from an appearance of uncertainty as to the level at which it is aimed. Even the elementary chapters tend to end with citations of recent papers (often unrepresentative of the field as a whole). There is little attempt to convey a sense of the history of the subject; for example, Fisher, Haldane, and Wright are given their major citations as 1958, 1966, and 1969 respectively. There is also a somewhat annoying level of misprints and minor factual errors (the picture of a *Primula* on p. 171 and on the cover seems to represent a species hitherto unknown to science, and I doubt whether Timoféef-Ressovsky will be flattered by being consistently referred to as Timoféef-Rossovsky). All this will be confusing to a beginner. The strength of the book lies in its detailed treatment of certain theoretical topics not available in book form elsewhere. This is particularly true of the last two chapters, which deal with topics close to the author's heart, and which professionals and advanced students will certainly wish to consult.

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Volcanoes

Volcanology. HOWEL WILLIAMS and ALEXANDER R. MCBIRNEY. Illustrated by Christine McBirney. Freeman, Cooper, San Francisco, 1979. 398 pp. $33.50.

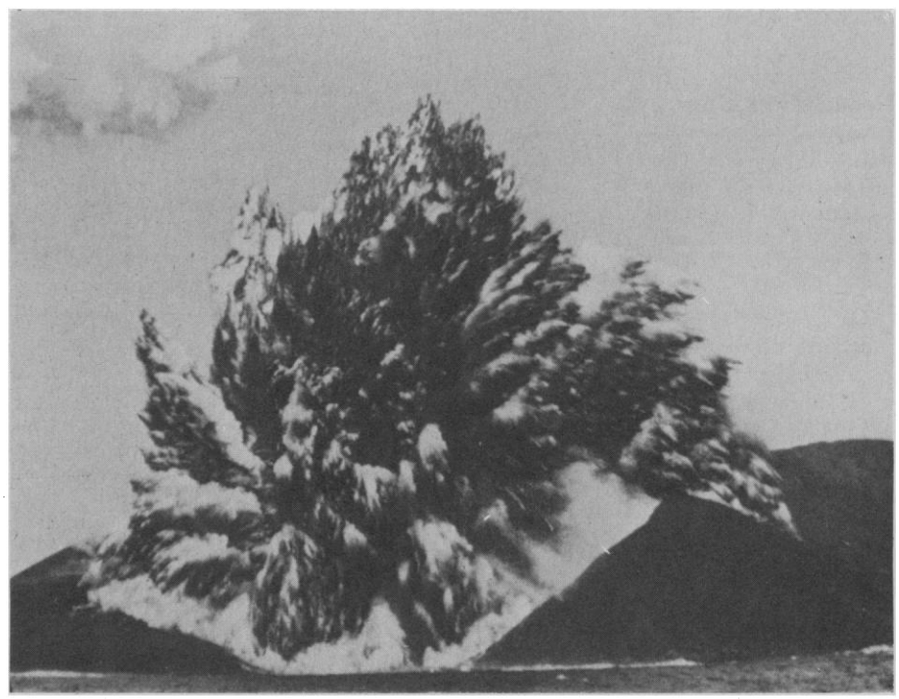
Over the past half-dozen years interest in volcanology has been greatly stimulated by studies of volcanic processes on the sea floor and by the recognition of volcanic activity as a major process on several extraterrestrial planetary bodies. As a discipline, volcanology embraces the study of the mechanics of volcanic eruptions, the physical properties of magma, the nature of volcanic gases, the morphology of landforms, and the distribution of volcanic activity in relation to various geologic settings. The important practical concerns of volcanology include the prediction of volcanic hazards, the restoration and reclamation of areas devastated by eruptions, and the utilization of geothermal energy. Earth scientists wishing for a review of these topics or for a textbook on which to base a course in volcanology will welcome the appearance of this book.

Readers for whom the book serves as an introduction to volcanology will find much of value in each of the 15 chapters, although the level of treatment and the timeliness of the material are somewhat uneven. For the more advanced student or researcher, chapters 2 through 7 will probably be the most useful because of their extensive treatment of the physical properties of magmas and the generally good mixture of theoretical, experimental, and observational data. In contrast, chapters 8 through 11 cover a lot of familiar ground, with examples of major volcanic landforms and eruptions drawn from the same "classic" localities described in many other geologic books. This section could have been improved with more examples from the authors' own observations in the Galápagos and Central America, or from the recent extensive activity in and near Kilauea on Hawaii, such as the growth of Mauna Ulu. Chapter 12, on oceanic volcanism, suffers from the same deficiency in that there are only brief allusions to the latest observations by photography and from submersibles along the Mid-Atlantic Ridge and Galápagos spreading centers.

Chapter 13, "Volcanism and orogeny," attempts to relate volcanic activity to geologic setting. Much of the chapter deals with island arc volcanoes and their relation to marginal seas and to their oceanic or continental crustal setting. This is a readable and comprehensive summary in which the authors avoid uncritical acceptance of many of the attractive but simplistic ideas that have been proposed in the recent literature. The authors' discussions of relations such as the migration of volcanic centers relative to plate motions or the correlation between the composition and the tectonic setting of magma end with caveats that point to the need for more definitive research.

For those desiring to do further reading on specific topics, the level of documentation and the arrangement of the references are less than ideal. It would have been more convenient if references had been grouped at the end of the chapters instead of in a single bibliography at the end of the book. Some of the most interesting and provocative statements in the book are not referenced and with the present arrangement there is little chance of tracing such statements to their source. Also, the value of some of the figures is compromised by a lack of information on sources or by an inadequate explanation of the criteria used to compile the information in the figures. For example, the map of "active volcanoes of the world" inside the front and back covers will surprise many readers with its inclusion of several active centers in the western North Atlantic Ocean and the apparent omission of Tristan da Cunha in the South Atlantic.

