Kingdom's Operational Research Society. Third, the relation of the system's concept to operations research emerges with a sense of both primary and growing importance. Fourth, simulation techniques are repeatedly stressed as a means for resolving problems that are too complex for treatment by the methods of classical mathematical techniques.

One point about which I disagree with the authors must be cited. They overemphasize the team concept. Although circumstances exist wherein only a team can effectively perform, this condition should not be used to describe the "essential characteristics" of operations research, thereby excluding individual effort. As Aesop warned us, we must beware lest we lose the substance by grasping at the shadow.

Operations Research in Research and Development, edited by Burton Dean, contains 12 papers that were originally delivered in 1962 at a conference held at Case Institute of Technology on applications of operations research to the management of research and development.

In the past, OR has concentrated its attention on problems that can be classified as decision-making under conditions of *risk* (where reasonable forecasts could be made) or under conditions of *certainty* (where the system's behavior is invariant to noncontrollable forces). Thus, models were developed for short-term, repetitive conditions to obtain near-optimal work schedules, inventory policies, distribution systems, and so forth.

Long-range planning models laced with intangible factors and conditions of *uncertainty* were on the horizon. They still are, but the horizon seems to be moving closer. Operations research is observably metamorphosing in the direction of long-term problems; this collection of papers is additional evidence of that fact.

Three major areas appear to include most of the topics that received attention at the conference: The objectives of R&D and measures of system's performance (in the papers by Johnson, Perlman, and Martin); The use of network theory for planning and controlling projects (Malcolm, Norden, Freeman, and Ashley and Austin); The use of decision theory models for improving the management of R&D functions (Hertz and Carlson, Rubenstein, Shepard, Weiss, and Marschak).

In the lead-off paper, a hard-hitting,

heavily documented essay, Ellis Johnson attempts to develop relevant measures of the effectiveness of R&D, measures which can be used to illustrate that the performance of R&D management in the United States is inadequate. Johnson suggests that a committee be formed within the American Association for the Advancement of Science to study ways of remedying deficiences in the methods by which this country applies research to technology (p. 37).

Other papers are concerned with the development of mathematical models that might provide basic insights into the R&D process. Thus, for example, Martin presents a modified version of Ackoff's model of human communication, and Norden describes a model for predicting the utilization of manpower in development schedules. Perhaps more important than any one paper are the terms that are used and the study pattern which emerges. It is not yet time to tell whether OR has any fundamental contributions to make to the management of R&D projects, but there can be no doubt that OR wishes to participate in this critical endeavor.

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Chemical Engineering

High-Temperature Inorganic Coatings. John Huminik, Jr., Ed. Chapman and Hall, London; Reinhold, New York, 1963. x + 310 pp. Illus. $10.

This short book contains eight chapters which vary from 7 to 100 pages in length. The chapters cover coating materials and coating systems, structural materials for high temperature use, methods of applying coatings, the testing and evaluation of coatings, designing with coatings, and the mechanisms that operate in coatings.

The manner of presentation combines the style of a handbook with that of an encyclopedia. There are a large number of tables and graphs with fairly short, almost entirely qualitative, discussions, a reflection of the fact that the work is being done by a large number of people in widely separated locations who are working under great pressure to achieve the desired results in a hurry. That quality of the presentations varies greatly and the material is somewhat repetitious is to be expected in a text

authored by a number of persons but in one instance there is considerable repetition in two consecutive paragraphs.

The book appears to have been published hurriedly because the text needs editorial attention, and the quality of the plots and the printing ranges from fair to poor. The material is up to date and, despite its brevity, covers the subject matter.

According to the editor, the book is intended primarily for those who are beginning research in the field, for those who design and construct equipment for operation in hot environments, and as a general reference book, uses for which it is suited. Many will find its brevity an especial advantage.

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Silicon Chemistry

Volatile Silicon Compounds. E. A. V. Ebsworth. Pergamon, London; Macmillan, New York, 1963. vi + 179 pp. Illus. $7.50.

Although this excellent book is included in the publisher's "International Series of Monographs on Inorganic Chemistry," persons interested in either organosilicon or inorganic silicon chemistry should find it equally useful. The author stresses the fundamental experimental work and the hypotheses that are basic to both the organic and inorganic silicon fields.

The molecular and chemical properties of the silicon hydrides and all their known volatile inorganic derivatives are critically discussed. Where appropriate, comparisons are made between analogous carbon, silicon, germanium, and tin compounds. Properties of certain organosilicon, and to a much lesser extent organogermanium and organotin compounds, are examined where these serve to illustrate trends or concepts important to the understanding of the chemistry of silicon.

The role of $(p \rightarrow d)\pi$ bonding between silicon and an attached element is evaluated with particular care, and in the last chapter a concise but critical summary is presented, which gives physical and chemical evidence for the presence of this type of bonding in certain linkages containing silicon.

