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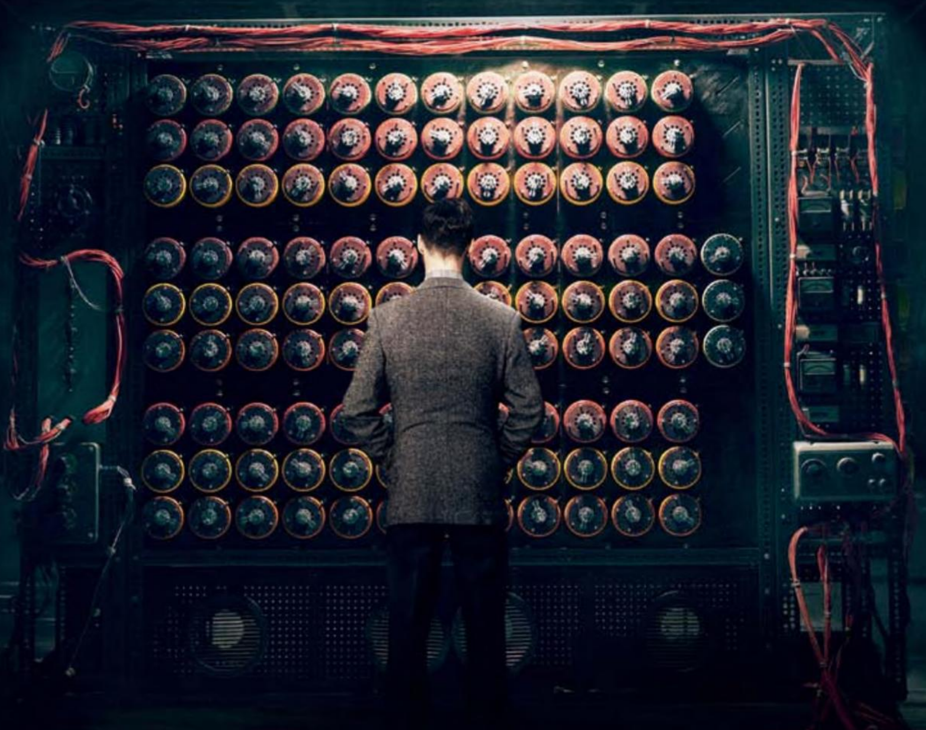
ANDREW HODGES



ALAN TURING: THE ENIGMA

THE BOOK THAT INSPIRED THE FILM
THE IMITATION GAME

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ANDREW HODGES

Alan Turing: The Enigma

The Book That Inspired the Film
The Imitation Game

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Contents

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List of Plates

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Alan's father, Julius Turing, in about 1907.

On the beach: Alan and his brother John at St Leonard's in 1917.

On the cliffs: Alan and his mother at St Lunaire, Brittany, in 1921 (see page 14).

Colonel Morcom, Mrs Morcom and Christopher on holiday, summer 1929.

George Maclure, Peter Hogg and Alan setting out on their hike, Easter 1931 (see page 75).

Alan Turing in a Guildford street, a chance snapshot taken in 1934.

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A brushed-up Alan with his father and mother and a family friend (right) outside 8 Ennismore Avenue in 1938.

Boy and buoys at Bosham, August 1939 (see page 200). From the front: Alan, Bob, Karl and Fred Clayton.

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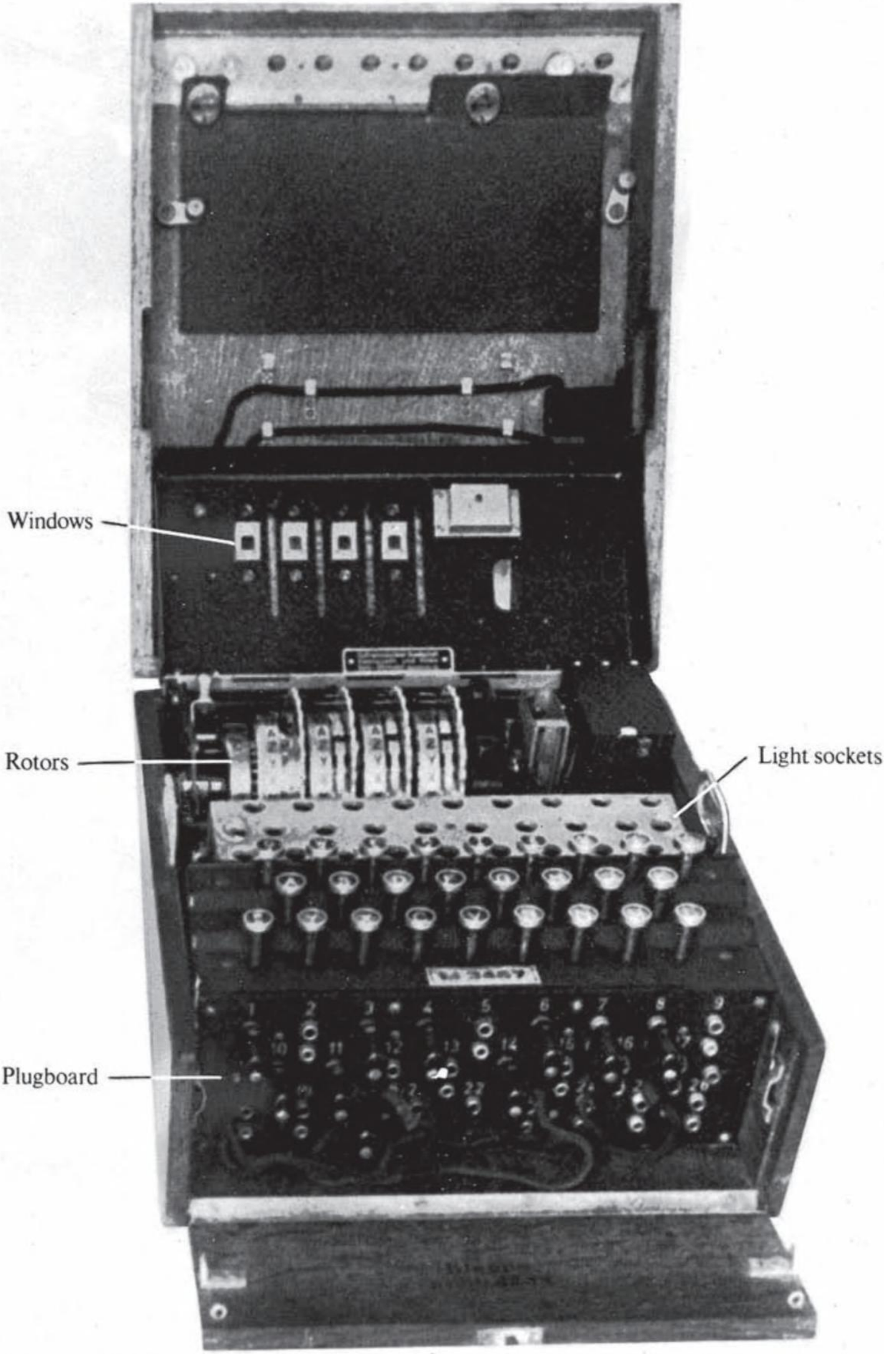

The naval Enigma machine with its lid raised to show the four rotors.

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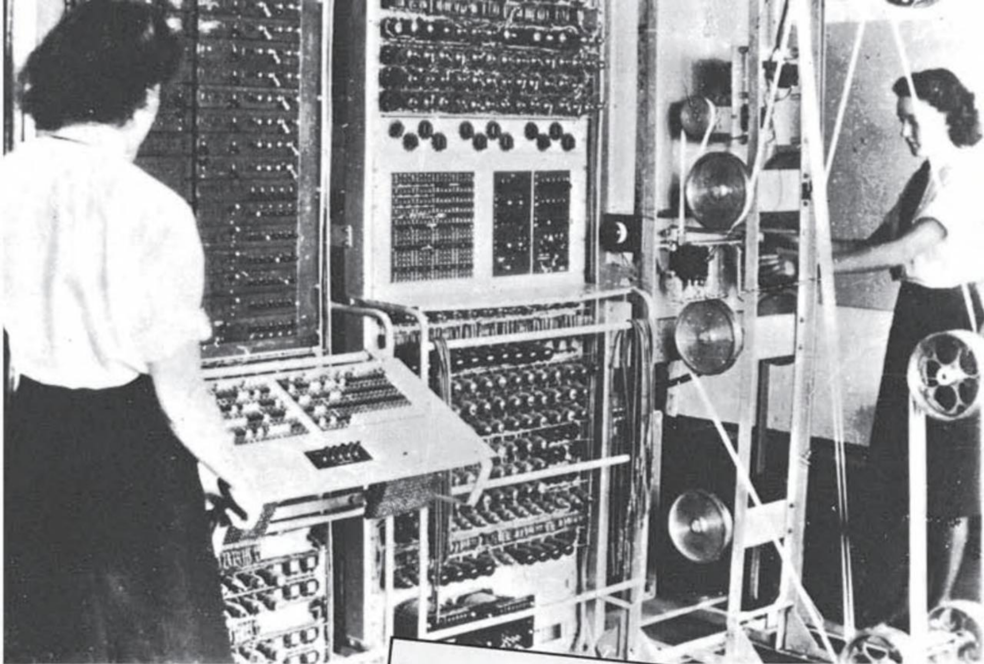
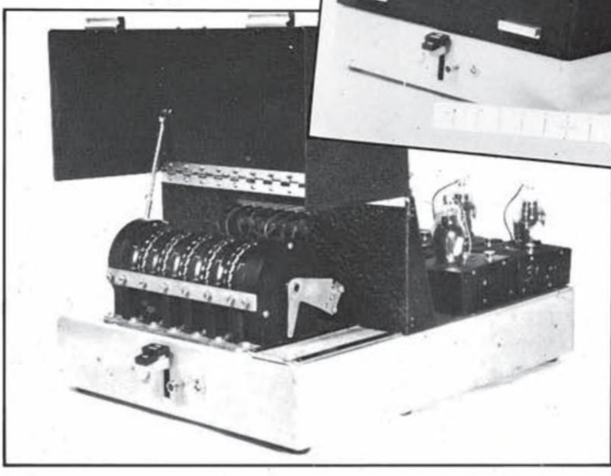


Above: The Colossus in operation at Bletchley Park, 1944–5, showing the rapid punched tape input mechanism.

Right: In contrast, the complete Delilah terminal fitted easily onto a table top (note the scale).



Left: The key unit, with lid removed to show both rotors and multivibrators.

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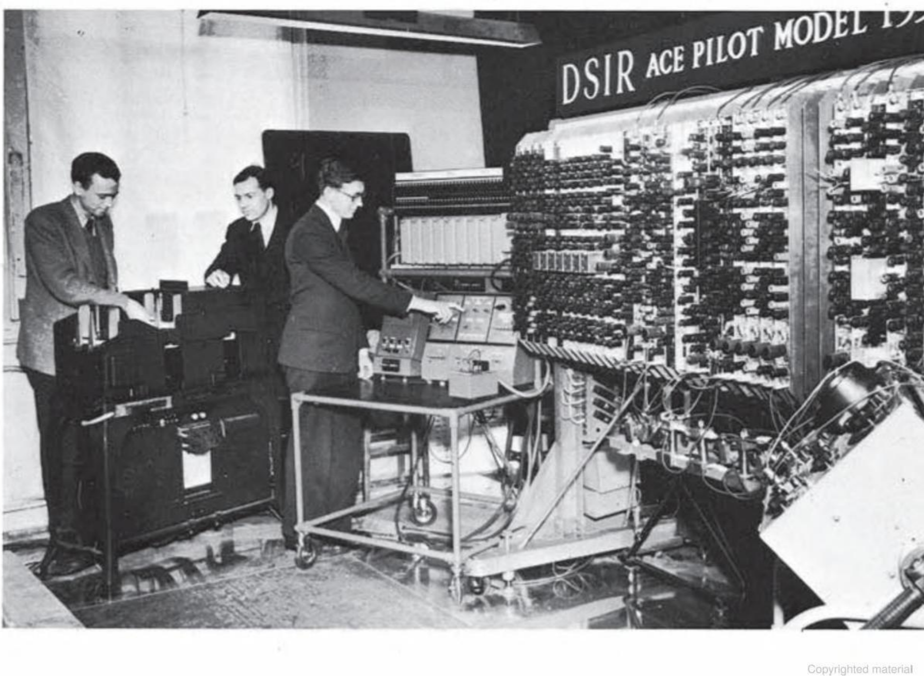
Above: Robin Gandy in Summer 1953, on holiday in France.

Left: A sporting second in a three-mile race: possibly the event of 26 December 1946 (see page 444).

Below: The pilot ACE computer, on show at the NPL in November 1950. Jim Wilkinson is the right hand figure.



