Book Reviews

A Mathematician

Alan Turing. The Enigma. ANDREW HODGES. Simon and Schuster, New York, 1983. xii, 587 pp., illus., + plates. $22.50.

Interest in computers and their history has prompted a host of books and articles tracing the development of the new machines. At the same time declassification of wartime documents has brought to light the dramatic accomplishments of the ultrasecret British cryptanalysis establishment. The English mathematician Alan M. Turing (1912–1954) played crucial roles both in the work at Bletchley Park, where the German code was cracked, and in the early British computer projects. Andrew Hodges's new biography of Turing explores the personal side of both enterprises and offers new insights into the wide-ranging interests and accomplishments of the remarkable Turing.

Turing's first major publication, "On computable numbers, with an application to the *Entscheidungsproblem*" (the problem of decidability), appeared in 1937, during a two-year absence from Cambridge. This work, which took on a problem posed by Hilbert, revealed Turing's mathematical talent. It also introduced the innovative and fruitful concept of a universal machine, now known as a "Turing machine," capable of executing a series of operations on sequences of binary digits. The logical question of solvability also figured prominently in Turing's influential article (published in 1939) on systems of logic based on ordinals.

The same year Turing left Cambridge and began a nine-year association with the British cryptanalysts of the Government Code and Cypher School in their attack on Enigma, the machine on which nearly all German military radio communications were enciphered. Hodges provides a lengthy account of Turing's meritorious service in this endeavor, on which depended the safety of convoys supplying the needs of besieged Britain. It illustrates how Turing's thinking about universal machines and his concern with solvability found concrete application in cryptanalysis.

After the war questions of computers occupied much of Turing's attention, first at the National Physical Laboratory, where he worked on the Automatic Computing Engine, and then at the University of Manchester, where he served as assistant director of its computer project. He was particularly intrigued by the possibility that a machine might learn, as discussed in his article "Computer machinery and intelligence," later reprinted in J. R. Newman's compilation *The World of Mathematics*. Turing continued to publish on mathematical topics in group and semigroup theory and exploited the new computing technology in calculations on the Riemann zeta-function. His long-standing fascination with mathematical pattern in nature gave rise to work on "The chemical basis of morphogenesis," in which he explored a mathematical model of embryonic growth.

Unlike previous biographers of Turing, Hodges does not skirt the issue of his subject's homosexuality: schoolboy attachments, the atmosphere of discreet decadence at Cambridge in the 1930's, Turing's 1952 arrest for homosexual activity, and the decision of the court to prescribe estrogen therapy. As a member of the gay liberation movement, Hodges discusses with considerable detail and sympathy the social, legal, and political circumstances facing Turing and other homosexuals in postwar Britain and draws attention to the American insistence that the British intelligence establishment rid itself of security risks, including homosexuals. Turing's untimely death, perhaps by his own hand, took place in just this atmosphere of suspicion.

The author, who bills himself as a historical journalist, brings training in mathematical physics and extensive research to bear on his subject. The book, nearly 600 pages long, would have profited from more vigorous editing—in particular, the pruning of metaphor. The image of America as the land of Oz, with Turing as Dorothy and John von Neumann as the Wizard, is especially jarring. Readers will appreciate, however, the care with which Hodges follows the often tangled threads of Turing's intellectual development: solvability and computability, determinism, the significance of mathematical patterns in nature. The book offers incidental, and illuminating, portraits of other notable scientific personalities, among them C. G. Darwin, Turing's boss at the National Physical Laboratory, and M. H. A. Newman, architect of the Manchester computer.

Any Turing biographer faces a trying task, not just because of the breadth and depth of his subject's interests and ideas. As Hodges puts it, "At every stage his life raised questions about the connection (or lack of it) between the mind and the body, thought and action, intelligence and operations, science and society, the individual and history." Hodges has pieced together many of Turing's cryptic answers to these questions and has depicted the complexity of circumstances in which Turing's "ruthless, raw view of science" found expression. The fundamental message conveyed by the book is one of alienation and anomaly. Turing is portrayed throughout as the solitary, eccentric, often misunderstood scientist, disinclined to provide the administrative leadership demanded by modern team research. His ideas often outraced the ability of his contemporaries to appreciate them; his rejection of social conventions brought him in direct conflict with the authorities. The subtitle of the book can thus be read both as an emblem of Turing's career and as a suggestion that Turing's inner code remains unbroken.

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Fluvial Processes

Rivers. Form and Process in Alluvial Channels. KEITH RICHARDS. Methuen, New York, 1982. xii, 358 pp., illus. $35; paper, $17.95.

The study of the physical form and processes of rivers is of interest to two breeds of researcher: the river engineer and the fluvial geomorphologist. Keith Richards is a fluvial geomorphologist, but he has written a book that is of interest and use to all scientists studying rivers. This is a rare accomplishment. It is necessary to go back two decades to find a book on rivers (Leopold, Wolman, and Miller's *Fluvial Processes in Geomorphology*) that so successfully transgresses disciplinary boundaries.

Rivers has ten chapters. The first is an introduction setting out the broad issues and allowing the author to clarify his position on some of the unresolved questions concerning the theory of river form and process. The next eight chapters

follow a logical sequence, covering drainage basin (watershed) controls of river channels, flow mechanics, sedimentary processes, magnitude-frequency effects of storms, controls of cross-sectional, planform, and long-profile geometry, and channel changes. In chapter 10, channel management and design are considered.

