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Book Review

Book Review Essay: Alan Turing (1912–1954)

***The Man Who Knew Too Much: Alan Turing and the Invention of the Computer*. David Leavitt. New York: W.W. Norton, 2006. 319 pp. $14.95.**

***Alan Turing, the Enigma*. Alan Hodges. New York: Touchstone, 1983. 588 pp.**

The original focus of this review was David Leavitt's book, *The Man Who Knew Too Much: Alan Turing and the Invention of the Computer*, published in late 2006. However, in order to review Leavitt, you almost have to consider Alan Hodges book, *Alan Turing the Enigma*, alongside it, even though Hodges dates from 1983. Leavitt depends to a large extent on Hodges, is similar in approach, and they are the only two substantial biographical sources available on Alan Turing. I was dissatisfied with both of these biographies. Hodges is certainly the definitive source of information on Alan Turing and is by far the most comprehensive and detailed. But Hodges is very dense. It took me a very long time to read this book. He has a terrible habit of interrupting nearly every train of thought he begins, diverging for a few sentences, or perhaps through several paragraphs, or even whole pages, on tangential issues before finally picking up the original thread. It is one of the biggest reasons that this book is so hard to read: The narrative line is so disjointed. It is like free association set to print. But every tangent also has tangents so that rather than develop a continuous flow of thought your mind is being jarred and jolted from one partially treated topic to another, sometimes with only minimal connection. Mentally, it is exhausting. However, many of these dismembered facts are interesting and relevant in themselves—Hodges, I must emphasize, is without question the most knowledgeable source in the world about Alan Turing—but reading his book is like picking through a desk drawer that someone has dumped on the floor. I cannot tell you it is "readable."

Levitt's *The Man Who Knew Too Much*, on the other hand, is a much more reader-friendly condensation. It is primarily concerned with Turing's ideas and his professional career; less so with his personal life. It is generally clear and concisely presented, but you do not get a feel for the person that Turing was from reading Leavitt; from Hodges you do, although the massive amount of material and scrupulous assemblage of detail is not well organized. If you are interested in Turing's ideas, Leavitt is a straightforward, mostly nontechnical explanation of them that is relatively easy to follow, with the possible exception of some of the material on cryptography and how the various World War II era encryption machines worked. That can be bewildering, but it isn't absolutely crucial to the storyline. I thought he gave a particularly good exposition in his first two chapters of the background issues in the philosophy of mathematics that Turing was concerned with and a very accessible account of the differences between Turing's and Gödel's approaches to proving the incompleteness and undecidability of mathematics. It is instructive to Turing's character and personal psychology, I think, to present a brief summary of this matter.

In 1900, David Hilbert gave a lecture at the International Congress of Mathematicians in Paris, where he presented 23 problems that were to outline the major avenues of development in mathematics for the next century and beyond. The second of these problems was the so called "decidability problem." It could be divided into three parts: whether mathematics was *consistent*, that is, could it ever be possible to arrive at the conclusion that 2 + 2 = 5 by a series of valid steps of reasoning from the axioms of mathematics? Was mathematics *complete*: That is, given any mathematical statement, could it be proven to be either true or false? And, is mathematics *decidable*: That is, could a method be devised that would yield an answer to whether any given mathematical assertion is true? Hilbert, and most mathematicians of the time, believed that the answer to all three questions was yes. However, in 1929, a young Viennese mathematician by the name of Kurt Gödel shocked them all by proving that mathematics was not complete, that in any finite axiomatic system there exist assertions that are true, but for which no proof exists, nor could one prove the impossibility of a proof.

Gödel's proof works by constructing ingenious counterexamples. Alan Turing proved the same result soon after by a different approach. He saw proof within a formal axiomatic system as a mechanical process. Each mathematical statement could be seen as a long series of instructions and those long chains of instructions could be represented by huge, but finite, numbers. In principle, these long numbers could be ordered: sequenced. But then he showed how it would be possible to construct numbers that did not appear in the sequence but which did correspond to instruction sequences of the system. Thus, valid proofs would exist within the axiomatic system, but system could not allow those proofs to be generated. Alan Turing's work is the connection between the abstract philosophical problem of the incompleteness of mathematics and the development of the modern computer. Turing's work from the 1930s showed that computers, however wonderful, are inherently limited, and can never solve every human problem.