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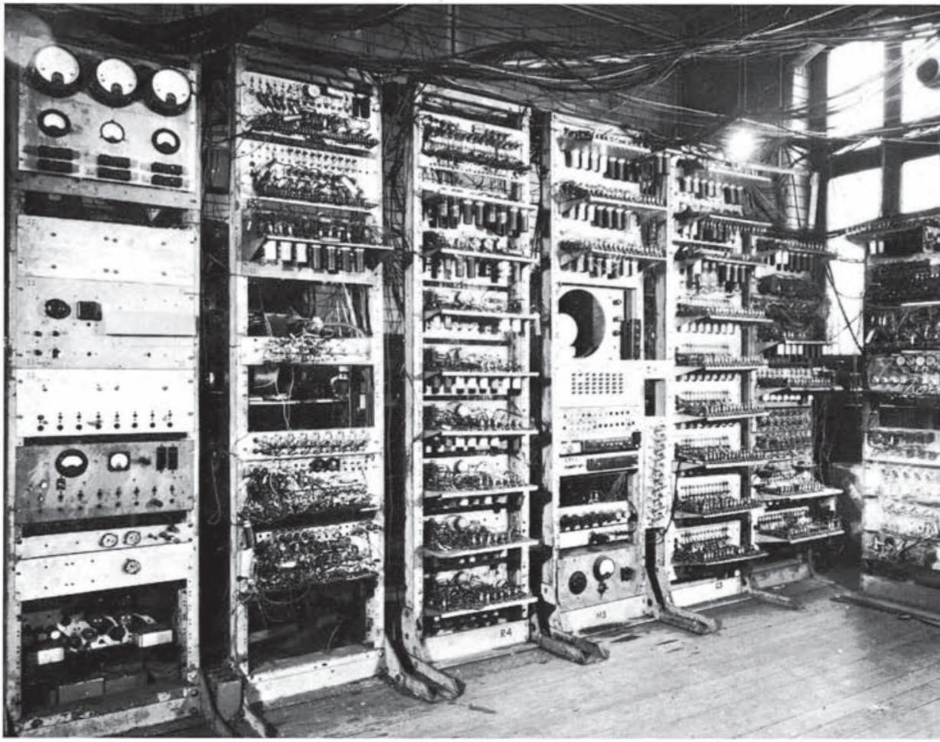

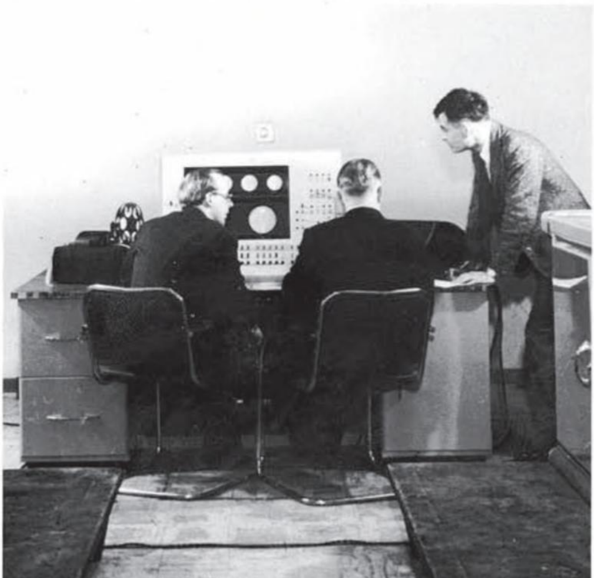

Above: The prototype Manchester computer. The six racks shown are essentially those of the 'baby machine' which ran its first program in June 1948; by June 1949 when this photograph was taken, the machine had roughly doubled in size.

Left: Alan Turing with two Ferranti engineers at the console of the 'Mark I' computer at Manchester, 1951.

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Alan Mathison Turing on election to Fellowship of the Royal Society, 1951.

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Foreword

Is a mind a complicated kind of abstract pattern that develops in an underlying physical substrate, such as a vast network of nerve cells? If so, could something else be substituted for the nerve cells – something such as ants, giving rise to an ant colony that thinks as a whole and has an identity – that is to say, a self? Or could something else be substituted for the tiny nerve cells, such as millions of small computational units made of arrays of transistors, giving rise to an artificial neural network with a conscious mind? Or could software simulating such richly interconnected computational units be substituted, giving rise to a conventional computer (necessarily a far faster and more capacious one than we have ever seen) endowed with a mind and a soul and free will? In short, can thinking and feeling emerge from patterns of activity in different sorts of substrate – organic, electronic, or otherwise?

Could a machine communicate with humans on an unlimited set of topics through fluent use of a human language? Could a language-using machine give the appearance of understanding sentences and coming up with ideas while in truth being as devoid of thought and as empty inside as a nineteenth-century adding machine or a twentieth-century word processor? How might we distinguish between a genuinely conscious and intelligent mind and a cleverly constructed but hollow language-using facade? Are understanding and reasoning incompatible with a materialistic, mechanistic view of living beings?

Could a machine ever be said to have made its own decisions? Could a machine have beliefs? Could a machine make mistakes? Could a machine believe it made its own decisions? Could a machine erroneously attribute free will to itself? Could a machine come up with ideas that had not been programmed into it in advance? Could creativity emerge from a set of fixed rules? Are we – even the most creative among us – but passive slaves to the laws of physics that govern our neurons?

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Could machines have emotions? Do our emotions and our intellects belong to separate compartments of our selves? Could machines be enchanted by ideas, by people, by other machines? Could machines be attracted to each other, fall in love? What would be the social norms for machines in love? Would there be proper and improper types of machine love affairs?

Could a machine be frustrated and suffer? Could a frustrated machine release its pent-up feelings by going outdoors and self-propelling ten miles? Could a machine learn to enjoy the sweet pain of marathon running? Could a machine with a seeming zest for life destroy itself purposefully one day, planning the entire episode so as to fool its mother machine into 'thinking' (which, of course, machines cannot do, since they are mere hunks of inorganic matter) that it had perished by accident?

These are the sorts of questions that burned in the brain of Alan Mathison Turing, the great British mathematician who spear-headed the science of computation; yet if they are read at another level, these questions also reveal highlights of Turing's troubled life. It would require someone who shares much with Turing to plumb his life story deeply enough to do it justice, and Andrew Hodges, an accomplished British mathematical physicist, has succeeded wonderfully in just that venture.

This biography of Turing, painstakingly assembled from innumerable sources, including conversations with scores of people who knew Turing at various stages of his life, provides a picture as vivid as one could hope of a most complex and intriguing individual. Turing's was a life that merits deep study, for not only was he a major player in the science of the twentieth century, but his interpersonal behavior was unconventional and caused him great grief. Even today, society as a whole has not learned how to grapple with Turing's brand of nonconformism.

Hodges's rich and engrossing portrait is not the first book about Turing; indeed, Turing's mother, Sara Turing, wrote a sketchy memoir a few years after her son's death, presenting an image of him as a lovable, eccentric boy of a man, filled with the joy of ideas and driven by an insatiable curiosity about questions concerning mind and life and mechanism. Although that little book has some merits and even some charm, it also whitewashes a great deal of

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the true story. Andrew Hodges explores Turing's mind, body, and soul far more deeply than Sara Turing ever dared to, for she wore conventional blinders and did not want to see, let alone say, how poorly her son fit into the standard molds of British society.

Alan Turing was homosexual – a fact that he took no particular pains to hide, especially as he grew older. For a boy growing up in the 1920s and for a grown man in the subsequent few decades, being homosexual – especially if one was British and a member of the upper classes – was an unmentionable, terrible, and mysterious affliction.

Atheist, homosexual, eccentric, marathon-running English mathematician, A. M. Turing was in large part responsible not only for the concept of computers, incisive theorems about their powers, and a clear vision of the possibility of computer minds, but also for the cracking of German ciphers during the Second World War. It is fair to say that we owe much to Alan Turing for the fact that we are not under Nazi rule today. And yet this salient figure in world history has remained, as the book's title says, an enigma.

In this biography, Andrew Hodges has painted an extraordinarily detailed and devoted portrait of a multifaceted man whose honesty and decency were too much for his society and his times, and who brought about his own downfall. Beyond the evident empathy that Hodges feels for his subject, there is another level of depth and understanding in this book, one that makes all the difference in a biography of a scientific figure: scientific accuracy and clarity. Hodges has done an admirable job of presenting to the lay reader each idea in detail, and most likely this is so because, as is obvious to a reader, he himself is passionately intrigued by all the ideas that fascinated Turing.

Alan Turing: The Enigma is a first-rate presentation of the life of a first-rate scientific mind, and given that this particular mind was attached to a body that had a mind of its own, the full story is an important document for social reasons as well. Alan Turing would probably have shuddered had he ever suspected that the tale of his personal life would one day be presented to the public at large, but he is in good hands: it is hard to imagine a more thoughtful and compassionate portrait of a human being than this one.

Douglas Hofstadter

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Preface

On 25 May 2011, the President of the United States, Barack Obama, speaking to the parliament of the United Kingdom, singled out Newton, Darwin and Alan Turing as British contributors to science. Celebrity is an imperfect measure of significance, and politicians do not confer scientific status, but Obama's choice signalled that public recognition of Alan Turing had attained a level very much higher than in 1983, when this book first appeared.

Born in London on 23 June 1912, Alan Turing might just have lived to hear these words, had he not taken his own life on 7 June 1954. He perished in a very different world, and his name had gone unmentioned in its legislative forums. Yet even then, in its secret circles, over which Eisenhower and Churchill still reigned, and in which the names of NSA and GCHQ were spoken in whispers, Alan Turing had a unique place. He had been the chief backroom boy when American power overtook British in 1942, with a scientific role whose climax came on 6 June 1944, just ten years before that early death.

Alan Turing played a central part in world history. Yet it would be misleading to portray his drama as a power play, or as framed by the conventional political issues of the twentieth century. He was not political as defined by contemporary intellectuals, revolving as they did round alignment or non-alignment with the Communist party. Some of his friends and colleagues were indeed party members, but that was not his issue. (Incidentally, it is equally hard to find money-motivated 'free enterprise', idolised since the 1980s, playing any role in his story.) Rather, it was his individual freedom of mind, including his sexuality, that mattered – a question taken much more seriously in the post-1968, and even more in the post-1989, era. But beyond this, the global impact of pure science rises above all national boundaries, and the sheer timelessness of pure mathematics transcends the limitations of his twentieth-century span. When Turing returned to the prime numbers in 1950 they were unchanged from when he

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left them in 1939, wars and superpowers notwithstanding. As G. H. Hardy famously said, *they are so.* Such is mathematical culture, and such was his life, presenting a real difficulty to minds set in literary, artistic or political templates.

Yet it is not easy to separate transcendence from emergency: it is striking how leading scientific intellects were recruited to meet the existential threat Britain faced in 1939. The struggle with Nazi Germany called not just for scientific knowledge but the cutting edge of abstract thought, and so Turing's quiet logical preparations in 1936–38 for the war of codes and ciphers made him the most effective anti-Fascist amongst his many anti-Fascist contemporaries. The historical parallel with physics, with Turing as a figure roughly analogous to Robert Oppenheimer, is striking. This legacy of 1939 is still unresolved, in the way that secret state purposes are seamlessly woven into intellectual and scientific establishments today, a fact that is seldom remarked upon.

The same timelessness lies behind the central element of Alan Turing's story: the universal machine of 1936, which became the general-purpose digital computer in 1945. The universal machine is the focal, revolutionary idea of Turing's life, but it did not stand alone; it flowed from his having given a new and precise formulation of the old concept of algorithm, or mechanical process. He could then say with confidence that *all* algorithms, all possible mechanical processes, could be implemented on a universal machine. His formulation became known immediately as 'the Turing machine' but now it is impossible not to see Turing machines as computer programs, or software.

Nowadays it is perhaps taken rather for granted that computers can replace other machines, whether for record-keeping, photography, graphic design, printing, mail, telephony, or music, by virtue of appropriate software being written and executed. No one seems surprised that industrialised China can use just the same computers as does America. Yet that such universality is possible is far from obvious, and it was obvious to no one in the 1930s. That the technology is *digital* is not enough: to be all-purpose computers must allow for the storage and decoding of a program. That needs a certain irreducible degree of logical complexity, which can only be made to be of practical value if implemented in very fast and reliable

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electronics. That logic, first worked out by Alan Turing in 1936, implemented electronically in the 1940s, and nowadays embodied in microchips, is the mathematical idea of the universal machine.

In the 1930s only a very small club of mathematical logicians could appreciate Turing's ideas. But amongst these, only Turing himself had the practical urge as well, capable of turning his hand from the 1936 purity of definition to the software engineering of 1946: 'every known process has got to be translated into instruction table form . . .' (p. 409). Donald Davies, one of Turing's 1946 colleagues, later developed such instruction tables (as Turing called programs) for 'packet switching' and these grew into the Internet protocols. Giants of the computer industry did not see the Internet coming, but they were saved by Turing's universality: the computers of the 1980s did not need to be reinvented to handle these new tasks. They needed new software and peripheral devices, they needed greater speed and storage, but the fundamental principle remained. That principle might be described as the law of information technology: all mechanical processes, however ridiculous, evil, petty, wasteful or pointless, can be put on a computer. As such, it goes back to Alan Turing in 1936.

That Alan Turing's name has not from the start been consistently associated with praise or blame for this technological revolution is due partly to his lack of effective publication in the 1940s. Science absorbs and overtakes individuals, especially in mathematics, and Alan Turing swam in this anonymising culture, never trying to make his name, although frustrated at not being taken seriously. In fact, his competitive spirit went instead into marathon running at near-Olympic level. He omitted to write that monograph on 'the theory and practice of computing', which would have stamped his name on the emergent post-war computer world. In 2000 the leading mathematical logician Martin Davis, whose work since 1949 had greatly developed Turing's theory of computability, published a book[1] which was in essence just what Turing could have written in 1948, explaining the origin of the universal machine of 1936, showing how it became the stored-program computer of 1945, and making it clear that John von Neumann must have learnt from Turing's 1936 work in formulating his better-known plan. Turing's very last publication, the *Science News* article of 1954 on computability, demonstrates how ably he could have written such an analysis. But

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even there, on terrain that was incontestably his own discovery, he omitted to mention his own leading part.