Each chapter is thoroughly researched and combines the author's own work with that reported in the literature. The bibliography contains well over a thousand entries, including most of the better relevant references from the engineering, geologic, geographic, and sedimentological literatures. In places the text becomes somewhat bogged down by the multiplicity and length of citations, which are by author and date rather than by number.

The chapters on flow mechanics and sediment transport are coherent and competent. They lack the detail and the worked examples of computational procedures expected in an engineering textbook. The chapters on magnitude-frequency, controls of channel geometry, and channel changes are quantitative, process-based geomorphology at its best. The book is at its best when discussing hydraulic and sedimentary processes in rivers and links between these processes and channel form and channel changes. The chapter on river management and design is a little thin by comparison, but in any event this is not the main thrust of the book.

Each chapter begins with well-established material and ends at the research frontier, where theories and hypotheses are still unproven. Though this gives the book appeal for both students and researchers, it makes it vulnerable to becoming dated quickly. For example, recent work by researchers at the University of Washington and the University of California at Berkeley calls into question much of the book's treatment of the sedimentology of meandering streams (pp. 206–211).

The book has few typographical errors. The figures are not easy to read, for each one contains several diagrams crowded together. Because of their small size the graphs can only be interpreted qualitatively. Also, the concentration of many diagrams at a single location makes it inevitable that some are far removed from the relevant part of the text.

In conclusion, *Rivers* can be comprehended by engineers and geomorphologists alike, and all but the very best read river scientists will find new material and ideas in it. It will certainly become a standard textbook in many geomorphology courses and will be useful in engineering courses too when used in conjunction with a suitable textbook on hydraulics and sediment transport. In a subject with the split personality of river studies that is praise indeed.

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Sexual Selection in Insects

The Evolution of Insect Mating Systems. RANDY THORNHILL and JOHN ALCOCK. Harvard University Press, Cambridge, Mass., 1983. xii, 547 pp., illus. $35.

The Evolution of Insect Mating Systems fills two large gaps in the growing literature in which behavior is considered from an evolutionary perspective. First, it brings to a vertebrate-biased literature a well-documented and persuasive demonstration of the importance of insects for the generation and testing of theory. Second, it organizes an immense and diverse literature on insect reproductive behavior into a logical framework that will allow more efficient and effective exploration of both insect behavior and sexual selection theory. Thornhill and Alcock demonstrate the utility of evolutionary (selectionist) thinking for organizing and explaining diverse and complex patterns of behavior. They also make a powerful case for the importance of sexual selection in molding much of insect reproductive behavior. As a result, their book goes well beyond a review and synthesis of the literature on insect behavior.

The book is filled with hypotheses, both general and specific, that are generated by its main thesis, which is as follows:

> The primary characteristic of males is their drive to secure mates, which leads to competition for access to females and the evolution of a host of traits associated with this struggle. Females, on the other hand, have the luxury of choosing among many potential partners; their preferences are expected to raise their genetic success and in turn exert pressure on males favoring traits considered desirable by females.

Following an introduction to the formulation and testing of evolutionary hypotheses, an overview of insect reproductive behavior, and a review of sexual selection theory, the authors expand upon their thesis. Eight chapters are devoted to male-male competition and male perspectives and three to female choice and female perspectives. Each chapter begins with one or more detailed examples of recent studies that illustrate its main point or points. These examples are then supplemented with others as each topic is explored. The result is a very effective presentation of ideas and evidence. Most of the major insect orders get ample treatment.

The text flows remarkably smoothly despite its 471 pages and over 1000 references, and it is handsomely illustrated. Its readability makes the book easily accessible to a wide range of readers, undergraduate to professional and evolutionary theorist to applied entomologist. Although the book is best read from beginning to end, the detailed author and subject indexes make searching for specific topics or taxa easy.

The book is not without its flaws. As in any work of this size, there are errors of both omission and interpretation. Few studies prior to 1960 are cited, but in exchange the bibliography is remarkably up to date. There is little discussion of the more quantitative aspects of sexual selection theory (for example, of frequency-dependent selection) or of the central problem of how one measures costs and benefits of behavior in terms of reproductive success. There is also little emphasis given to the kinds of quantitative testing of models, nicely demonstrated by G. A. Parker's dung fly studies, that insects are so well suited for. Some hypotheses are given stronger justification than others, and alternative hypotheses, especially nonselectionist ones, are occasionally ignored. Some ideas are developed over the entire book, and one must be careful to keep track of them. For example, there is a recurrent suggestion that females would enhance their fitness by mating with males that have proven themselves in combat or survival. Yet this theme is not strongly developed in the chapters on mate choice.

One particularly frustrating problem is that female perspectives are continually understated relative to male perspectives—even in the chapters on mate choice and female mating systems. For example, on p. 62 the ways in which females have more control over reproduction than do males are discussed, but some 20 pages later (pp. 85–89) a discussion of why polygyny is prevalent among insects focuses almost entirely on male perspectives and it is not until the last third of the book that female perspectives relative to monogamy and polygamy are discussed in any detail. Thornhill