical Photoelectric Photometry. Symposium presented on Dec. 31, 1951, at the Philadelphia meeting of the AAAS. Frank Bradshaw Wood, Ed. American Association for the Advancement of Science, Washington, D.C., 1953. 141 pp. Illus. $3.75.

Assembled in this book are eight papers presented at a symposium sponsored by the AAAS at Philadelphia. The purpose of the symposium was to outline the status of methods and techniques then in use and under development for astronomical photoelectric photometry. The contents of the book indicate that the purpose of the symposium was served admirably, and the book is a useful and available permanent record of the results.

There are papers by nine authors, each an authority in some particular aspect of the field. This number of authors, to say nothing of the large bibliography, is a good indication of the growth of the art since the pioneering work of Joel Stebbins began 40 years ago.

The first chapter, by Albert P. Linnell, on the use of direct-current techniques, covers the methods in general routine use for the bulk of successful photoelectric observing in most observatories. Following this, John Hall discusses alternating-current techniques and the special conditions under which they are particularly useful. Hall also gives a good discussion of the effects of stellar scintillation, of which he has made a special study.

William Blitzstein summarizes the methods, advantages, and disadvantages of photometry by counting pulses from individual electrons emitted by the cathode of a photomultiplier, and also gives descriptions of actual and projected installations of counter photometers at the Flower and Cook Observatories. Counting methods are considered further by R. O. Redman and G. G. Yates in another chapter. These authors describe the development of two counting-type instruments at Cambridge, England, and provide a good discussion of methods for extending the linear operating range of counter photometers and of correcting for the nonlinearity in a portion of the nonlinear range.

Two short chapters by the French authors A. Lallemand and F. Lenouvel describe, respectively, the characteristics and use of a 19-stage photomultiplier constructed by Lallemand. This multiplier has enough multiplying ability so that shot noise can be observed for an unrefrigerated cell with a glavanometer. Useful photometry has been done with the instrument at the Haute Provence Observatory. Certain precautions must be exercised to prevent fatigue effects in this multiplier, in which rather high current densities can prevail.

Th. Walraven discusses his developments in the use of servomechansims for providing a logarithmic output from a photometer. In this way a photometer, with the sacrifice of simplicity, can be made to read directly in magnitude instead of in light units.

The last chapter by A. E. Whitford is an able and realistic summary of the fundamental principles involved in the photometry of faint light. Although the chapter is quite properly placed last in view of its intended function, students of photometric techniques may well read it first for orientation.

All chapters contain useful data, equations, circuit diagrams, and descriptions of equipment and methods, in some cases in considerable detail. The book is valuable in that it presents a large variety of methods for the perusal of a prospective user, who can give consideration to all of them and pick the best for his particular application. The book also presents a fine bibliography, particularly in the case of Linnell's paper, which gives nearly 600 references.

There are a few omissions and inconsistencies, as might be expected, as a result of assembling papers by separate authors. There are also a few mistakes, of which one or two are rather unfortunate. Most of the flaws are readily recognizable and therefore unimportant. A person who would read this book from the viewpoint of 20 years ago would be surprised at the complexity now shown by techniques once thought to be complicated by Whitford's introduction of the one-tube amplifier.

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The Sun. The Solar System, Vol. I. Gerard P. Kuiper, Ed. Univ. Chicago Press, Chicago, 1953. 745 pp. Illus. $12.50.

For many years, astronomers and other scientists interested in solar physics have longed for an up-to-date, unified textbook that covered in a systematic way the various phases of this growing field of research. *The Sun,* the first of a series of four books on the solar system, fills this need in excellent fashion. Nine authors contributed to the main sections of the book, and 13 additional authors contributed to the final chapter, Empirical Problems and Equipment. The book was written for readers trained in the physical sciences and will be of great value to anyone interested in a comprehensive description of solar phenomena and in a thorough review of the theories that have been developed to explain them. More particularly, it will be greeted enthusiastically by those actively engaged in solar and solar-terrestrial research. It certainly will immediately become a standard reference textbook for this field of scientific investigation.

The Sun is a praiseworthy book from several standpoints. For the most part, the presentation is well organized and easy to read. The printing is excellent, and the text is liberally illustrated. The authors were careful to summarize and give credit to the work of others. The book gives extensive and well-chosen references. In general, there is a clear distinction between the observational data and the authors' interpretations of the data.

