drawn with discretion, and contour intervals appropriate to avoid "monograph" effects have been used.

At its best, not only is an atlas useful for general orientation and a pleasure to the eye, but it puts masses of scattered information into a compact and accessible reference work the utility of which is limited only by the accuracy and scope of the available data. It can relieve researchers of much unnecessary archive work and let them get on with their main studies. The care and thoroughness with which this atlas was prepared suggest that it will fill this function to a high degree; its compilers deserve the thanks of scientists everywhere.

References and Notes

1. From the International Book. Service (V/O Mezhdunarodnaya Kniga). A few firms in the United States also maintain limited stocks of current books.
2. H. E. Hawkes, *Geotimes* **10**, 23–43 (1965).
3. Publication approved by the Director, U.S. Geological Survey.

Numbers

Francis D. Parker's **The Structure of Number Systems** (Prentice-Hall, Englewood Cliffs, N.J., 1966. 151 pp., illus. $3.95) is an excellent book. It is written with clarity, directness, and simplicity, and these are attributes we cannot take for granted. The entire contents form a single coherent story, told from start to finish. What this story is all about can best be indicated by comparing different approaches to the study of numbers.

In the first place, there is the confused approach which most of us experienced in elementary school, high school, and probably even college. We have all become accustomed to the easier ideas about numbers—we believe there is a number 4, and perhaps even a complex number like $3 + 2i$. When a number like $\sqrt{2}$ or π is concerned, we may feel a bit more doubtful.

There is a second approach, commonly used nowadays by professional mathematicians (and prominently featured in the "new math" programs for schools): one summarizes a sizable amount of information about numbers in a very succinct form, namely in the axioms dealing with commutativity, associativity, the distributive law, the existence of identity elements and inverses, axioms on order, and (ultimately) something like the Cauchy axiom on topological completeness. (I admit to a prejudice in favor of this approach as the one closest to the main concerns of contemporary mathematics.)

Now any axiom system bears some resemblance to an iceberg: there is the small amount of information which the axioms tell us clearly and explicitly, but the vast amount of information given by the axioms is not of this sort—rather, it lies beneath the surface. If our axioms are adequate, the information *implied* by them includes every single fact about our entire number system. Of course, extracting this information requires the devices of the formal logic of implications, and usually also requires considerable ingenuity and patience as well. The less our axioms say explicitly, the more they must say implicitly, and the harder it will be (in general) to carry out the necessary implications.

This brings us to our third approach to number systems. Using the axioms developed by Peano, we work with an almost unbelievably tightly knit approach: there are only five axioms. From them, using set theory and logic, we can build up all that we know about numbers, whether we think of the integers, the rational numbers, the real numbers, or the complex numbers.

Why is so much discussion of numbers worth the effort? One could claim that the answer is related to settling matters of genuine doubt about such things as infinite decimals or questions of limits, integrals, and so forth. But I think the value does not lie in this direction—indeed, set theory itself poses enough new problems and uncertainties to more than match the old problems that it may appear to settle. The real value of the Peano approach, as presented in *The Structure of Number Systems,* seems to me to lie in the tone that it takes, the point of view from which it approaches mathematical questions. Any reader whose mathematical education consisted primarily of calculus as taught two decades ago will probably see in this book a whole new way of looking at mathematics. It is an interesting viewpoint, and an important one—but perhaps it should not become the only one.

For maximum effectiveness, a book like this should probably be read before the student undertakes the study of calculus. It would make calculus take on an entirely new appearance.

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Studies of the Moon: The End of an Era

The detailed physical nature of the lunar surface has occupied the attention of astronomers for years and is now of pressing importance because manned lunar exploration is near at hand. The state of knowledge as it existed before the Surveyor landing is admirably summarized in **The Nature of the Lunar Surface**, the proceedings of the 1965 IAU–NASA Symposium (Johns Hopkins Press, Baltimore, 1966. 328 pp., illus. $13.50), edited by Wilmot N. Hess, Donald H. Menzel, and John A. O'Keefe.

The volume is organized into four parts, Interpretation of Ranger Photographs and Related Topics, Crater Formation and Surface Structure, Physics and Chemistry of the Lunar Surface, and Conclusions. Part 1 presents the various theories of the lunar surface, with strong emphasis on the Ranger photographs. The results of these papers are the most likely to be revised in the near future. Parts 2 and 3 describe the results of observational and experimental programs in which lunar luminescence, projectile cratering, optical and radar properties, physics of sputtering, lunar temperature, and the possible relationships of lunar formations to geology were investigated.

The quality of the papers is not uniform, but generally they make interesting reading. For example, there is the classical problem of the low visual albedo of the moon. Laboratory studies show that many kinds of rock powders obtain low albedos after exposure to energetic proton and alpha particles. In fact, the albedo would be less than the lunar value after prolonged exposure, and the result should be an equilibrium situation in which darkening by irradiation would be balanced by brightening due to continual exposure of undarkened material by meteoritic bombardment.