The tragedy of Alan Turing's life is also a vivid illustration of the limitations of human rationality and moral values. Values and principles, thought to be good, yet blindly applied, can lead to utterly perverse and destructive consequences, both for individuals and for society. In other words, moral values are not consistent, complete, or decidable either. He proved that the hard way in his life, rather than on paper.

Another telling relationship that I noticed between Alan Turing's work as an intellectual and his character as a person was in his attitude toward the famous Riemann Hypothesis that deals with the distribution of the prime numbers—numbers that have no divisors except themselves and one. There is no known formula for generating all of the prime numbers, or even for determining whether any given number is prime. As Paul Erdös famously put it, "God does not play dice, but there is something strange going on with the prime numbers." However, the Prime Number Theorem, which has been proven, tells us that the number of primes less than any given number [denoted $\pi(x)$] approximates a function Li(x) which is $\int_0^x \frac{1}{\log t} dt$ as x gets bigger and bigger. Approximates means that Li(x) – $\pi(x)$ equals an error term that fluctuates. They do not converge. According to a hypothesis first formulated by the German mathematician Bernhard Riemann (1826–1866), this error term can be calculated and these fluctuations are in some sense "orderly." In other words, the distribution of the prime numbers lends itself well to human conceptualization. While there is a certain randomness in the distribution of the prime numbers, they are not wildly random; the randomness is comprehensible and mathematically representable. It had been thought that Li(x) was consistently larger than $\pi(x)$, and indeed it is for numbers that any of us humans would ever care to use. However, in 1914, the British mathematician, J. E. Littlewood, stunningly proved that in general this is not the case, but in fact the graphs of these two functions $\pi(x)$ and Li(x) actually crisscross as x gets larger and larger. Indeed, they cross each other infinitely many times. However, this crisscrossing behavior does not begin until we reach numbers that are so astronomical in size that no human would ever have need to use them. The numbers we are talking about are far in excess of the total number of atoms in the entire universe. If the Riemann Hypothesis is false, then it means that the distribution of prime numbers is far more chaotic and disorderly than we could ever imagine, albeit only for values in the Kuiper Belt of numbers. But it would mean that much of modern mathematics that has been generated on the assumption that the Riemann Hypothesis is true would be in dire need of rethinking. Today, the Riemann Hypothesis has been verified for values up into the many zillions, although no general proof of it has yet been found. Most mathematicians today believe it is true and a lot of mathematics is generated on the assumption that it is true. When Stephen Smale, one of the greatest mathematicians of our own time, was asked by the International Mathematics Union to make a list of outstanding problems for the twenty-first century to mirror those of David Hilbert for the last century, he put the Riemann Hypothesis at the top of the list.[1]

Alan Turing believed that the Riemann Hypothesis is false. It is a minority view among mathematicians. However, mathematics is not a democracy, and the majority does not always turn out to be right. This was the case with the decidability issue, which Turing disproved along with Gödel in his early years, contrary to the majority view of the time. Much of Turing's personal motivation in developing the computer was to make calculations necessary to [he hoped] invalidate the Riemann Hypothesis.

I think Turing's attitude toward the Riemann Hypothesis says something psychologically important about him. Alan Turing was an extremely independent, individualistic thinker. He was willing to take up and explore unpopular and even unlikely positions against long odds of their being correct. He was not afraid to be wrong. In fact it was a point he often made in his arguments about whether machines could be constructed that could "think." He insisted that a machine that could "think" did not need to be infallible; in fact, fallibility was a necessary ingredient of intelligence. This inner security he felt in his intellectual capabilities and his own limitations gave him a freedom from the anxious need for self validation that hampers and limits many intelligent people from taking bold, independent chances in their ideas and in their approaches to problems. There is also, I think, an iconoclasm evident in Turing's attitude toward the intellectual issues he undertook. He held a deep inner skepticism about the views and attitudes that were commonly accepted in his society, which may have been related to his sense of alienation on account of his homosexuality. He understood that most people in his society disparaged and rejected homosexuality—at least officially—although he himself did not. In fact, to the shock and annoyance of some of his acquaintances, he seemed rather proud of it. This stubborn defiance of the prevailing ethos in society carried over into his intellectual pursuits. There was a quiet, intransigent skepticism in Alan Turing's outlook on life. I think he found great inner satisfaction in showing up and confounding the widely accepted views of his time. Turing was indifferent to the commonly held opinions of his peers, and this applied to mathematics, computer science, cryptography, and his private life. I think it also reflects a deep disquiet in Turing that the world is not as predictable and comprehensible a place as our rationality demands. If the Riemann Hypothesis is true, then the prime numbers, which have the appearance of incomprehensible randomness, will be more comprehensible and subject to our understanding. All of mathematics will be more comprehensible and subject to our understanding. The universe itself will be a place that our rationality and our intelligence can encompass and comprehend.