Since portions of organosilicon, ger-

manium, and tin chemistry are included in discussions, the book will interest a larger number of persons than it would if it were restricted to inorganic silicon compounds. It was therefore necessary to make somewhat arbitrary decisions about the parts of organometallic chemistry that should, or should not be included, and the reader may disagree at times with the relative importance of certain of the material selected.

There are more typographical errors than one would expect to find, but otherwise this book presents a careful, well-written picture of silicon chemistry. It should be of particular value to the advanced student and to those concerned with any phase of research that involves silicon.

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Mathematical Analysis

Linear Partial Differential Operators. Lars Hörmander. Springer, Berlin; Academic Press, New York, 1963. viii + 287 pp. Illus. $10.50.

In the late 1940's Laurant Schwartz devised the theory of distributions, a formulation of some of the important classical concepts of mathematical analysis in the modern language of topological vector spaces. At the time many analysts were skeptical of the interest this work attracted, a typical comment being that Schwartz was acting like a linguist and not like a mathematician. Yet, during the 15-year interval, the theory has had a profound effect on partial differential equations and on some branches of physics and has, to a great extent, revolutionized some important trends in these fields. *Linear Partial Differential Operators*, by Hörmander, represents the progress that has been made in partial differential equations as a result of this new viewpoint. The author himself is a major contributor to that progress.

The concepts of irrational and complex numbers were introduced into mathematics primarily to better our understanding of rational numbers. Similarly, distributions are generalized functions whose *raison d'être* is that they help us to study ordinary functions. Of course, generalized functions are not new to mathematics. Their beginnings can be traced to Riemann, and they are found in all modern treatments of integration theory; the L_p spaces are spaces of generalized functions. But Schwartz has given a greater generalization, one that allows iterated differentiation and thus provides the freedom that is needed. In studying the function solutions of partial differential equations, it is often important to introduce distribution solutions, the most important being the fundamental solution. Hörmander begins by studying the fundamental solution of partial differential equations and ends with a study of fundamental solutions to elliptic boundary value problems. One of his principal tools is the associating of mappings to the problems in question. Thus, for example, for a boundary value problem we have the map $f \to (Df,$ boundary date of $f)$ where D is the operator. Then we can study the adjoint of this map which involves distributions.

The most important topics treated in the book can be divided into three parts: (i) Inhomogeneous problems (under what conditions can the inhomogeneous equation $Df = g$ be solved for f?) (ii) hypoelliptic operators (those D for which the solutions of $Df = 0$ must be smooth); and (iii) existence and uniqueness questions for Cauchy's problem, and for elliptic boundary value problems.

Linear Partial Differential Operators contains very deep results. It is lucid and extremely readable, and it should become one of the classics in the field.

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Bacteriology

The Life of Bacteria. Their growth, metabolism, and relationships. Kenneth V. Thimann. Macmillan, New York, ed. 2, 1963. xviii + 909 pp. Illus. $17.50.

My old friend, *The Life of Bacteria* [which I reviewed in *Science* **126**, 455 (1957)], has put on some weight in the past 8 years! Does this increment represent an uncontrolled obesity, a malignant neoplasm, a teratological or psychological macrocephaly, or the well-distributed growth that is a concomitant of a healthy development? After con-siderable scrutiny and reflection, I favor the latter diagnosis.

During the past decade, bacteriology has suffered an information explosion of unprecedented magnitude. New continents, indeed new planets and galaxies, have been discovered, explored, populated, and interconnected by an imaginative communication system. Kenneth Thimann has done a magnificent job of depicting this dynamic development. It is a testimonial to his unsurpassed literary and critical skill that he has been able to do so within the framework of a single volume—beautifully ordered, clearly written, excellently illustrated, admirably indexed, and heavily documented by well-chosen references to the original literature.

Conceptually, this second edition of Thimann's book is an eminently successful "attempt not only to see bacteriology as a whole—that is, as a branch of biology—but also to see it in its perspective as a development from the past and as an active area of modern investigation." The organization once again is tetrapartite: Morphology and General Physiology, Nitrogen Cycle, Carbohydrate Metabolism, and Growth and Synthesis. Within this framework are grouped 26 chapters, essentially all of them reworked, rewritten, or new since the original edition was published in 1955.

Thimann notes that "the greatest change is the swing in interest toward the synthetic processes in bacteria . . . which have taken over much of the center of the stage, where formerly the destructive actions exerted by bacteria on their surroundings were dominant." The marvel of his presentation permits this change of emphasis to be depicted clearly, without losing sight of the contemporarily unfashionable aspects of bacteriology. Somehow, he has managed to weave in sketches of diverse kinds of bacteria, including those unusual ones that may well provide the new directions of the future, because of structural or functional traits vastly different from the overstudied *Escherichia coli* sort.

Thimann need not have invoked Shakespeare's "Let me have men about me that are fat," to excuse the "corpulence" of his tome—*The Life of Bacteria* is not fat; it is rather a solidly muscled creature with a lean and hungry look.

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