Part 4 contains a summary of the conference by E. Öpik and a substantial panel discussion. Ranger photographs are presented throughout the volume, and their reproduction is excellent.

We are entering a new era of lunar surface studies, of which the Surveyor landing and Lunar Orbiter are but the beginning. Undoubtedly our fund of knowledge and working theories will soon be revised beyond the reports contained in *The Nature of the Lunar Surface*. These reports provide a useful and valuable fossilization of the state of knowledge before *in situ* investigations of the lunar surface.

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Organisms in Communities

George Bernard Shaw, in a discussion of medical education, said:

> . . . there are two ways of making the action of the heart visible to students. One, a barbarous, ignorant and thoughtless way, is to stick little flags into a rabbit's heart and let the students see the flags jump. The other, an elegant, ingenious, well informed and instructive way, is to put a sphygmograph on the student's wrist and let him see a record of his heart's action traced by a needle on a slip of smoked paper.

Robert H. MacArthur and Joseph H. Connell have written their book **The Biology of Populations** (Wiley, New York, 1966. 216 pp., illus. $5.95) in such a way that I am not convinced that they could tell what was wrong with Shaw's argument.

At the end of their book is an appendix of exercises designed to demonstrate the "mechanisms of evolutionary change. . . . The materials are beads [or] lead shot." These beads are to be used to demonstrate mathematical models of selection and predator-prey interaction. The authors encourage students to design similar "experiments" since "designing such exercises helps to solidify one's knowledge of population biology." The only mention of real organisms in this appendix occurs in the sentence "Whenever possible [the bead exercises] should be supplemented by field trips in which real organisms rather than imitations are studied," but no suggestions for this study are provided. This strange gap between theory and organisms pervades the book so that those sections which relate to actual organisms and their environments are inserted as if by afterthought.

Much of the book consists of abstract models. Some of these are the standard population models (for example, those of Volterra and Fisher and of Wright). Many, however, are taken from very recent papers by MacArthur and his collaborators. These are characterized by heavy reliance on plausible analogy rather than empirical predictions and tests. The words "effectiveness," "simplicity," "efficiency," and "need" are used in oddly nonoperational contexts. Communities of animals are likened to libraries full of books, and a contrast is made between "jack of all trades" and more "specialized" species, but these remain metaphors rather than being developed into theories. Perhaps the authors were aiming at simplicity of presentation, for the freshman text market. The distinction between simplification and caricature has not been maintained.

The pattern of citing references is a little surprising and, on occasion, highly misleading (for example, the impression is given that Hutchinson developed the process of carbon-14 dating!). Occasionally material is taken from some source without being adapted to this text.

I regretfully conclude that this book, although clever in spots, is neither profound nor complete nor carefully prepared. It does not do justice to the field of population biology or to the reputation of its authors. It is not appropriate either as a text or as supplementary reading.

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Radiation Problem

Dipole Radiation in the Presence of a Conducting Half-Space, by Alfredo Baños, Jr. (Pergamon, New York, 1966. 263 pp., illus. $11), is a systematic and unified treatment of an electromagnetic radiation problem that has been studied by many investigators during the past 60 years. The author gives a detailed historical account of the numerous investigations and of the controversies that have arisen. In addition, he has given a mathematical treatment of the problem sufficiently general in scope that he is able to obtain the solutions of previous investigators as special cases. This enables him to make detailed comparisons of the work of those investigators and to evaluate their contributions critically.

The problem considered is that of finding the radiation from an elemental dipole, assuming that space is divided into two parts separated by a plane interface. On one side of the interface is air, and on the other side is a medium having a finite electrical conductivity. It is assumed that the radiating dipole can be either perpendicular or parallel to the interface and on either side of it; furthermore, it can be either an electric or a magnetic dipole. The formulation of the problem for all eight of the configurations is given in chapter 1, and the solutions in terms of integrals are given in chapter 2. The remainder of the book is devoted to the asymptotic expansions of these solutions.

Chapter 3 is a discussion of the saddle-point method of integration. This method is then applied in chapter 4 to obtain asymptotic expansions valid in the vicinity of the interface when the dipole is in the air. These expansions are carried out to three and sometimes four terms; and, in addition, the errors involved in using the expansions are evaluated. This has not been done previously and is a significant contribution to the theory.

The same configurations are treated in chapter 5, but the asymptotic expansions obtained are valid in the vicinity of the axis of the radiating dipole. In chapter 6 asymptotic expansions are obtained which are valid over an entire hemisphere. These chapters contain a substantial amount of original material.

Finally, chapter 7 treats the case of the dipole in the conducting medium, by the same general methods used in the preceding chapters.

The extensively debated error in sign that occurred in the first analysis of the dipole radiation problem by Sommerfeld in 1909 is discussed in chapter 4. This error caused some persons to doubt the validity of Sommerfeld's formulation of the problem and even to question the existence of the Sommerfeld surface wave. The author reviews this controversy from its inception to the present and concludes that there can no longer be any doubt that Sommerfeld's formulation was correct and that the Sommerfeld surface wave does exist.

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