Online search engines, which work with such astonishing speed and power, are algorithms, and so equivalent to Turing machines. They are also descendants of the particular algorithms, using sophisticated logic, statistics and parallel processing, that Turing expertly pioneered for Enigma-breaking. These were search engines for the keys to the Reich. But he asked for, and received, very little public credit for what has subsequently proved an all-conquering discovery: that all algorithms can be programmed systematically, and implemented on a universal machine. Instead, he nailed his colours to the mast of what he called 'intelligent machinery', but which came to be called Artificial Intelligence after 1956. This far more ambitious and contentious research programme has *not* developed as Turing hoped, at least as yet. Why did Turing go so public on AI, and make so little of himself as an established maestro of algorithms and the founder of programming? Partly because AI was for him the really fundamental scientific question. The puzzle of mind and matter was the question that drove him most deeply. But to some extent he must have been a victim of his own suppressed success. The fact that he knew so much of the algorithms of the secret war, and that the war had made the vital link between logic and electronics, cramped his style and constrained his communication. In his 1946 report his guarded allusion to the importance of cryptographic algorithms (p. 418) reflects an inhibition that must have infected all that came later.

Only after thirty years did the scale and depth of wartime cryptanalysis at Bletchley Park begin to leak out, allowing a serious assessment of Alan Turing's life to be attempted. This point coincided with the break-out of cryptology theory into an expanding computer science, with a reassessment of the Second World War in general, and with the impact of 1970s sexual liberation. The 1968 social revolution, which Turing anticipated, had to happen before his story could be liberated. (Even so, the change in UK vetting and military law came only in the 1990s, and a legal principle of equality was not established until 2000. 'Don't ask don't tell' ended only in 2011, showing how the issues of chapter 8 have remained literally unspeakable in the US military.) Alan Turing's story shows the first elements of this liberating process in the Norway of 1952, since the

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men-only dances he heard about (p. 599) were probably organised by the fledgling Scandinavian gay organisation. In addition to the gay-themed novels mentioned on p. 613, Norman Routledge recalled in 1992 how Turing expected him to read André Gide in French. One regret, voiced in note 8.31, is that his letters to Lyn Newman did not survive. Their content can be guessed from what in 1957 she wrote to a friend: 'Dear Alan, I remember his saying to me so simply & sadly "I just can't believe it's as nice to go to bed with a girl as with a boy" and all I could say was "I entirely agree with you – I also much prefer boys."' This interchange, then confined to a discreet privileged circle, could now be a TV chat show joke, with a happy resonance of the repartee of his famous imitation game. But Alan Turing's simple openness came decades too early.

It is not difficult to imagine the hostility and stigma of those days, for such hatred and fear is still, whether in Africa, the Middle East or the United States, a major cultural and political force. It is harder now to imagine a world where persecution was not just asserted but taken as an unquestionable axiom. Alan Turing faced the impossible irony that his demand for honesty ran up against the two things, state security and homosexuality, which were the most fraught questions of the 1950s. It is not surprising that it proved impossible to contain them in a single brain. His death left a jagged edge in history, something no one (with the extraordinary exception of his mother) wanted to talk about. My fusion of these elements into a single narrative certainly encountered criticism in 1983. But *nous avons changé tout cela:* since then, his life and death have been as celebrated as those of any scientific figure. Hugh Whitemore's play *Breaking the Code,* based on this book and featuring leading performers, pushed at the envelope of public acceptability. It made Alan Turing's life a popular story in 1986, reinforced by a television version in 1997. By that time the Internet had transformed personal openness. In a curious way, Turing had anticipated this use of his technology, already hinted at in the risqué text-messaging of his imitation game. The love letters created by the Manchester computer (p. 601), and his message about the Norwegian youth, rendered as a nerdy computer printout (p. 608), suggest a Turing who would have relished the opportunity for electronic communication with like-minded people.

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In 2009 the British prime minister, Gordon Brown, made a statement of apology for Turing's trial and punishment in 1952–54, framed by a wider vision of how the values of post-war European civil society had been won with his secret help. This statement was enlisted through a popular web-based petition, something impossible in 1983, but already then being mooted as the sort of thing the 'mighty micro' could bring about. My own comments (p. 608) in the concluding Author's Note about future revision of printed text reflected this mood. And indeed from 1995 onwards my website has supplied updating material. In this light it is surprising that such a long volume has remained continuously in print since 1983. But perhaps one thing that a traditional stack of paper still makes possible is an immersion in storytelling, and this time-consuming experience was one I certainly supplied.

As narrator I adopted a standpoint of a periscope looking just a little ahead of Alan Turing's submerged voyage, punctuated by just a few isolated moments of prophecy. The book bears in mind that what is now the past, the 1940s and 1950s, was once the completely unknown future. This policy required an unwarranted confidence that readers would wade through the pettier details of Alan Turing's family origins and early life, before being offered any reason for supposing this life had any significance. But it has had the happy outcome that the text has not dated as do texts resting on assertions about 'what we know now'. So although so much has changed, the story that follows can be read without having to subtract 1983-era comment. (Of course, this is not true of the Notes, which now show what sources were available in 1983, but do not indicate a guide to 'further reading'.)

After a further thirty years, how would I reassess Alan Turing's pure scientific work and its significance? My book made no attempt to trace the legacy of Turing's work after 1954; that would be far too large a task. But naturally, the expansion of scientific discovery continually forces fresh appraisals of Turing's achievement. His morphogenesis theory, since 2000 more actively pursued as a physico-chemical mechanism, would now require more material on the various different approaches and models. As another example, Turing's strategy of combining top-down and bottom-up approaches to AI, and the neural nets he sketched in 1948, have acquired new significance. There has been a parallel explosion in quality and

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quantity of the history of science and technology since the 1970s, with many detailed studies of Turing's papers. The centenary year of 2012 saw a climax of new analysis from leading scientific figures. Alan Turing's work is accessible as never before, and topics that attracted scant attention in 1983 are now the subject of lively debate.

But I would not take a radically different point of view. My division of the book into Logical and Physical was already radical, reflecting a rejection of conventional description of him as a pure logician, and portraying him as always, and increasingly, involved in the nature of the physical world. This fundamental perception could now be asserted with even greater confidence. He came to the ideas of 1936 with an unusual knowledge of quantum mechanics, and this is now a more interesting connection, for since the mid-1980s quantum computing and quantum cryptography have become important extensions of Turing's ideas. Likewise, the renewed interest in quantum mechanics in Turing's last year, whose significance was correctly signalled with a supersized footnote (p. 645) could now be linked more closely with his 1950 and 1951 arguments about computers and minds. These issues have arisen sharply since 1989, when Roger Penrose[2] discussed the significance for minds of the uncomputable numbers Turing had discovered. Penrose himself suggested an answer which related Turing machines to a radical new view of quantum mechanics. Writing now, I would draw more attention to what is now called the physical Church–Turing thesis. Did Turing consider that the scope of the computable includes everything that can be done by any physical object? And what would this mean for his philosophy of the mind? In this light, Church's 1937 review (p. 157) of Turing's work has more importance than I noted. Turing's decisive shift of focus to what *could* be done by algorithms, as stated on p. 138, I would now move from 1936 to 1941 (at p. 266). Turing's argument about infallibility (p. 454) would deserve more analysis, as also his use of 'random' elements, and a number of general statements about thinking and doing in my text. But sharper sensitivity to these questions would bring out few if any new answers; it would only make more acute the questions about what Turing really thought.

Much more positive detail could now be given regarding his secret wartime work. Even in the 1992 preface to the Vintage edition, new material could be given from the third volume of

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F. H. Hinsley's official history of British Intelligence. But since the mid-1990s, raw American and British documents on Second World War cryptanalysis have been officially released, and it has been possible to elucidate the internal story with far more details than Hinsley allowed. What has emerged has only enhanced the quality and significance of Bletchley Park work, and of Turing as its chief scientific figure. The park itself is now a famous visitor attraction, though its lesson, that reason and scientific methods were the heroes of the hour, has not really caught on.

These documents show how on 1 November 1939 Turing could announce 'the machine now being made at Letchworth, resembling, but far larger than the Bombe of the Poles (superbombe machine)'. That prefix 'super' dramatised the advance that my explanation (p. 229) was unable, for lack of supporting narrative detail, to highlight as the crucial breakthrough. Turing's own 1940 report on the Enigma-breaking methods clarified how he made this advance, called 'parallel scanning'. All of this is now working physically in the rebuilt Bombe at the Bletchley Park Museum. In addition to the document release, members of the original cryptanalytic team have written fully about the technical work, such as the details of the bigram tables which made the Naval Enigma so much more challenging, and the statistical Banburismus method. The super-fast bombes, the break into the Lorenz cipher, and the now-famous Colossus are all open to study, a great deal being due to the inspiring work of the late Tony Sale. The description in this book is now unnecessarily hazy. On the other hand, there was no room for any more codebreaking technicalities in the book, and the reader will not be seriously misled by its summary.

In particular, these revelations have only reinforced the significance of the 'Bridge Passage' between the logical and the physical, Turing's top-level liaison visit to the United States in the winter of 1942–43. His report of 28 November 1942 from Washington, now released, documents the difficult and anomalous position he faced, including an initial confinement to Ellis Island (p. 305). He was not overawed by the US Navy: 'I am persuaded that one cannot very well trust these people where a matter of judgment in cryptography is concerned.' Something that I had heard only as rumour in 1983 has been confirmed: on 21 December a train

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brought Turing to Dayton, Ohio, where the US Bombes were under construction. There is also more revealed on his initiation into the most secret US speech encipherment technology. There is more on his response to it, the Delilah speech scrambler – an interim report dated 6 June 1944, and a later complete description. As a precursor of the mobile phone, this belongs to the future, whilst the Enigma was a mediocre adaptation of 1920s mechanical engineering. This new material only underlines that in the post-war period, Turing had a unique knowledge of the most advanced American technology, as it emerged from victory in 1945.

This fact draws further attention to the question of what he did for GCHQ after 1948. In the 1992 preface I floated the suggestion that this might have been connected with the now famous Venona problem of Soviet messages. But there has been no comparable release of GCHQ or other secret documents on 1948–54, which might indicate the nature of his work. Richard Aldrich's recent history of GCHQ[3] opened by saying that 'Today it is more important than ever – yet we know almost nothing about it.' We know more now, from Edward Snowden, about the work whose foundation stone was laid by Alan Turing. No one could miss seeing how much it has to do with the power of the universal machine. And it is hard to believe that Turing played no part in giving secret advice about the potential of computing in the early days of the Cold War. As I wrote in the 1992 preface, who else could have done this?

Answers to such questions were strikingly absent from the British government statement of 24 December 2013 when, in response to a demand from illustrious figures, a posthumous Royal Pardon was granted to Turing in respect of the conviction for 'gross indecency' of 31 March 1952. There must have been memoranda within government detailing the prospect of their top scientific consultant going on public trial for a crime which rang all the alarm bells of Security. Hugh Alexander must have reported on his participation in the trial. As observed in note 8.17 the question arises as to whether the Foreign Office had an influence on Turing being treated with hormones (then seen as a soft option) instead of going to prison. But no such papers appeared; nor indeed were they asked for.

The pardon captured the public imagination and was received with elation as a fairy-story Christmas present. But its principle was

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less elevated: it conceded the plea made in Turing's defence at his trial in 1952, that he was a national asset. It was an act of pulling rank which, in 1952, Hugh Alexander's advocacy had not been able to achieve, but sixty years later, dressed up with the formal magic of monarchy, was widely applauded.

Queen Elizabeth's reign had begun with Turing's arrest, giving extra piquancy to the medieval language of the Royal Pardon, but those unfamiliar with the decorative aspects of the British constitution should appreciate that this was simply an executive action by the government. Its language recognised Turing as exceptional in his service of the state, and thus re-emphasised the central question of Turing's relationship with that state. But even by 1954, the state that really counted was on the other side of the Atlantic. What did American authorities know of what transpired in 1951–52, and how did they react, given that Turing had explicitly been granted special access to US secrets? Was he vetted under US-inspired rules in 1948? Did he knowingly flout the new rules when he started cruising the Manchester milk bar in 1950? Did British authorities convey the reality of Turing's sex tourism in Europe in 1952–53? What demands, threats and surveillance did Turing have to deal with as a result? None of this was addressed.

The petitioners for the pardon explicitly said Turing was *sui generis,* and that a pardon would create no precedent to apply to anyone else. It was granted on that exceptional basis. So it left Arnold Murray, who was charged in exactly the same way as Turing, unpardoned: no reference was even made to whether he was still alive (he was not). Readers of this book will see that Turing himself took great interest in the background and character of this vulnerable young man, writing a short story based on his breaching of class barriers. It is hard to believe that Turing would have been high-minded enough actually to object if the trial had been stopped on the grounds of his rank, and the whole thing hushed up. On the other hand, it is also hard to believe that he would rejoice in an exception being made for himself while so oppressive a law was enforced on thousands of others.