Alan Turing didn't believe it. He saw the world differently. To him the world is fundamentally a more disturbing, less comprehensible place than most of us care to conceive.

Turing grew up in the English public school, Sherborne. Homosexuality was pervasive in these English public schools as it had been throughout the nineteenth century. However, the nominally tolerant atmosphere in which this male homosexual culture thrived was changing since the criminalization of homosexuality in England in 1885—a law passed in 1885 that defined "indecency" as a peculiarly *male* crime. The House of Commons voted in 1921 to extend the law to women also. However, the House of Lords rejected the extension "believing that even to mention the crime would have the effect of giving women ideas." (Hodges, p. 458n) These developments in Britain paralleled a similar hostility that was becoming widespread in the United States around the same time. Homosexuality, which had once been an accepted commonplace in the lives of young males, was being forced into the closet. The closet was invented in the United States and Great Britain in the first decades of the twentieth century with the United States being somewhat ahead. The male homosexual cultures within the British public schools were extremely resistant to persecution. This is the atmosphere that Alan Turing grew up in and which shaped his sexual identity and his attitude toward himself and his own sexual behavior. Turing did not find his sexuality in the least bit questionable. He was very frank and open displaying neither shame nor assertion about it. Leavitt attributes this to Turing's distaste for dishonesty and his "remarkable degree of self-confidence and comfort in his own sexual identity." (p.195) He simply accepted it as a matter of fact—and he expected others to do the same. It was the latter assumption that proved faulty.

Turing became strongly attracted to a boy a year older than himself by the name of Christopher Morcom in 1927 when he was 15. Turing regarded it as his "first love." It was a passionate preoccupation. Leavitt discounts the possibility of it being sexual. Hodges offers ample details of the relationship but nothing suggesting sexual experimentation. Morcom died suddenly and unexpectedly in 1930 when Turing was 17. Turing took it hard and probably never fully recovered. He doesn't seem to have had another relationship with this kind of passionate intensity.

Most of the information to be had about Turing's sexuality is in Hodges, but it is scattered throughout and does not form a continuous thread. Leavitt also touches on Turing's sexuality, but again in occasional fragments rather than in a well-developed narration. Hodges describes Turing in his 30s as having "been involved in two extended relationships, but he was not by nature the most conjugal person, and his exploratory urge was better suited to the possibilities of the cruising grounds, once he had overcome his shyness." (p. 462)

I found the most challenging sections in both of these books to be those that dealt with cryptography. It was during World War II that encryption became mechanized and sophisticated to a degree hitherto unprecedented. Alan Turing played a key role in the development of these encryption machines during World War II. It is fair to say that Alan Turing was instrumental to the Allies victory over the Nazis in World War II. Without his brilliance in breaking the German Navy's communications code the naval war in the North Atlantic that was crucial to maintaining the Allied supply line in Europe might have gone the other way. Both books explain in mind-boggling detail how these World War II era encryption machines worked with their numerous modifications and innovations. It was very hard for me to follow in all the details, but I am not at all inclined toward cryptography. Leavitt is probably a little easier to read, but Hodges is much more detailed.