Some chapters are especially well done. Particular praise should go to Bengt Stromgren's discussion of the problems concerned with the solar interior and to M. Minnaert's chapter on transfer of radiation and the formation of the spectrum. These are both unusually valuable surveys of the current knowledge and state of research on these fundamental problems. The chapter on solar activity by K. O. Kiepenheuer is thorough, and the author has injected many interesting suggestions regarding the interrelationships among the various phenomena.

The chapter on solar emission in the radio wavelengths by J. L. Pawsey and S. F. Smerd is the most satisfactory summary to date of the observational data in this interesting new field. T. G. Cowling has surveyed the many and varied interpretations of solar phenomena in terms of interacting charged particles and magnetic fields. His main contribution, aside from the unified review, is his criticism of existing theories through order of magnitude arguments. For many theories, his arguments appear to be fatal. However, the ranges of possible values of the parameters, on which all theories of this type depend, are so broad that even order of magnitude arguments are in some cases inconclusive.

The chapter on the chromosphere and corona by H. C. van de Hulst requires special comment. In the author's own words, "To study the corona and chromosphere requires a firm optimism." The author has done a masterful job with a very difficult problem. This is especially true of his treatment of the corona. His surveys of the chromospheric data and the work of others in interpreting the data are excellent. Unfortunately, his own interpretation of the data in terms of a "model" chromosphere is not convincing. Specifically, he has combined the various data in a very arbitrary manner that obscures some of the most basic facts given by these data. He then proceeds to derive a "model" chromosphere by a method that is based on what seems to us very dubious assumptions.

We have the feeling that the discussion of the identification of solar lines, in Chapter 4, devotes too much space to discussions of elementary laboratory spectroscopy and not enough space to the important research problems in this field. The general unity of the book is also slightly marred by the adoption of a different system of citing references in this chapter.

Chapter 3 contains a few obvious typographical errors in both mathematical equations and the text. A statement in the section on eclipse problems in Chapter 9 to the effect that the chromosphere disappears behind the eclipsing moon in "3 or 4" seconds might more appropriately have said "20 seconds or more," even though it is true that to the naked eye the chromospheric "flash" seems to last only 3 or 4 seconds.

The editor is to be complimented for including the valuble chapter on Empirical Problems and Equipment and also the tables giving locations and types of observations of all solar observatories throughout the world.

The Sun is obviously of first importance in solar research and fills a long-standing need of investigators in many fields of study.

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The Elements of Mathematical Analysis, Vols. I and II. 2nd ed. J. H. Michell and M. H. Belz. Macmillan, London, 1950. 1087 pp. Illus.

In the preface to the first edition (1937), the authors said:

> In writing the present book we have tried to make it conform to three main conditions. . . . (i) The book should assume as known only those elements of Algebra, Geometry and Trigonometry which are taught in the secondary schools to all those preparing to attend any lectures in Mathematics at a university. . . . (ii) The second main condition is that the book should form a practical or working text provided with an abundance of illustrative examples treated at length and of other examples to be solved by the student. . . . (iii) The third condition is that the subject should be expounded on the basis of the theory of real numbers, geometrical notions being employed only illustratively and not as replacing abstract discussions. . . .

These stipulations and principles apply to the second edition also, for the new preface states that, apart from corrections and improved modes of expression, no other substantial changes have been made.

The authors have succeeded admirably in meeting their aims. With regard to the first condition, it is a question, of course, of how well the necessary comprehension and facility in the use of the assumed "elements" have been ingrained in the student. If no obstacles of inadequate preparation or ability interfere, the second condition can also be said to have been well fulfilled. The illustrative examples have been carefully chosen and painstakingly expounded, and the student should benefit further by independent work with the equally excellent exercises and problems.

The third condition is fulfilled also in a manner consistent with the first one. As an indication of the book's level, the appearance of the Bolzano-Weierstrass theorem as early as page 15 may be cited. But, in fairness to the authors, it should also be mentioned that their preface includes the sentence:

> If, nevertheless, any student finds the first Chapter too heavy to read as a whole, he may well be guided to postpone the reading of various discussions until they are appealed to in the sequel.

Although mathematical precision is almost always maintained throughout the book, there are a few lapses that may be misleading or are lacking in rigor. On page 6, for instance, it is a bit of a jar to read that ''0/0 may be any number, or is indeterminate.'' Also, on page 95, in connection with a discussion of orders of infinitesimals (which could easily have been avoided entirely, and should have been), one finds the statement that ''an infinitesimal of the nth order is ultimately indifinitely small compared with one of the $(n-1)$th or lower order.''