In 1950, Turing had written a description of what would now be called 'the butterfly effect', ending with a man being killed by an avalanche, and when writing his short story, the events of 1951–52 might have appeared to him in just this light. We now have a further

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glimpse of the chance events which precipitated the crisis. Amidst that scene on the Oxford Road, as described on p. 540, was an eighteen-year-old lad on weekend leave from the Navy. He recognised and greeted Alan Turing in the milk bar – not as a mathematician, but as a champion amateur runner. This young man, Alan Edwards, later noticed Turing connect with Arnold Murray. An athlete himself, of keen intelligence, and very clear about his homosexual identity, Alan Edwards would have made a far more suitable boy. But, by the cussedness of human nature, Alan Turing was not his type. Not because he was too old, but because he was too similar, being lithe and fit.

Another witness has emerged to the importance of running in Turing's life, even after his competitive days were over. This is Alan Garner, famous for *The Owl Service* (1967). In 2011 he told a story that he alone knew. He had been Alan Turing's training partner; they had run perhaps a thousand miles together through Cheshire country lanes in 1951–52. Garner was seventeen in 1951, and a sixth-former at Manchester Grammar School, studying classics. The meeting arose in that year, as fellow athletes spotting each other on the road. From the start, Garner felt himself treated as an equal, something he could appreciate and cope with because of this school's distinctive ambience (a culture that yet another Alan has evoked in *The History Boys*). He was also just about to become a serious competitive young sprinter. Their disparate long- and short-distance strengths were compatible with an equal pace over a run of several miles. Equality also was found in banter full of word play and scurrilous humour. It came as no surprise to Garner when Turing asked him if he thought intelligent machinery was possible. After running silently for ten minutes, along Mottram Road, Alderley Edge, he said no. Turing did not argue. 'Why learn classical languages?' Turing asked, and Garner said, 'You have to learn to use your brain in a different way': the kind of answer that Turing would have appreciated.

Their chat kept away from the personal: it was focused on sustaining the six or seven miles of running. But once, probably late in 1951, Turing mentioned the story of Snow White. 'You too!' said Garner, amazed. For he connected immediately with a singular event from his childhood. It was his first cinema outing when five years old. *Snow White and the Seven Dwarfs* had terrified him with the image of the poisoned apple. Turing responded with immediate empathy. 'He

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used to go over the scene in detail, dwelling on the ambiguity of the apple, red on one side, green on the other, one of which gave death.' Their shared trauma – as Garner saw it – remained a bond.

The training extended into 1952 and overlapped with the period of Turing's trial. Turing never spoke of what he was undergoing and somehow Garner only heard the news late in 1952, when he was warned by the police not to associate with Turing. Garner was very angry at this, and at what he learnt had happened, and he never had the least sense of having been approached in any predatory way. And yet, inevitably, it ended sadly. Alan Garner painfully recalls seeing Turing for the last time in 1953, as a fellow passenger on the bus from Wilmslow to Manchester. Being with his girlfriend, Garner found it too difficult to say anything appropriate and so he pretended not to have noticed his presence. This incident, so redolent of the fiction and film of final teenage years, was soon followed by Garner's departure to National Service, during which he heard of Turing's death. Alan Garner revealed nothing of this for sixty years.[4]

Alan Turing would naturally have delighted to see a lad from a very ordinary Cheshire village background showing such curiosity and intellectual ambition. But it is as though he also saw something extra in Garner, sensing a writer of the future who would combine modernity and mythology. The story of the apple is like a glimpse of the Jungian analysis he went in for after 1952, of which we know virtually nothing. It is also striking to know that when Turing saw *Snow White* at its Cambridge release in 1938 (p. 189) a five-year-old boy was reacting in parallel, and one day would share it. The year 1938 was Turing's year of choice: he chose to return from America and chose active engagement with war rather than pure mathematics. He accepted secrecy and the death of innocence. That the apple had already figured in a suicide plan (p. 164) must have made the film scene an intense (and as Garner saw it, traumatic) image. His analyst, Franz Greenbaum, might have been the perfect confidant in working out such conflicts, but state secrecy would have made it impossible for Turing to convey the true seriousness of his situation. His total isolation in 1954 is virtually impossible to conceive of in today's world.

It will be surprising if any more such witnesses emerge, but further personal documents do exist and may eventually become

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available. Meanwhile, this Preface ends with a few gems of writing which surfaced too late for the 1983 book, but were included in the 1992 preface. They are given again here.

A cosy continuity between King's College, Cambridge, and the pre-war codebreaking establishment is evoked by some brief letters placed in the King's archive in 1990. 'Dilly Knox, who is my boss, sends you greetings,' wrote Turing on 14 September 1939 to the Provost, John Sheppard. 'It is always a joy to have you here,' wrote back the Provost, encouraging him to visit. The economist J. M. Keynes, who looked after the question of Turing's fellowship for the duration of the war, also knew the older generation of codebreakers (and indeed had apparently enjoyed an intimate relation with the 'boss'). These connections lend further colour to my description (p. 148) of how in 1938 Turing's interest in ciphers could have been transmitted to the British government, thus making possible his fateful appointment.

The following account, which in 1983 was only available in Polish, also concerns the early months of the war.[5] It settles the question raised in note 4.10 as to whether Turing was the personal emissary who took the new perforated sheets to the Polish and French cryptanalysts. Indeed he was: there is no mistaking his voice in this account of their farewell supper.

> In a cosy restaurant outside Paris staffed by Deuxième Bureau workers, the cryptologists and the chiefs of the secret decryptment centre, Bertrand and Langer, wished to spend an evening in a casual atmosphere free of everyday concerns. Before the dishes ordered and the choice wine selected for the occasion had been served, the attention of the diners was drawn to a crystal flower glass with flowers, placed on the middle of the tablecloth. They were delicate rosy-lilac flowers with slender, funnel-shaped calyces. It was probably Langer who uttered their German and then their Polish names: 'Herbstzeitlose . . . Zimowity jesienne . . .'
>
> This meant nothing to Turing, as he gazed in silence at the flowers and the dry lanceolate leaves. He was brought back from his reverie, however, by the Latin name, *Colchicum autumnale* (autumn crocus, or meadow saffron), spoken by mathematician-geographer Jerzy Rózycki.
>
> 'Why, that's a powerful poison!' said Turing in a raised voice.
>
> To which Rózycki slowly, as though weighing each word, added: 'It would suffice to bite into and suck at a couple of stalks in order to attain eternity.'

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For a moment there was an awkward silence. Soon, however, the crocuses and the treacherous beauty of the autumnal flowers were forgotten, and an animated discussion began at the richly laid table. But despite the earnest intention of the participants not to raise professional questions, it proved impossible to get completely away from Enigma. Once again, there was talk of the errors committed by German operators and of the perforated sheets, now machine- rather than handmade, which the British sent in series from Bletchley to the Poles working at Gretz-Armainvillers, outside Paris. The inventor of the perforated sheets, Zygalski, wondered why their measurements were so peculiar, with each little square being about eight and a half millimetres on a side.

'That's perfectly obvious,' laughed Alan Turing. 'It's simply one-third of an inch!'

This remark in turn gave rise to a dispute as to which system of measures and currency, the traditionally chaotic British one or the lucid decimal system used in France and Poland, could be regarded as the more logical and convenient. Turing jocularly and eloquently defended the former. What other currency in the world was as admirably divided as the pound sterling, composed of 240 pence (20 shillings, each containing 12 pence)? It alone enabled three, four, five, six or eight persons to precisely, to the penny, split a tab (with tip, generally rounded off to a full pound) at a restaurant or pub.

The dark tone of Turing's knowledge of poisonous plants, arising unexpectedly in the midst of secret work and mathematical banter, recalls the manner of his death. The shock of that event is vividly portrayed by another first-hand account, that written by Turing's housekeeper Mrs Clayton on the night of Tuesday 8 June 1954:

My dear Mrs Turing

You will by now have heard of the death of Mr Alan. It was such an awfull shock. I just didn't know what to do. So I flew across to Mrs Gibson's and she rang Police & they wouldn't let me touch or do a thing & I just couldn't remember your address. I had been away for the weekend and went up tonight as usual to get his meal. Saw his bedroom light on the lounge curtains not drawn back, milk on steps & paper in door. So I thought he'd gone out early & forgot to put his light off so I went & knocked at his bedroom door. Got no answer so walked in, Saw him in bed he must have died during the

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night. The police have been up here, again tonight for me to make a statement & I understand the inquest will be Thursday. Shall you or Mr [John] Turing be coming over[?] I feel so helpless & not able to do anything. The Webbs removed last Wed. & I don't know their new address yet. Mr & Mrs Gibson saw Mr Alan out walking Mon. evening he was perfectly all right then. The weekend before he'd had Mr Gandy over for the weekend & they seemed to have had a really good time. The Mr & Mrs Webb came to dinner Tues. & Mrs Webb had aftern[oon] tea with him Wed. the day she removed.

You do know you have my very deepest sympathy in your great loss & what I can do to help at this end you know I will continue to do so.

Yours respectfully, S. Clayton

This account indicates how the police took charge of the house immediately, leaving open the possibility that there was information in official hands not made public at the inquest. It is now in the archive at King's College.

The police also feature in two valuable letters written by Alan Turing himself to his friend Norman Routledge, and now also in the archive. The first, undated, must be from early 1952:

My dear Norman,

I don't think I really do know much about jobs, except the one I had during the war, and that certainly did not involve any travelling. I think they do take on conscripts. It certainly involved a good deal of hard thinking, but whether you'd be interested I don't know. Philip Hall was in the same racket and on the whole, I should say, he didn't care for it. However I am not at present in a state in which I am able to concentrate well, for reasons explained in next paragraph.

I've now got myself into the kind of trouble that I have always considered to be quite a possibility for me, though I have usually rated it at about 10:1 against. I shall shortly be pleading guilty to a charge of sexual offences with a young man. The story of how it all came to be found out is a long and fascinating one, which I shall have to make into a short story one day, but haven't the time to tell you now. No doubt I shall emerge from it all a different man, but quite who I've not found out.

Glad you enjoyed broadcast. J[efferson] certanly was rather disappointing though. I'm rather afraid that the following syllogism may be used by some in the future

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Turing believes machines think
Turing lies with men
Therefore machines do not think

Yours in distress, Alan.

The allusion to the traditional syllogism about Socrates, who drank the hemlock, is an extraordinary piece of black humour. (It also stands as a superb example of how Turing himself fused the elements of his life.) The opening of the letter is perhaps equally remarkable in its absurdly off-hand description of six years of crucial wartime work, and in its inexplicable statement that the work had not involved any travelling.

The second is dated February 22, and must be from 1953:

My dear Norman

Thanks for your letter. I should have answered it earlier.

I have a delightful story to tell you of my adventurous life when next we meet. I've had another round with the gendarmes, and it's positively round II to Turing. Half the police of N. England (by one report) were out searching for a supposed boyfriend of mine. It was all a mare's nest.

Perfect virtue and chastity had governed all our proceedings. But the poor sweeties never knew this. A very light kiss beneath a foreign flag under the influence of drink, was all that had ever occurred. Everything is now cosy again except that the poor boy has had rather a raw deal I think. I'll tell you all when we meet in March at Teddington. Being on probation my shining virtue was terrific, and had to be. If I had so much as parked my bicycle on the wrong side of the road there might have been 12 years for me. Of course the police are going to be a bit more nosy, so virtue must continue to shine.

I might try to get a job in France. But I've also been having psychoanalysis for a few months now, and it seems to be working a bit. It's quite fun, and I think I've got a good man. 80% of the time we are working out the significance of my dreams. No time to write about logic now!

Ever, Alan

The style is a reminder that whilst Turing's plain-speaking English might be compared with that of Orwell or Shaw, it also had a strong element of P. G. Wodehouse. Both letters perhaps indicate

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a state of denial about the seriousness with which those in charge of the nosy 'sweeties' would contemplate his Euro-adventures.

Alan Turing used logarithms of betting odds as the key to the work he had done for the 'racket' of cryptography, and his sustained fascination with probability is illustrated by that reference to a one-in-ten chance of being caught. In his 1953 stoic humour there is a link with innocent Anti-War undergraduate days of twenty years earlier, when he analysed Alfred Beuttell's Monte Carlo gambling system. While the tectonic forces of geopolitics ground away, Alan Turing dodged his way through as a nimble, insouciant, individual. The lucky streak did not last for ever.

As well as supplying *addenda,* this Preface must also confess to *corrigenda*. Inevitably, a number of errors are perpetuated by reprinting this text. Here are some examples. Note 2.11 severely understates the significance of Turing's work on normal numbers and of his friend David Champernowne's 1933 contribution. It seems possible that Turing's study of such infinite decimals suggested his model of 'computable numbers'. Note 3.40 on Turing's work on the Skewes number is inaccurate: his incomplete manuscript actually dates from about 1950 when he briefly resumed this work, and corresponded briefly with Skewes. Audrey *née* Bates (p. 505) did more interesting and substantial work than is suggested; her Master's thesis involved representing Church's lambda calculus on the Manchester computer, an advanced idea which was never published. This sharpens the point made on the footnote on that page, concerning how Turing failed to turn his vision for programming and logic into the creation of a lively school of research and innovation. One clue to the problems he faced comes from her recollection that 'Max Newman made the immortal statement that "there is nothing to do with computers that merits a Ph.D."' Further additional and corrective material may be found on www.turing.org.uk.

