rated as predominantly correct; success was greatest for those predictions in which the predictor had expressed a high degree of confidence. Results were broken down in terms of such variables as sex of the subject, his age at the time of the initial and later studies, and the formal and content characteristics of the predictions. This itemized-outcome rating method constitutes Escalona's purely descriptive presentation of results.

Heider has preferred to present findings in terms of the correctness of prediction for each individual child and to employ nonparametric techniques, as well as Pearson's $r$, in the analysis of the data. I consider this a more justifiable approach than Escalona's treatment of 882 predictions about 31 subjects as if these predictions constituted a single population.

In addition to formal presentation of findings, the book contains illustrative case descriptions and some interesting theoretical discussions.

The methodology of the study is extremely weak. Some of its weaknesses are shared by many other studies in child development, which have employed data collected before the studies were planned. Other weaknesses—for example, the use of the authors as judges of the correctness of predictions—could easily have been avoided. The main fault of the study, however, lies in the manner in which the predictions were written. Had these predictions been set up in a more formal manner, thus allowing for planned observations that would confirm or disprove them, the authors would have been able to present their findings in a more meaningful way and could have avoided some of their statistical problems.

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**A Short History of Scientific Ideas to 1900.** Charles Singer. Oxford University Press, New York, 1959. xx + 525 pp. Illus. $8.

Singer's original *Short History of Science to the Nineteenth Century* was a work of his middle years. First published in 1941, it has been deservedly popular. The present volume, more than a hundred pages longer and much better illustrated, is a revision and expansion of the same book. Large portions of the original stand unchanged, and the plan and the themes remain unaltered. The chief difference lies in the enlargement of the treatment of biological science from about 1850 to 1900; this section is paralleled by a new section on physical science during the same period, contributed by Herbert Dingle. The new book is much better printed and is more pleasing to read than the older one.

Despite a new look on the contents pages, the structure of the earlier part of the book has not been greatly modified. It now opens with a few pages on Babylonian and Egyptian astronomy and mathematics (by Angus Armitage). The importance of the Alexandrian period of Greek science is more justly recognized. But Singer has not thought fit to revise the part that relates the pattern in which Roman decadence heralds the medieval collapse, and modern science is founded solidly on the Renaissance of the 15th and 16th centuries. No medieval "precursors" of modern science are admitted, and one will look in vain for such names as Buridan, Ockham, and Oresme. While I agree with Singer that modern science is the creation of modern times, it seems regrettable that the background to Vesalius, Copernicus, and Galileo is not more clearly sketched; one is left with the paradox that a return to Greek sources produced a revolt against Greek science. On the other hand, medieval technological advances do now receive a favorable mention.

The central section, "The insurgent century," has been improved by a section on Newton's optical work (unaccountably omitted from the earlier version) and remains an excellent survey of the turning point in modern science.

In the new material, Dingle is mainly concerned with the limitations of "billiard-ball" physics and the new science of astrophysics. Singer's own new pages follow the lines of his volume on the history of biology. On the whole—partly because the sequel is cut off by abandoning the story—the continuation is less successful than the older bulk of the book.

As is inevitable, some fresh errors have crept in: thus, Ptolemy's observations were not accurate to 5 *seconds* of arc (page 90); a plumb line should be normal to the horizontal (Figure 70); Newton's first law of motion is not generalized from Galileo's concept of inertia (pages 235–36); medieval blast furnaces did not produce steel (page 254); the two sentences about eyepieces are meaningless in conjunction (page 298). In general, however, the changes in this new version are all for the better, and, if the broad historical picture emerging from it owes few touches to the fresh scholarship of the last 25 years, it is the best we have within its limits. The organization is good, the language is neat and sometimes witty, and thought is there for those who look for it. The Grand Old Man of the history of science is still a master of his craft of easy presentation.

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**Applications of the Theory of Matrices.** F. R. Gantmacher. Translated and revised by J. L. Brenner, D. W. Bushaw, and S. Evanusa. Interscience, New York, 1959. ix + 317 pp. $9.

There are today many fine books in English on the theory of matrices. Few of them, however, treat applications of the theory in more than an incidental manner. A book of the caliber of the present one is, therefore, a valuable addition to the bookshelf of the analyst, applied mathematician, or physicist, for it contains sophisticated and elegant treatments of several topics which ultimately require matrix analysis.

The first chapter contains a fairly exhaustive treatment of the normal forms of complex symmetric, antisymmetric, and orthogonal matrices. The second chapter deals with equivalence relations between singular bundles of matrices and follows closely the work of Kronecker. The results are applied to the integration of systems of differential equations with constant coefficients. Then there is an excellent account of the theory of matrices with non-negative elements. This includes the classic work of Frobenius and various recent extensions. The preceding results are then specialized for the study of stochastic matrices, and the theory of Markov processes with a finite number of states is discussed from the matrix-theory point of view. A succeeding chapter treats applications to the theory of differential equations, including the little-known but elegant concept of the multiplicative integral developed by Volterra. A final chapter (alone almost worth the price of the book) deals very comprehensively with the Routh-Hurwitz problem of determining the number

of roots of a polynominal in a half plane. The original method of Routh is given in full detail. A somewhat more useful criterion, developed by Lienard and Chipart, is presented; it involves the calculation of fewer determinants than the original Hurwitz technique.