After the war, Turing began to work in earnest on what would become the modern computer. As usual, Turing was interested in the theoretical questions: Could a machine actually be made to "think," or were they just calculators? Could a machine make decisions? Could a machine learn from its mistakes? What is the nature of learning? What did it mean to be "intelligent"? What are the limits of intelligence? How you answer these questions influences the kind of machines you try to build. But Turing was more interested in using the computer to help resolve theoretical questions in mathematics than in actually building the machines themselves. In 1953, he designed a program for making calculations related to the Riemann Hypothesis. His ideas were outside the mainstream in the development of the computer as they were in every other field that he pursued.

Leavitt never makes good on his chosen title: *The Man Who Knew Too Much*, which refers to Alfred Hitchcock's 1934 film of the same name. The film is an assassination drama involving government intelligence agencies. This title choice seems to imply that Turing's knowledge and expertise somehow came to be seen as a threat and thus was a cause for elimination. But in fact it was not Turing's knowledge that got him into trouble, but his sexual behavior, and the incident in which he became embroiled had no relation to his governmental work. Turing was arrested when he reported one of his lovers to the police for breaking into his house and burglarizing it. The police in turn found out about the sexual affair and instead of arresting the thief, arrested Turing for gross indecency with another male. Turing, quite typically, was very matter of fact and straightforward with the detectives who investigated the incident, even playing his violin for them and serving them wine. His statement left no doubt about his guilt, but Turing initially refused to plead guilty because why should he plead "guilty" to something he saw nothing wrong with? But then to plead "not guilty" would be seen as denying the facts, which he saw no need to do either—a different kind of decidability paradox. He eventually pleaded guilty to "gross indecency" and was placed on probation with the proviso that he undergo treatment with a qualified medical professional. He was forced to undergo hormone treatments for one year, which were supposed to impede his sex drive, but which also caused him to grow breasts. The prosecutor remarked on his unrepentant attitude. Between 1931 and 1951, Hodges reports that there had been a five-fold increase in the number of prosecutions for male-male indecency in England. Seven hundred forty-six men were prosecuted for "gross indecency" in 1951, but of these only 174 were actually imprisoned, and then usually for less than six months (p. 467). Turing was an unfortunate casualty in this aberrant, perverse warfare.

Leavitt says that Turing's life after his arrest was "a slow, sad descent into grief and madness" (p. 268). I don't agree with that assessment. Turing did not go mad—whatever that means—although the episode undoubtedly shook him. His death occurred two years after his trial and one year after his hormone treatments had ended. In fact, he continued to work. In 1953, the University of Manchester gave him a specially created five-year position in the Theory of Computing. He took a vacation that year to Paris and the eastern Mediterranean. He wrote a popular article that was published in *Science News* in 1954. He worked on theoretical problems in mathematics, including the Riemann Hypothesis. He saw friends, wrote letters; but some friends did notice a change. He had told his friend, Don Bayley, in 1952, that mathematics satisfied him less and less. He began reading Jung, Tolstoy, and Forster. He was impressed with George Orwell's *Nineteen Eighty-Four*, which appeared in 1949.

Hodges relates an incident that I found particularly interesting: A few weeks before he died he went on a Sunday outing with his psychoanalyst, Franz Greenbaum and his family—a Freudian in the most authentic sense, when psychoanalysis was only one aspect of a complete human relationship. They walked along a seaside tourist area and came upon a gypsy fortune teller. Alan Turing went in while the Greenbaum family waited for him outside. They waited half an hour. When Turing emerged, they reported that he was "white as a sheet, and would not speak another word as they went back to Manchester on the bus" (p. 496)—an interesting turn for a man who spent his entire life on the frontiers mathematical logic and the foundations of computer science.

The circumstances of his death on June 7, 1954, have been the subject of some controversy and speculation. He was found dead in his bed by his housekeeper on June 8. An apple was found nearby out of which several bites had been taken. There was a froth around his mouth consistent with cyanide poisoning. Hodges states that the apple was never analyzed, so it had never been indubitably confirmed that it had, indeed, been laced with the cyanide, although there was both potassium cyanide and cyanide solution in his house. Turing's mother, his psychoanalyst, and others close to him never accepted the conclusion that his death was a suicide. His mother insisted for years afterward that the death had been accidental. Numerous others wrote letters and made comments supporting Mrs. Turing's version of events, including Franz Greenberg.