The curious cocktail of topics in this Preface is also offered as an aperitif for the story itself, inviting the reader to travel back over more than a century, and to enter the world of 1911. In making that journey as author, I had the peculiar experience of living a previous life. The strangeness is now doubled since I am as far now removed from that Reagan era as it was from Eisenhower's. The landscape has changed: the science-fiction *2001* in my Author's

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Note has become well-trodden history, and Turing's scientific 'least waste of energy' now has a more urgent meaning. But the Victorian roots I drew upon, one English, one American, need no revision or apology. I chose a setting with the binary classicism of Lewis Carroll's mathematical chessboard, on which Alan Turing was the pawn. But I also imbued it with Whitman's romance of the 'history of the future'. These dreams from the nineteenth century still speak to the crimes and follies of the twenty-first.

1 Martin Davis, *The Universal Computer* (Norton, 2000).
2 Roger Penrose, *The Emperor's New Mind* (OUP, 1989).
3 Richard J. Aldrich, *GCHQ: The Uncensored Story of Britain's Most Secret Intelligence Agency* (Harper, 2010).
4 *The Observer,* 11 November 2011: 'My Hero, Alan Turing'.
5 W. Kozaczuk, tr. C. Kasparek, *Enigma*... (Arms and Armour Press, 1984). The original Polish text was published in Warsaw, 1979.

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PART ONE

The Logical

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1 Esprit de Corps

Beginning my studies the first step pleas'd me so much,
The mere fact consciousness, these forms, the power of motion,
The least insect or animal, the senses, eyesight, love,
The first step I say awed me and pleas'd me so much,
I have hardly gone and hardly wish'd to go any farther,
But stop and loiter all the time to sing it in ecstatic songs.

A son of the British Empire, Alan Turing's social origins lay just on the borderline between the landed gentry and the commercial classes. As merchants, soldiers and clergymen, his ancestors had been gentlemen, but not of the settled kind. Many of them had made their way through the expansion of British interests throughout the world.

The Turings could be traced back to Turins of Foveran, Aberdeenshire, in the fourteenth century. There was a baronetcy in the family, created in about 1638 for a John Turing, who left Scotland for England. *Audentes Fortuna Juvat* (Fortune Helps the Daring) was the motto of the Turings, but however brave, they were never very lucky. Sir John Turing backed the losing side in the English civil war, while Foveran was sacked by the Covenanters. Denied compensation after the Restoration, the Turings languished in obscurity during the eighteenth century, as the family history, the *Lay of the Turings*[1], was to describe:

Walter, and James and John have known,
Not the vain honours of a crown,
  But calm and peaceful life –
Life, brightened by the hallowing store
Derived from pure religion's lore!
And thus their quiet days passed by;
And Foveran's honours dormant lie,

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Till good Sir Robert pleads his claim
To give once more the line to fame:
Banff's castled towers ring loud and high
To kindly hospitality
And thronging friends around his board
Rejoice in TURING's line restored!

Sir Robert Turing brought back a fortune from India in 1792 and revived the title. But he, and all the senior branches of the family, died off without male heirs, and by 1911 there were but three small clusters of Turings in the world. The baronetcy was held by the 84-year-old eighth baronet, who had been British Consul in Rotterdam. Then there was his brother, and his descendants, who formed a Dutch branch of Turings. The junior branch consisted of the descendants of their cousin, John Robert Turing, who was Alan's grandfather.

John Robert Turing took a degree in mathematics at Trinity College, Cambridge, in 1848, and was placed eleventh in rank, but abandoned mathematics for ordination and a Cambridge curacy. In 1861 he married nineteen year old Fanny Boyd and left Cambridge for a living in Nottinghamshire, where he fathered ten children. Two died in infancy and the surviving four girls and four boys were brought up in a regime of respectable poverty on a clerical stipend. Soon after the birth of his youngest son, John Robert suffered a stroke and resigned his living. He died in 1883.

As his widow was an invalid, the care of the family fell upon the eldest sister Jean, who ruled with a rod of iron. The family had moved to Bedford to take advantage of its grammar school, where the two elder boys were educated. Jean started her own school, and two of the other sisters went out as schoolteachers, and generally sacrificed themselves for the sake of advancing the boys. The eldest son, Arthur, was another Turing whom fortune did not help: he was commissioned in the Indian Army, but was ambushed and killed on the North-West Frontier in 1899. The third son Harvey[2] emigrated to Canada, and took up engineering, though he was to return for the First World War and then turn to genteel journalism, becoming editor of the *Salmon and Trout Magazine* and fishing editor of *The Field*. The fourth son Alick became a solicitor. Of the daughters only Jean was to marry: her husband was Sir Herbert Trustram Eve,

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a Bedford estate agent who became the foremost rating surveyor of his day. The formidable Lady Eve, Alan's Aunt Jean, became a moving spirit of the London County Council Parks Committee. Of the three unmarried aunts, kindly Sybil became a Deaconess and took the Gospel to the obstinate subjects of the Raj. And true to this Victorian story, Alan's grandmother Fanny Turing succumbed to consumption in 1902.

Julius Mathison Turing, Alan's father, was the second son, born on 9 November 1873. Devoid of his father's mathematical ability, he was an able student of literature and history, and won a scholarship to Corpus Christi College, Oxford, from where he graduated with a BA in 1894. He never forgot his early life of enforced economy, and typically never paid the 'farcical' three guineas to convert the BA into an MA. But he never spoke of the miseries of his childhood, too proud to moan of what he had left behind and risen above, for his life as a young man was a model of success. He entered for the Indian Civil Service, which had been thrown open to entry by competitive examination in the great liberal reform of 1853, and which enjoyed a reputation surpassing even that of the Foreign Office. He was placed seventh out of 154 in the open examination of August 1895.[3] His studies of the various branches of Indian law, the Tamil language and the history of British India then won him seventh place again in the Final ICS examination of 1896.

He was posted to the administration of the Presidency of Madras, which included most of southern India, reporting for duty on 7 December 1896, the senior in rank of seven new recruits to that province. British India had changed since Sir Robert left it in 1792. Fortune no longer helped the daring; fortune awaited the civil servant who could endure the climate for forty years. And while (as a contemporary writer put it) the district officer was 'glad of every opportunity to cultivate intercourse with the natives', the Victorian reforms had ensured that 'the doubtful alliances which in old days assisted our countrymen to learn the languages' were 'no longer tolerated by morality and society.' The Empire had become respectable.

With the help of a £100 loan from a family friend he bought his pony and saddlery, and was sent off into the interior. For ten years he served in the districts of Bellary, Kurnool and Vizigapatam

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relationship between Mr Turing and the commercial Mr Stoney, with an argument over who was to pay for the wedding carpet rankling for years.) In January 1908 they returned to India, and their first child John was born on 1 September at the Stoney bungalow at Coonoor. Mr Turing's postings then took them on long travels around Madras: to Parvatipuram, Vizigapatam, Anantapur, Bezwada, Chicacole, Kurnool and Chatrapur, where they arrived in March 1911.

It was at Chatrapur, in the autumn of 1911, that their second son, the future Alan Turing, was conceived. At this obscure imperial station, a port on the eastern coast, the first cells divided, broke their symmetry, and separated head from heart. But he was not to be born in British India. His father arranged his second period of leave in 1912, and the Turings sailed *en famille* for England.

This passage from India was a journey into a world of crisis. Strikes, suffragettes, and near civil war in Ireland had changed political Britain. The National Insurance Act, the Official Secrets Act, and what Churchill called 'the gigantic fleets and armies which impress and oppress the civilisation of our time,' all marked the death of Victorian certainties and the extended role of the state. The substance of Christian doctrine had long evaporated, and the authority of science held greater sway. Yet even science was feeling a new uncertainty. And new technology, enormously expanding the means of expression and communication, had opened up what Whitman had eulogised as the *Years of the Modern*, in which no one knew what might happen next – whether a 'divine general war' or a 'tremendous issuing forth against the idea of caste'.

But this conception of the modern world was not shared by the Turings, who were no dreamers of the World-City. Well insulated from the twentieth century, and unfamiliar even with modern Britain, they were content to make the best of what the nineteenth had offered them. Their second son, launched into an age of conflicts with which he would become helplessly entangled, was likewise to be sheltered for twenty years from the consequences of the world crisis.

He was born on 23 June 1912 in a nursing home in Paddington,* and was baptised Alan Mathison Turing on 7 July. His father extended

* Warrington Lodge, now the Colonnade Hotel, Warrington Crescent, London W9. His baptism was at St Saviour's Church, immediately across the road.

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his leave until March 1913, the family spending the winter in Italy. He then returned to take up a new posting, but Mrs Turing stayed on with the two boys, Alan a babe in arms and John now four, until September 1913. Then she too departed. Mr Turing had decided that his sons were to stay in England, so as not to risk their delicate health in the heat of Madras. So Alan never saw the kind Indian servants, nor the bright colours of the East. It was in the bracing sea winds of the English Channel that his childhood was to be spent, in an exile from exile.

Mr Turing had farmed out his sons with a retired Army couple, Colonel and Mrs Ward. They lived at St Leonards-on-Sea, the seaside town adjoining Hastings, in a large house called Baston Lodge just above the sea front. Across the road was the house of Sir Rider Haggard, the author of *King Solomon's Mines*, and once, when Alan was older and dawdling along the gutter in his usual way, he found a diamond and sapphire ring belonging to Lady Haggard, who rewarded him with two shillings.

The Wards were *not* the sort of people who dropped diamond rings in the street. Colonel Ward, ultimately kindly, was remote and gruff as God the Father. Mrs Ward believed in bringing up boys to be real men. Yet there was a twinkle in her eye and both boys became fond of 'Grannie'. In between lay Nanny Thompson, who ruled the nursery which was the boys' proper place, and the governess of the schoolroom. There were other children in the house, for the Wards had no fewer than four daughters of their own, as well as another boy boarder. Later they also took in the Turing boys' cousins, the three children of Major Kirwan. Alan was very fond of the Wards' second daughter Hazel, but hated the youngest Joan, who was intermediate in age between him and John.

Both Turing boys disappointed Mrs Ward, for they scorned fighting and toy weapons, even model Dreadnoughts. Indeed, Mrs Ward wrote to Mrs Turing complaining that John was a bookworm, and Mrs Turing loyally wrote to John chiding him. Walks on the windswept promenade, picnics on the stony beach, games at children's parties, and tea before a roaring fire in the nursery were the most that the Ward environment had to offer in the way of stimulation.

This was not home, but it had to do. The parents came to

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England as often as they could, but even when they did, that was not home either. When Mrs Turing returned in spring 1915, she took the boys into furnished and serviced rooms in St Leonards – gloomy places decorated by samplers embroidered with the more sacrificial kind of hymn. By this time Alan could talk, and proved himself the kind of little boy who could attract the attention of strangers with precocious, rather penetratingly high-pitched comments, but also a naughty and wilful one, in whom winning ways could rapidly give way to tantrums when he was thwarted. Experiment, as with planting his broken toy sailors in the ground, hoping they would grow afresh, was easily confused with naughtiness. Alan was slow to learn that indistinct line that separated initiative from disobedience and resisted the duties of his childhood. Late, untidy and cheeky, he had constant battles with his mother, Nanny and Mrs Ward.

Mrs Turing returned to India in the autumn of 1915, saying to Alan, 'You'll be a good boy, won't you?', to which Alan replied 'Yes, but sometimes I shall forget!' But this separation was only for six months, for in March 1916 Sahib and Memsahib together braved the U-boats, wearing lifebelts all the way from Suez to Southampton. Mr Turing took his family for a holiday in the Western Highlands, where they stayed in a hotel at Kimelfort, and John was introduced to trout fishing. At the end of his leave, in August 1916, they decided not to risk travelling together again, but instead to separate for the next three-year period. Alan's father returned to India, and his mother resumed a double exile at St Leonards.

The Great War had remarkably little direct impact on the Turing family. The year 1917, with the mechanised slaughter, the U-boat siege, the air raids, the appearance of America and the Russian revolution, set up the pattern which was to be the newborn generation's inheritance. But it had no private meaning except in keeping Mrs Turing in England. John was packed off to a preparatory school called Hazelhurst near Tunbridge Wells in Kent in May of that year, and thereafter Mrs Turing had only Alan about her. Church-going was one of her favourite pastimes, and in St Leonards she adopted a certain very high Anglican church, where Alan was dragged every Sunday for the communion service. He did not like the incense, and called it 'the church with the bad smells'. Mrs Turing also pressed on with her water-colours, for which she enjoyed a definite talent.

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She took Alan out on her sketching parties where, with big eyes and sailor hat, and with quaint expressions of his own like 'quockling' for the screech of seagulls, he delighted the lady art students.

Alan taught himself to read in about three weeks from a book called *Reading without Tears*. He was quicker, however, to recognise figures, and had an infuriating habit of stopping at every lamp post to identify its serial number. He was one of those many people without a natural sense of left and right, and he made a little red spot on his left thumb, which he called 'the knowing spot'.

He would say that he wanted to be a doctor when he grew up – an ambition that would have been agreeable to the Turings, for his father would approve of the fees, and his mother of the distinguished clients and the practice of good works. But he could not learn to be a doctor on his own. It was time for some education. And so in the summer of 1918 Mrs Turing sent him to a private day school called St Michael's, to learn Latin.

