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Alan M. Turing (author) and B. Jack Copeland (editor)

*The Essential Turing: Seminal Writings in Computing, Logic,
Philosophy, Artificial Intelligence, and Artificial Life
plus The Secrets of Enigma*

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REVIEW

JOHN W. DAWSON, JR.

Alan Turing's collected works are contained in four volumes. The first three were published in 1992 and the last in 2001. But the existence of that collection has likely remained unnoticed by many, since the volumes bear different titles (*Pure Mathematics*; *Mechanical Intelligence*; *Morphogenesis*; and *Mathematical Logic*) and were prepared by different editors; consequently, many library catalogs do not list them as a set. There is also some overlap among the contents of the volumes, and considerable variation in the quality of editing.

It is thus most welcome that Turing's most important works have been gathered together in a single paperback volume of manageable size and modest price, edited by a distinguished historian of computer science. Its subtitle, "Seminal Writings in Computing, Logic, Philosophy, Artificial Intelligence, and Artificial Life, plus the Secrets of Enigma", accurately describes both its contents and the breadth of Turing's intellect.

The volume begins with a brief sketch of Turing's life. Following that are sixteen texts by Turing and one by Patrick Mahon, including not only published papers, but items of correspondence and transcripts of lectures. They are organized into four groups, each prefaced by a detailed and informative introductory note by the editor.

The first section, Computable Numbers, begins with Turing's earliest and most influential publication, his 1936 paper "On Computable Numbers, with an Application to the Entscheidungsproblem", in which he analyzed the operations involved in human computational procedures and described how to construct a universal finite-state machine (with an unbounded input/output tape) that is capable of carrying

out any such procedure—an abstract model of today’s general purpose digital computers (albeit endowed with unbounded memory). There, too, is Turing’s 1938 Princeton dissertation, “Systems of Logic Based on Ordinals”, a difficult and undervalued paper in which Turing introduced the notion of a non-deterministic ‘oracle’ as an adjunct to the operation of a deterministic machine and studied the theories obtained through constructive transfinite iteration of the operation of extending a consistent system L of logic by adjoining to it a statement asserting its own consistency (a statement undecidable within L itself, according to Gödel’s second incompleteness theorem).

The second section, Enigma, contains items related to Turing’s cryptographic work at Bletchley Park—in particular, excerpts from his “Treatise on the Enigma [cipher machine]”, a document not declassified until 1996. To understand this material, considerable background knowledge is needed. It is supplied both by Copeland’s excellent introductory note and by Patrick Mahon’s “History of Hut 8 to December 1941”. In particular, Turing’s statistical procedure known as ‘Banburismus’ is explained in detail (something not done in his collected works, nor in most accounts of the work at Bletchley), and definitions are given for various bits of terminological jargon (“females”, “sillies”, “stecker”, *etc.*) that the codebreakers employed. This section also includes Turing’s famous letter to Winston Churchill, urging greater support for the codebreaking efforts, as well as a memorandum (released only in 1998) that Turing wrote to the U.S. Navy’s codebreaking unit OP-20-G, in which he questioned the efficacy of one of the methods they had proposed for breaking the German naval Enigma cipher.

Section 3 contains six papers on Artificial Intelligence, dating from 1947 to 1952. Among them are Turing’s unpublished paper “Intelligent Machinery”, described by Copeland as “the first manifesto of AI”; the well-known article “Computing Machinery and Intelligence”, in which Turing proposed the “imitation game” now known as the Turing test; and transcripts of two BBC radio broadcasts devoted to the question “Can digital computers be said to think?”. The first broadcast, aired in 1951, was a lecture by Turing, while the second, aired a year later, was a panel discussion involving Turing, the philosopher Max Braithwaite, the neurosurgeon Geoffrey Jefferson, and Turing’s Bletchley Park colleague, Max Newman. Two further papers, “Chess” (1953) and “Solvable and Unsolvable Problems” (1954) would seem to belong in this section as well, but for some reason they are placed instead at the end of the volume.

The final section, Artificial Life, contains a single paper: “The Chemical Basis of Morphogenesis”, which appeared in 1952 in the *Philosophical Transactions of the Royal Society of London*. “The purpose of the paper,” Turing wrote in its abstract, “is to discuss a possible mechanism by which the genes of a zygote may determine the anatomical structure of the resulting organism.” The mechanism in question was one of reaction-diffusion. In particular, Turing analyzed the onset of instability in several reaction-diffusion systems. He distinguished six types of instability, including one that gave rise to stationary waves, and suggested that the latter might account for such biological phenomena as whorled leaves, gastrulation, dappling, and phyllotaxis. The paper on morphogenesis was a pioneering venture that might well have heralded a major new direction in Turing’s thought, had the British government’s persecution of him as a homosexual not driven him to suicide at age 42.

Although there is no overall bibliography, numerous suggestions for further reading are given throughout the book, at the end of introductory notes and the articles themselves. The volume seems to have been very well proofread, and includes a detailed index. Both the editorial commentaries and Turing’s own writings are engrossing reading. The selections from Turing’s *corpus* are very well chosen and amply illustrate the depth and originality of his thinking.

PROFESSOR OF MATHEMATICS, EMERITUS, PENN STATE YORK, 393 WATERS ROAD, YORK, PA 17403

E-mail address: jwd7@psu.edu