When I first read of the suicide, after having gone through Hodges' entire tome, I didn't accept this verdict either. It was incongruous with the personality of Alan Turing drawn by Hodges' through his entire life antecedent to his death. An accident, while possible, did not seem likely to me either. Wikipedia wrongly suggests that Leavitt supports a theory that Turing's suicide was staged and that he was in fact murdered by elements in the British government who perceived him as a security risk. In fact, Leavitt explicitly states that there is no evidence for such a possibility, even though the title of his book misleadingly suggests that he favors such a view. I, too, considered the possibility that he may have been murdered by the British Secret Intelligence Service, staged to look like a suicide. There is plenty of evidence that intelligence agencies have frequently perpetrated assassinations disguised as suicides since World War II. However, after studying the matter carefully for some time, I have come to the conclusion that, in Turing's case, suicide is the most likely scenario. Its initial implausibility I attribute to the inadequacy of these two biographies and their failure to create an appropriate portrait of Turing's inner life. Combing carefully through Hodges, however, it is possible to piece together the indicators of considerable inner turmoil and suicidal ideation in Alan Turing, albeit rather low key. Hodges, however, often fails to recognize the personal and psychological significance of his own material and thus his biography is not an inner exploration, but tends to emphasize tangible events and outward appearances.

According to his student and close friend Robin Gandy, Turing did discuss the merits of different methods of committing suicide on a number of occasions with various people. At the time, it appeared to be something of an intellectual exercise, but apparently underneath it was an option that he had long held in reserve—for example, he had a new will drawn on February 11, 1954. But I think one of the most telling arguments for suicide was his fascination with the Snow White story. In 1937, Disney came out with an animated version of the story, which Turing saw in Cambridge with some friends. He was particularly taken with the scene where the Wicked Witch dangled an apple into a boiling brew of poison as she repeated to herself, "*Dip the apple in the brew/Let the Sleeping Death seep through.*"

Turing reportedly liked to chant the couplet over and over again. When it came time to kill himself, this was the method he chose. It was a personal signature on the act, which I think makes it unlikely to have been accidental, contrary to what his mother long maintained. In defense of the biographers, however, there is one crucial piece of evidence that was lost. During his psychoanalytic treatment with Franz Greenbaum, Turing kept three dream notebooks. Greenbaum destroyed them after Turing's death, but not before allowing Turing's brother, John, to look at them. Hodges recounts:

> John Turing read through two of the dream books, which Franz Greenbaum lent him before destroying them. Alan's "scarifying" comments on his mother, and his description of homosexual activity since adolescence, told John far more than he wished to know, and he found these revelations in themselves sufficient explanation for what had occurred, thankful that he had managed to prevent them from reaching his mother's eyes." (p. 491)

Alas, that these dream books did not survive! If they had, we might be reading a very different and much richer, more psychologically informed biography. I think Alan Turing was a more inwardly tormented man that his biographers present. The emphasis in the biographies is on his ideas and his accomplishments. This is especially true of Leavitt. But these accomplishments were achieved atop a very dark and disordered inner life that he rarely revealed even to intimates, of which he had few. Suicide was an option which he had held in reserve for many years, perhaps going back to his teens following the death of Christopher Morcom. As early as 1937, he had written a letter to his friend James Atkins that spoke of feeling depressed and even considering a suicide method involving an apple. Although not evident to those who did not know him well, and even to some of those who did, Alan Turing's suicide had precursors that went unrecognized. It is probably correct to say that had he not been outed as a homosexual and subjected to a public humiliation and the loss of credibility within the government that he was largely responsible for saving, he might not have carried it out. The public trauma probably intensified a sense of alienation and estrangement that had been in place for many years. Many people maintain suicide as a reserve option for years without actually making an attempt. It is circumstances that bring these quietly held inclinations to their ultimate fruition–and this is what happened in Alan Turing's case. It is a compelling example of the high cost of persecuting homosexuality, not only to the individuals who suffer its brunt, but also to the society that loses a mind with the creativity and originality of an Alan Turing.

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NOTE

1. Lecture given by Steve Smale on the occasion of V. I. Arnold's 60th birthday at the Fields Institute, Toronto, Ontario, Canada, June 1997. The original version appeared in the *Mathematical Intelligencer, 20* (Spring 1998) 7–15.