George Orwell, who was born nine years earlier but likewise to an ICS father, described himself [5] as from 'what you might describe as the lower-upper-middle-class.' Before the war, he wrote:

> you were either a gentleman or not a gentleman, and if you were a gentleman you struggled to behave as such, whatever your income might be... Probably the distinguishing mark of the upper-middle class was that its traditions were not to any extent commercial, but mainly military, official, and professional. People in this class owned no land, but they felt that they were landowners in the sight of God and kept up a semi-aristocratic outlook by going into the professions and the fighting services rather than into trade. Small boys used to count the plum stones on their plates and foretell their destiny by chanting 'Army, Navy, Church, Medicine, Law'.

The Turings were in this position. There was nothing grand about the life of their sons, except perhaps on the few Scottish holidays. Their luxuries were the cinema, the ice rink, and watching the stunt-man dive off the pier on a bicycle. But in the Ward establishment there was an incessant washing away of sins, washing away of smells, to distinguish them from the other children of the town. 'I

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was very young, not much more than six,' recalled Orwell, 'when I first became aware of class-distinctions. Before that age my chief heroes had generally been working-class people, because they always seemed to do such interesting things, such as being fishermen and blacksmiths and bricklayers. . . . But it was not long before I was forbidden to play with the plumber's children; they were "common" and I was told to keep away from them. This was snobbish, if you like, but it was also necessary, for middle-class people cannot afford to let their children grow up with vulgar accents.'

The Turings could afford very little, since even in the well paid ICS it was always necessary to save for the future. What they *had* to afford could be summed up in two words: public school. In this respect the war, the inflation, the talk of revolution changed nothing. The Turing boys had to go to public schools, and everything had to be subordinated to this demand. Never, indeed, would Mr Turing allow his sons to forget the debt they owed him for a public school education. Alan's duty was to go through the system without causing trouble, and in particular to learn Latin, which was required for entrance to a public school.

So as Germany collapsed, and the bitter armistice began, Alan was set to work on copy-books and Latin primers. He later told a joke against his own first exercise, in which he translated 'the table' as *omit mensa* because of the cryptic footnote 'omit' attached to the word 'the'. He was not interested in Latin, and for that matter he had great difficulty in writing. His brain seemed barely coordinated with his hand. A whole decade of fighting with scratchy nibs and leaking fountain-pens was to begin, in which nothing he wrote was free from crossings-out, blots, and irregular script which veered from stilted to depraved.

But at this stage he was still the bright, jolly little boy. On Christmas visits to the Trustram Eves in Earls Court, his uncle Bertie liked making Alan the butt of his practical jokes because of his innocent giggly humour. These occasions were more of a trial for John, who was now considered to be responsible for his younger brother's appearance and behaviour – a responsibility that no human being would ever lightly shoulder. To make matters worse, as John saw it,[6]

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Hazelhurst was a small establishment of thirty-six boys of ages from nine to thirteen, run by the headmaster Mr Darlington, a Mr Blenkins who taught mathematics, Miss Gillett who taught drawing and music of a Moody and Sankey variety, and the Matron. John had loved his time there, and now in his last term was head boy. His younger brother proved to be a thorn in the flesh, for Alan found the Hazelhurst regime a distraction. It 'deprived him of his usual occupations,' as his mother saw it. Now that the whole day was organised into classes, games and meal-times, he had but odd minutes in which to indulge his interests. He arrived with a craze for paper-folding, and when he had shown the other boys what to do, John found himself confronted everywhere with paper frogs and paper boats. Another humiliation followed when Alan's passion for maps was discovered by Mr Darlington. This inspired him to set a geography test to the whole school, in which Alan came sixth, beating his brother, who found geography very boring. On another occasion Alan sat in the back row at a school concert, choking himself with laughter while John sang *Land of Hope and Glory* as a solo.

John left Hazelhurst at Easter for Marlborough, his public school. In the summer, Mr Turing again took the family to Scotland, this time to Lochinver. Alan exercised his knowledge of maps on the mountain paths, and they fished in the loch, Alan now competing with John. The brothers had a good line in non-violent rivalry, as for instance when they played a game to alleviate the awfulness of their grandfather Stoney's visits. This depended upon winning points by leading him on, or heading him away from one of his well-rehearsed club bore stories. And at Lochinver Alan defeated his family in what Mrs Turing considered the rather vulgar after-dinner sport of throwing discarded gooseberry skins as far as possible. Cleverly inflating them, he made them soar over the hedge.

Life when off duty, in this early afternoon of the Empire, could be very agreeable. But in September his parents saw Alan back to Hazelhurst, and as they drove away in their taxi, Alan rushed back along the school drive with arms flung wide in pursuit. They had to bite their lips and sail away to Madras. Alan continued to maintain his detached view of the Hazelhurst regime. He gained average marks in class, and in turn held an unflattering view of the

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instruction. Mr Blenkins initiated his class into elementary algebra, and Alan reported to John, 'He gave a *quite false impression* of what is meant by *x*.'

Although he enjoyed the feeble little plays and debates, he hated and feared the gym class and the afternoon games. The boys played hockey in winter, and Alan later claimed that it was the necessity of avoiding the ball that had taught him to run fast. He did enjoy being linesman, judging precisely where the ball had crossed the line. In an end-of-term sing-song, the following couplet described him:

> Turing's fond of the football field
> For geometric problems the touch-lines yield

Later another verse had him 'watching the daisies grow' during hockey, an image which inspired his mother to a whimsical pencil sketch. And although intended as a joke against his dreamy passivity, there might have been a truth in the observation. For something new had happened.

At the end of 1922, some unknown benefactor had given him a book, called *Natural Wonders Every Child Should Know.*[8] Alan told his mother later that this book had opened his eyes to science. Indeed, it must have been the first time that he became conscious that such a kind of knowledge as 'science' existed. But more than that, it opened the book of life. If anything at all can be said to have influenced him, it was this book which, like so many new things, came from the United States.

The book had first appeared in 1912 and its author, Edwin Tenney Brewster, had described it as

> . . . the first attempt to set before young readers some knowledge of certain loosely related but very modern topics, commonly grouped together under the name, General Physiology. It is, in short, an attempt to lead children of eight or ten, first to ask and then to answer, the question: What have I in common with other living things, and how do I differ from them? Incidentally, in addition, I have attempted to provide a foundation on which a perplexed but serious-minded parent can himself base an answer to several puzzling questions which all children ask – most especially to that most difficult of them all: By what process of becoming did I myself finally appear in this world?

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In other words, it was about sex and science, starting off with 'How the Chicken got inside the Egg', rambling through 'Some Other Sorts of Eggs' until arriving at 'What Little Boys and Girls are Made Of'. Brewster quoted 'the old nursery rhyme' and said that:

> It has this much truth in it, that little boys and little girls are far from being alike, and it isn't worth while trying to make either one over into the other.

The precise nature of this difference was not revealed, and only after a skilful diversion on to the subject of the eggs of starfish and sea-urchins did Brewster eventually arrive back at the human body:

> So we are not built like a cement or a wooden house, but like a brick one. We are made of little living bricks. When we grow it is because these living bricks divide into half bricks, and then grow into whole ones again. But how they find out when and where to grow fast, and when and where to grow slowly, and when and where not to grow at all, is precisely what nobody has yet made the smallest beginning at finding out.

The process of biological growth was the principal scientific theme of E. T. Brewster's book. Yet science had no explanations, only descriptions. In fact on 1 October 1911, when Alan Turing's 'living bricks' were first dividing and redividing, Professor D'Arcy Thompson was telling the British Association that 'the ultimate problems of biology are as inscrutable as of old.'

But equally inscrutable, *Natural Wonders* conspicuously failed to describe where the *first* cell in the human process came from, only dropping the elusive hint that 'the egg itself arose by the splitting of still another cell which, of course, was part of the parent's body.' The secret was left for the 'perplexed but serious-minded parent' to explain. Mrs Turing's way of dealing with the thorny topic was, in fact, highly consonant with Brewster's, for John at least was the recipient at Hazelhurst of a special letter starting with the birds and the bees, and ending with instructions 'not to go off the rails'. Presumably Alan was informed in the same way.

In other ways, however, *Natural Wonders* was indeed 'very modern', and certainly no little 'nature book'. It conveyed the idea that there had to be a reason for the way things were, and that the reason came not from God but from science. Long passages

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explained why little boys liked throwing things and little girls liked babies, and derived from the pattern of the living world the ideal of a Daddy to go out to work at the office and a Mama to stay at home. This picture of respectable American life was rather remote from the training of the sons of Indian civil servants, but more relevant to Alan was a picture of the brain:

> Do you see now why you have to go to school five hours a day, and sit on a hard seat studying still harder lessons, when you would much rather sneak off and go in swimming? It is so that you may build up these thinking spots in your brains. . . . We begin young, while the brain is still growing. With years and years of work and study, we slowly form the thinking spots over our left ears, which we are to use the rest of our days. When we are grown up, we can no more form new thinking places. . . .

So even school was justified by science. The old world of divine authority was reduced to a vague allusion in which Brewster, having described evolution, said that 'why it all happens or what it is all for' was precisely 'one of those things that no fellah can find out.' Brewster's living things were unequivocally *machines*:

> For, of course, the body is a machine. It is a vastly complex machine, many, many times more complicated than any machine ever made with hands; but still after all a machine. It has been likened to a steam engine. But that was before we knew as much about the way it works as we know now. It really is a gas engine; like the engine of an automobile, a motor boat, or a flying machine.

Human beings were 'more intelligent' than the other animals, but were not accorded a mention of 'soul'. The process of cellular division and differentiation was something no one had *yet* begun to understand – but there was no suggestion that it required the interference of angels. So if Alan was indeed 'watching the daisies grow', he could have been thinking that while it looked as though the daisy knew what to do, it really depended upon a system of cells working like a machine. And what about himself? How did *he* know what to do? There was plenty to dream about while the hockey ball whizzed past.

Besides watching the daisies, Alan liked inventing things. On 11 February 1923 he wrote:[9]

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Dear Mother and Daddy,

I have got a lovely cinema kind of thing Micheal* sills gave it to me and you can draw new films for it and I am making a copy of it for you for an easter present I am sending it in another envelope if you want any more films for it write for them there are 16 pictures in each but I worked out that I could draw 'The boy stood at the tea table' you know the Rhyme made up from casabianca I was 2nd this week again. Matron sends her love GB said that as I wrote so thick I was to get some new nibs from T. Wells and I am writing with them now there is a lecture tomorrow Wainwright was next to bottom this week this is my patent ink

There was nothing about science, inventions, or the modern world in the Common Entrance examination – the public school admission test, which was the *raison d'être* of schools like Hazelhurst. *Casabianca* was nearer the mark. In the American *Natural Wonders* everything had to have a reason. But the British system was building different 'thinking spots' – the virtue of Casabianca, the boy on the burning deck, was that he carried out his instructions literally, losing his life in the process.

The masters did their best to discourage Alan's irrelevant interest in science, but could not stop his inventions – in particular, machines to help him in the writing problems that still plagued him:

April 1 (fool's day)

Guess what I am writing with. It is an invention of my own it is a fountain pen like this: – [*crude diagram*] you see to fill it scweeze E ['*squishy end of fountain pen filler*'] and let go and the ink is sucked up and it is full. I have arranged it so that when I press a little of the ink comes down but it keeps on getting clogged.

I wonder if John has seen Joan of Arc's Statue yet coz it is in Rouen. Last monday we had scouts v cubs it was rather exiting there was no weeks order this week I hope John likes Rouen I don't feel much like writing much today sorry. Matron says John sent something.

This provoked another couplet, about a fountain pen that 'leaked enough for four'. Another letter in July, written in green ink which

* Alan's spelling and punctuation, here and throughout, is faithfully reproduced.

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qualities required in a district officer were very different from those of rule-book-keeping and deference to rank. Governing millions of people spread over an area equal to that of Wales called for an independent judgment and force of personality which were less welcome in the more courtly circles of metropolitan Madras. They were certainly little needed in his retirement, in which the busy intrigue of India assumed a retrospective appeal. His remaining years were dogged by a sense of loss, disillusion, and an intense boredom which fishing and bridge parties could never alleviate. He was aggravated by the fact that his younger wife found the return to Europe an opportunity to emerge from the constricting mental atmosphere of Dublin and Coonoor. For he had little regard for her more intellectual ambitions, combined as they were with a rather nervous, fussy domesticity; while she suffered from his obsessive penny-pinching and sense of being betrayed. They were both emotionally demanding, but neither met the other's demands, and they came to communicate in little but planning the garden.

One result of the new arrangement was that Alan now saw some point to learning French, and it became Alan's favourite school subject. But he also liked it as a sort of code, in which he naively wrote a postcard to his mother about *'la revolution'* at Hazelhurst that Mr Darlington was not supposed to be able to read. (The joke was on their Breton maid at Dinard, who often spoke of a socialist revolution being imminent.)

But it was science that entranced him, as his parents discovered when they arrived back to find him clutching *Natural Wonders.* Their reaction was not entirely negative. Mrs Turing's grandfather's second cousin, George Johnstone Stoney (1826–1911), had been a famous Irish scientist whom she had once met as a girl in Dublin. He was best known as the inventor of the word 'electron' which he coined in 1894 before the atomicity of electric charge had been established. Mrs Turing was very proud of having a Fellow of the Royal Society in her family, for ranks and titles made a great impression upon her. She would also show Alan the picture of Pasteur on the French postage stamps, which suggested the prospect of Alan as a benefactor of humanity. Perhaps she recalled that doctor missionary in Kashmir, all those years ago! – but there was also the simple fact that although she herself pressed her ideas into a suitably ladylike

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form, she still represented the Stoneys who had married applied science to the expanding empire. Alan's father, however, could well have pointed out that a scientist could expect no more than £500 a year, even in the Civil Service.