Several topics not customarily seen in similar treatises are considered here, such as finite differences, line coordinates, least squares, and orthogonal functions. An interesting feature is the inclusion of epicene and expocyclic functions, ''thereby avoiding the introduction of complex numbers in the treatment of the elementary theory of functions of real variables'' (p. 443), and similarly using these real functions when dealing with linear differential equations in Chapter XX.

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Physics

Scientific Papers Presented to Max Born. Sir Edward Appleton *et al.* Hafner, New York, 1953. 94 pp. Illus. $2.50.

This "modest volume of essays," as it is accurately described in the foreword, was prepared last year as a tribute to Professor Born upon his retirement at a vigorous 70 years from the Tait Chair in the University of Edinburgh. In 10 brief essays the contributors, most of them old friends and colleagues of Born, treat a variety of subjects ranging from the ionosphere to the theory of algebraic fields.

The hero of the work appears himself only in the lines of a formal bibliography that somehow becomes about as interesting as many a scientific paper. Almost 300 papers by Born and his coworkers are listed, and nearly a score of books, two still gaining form in his fruitful hands. If, like this reviewer, you owe much to Professor Born's books, to the *Restless Universe* in its charm and depth, to the compendious, *Optik,* to the meaty *Atomic Physics,* or to any of the others, you will be especially struck by this list. But anyone may see in the titles a kind of précis of the physics of our century. Here are named the elegant early exploitations of special relativity 40 years back, the complex and powerful theory of lattice vibrations, the studies on collisions in which that essential first bridge to understanding, which we now call the Born approximation was built, the adiabatic approximation, still the heart of the theory of molecular structure, and many more. There are less familiar matters, too, such as the boldly nonlinear electrodynamics and the still hotly discussed kinetic theory of liquids. All these are a good harvest indeed.

About 30 years ago Born set one stone which has become the builders' chief cornerstone. Hamiltonians and wave equations may give way to state vectors and path integrals, but the statistical interpretation of the probability amplitude remains the foundation of every quantum theory. It is fitting and proper that four of the 10 papers of the present book, papers by Bohm, de Broglie, Einstein, and Landé, in three tongues, all address themselves to this general question. Once again Professor Einstein acutely questions the completeness of quantum mechanics, because (if I may peremptorily summarize his careful thought) it cannot lead to an unambiguous classical limit of specific, and not probabilistic, description. He dismisses the use of the wave packet, it seems to me, too lightly, on the grounds of its finite duration. It is interesting indeed that the makers of casual alternatives to quantum theory, Bohm and de Broglie, earn from him the same blame because their theories make a particle in a well stand still, while classical physics gives it a velocity, and the ordinary quantum theory of stationary states only a probability ensemble of two possible velocity values. Their answers contain much of what a quantum mechanician would say in his own defense. Landé has a thoughtful paper again emphasizing the naturalness of the statistical theories.

The other papers range from a specialized piece on the theory of flame propagation by von Kármán and S. S. Penner to a conjectural little note by P. Jordan on fundamental biology. Courant, Schrödinger, and Weyl are other contributors whose names serve to remind us again how great a debt we all owe to those Göttingen years of decades back. Sir Edward Appleton, the one experimenter, writes his views on the interaction of the ionosphere with the earth's magnetic field and speaks as the spokesman of Edinburgh, which Professor Born has served and graced for 17 years.

As a frontispiece there is a signed photographic portrait of Professor Born, elegantly made by a London photographer, whose name, Lotte Meitner-Graf, is not without interest for physicists. The fabric of the history of physics in our time is closely knit.

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Thunderstorm Electricity. Horace R. Byers, Ed. Univ. Chicago Press, Chicago, 1953. 344 pp. Illus. $6.00.

Thunderstorms are the most spectacular electric manifestations of the atmosphere. In 1912, C. T. R. Wilson suggested that they acted as the generators which maintain an electric charge on the earth in the presence of the considerable current conducted by the atmosphere. Although this hypothesis has met with considerable favor ever since, it is only in the last few years that substantial experimental evidence in its support has been available. It is, therefore, an appropriate time to gather together the known facts on the electric behavior of thunderstorms and (to quote the editor's preface) "bring some order out of the chaos of facts on thunderstorm electricity." This was the object of a conference held at the University of Chicago in April, 1950, and sponsored by the U.S. Air Force Cambridge Research Center. This book makes available the material presented at that conference, together with some results obtained since that time.

It thoroughly covers the subject of thunderstorm electricity and spreads into many neighboring fields, such as cloud thermodynamics, the charging of dust