On balance, this is an attractive and readable book. It is logically organized and free of obvious typographical errors. The many excellent pen drawings by Christine McBirney are a positive feature. The book is a good source of material on those aspects of volcanology that



"A phreatomagmatic explosion caused by eruption of basaltic magma into shallow seawater during the early phases of formation of the island of Surtsey off the southern coast of Iceland in 1964." [Photo by S. Einarsson; reproduced in *Volcanology*]

are usually taught in elementary geology courses or in conjunction with more advanced courses in igneous petrology. It is also well suited for self-study or for a one-semester course in volcanology for seniors or graduate students.

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Capacities of Young Children

The Child's Understanding of Number. ROCHEL GELMAN and C. R. GALLISTEL. Harvard University Press, Cambridge, Mass., 1978. xvi, 260 pp. $13.50.

The topic of this book, the development of number concepts, has been an important one in developmental psychology. The approach to the subject that has predominated in recent years is the Piagetian. Piagetian theory revolves around the presence (or absence) of certain logical operations that develop in the 6- to 12-year range. Piagetians characterize the number (and other) behavior of younger children primarily in terms of what the children cannot do. Such children are referred to as "preoperational": they are at a stage of development that precedes the concrete-operational stage in which they will be able to perform the various kinds of operations that form the core of the Piagetian theoretical and measurement apparatus. Consider, for example, conservation ability. Suppose a preoperational child is presented with two rows of toys each of which contains five toys. In one row the toys are spaced one inch apart; in the other they are spaced two inches apart. The child will fail to "conserve quantity" and will state that the row with the toys spaced farther apart contains more toys than the other row.

The authors of the present book believe that the cognitive capacities of so-called preoperational children have been underestimated, and they set out to discover what such children *can* do. The emphasis in their approach is upon understanding the representations, processes, and strategies that constitute number ability. The authors indeed show that three-year-olds and even some two-year-olds have rudimentary counting abilities that they can use in simple counting tasks.

Another difference worth noting between the approaches of Piaget and of Gelman and Gallistel is a methodological one: whereas the approach of Piaget and his co-workers tends to be clinical, based upon rather informal observations of very small numbers of children, Gelman and Gallistel's is basically experimental, relying upon larger numbers of subjects in carefully controlled experiments—though they also make astute use of observation to supplement the findings gleaned from experiments.

Underlying Gelman and Gallistel's research is a set of five principles, mastery of which they consider to underlie the ability to count.

1) *The one-one principle*. A distinct tag must be assigned to each object in an array, and only one tag may be assigned to each object. (The authors emphasize that these tags need not be conventional numerals. They take as evidence of mastery of the principle in particular, and of counting in general, the assignment by young children of letters of the alphabet to successive objects. Satisfaction of the principle does not even require that the letters or numbers be assigned in conventional order, so long as the assignment of tags to objects is unique.)

2) *The stable-order principle*. The tags must be arranged in a stable (repeatable) order, and the number of tags must be as large as the number of objects in the array.

3) *The cardinality principle*. The tag applied to the final object in an array must represent the number of objects in that array. (This principle involves recognition of a special property of the last tag used, namely that this tag represents the cardinality of the array of objects.)

4) *The abstraction principle*. The preceding principles can be applied to any array or collection of entities, whether physical or nonphysical. (The importance of this principle lies in the inability of very young children to recognize that nonphysical entities, such as the number of minds in a room, can be counted in the same way that physical entities can be counted. As the authors also point out, very young children often do not recognize the possibility of counting together members of ludicrous sets, such as the set of all minds and all chairs in a room.)

5) *The order-irrelevance principle*. The order in which objects in an array are tagged is irrelevant to the number of objects in the array.

These principles are not proposed as unitary processes or components of performance. Rather, acquisition and utilization of each principle is alleged to consist of several component processes, for example, partitioning of items into already-counted and to-be-counted sets and tagging of the items in the case of the one-one principle. Moreover, application of principles can be partial. For example, children's ability to apply the first three, "how-to-count," principles, is a function of set size. The authors conclude that many two- and three-year olds cannot count reliably beyond three or four. Nevertheless, the children show some differentiation among higher quantities in making absolute judgments about them. Finally, abilities to apply the various principles are not fully independent. Application of the cardinality principle, for example, presupposes successful application of the one-one and stable-order principles.

The first three chapters of Gelman and Gallistel's book deal with some general issues in developmental metatheory and methodology. To a general reader or a developmental psychologist whose interest is not in number concepts per se, these chapters may be the most valuable ones in the book. They are clearly written and deal with some key issues in developmental research. They contain, for example, a discussion of the unfortunate tendency to characterize preschoolers in terms of what they cannot rather than what they can do; a discussion of the failure of the task-centered approach to psychology, in which research becomes a study of tasks rather than of the psychological structures and processes used in their performance; and a discussion of the role of training studies in psychological research. Although some of the points the authors make have been made elsewhere in the psychological literature, they seem to be quickly forgotten and need to be stated and restated. I recommend this first set of chapters to anyone interested in conducting developmental research.

Chapters 4 through 10 and chapter 12 of the book present the basic theoretical framework, methodologies, and results of research on number concepts. Although theory and data from a variety of sources find their way into the presentation, the overwhelming emphasis in these chapters is upon the Gelman research program of the last decade. Despite their sometimes technical content, these chapters are lucid and usually easy to follow.

The approach of chapter 11 seems at times to be at variance with that of the rest of the book. Whereas the other chapters subordinate mathematical formalisms to psychological ones, this chapter seems to do the reverse. Although interesting and edifying, it seems more like a lesson in formal mathematical theory than like one in psychological theory. The book concludes with a concise (three pages) summary of most of the major points.