But he also helped Alan in his own way, for when back at school in May 1924 Alan wrote:

> . . . You (Daddy) were telling me about surveying in the train, I have found out or rather read how they find out the heights of trees, widths of rivers, valley's etc. by a combination of both I found out how they find heights of mountains without climbing them.

Alan had also read about how to draw a geographical section, and had added this accomplishment to 'family tree, chess, maps etc. (gennerally my own amusements)'. In the summer of 1924 the family stayed for a time at Oxford – a nostalgic exercise on Mr Turing's part – and then in September they holidayed at a boarding house in North Wales. The parents stayed on awhile when Alan went back by himself to Hazelhurst ('I tipped the porter all right and the taxi too . . . I did not tip the Frant chap but that was not expected of me. Was it?') where he made his own maps of the Snowdonia mountains. ('Will you compare my map with the Ordnance one and send it back.')

Maps were an old interest: family trees he also liked, and the particularly awkward Turing genealogy, with its leaps of the baronetcy from bough to bough and its enormous Victorian families, exercised his ingenuity. Chess was the most social of his activities:

> There was not going to be any Chess Tournament because Mr Darlington had not seen many people playing but he said that if I asked everyone who could play and made a list of everyone who had played this term we would have it. I managed to get enough people so we are having it.

He also found the work in class 1B to be 'much more interesting'. But all this paled before chemistry. Alan had always liked recipes, strange brews and patent inks, and had tried clay-firing in the wood when staying with the Meyers. The idea of chemical processes would not have been strange to him. And in the summer holidays at Oxford, his parents had allowed him to play with a box of chemicals for the first time.

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Natural Wonders did not have much to say about chemistry, except in terms of poisons. A strong defence of Temperance, not to say Prohibition, flowed from Brewster's scientific pen:

> The life of any creature, man, animal or plant, is one long fight against being poisoned. The poisons get us in all sorts of ways . . . like alcohol, ether, chloroform, the various alkaloids, such as strychnin and atropin and cocain, which we use as medicines, and nicotin, which is the alkaloid of tobacco, the poisons of many toadstools, caffein which we get in tea and coffee. . . .

There was another section headed 'Of Sugar and Other Poisons', explaining the effect of carbon dioxide in the blood, causing fatigue, and the action of the brain:

> When the nerve center in the neck tastes a little carbon dioxid, it doesn't say anything. But the moment the taste begins to get strong (which is in less than a quarter minute after one starts running hard) it telephones over the nerves to the lungs:
>
> 'Here, here, here! What is the matter with you fellows. Get busy. Breathe hard. This blood is fairly sizzling with burnt up sugar!'

All this was grist to Alan's mill, although at this point what interested him was the more sober claim that:

> The carbon dioxid becomes in the blood ordinary cooking soda; the blood carries the soda to the lungs, and there it changes to carbon dioxid again, exactly as it does when, as cooking soda, or baking powder, you add it to flour and use it to raise cake.

There was nothing in *Natural Wonders* to explain chemical names or chemical change, but he must have picked up the ideas from somewhere else, for on arriving back at school on 21 September 1924 his letter reminded his parents 'Don't forget the science book I was to have instead of the Children's Encyclopedia,' and also:

> In Natural wonders every child should know it says that the Carbon dioxide is changed to cooking soda in the blood and back to carbon dioxide in the lungs. If you can will you send me the chemical name of cooking soda or the formula better still so that I can see how it does it.

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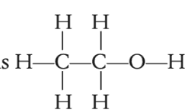
Presumably he had seen the *Children's Encyclopedia*, if only to reject it as too childish and vague, and could well have learnt the basic ideas of chemistry from its multitude of little 'experiments' with household substances. The prophetic spark of enquiry lay in his trying to combine the ideas of chemical formulae on the one hand with the mechanistic description of the body on the other.

Chemistry was not the Turing parents' *forte*, but in November he found a more reliable source of information: 'I have come into great luck here: there is an Encyclopedia that is 1st form property.' And at Christmas 1924 he was given a set of chemicals, crucibles and test-tubes, and allowed to use them in the cellar of *Ker Sammy*, their villa in the Rue du Casino. He heaved great quantities of sea-weed back from the beach in order to extract a minute amount of iodine. This was much to the amazement of John, who with different eyes saw Dinard as an expatriate English colony of the bright 1920s, and spent his time on tennis, golf, dancing and flirting in the Casino. There was an English schoolmaster in the neighbourhood, whom Alan's parents employed to coach Alan for the Common Entrance examination, who found himself plied with questions about science. In March 1925, back at school, Alan wrote:

> I came out in the same place in Common Entrance* this term as last with 53% average. I got 69% in French.

But it was the chemistry that mattered:

> I wonder whether I could get an earthenware retort anywhere for some high-heat actions. I have been trying to learn some Organic Chemistry, when I began if I saw something like this
>
> $$H(CH_2)_{17}CO_2H(CH_2)_2C$$
>
> I would try and work it out like this $C_{21}H_{40}O_2$ which might be all sorts of things it is a kind of oil. I find the Graphic formulae help too, thus Alcohol is
>
> $H(CH_2)_2OH$ or C_2H_6O) is 
>
> while Methyl ether $HCH_2.O.CH_2H$ or C_2H_6O

* These were practice papers

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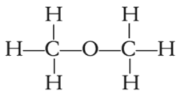
> is 
>
> you see they shew the molecular arrangement.

And then a week later:

> . . . The earthenware retort takes the place of a crucible when the essential product is a gas which is very common at high temperatures. I am making a collection of experiments in the order I mean to do them in. I always seem to want to make things from the thing that is commonest in nature and with the least waste in energy.

For Alan was now conscious of his own ruling passion. The longing for the simple and ordinary which would later emerge in so many ways was not for him a mere 'back to nature' hobby, a holiday from the realities of civilisation. To him it was life itself, a civilisation from which everything else came as a distraction.

To his parents the priorities were the other way round. Mr Turing was not at all the man for airs and graces; a man who would insist on walking rather than take a taxi, there was a touch of the desert island mentality in his character. But nothing altered the fact that chemistry was merely the amusement allowed to Alan on his holidays and that what mattered was that at thirteen he had to go on to a public school. In the autumn of 1925 Alan sat the Common Entrance for Marlborough, and to the surprise of all did rather well. (He had not been allowed to try for a scholarship.) But at this point John played a decisive part in the life of his strange brother. 'For God's sake don't send him here,' he said, 'it will crush the life out of him.'

Alan posed a difficult problem. It was not in question that he must adapt to public school life. But what public school would cater best for a boy whose principal concern was to do experiments with muddy jam jars in the coal cellar? It was a contradiction in terms. As Mrs Turing saw it,[11]

> Though he had been loved and understood in the narrower homely circle of his preparatory school, it was because I foresaw the possible difficulties for the staff and himself at a public school that I was at such pains to find the right one for him, lest if he failed in adaptation to public school life he might become a mere intellectual crank.

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> I am getting more and more settled down. But I won't be quite right until my things come. Fagging starts for us next Teusday. It is run on the same principle as the Gallic councils that tortured and killed the last man to arrive; here one fagmaster calls and all his fags run the last to arrive getting the job. You have to have cold showers in the morning here like cold baths at Marlborough. We have tea at 6.30 here on Mon., Wed., Frid. I manage to go without food from lunch to then. . . . The general strike had a part of it as a printer's strike the result of that is that 'Bennetts' booksellers had none of the books ordered and I am without a lot of them. As in most public schools new boys have to sing some song. The time has not yet come. I am not sure what to sing anyhow it won't be 'buttercup'. . . . The amount of work we are given for Hall here is sometimes absurdly small e.g. Read Acts chapters 3 and 4 and that is for ¾hr.
>
> Yr loving son Alan

There was indeed a song-singing and another ceremony in which he was kicked up and down the day room in a waste paper basket. However, if *his* mother read between the lines, she subordinated sympathy to her sense of duty. Her comment on this letter was that it displayed Alan's 'whimsical sense of humour'.

He was now at last being taught science, and reported:

> We do do Chemistry 2 hrs. a week. We have only got to about the stages of 'Properties of Matter', 'Physical and chemical change' etc. The master was quite amused by my Iodine making and I shewed him some samples. The headmaster is called 'Chief'. I seem to be doing Greek and not Hellenics. . . .

The master, Andrews, was no doubt 'amused' that Alan already knew so much. He had arrived 'delightfully ingenuous and unspoilt'. And the head boy of Westcott House, Arthur Harris, had rewarded Alan's cycling initiative by appointing him his 'fag', or servant. But neither scientific education nor initiative were exactly Sherborne priorities.

The headmaster used to expound the meaning of school life in his sermons.[15] Sherborne was not, he explained, entirely devoted to 'opening the mind', although 'historically . . . this was the primary meaning of school.' Indeed, said the headmaster, there was 'constantly a danger of forgetting the original object of school.' For the English public school had been consciously developed into what

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he called 'a nation in miniature'. With a savage realism, it dispensed with the lip service paid to such ideas as free speech, equal justice and parliamentary democracy, and concentrated upon the fact of precedence and power. As the headmaster put it:

> In form-room and hall and dormitory, on the field and on parade, in your relations with us masters and in the scale of seniority among yourselves, you have become familiar with the ideas of authority and obedience, of cooperation and loyalty, of putting the house and the school above your personal desires . . .

The great theme of the 'scale of seniority' was the balance of privilege and duty, itself reflecting the more worthy side of the British Empire. But this was a theme to which 'opening the mind' came as at best an irrelevance.

The Victorian reforms had made their mark, and competitive examinations played a part in public school life. Those who came as scholars had an opportunity to take on the role of an intelligentsia in the 'nation in miniature', tolerated provided they interfered with nothing that mattered. But Alan, who did not belong to this group, was quick to note the 'absurdly small' amount expected of him. And in fact it was the organised team games of rugby football ('footer') and cricket which for most boys would dominate the years at Sherborne and through which the emotional lessons were taught. Nor had the social changes of the Great War made any difference to the total, introverted, self-conscious system of house life, with its continuous public scrutiny and control of every individual boy. These were the true priorities.

In one respect only a token concession had been made to Victorian reform. There had been a science master at Sherborne since 1873, but this was primarily for the sake of the medical profession. It was not for the Workshop of the World, stigmatised as too mundanely utilitarian in spirit to occupy the time of a gentleman. The Stoneys might build the bridges of the Empire, but it was a higher caste which commanded them. Neither did science enjoy respect for its enquiry, irrespective of usefulness, into truth. Here again the public school had resisted the triumphant claims of nineteenth-century science. Nowell Smith divided the intellectual world into Classical, Modern and Science, in that order, and held that

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> it is only the shallowest mind that can suppose that all the advance of discovery brings us appreciably nearer to the solution of the riddles of the universe which have haunted man from the beginning . . .

Such was the miniature, fossilised Britain, where masters and servants still knew their places, and where the miners were disloyal to their school. And while the boys were playing at being servants, loading the milk churns on to the trains until the strike was broken by the masters of their country, the shallow mind of Alan Turing had arrived in their midst. It was a mind that had no interest in the problems of would-be landowners, empire-builders, or administrators of the white man's burden; they belonged to a system that had no interest in him.

The word 'system', indeed, was one which was a constant refrain, and the system operated almost independently of individual personalities. Westcott House, which Alan joined, had taken its first boarders only in 1920, and yet already existed as though the traditional prefects and 'fags' and beatings in the washroom were laws of nature. This was true even though the housemaster, Geoffrey O'Hanlon, had a mind of his own. Then a bachelor in his forties, and nicknamed (rather snobbishly) Teacher, he had extended the original house building with his own private fortune derived from Lancashire cotton. He personally did not believe in moulding the boys to a common form, and failed to instil the religion of 'footer' with quite the enthusiasm of the other housemasters. His house enjoyed in consequence a dim reputation for 'slackness'. He encouraged music and art, disliked bullying, and stopped the song-singing initiation soon after Alan arrived. A Catholic classicist, he was the nearest thing to a liberal government in the 'nation in miniature'. Yet the system prevailed, in all but details. One could conform, rebel, or withdraw – and Alan withdrew.

'He appears self-contained and is apt to be solitary,' commented O'Hanlon.[16] 'This is not due to moroseness, but simply I think to a shy disposition.' Alan had no friend, and at least once in this year he was trapped underneath some loose floorboards in the house day-room by the other boys. He tried to continue chemistry experiments there, but this was doubly hated, as showing a swottish mentality, and producing nasty smells. 'Slightly less dirty and untidy in his habits,' wrote O'Hanlon at the end of 1926, 'rather more conscious

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of a duty to mend his ways. He has his own furrow to plough, and may not meet with general sympathy: he seems cheerful, though I'm not always certain he really is so.'