This book cannot be recommended too highly, for it contains material otherwise unavailable in book form. One could wish that material on infinite matrices were included, but this lack does not detract from the stature of Gantmacher's book as an exposition on finite matrices. The translation is a good one, but there are several misprints which are easily spotted.

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**Measurement of Subjective Responses: Quantitative Effects of Drugs.** Henry K. Beecher. Oxford University Press, New York, 1959. xvi + 499 pp.

Henry Beecher, well-known research professor of anesthesia at Harvard, has written an important volume, summarizing a vast amount of recently developed information on the subjective responses of various kinds of people to various kinds of drugs. It is interesting that this subject was popular a little more than a century ago; S. F. C. Hahnemann (1755–1843), founder of the medical sect of "homeopathy," systematically tested all kinds of drugs, even in extremely small doses, in order to note their effects on himself. Responses to these tiny doses were largely subjective.

Let me say at once that Beecher's volume is a comprehensive, detailed, systematic, well-written, carefully arranged, and very useful reference work. It is fully documented (1063 references, with full titles and pagination), and it has a helpful index.

The volume is skillfully organized. The first part deals with the measurement of pain: a prototype for the quantitative study of subjective responses. The second part deals with the quantitative study of the effects of drugs on various subjective states.

After an interesting introduction attempting to define pain and its characteristics as a sensation, Beecher goes on to give a systematic critique of methods for measuring pain. An important discussion of placebos and placebo reactors follows. It is astonishing what a large number of subjective responses are obtained from the administration of biologically inert chemicals, such as lactose. This simply confirms Hahnemann.

Beecher goes on to consider statistical problems in double-blind testing, pain thresholds, the effects of analgesic agents on pain thresholds, the important matter of drug interactions, synergism and potentiation, factors producing variation in the pain threshold, and action factors of the pain experience.

Beecher concludes that pain cannot be satisfactorily defined. Pain sensations and pain perceptions are identical, representing an indefinite amount of psychic processing. Pain thresholds are not constant, either with respect to individuals or from time-to-time in a given person. Experimentally induced pain and pain resulting from disease differ in their components, and the techniques of producing experimental pain are not fully satisfactory for appraising analgesic agents. There is no dependable relationship between the number of pain spots stimulated, or the degree of their stimulation, and the extent of pain invoked. Analgesic agents appear to exert their effect on the "reaction component" rather than on the "original sensation."

The second part of the volume begins with a discussion of the measurement of "mental clouding" and other subjective effects of morphine. It proceeds to a consideration of sedation and hypnotic states, and then to a review of the effects of anesthetic agents on subjective states. Psychotomimetic drugs, as well as the general subject of euphoria and dysphoria, are surveyed; and then consideration is given to quantifiable expressions of anxiety, with a review of quantitative studies of the effects of narcotics on hunger. Nausea and pruritis are discussed separately. There is consideration of experimental and pathological cough, with regard to subjective and objective components.

Unfortunately, this second part of the book does not include a summarizing chapter. Perhaps Beecher thought that the intelligent reader would go back over the whole effort and attempt to make his own summary. This would not be easy, because such a vast amount of information is explored so thoroughly and so significantly that it really would be a repetitive effort to try to compile a summary. For these same reasons, it is difficult to review the book except in generalizations.

Beecher's effort is provocative, stimulating, and inspiring: its skillful analysis of the various factors concerned in the complicated concept, "pain," is provocative; its suggestions for logical approaches to pain relief are stimulating; and the way in which it has been compiled, written and published is inspiring. This is really a monumental contribution.

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**Zulu Journal.** Field notes of a naturalist in South Africa. Raymond B. Cowles. University of California Press, Berkeley, 1959. xiv + 269 pp. Illus. $6.

Each of Raymond Cowles' many fine research papers contains a little extra. Beyond its technical content, each paper brings a smell of the outdoors into modern scientific periodicals, an all-too-rare aroma that comes from a naturalist's broad curiosity about the living animal in its native haunts. *Zulu Journal* is the other side of the coin. In this sensitive, often poetic account of human ecology in Natal Province, Union of South Africa, are intriguing bits of information—adaptations in color matching (including negroid skin and zebra stripes), food webs, and heterothermism. For this reason, the book will give the scientist rewards beyond the pleasure of reading colorful, picture-evoking descriptions of animal and human life on the African veld.

*Zulu Journal* is not a journal, for it gives no consecutive account of Cowles' field work. Instead, it flits about with the deceiving aimlessness of a butterfly, picking up an anecdote here and there, inspecting an ecological situation briefly, encountering amazing numbers of different animals and sizing up each for its place in the African world. Without effort the reader comes to see through experienced eyes "the mood of the country, its seasons, and the passing years."

In chapter after chapter, Cowles tips his hand to reveal what is coming in the final one. To him it is evident from the rapid changes of the past 50 years in the land of his birth that "Against the deadliest weapons of man, fecundity and agriculture, scarcely anything but weeds or parasites can survive for many more decades." The final chapter, starkly titled "Man," still comes