'His ways sometimes tempt persecution: though I don't think he is unhappy. Undeniably he is not a "normal" boy: not the worse for that, but probably less happy,' he wrote somewhat inconsistently at the end of the spring term of 1927. The headmaster commented more briskly:

> He should do very well when he finds his *métier*; but meanwhile he would do much better if he would try to do his best as a member of this school – he should have more *esprit de corps.*

Alan was not what Brewster called a 'proper boy', whose instincts, inherited from thousands of years of warfare, made him want to throw things at other people. In this respect he was more like his father, who had managed to escape games as a boy in Bedford. Mr Turing, who lacked his wife's excessive respect for schoolmasters, made a special request for Alan to be excused from cricket, and he was allowed by O'Hanlon to play golf instead. But he made himself 'a drip' by letting down his house contingent at the gym with his 'slackness'. He was also called *dirty*, thanks to his rather dark, greasy complexion, and a perpetual rash of ink stains. Fountain pens still seemed to spurt ink whenever his clumsy hands came near them. His hair, which naturally fell forward, refused to lie down in the required direction; his shirt moved out of his trousers, his tie out of his stiff collar. He still seemed unable to work out which coat button corresponded to which buttonhole. On the Officers Training Corps parade on Friday afternoons, he stood out with cap askew, hunched shoulders, ill-fitting uniform with puttees like lampshades winding up his legs. All his characteristics lent themselves to easy mockery, especially his shy, hesitant, high-pitched voice – not exactly stuttering, but hesitating, as if waiting for some laborious process to translate his thoughts into the form of human speech.

Mrs Turing saw the fulfilment of her worst fear, which was that Alan would not adapt to public school life. Nor was he the kind of boy who was unpopular in the house but pleased the masters in class. He failed there too. In his first term, he had been placed in a form called 'the Shell', with boys a year older than himself who

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were not good at the work. Then he was 'promoted', but only to the entrance form for those supposed of average ability. Alan took little notice. The masters streamed past – seventeen in those first four terms – and none understood the dreaming boy in a class of twenty-two. According to a classmate of the period:[17]

> he was the cruel butt of at least one master because he always managed to get ink on his collar so that the master could raise an easy laugh by saying 'Ink on your collar again, Turing!' A small and petty thing but it stuck in my mind as an example of how a sensitive and inoffensive boy . . . can have his life made hell at public school.

Reports were issued twice a term, and the unopened envelopes would lie accusingly on the breakfast table, while Mr Turing 'fortified himself with a couple of pipes and *The Times*.' Alan would say, unconvincingly, 'Daddy expects school reports to be like after-dinner speeches,' or 'Daddy should see some of the other boys' reports.' But Daddy was not paying for the other boys, and was seeing the hard-won fees disappear without detectable effect.

Daddy did not mind his divergences from conventional behaviour, or at least regarded them with an amused tolerance. In fact both John and Alan took after their father, all three believing in speaking their mind and applying their ideas with a determination punctuated by moments of recklessness. Within the family, the voice of public opinion was supplied by Mama, whose tastes and judgments were thought insipidly provincial by the others. It was she, not her husband nor John, who felt called upon to reform Alan. However, Mr Turing's tolerance did not extend to the waste of a precious public school education. His finances were particularly tight at this point. He had finally tired of exile, and had taken a small house on the edge of Guildford in Surrey, but besides paying income tax he now had to launch John on a career. He had dissuaded his son from the ICS, predicting that the 1919 reforms, introducing Indian representation into provincial government, spelt the beginning of the end. John had spiritedly thought of going into publishing instead, and his father's pet idea was that he should go to South America to make money out of guano, but in the end it was Mrs Turing's safer suggestion that he should be a solicitor which won. Mr Turing was obliged to pay £450 for his son to be articled and to support him for five years.

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He had his own kind of seriousness. The headmaster's words would more appropriately have been directed at the outward conformity that Alec Waugh had written about:

> As is the case with most boys, Confirmation had very little effect on Gordon. He was not an atheist; he accepted Christianity in much the same way as he accepted the Conservative party. All the best people believed in it, so it was bound to be right; but at the same time it had not the slightest influence over his actions. If he had any religion at this time it was House football . . . .

These were strong words for a book which had appeared in 1917 when Shirburnians were being sacrificed at the rate of one a week. It was because of such remarks that *The Loom of Youth* was forbidden at Sherborne, and any boy found with it was subject to an immediate beating.

Yet the renegade author had said little more, although in different language, than was revealed by the headmaster:

> Mind you, I am not attacking the Public School system. I believe in its enormous value, above all in the sense of duty and the loyalty and the law-abidingness which it inculcates. But it cannot escape the dangers attendant upon any system of discipline, the dangers of submitting to mere routine, of adopting ready-made sentiments at second-hand, of a slavish, or perhaps I should rather say a sheepish, want of independence of character.

'The system cannot escape these dangers,' he continued, 'but we individuals . . . can overcome them if we set the right way about it.' It was, however, very difficult for individuals to go against the grain of a total organisation. As Nowell Smith said, 'of all societies very few are so definite and easily understood as a school like this . . . we all here live under a common life, under a common discipline. Our life is organised with great thoroughness, and the organisation is directed to a definite aim. . . .' And the headmaster further observed that 'schoolboys, however much originality they may possess as individuals, are in their conduct to the highest degree conventional.' Nowell Smith was not a small-minded man and somehow managed to reconcile this system of education with his love of Wordsworth's poetry, of which he was an editor. Within the classicist there beat a romantic heart, and one which perhaps troubled him.

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But the problem of inspiring 'independence of character' within a system of 'mere routine' arose principally in connection with what was called 'dirty talk', rather than with the more elevated questions treated by the romantic consciousness. The headmaster called upon individuals to show their true patriotism to Sherborne by avoiding it, and appealed to the boy of independent character, who

> brought up in a civilised home, has an instinctive dislike of swearing and coarse jokes and vulgar innuendoes, and yet from sheer cowardice will conceal his dislike, and perhaps force a laugh, and even begin to learn the vile jargon!

In an all-male school there was only one kind of 'vulgar innuendo' possible. Contact between the boys was fraught with sexual potential, a fact which was reflected in the effective ban on associations between boys of different houses, or of different ages. These bans, and the 'gossip' or 'scandal' associated with them, were not part of the *official* life of a public school, but were no less real for that. Nowell Smith might condemn the fact that there was 'one kind of language suitable for home or for a master's ears, and another kind for the study or the dormitory,' but it was a fact of school life. *Natural Wonders* explained that

> We say commonly that we think with our brains. That is true; but it is by no means the whole story. The brain has two halves, just alike, exactly as the body has. In fact, the two sides of the brain are even more precisely alike than the two hands. Nevertheless, we do all our thinking with one side only.

It was Alec Waugh's accusation that Sherborne provided a training in – metaphorically speaking – using two halves of the brain independently. 'Thinking', or rather official thinking, went on in one hemisphere, and ordinary life in the other. It was not hypocrisy: it was that no one in his senses would confuse the two worlds. It worked very well, and only went wrong when something happened to bridge the gap. Then, as Waugh said with some feeling, the real crime was to be found out.

In 1927 the school had changed somewhat in its unofficial conventions. When the boys read *The Loom of Youth* (as of course they did, because it was forbidden) they were rather surprised at the tolerance shown, or at least suggested, of sexual friendships. When

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the games teams met their counterparts from other public schools, they were amazed at the latitude allowed at the rival establishments. Sherborne boys were at this period asserting a more puritanical, less cynical orthodoxy than that of Alec Waugh's 1914. Nowell Smith was no longer appealing to the independent boys to stamp out what he called 'filth'. But he had not prevented the chemical messages from flowing in four hundred budding 'living apothecary shops', and not even the cold baths had put a stop to 'dirty talk'.

Alan Turing was a boy of independent character, but this subject presented him with a problem which was the opposite of the headmaster's. To most boys 'scandal' would be a quickly-forgotten bantering, alleviating the monotony of school. But to him, it touched the centre of life itself. For although he had surely learnt by now about the birds and the bees, his heart was to be elsewhere. The secret of how the babies were born was hidden well, but everyone knew there *was* a secret. He, however, had been made aware by Sherborne of a secret that in the outside world was not even supposed to exist. And it was *his* secret. For he was drawn by love and desire not only to 'the commonest in nature', but to his own sex.

He was a serious person, and not what Alec Waugh called 'the average boy'. He was not 'in the highest degree conventional', and he was suffering for it. For him there had to be a reason for everything; it had to make sense – and to make one sense, not two. But Sherborne was no help to him in this respect, except in making him more conscious of himself. To be independent he had to work his way through official and unofficial rules alike, and there were certainly no 'ready-made sentiments' for him. At Sherborne the two natural wonders of his life were 'Stinks' and 'Filth'.

If Nowell Smith sometimes had reservations about the public school system, no such doubts assailed Alan's form-master in the autumn of 1927, a certain A. H. Trelawny Ross. A man schooled at Sherborne, who had returned there immediately from Oxford in 1911, he learnt nothing and forgot nothing in his thirty years as a housemaster.[18] A stern foe of 'slackness', he shared none of the headmaster's qualms about slavishness. His style of English

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also contrasted with that of Nowell Smith, his 1928 'house letter' commencing thus:

> I have a bone to pick with my Captain of the Dayroom (height 4′11″). He has been telling people I am a woman-hater. This fib was started some years ago by a dame who did not find me gushing enough. My view actually is that a woman-hater has a mental kink, just as a female man-hater has, of whom there are plenty about. . . .

A narrow nationalist, who had not properly learnt the lesson of loyalty to school as well as to house, Ross was little interested in his form. However, he gave them the benefit of his knowledge and experience of life. He taught Latin translation for a week, Latin prose for a week, and English for a week, this consisting of spelling, 'how to start, write, and address a letter,' 'how to make a précis,' 'how a sonnet is built up, and by a typed summary of the main points, to show how to get good sensible, well-arranged written essays.'

In this respect Ross urged his sensible opinion that, 'As democracy advances, manners and morals recede', and urged the staff to read *The Rising Tide of Colour.* He held that the defeat of Germany had come about 'because she thought that Science and materialism were stronger than religious thought and observance.' He called the scientific subjects 'low cunning', and would sniff and say, 'This room smells of mathematics! Go out and fetch a disinfectant spray!'

Alan used the time on something he found more interesting. Ross caught him doing algebra during time devoted to 'religious instruction', and wrote at half-term:

> I can forgive his writing, though it is the worst I have ever seen, and I try to view tolerantly his unswerving inexactitude and slipshod, dirty, work, inconsistent though such inexactitude is in a utilitarian, but I cannot forgive the stupidity of his attitude towards sane discussion on the New Testament.
>
> He ought not to be in this form of course as far as form subjects go. He is ludicrously behind.

In December 1927, Ross placed him bottom in both English and Latin, attaching to the report an inky, blotted page which clearly indicated the negligible amount of energy conceded by Alan to the deeds of Marius and Sulla. Yet even Ross tempered his complaint with the comment 'I like him personally'. O'Hanlon wrote of his

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'saving sense of humour'. At home, Alan's messy experiments might be tiresome, but he had a jolly way of coming out with scientific facts, and of telling jokes against his own clumsiness, naive and free from showing off, that it was hard not to like. He was certainly foolish in not making life easier for himself; lazy and perhaps arrogant in supposing he knew what was good for him; but he was not so much obstreperous as bewildered by demands which had nothing to do with his interests. Nor did he complain at home about Sherborne, for he seemed to regard it as the fact of life which indeed it was.

Anyone might like him personally, but as part of a system it was a very different story. At Christmas 1927 the headmaster wrote:

> He is the kind of boy who is bound to be rather a problem in any kind of school or community, being in some respects definitely anti-social. But I think in our community he has a good chance of developing his special gifts and at the same time learning some of the art of living.

With that judgment Nowell Smith suddenly retired, perhaps not sorry to relinquish the contradictions of his community, and the problem of Alan Turing's independent character.

The new year of 1928 marked a period of change for Sherborne. Nowell Smith's successor was a C. L. F. Boughey, who had been an assistant master at Marlborough. By chance, the headmaster's departure had coincided with the death of Carey, the school games master. Between them, as 'Chief' and 'The Bull', the two had divided the Sherborne world into *mens* and *corpus*, and ruled them respectively for twenty years. Carey was succeeded in his role by that bulldog figure Ross.

It also marked a change for Alan. His housemaster asked Blamey, an earnest and also rather isolated boy a year older than Alan, to share a two-boy study with him. Blamey was to try to make Alan more tidy, to 'help him conform, and try and show him there were other things in life besides mathematics.' In the first objective there was a lamentable failure; in the second he came up against the difficulty that Alan 'had wonderful concentration, and would become absorbed in some abstruse problem.' Blamey would consider it his duty to 'interrupt and say it is time to go to chapel, to games, or afternoon classes' as the case might be, he being a

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regarded as subsidiary. Nor was Alan promoted to the sixth form immediately; he was held back in the fifth for the autumn of 1928, but allowed to join the sixth form for their mathematics classes. These were taught by a young master, Eperson, just a year down from Oxford and a gentle, cultured person, the kind of master who would constantly be played up by the boys. Here was the chance for the system to redeem itself at last, the spirit breaking through the letter of the law. And in a negative way, Eperson did what Alan wanted, by leaving him alone:[21]

> All that I can claim is that my deliberate policy of leaving him largely to his own devices and standing by to assist when necessary, allowed his natural mathematical genius to progress uninhibited . . .

He found that Alan always preferred his own methods to those supplied by the text book, and indeed Alan had gone his own way all the time, making few concessions to the school system. During the machinations over the School Certificate, or even before, he had been studying the theory of relativity from Einstein's own popular account.[22] This employed only elementary mathematics, but gave full rein to ideas which went far beyond anything in the school syllabus. For if *Natural Wonders* had introduced him to the post-Darwinian world, Einstein took him into the twentieth-century revolution of physics. Alan produced a small red Memo Book of notes, which he gave to his mother.

'Einstein here throws doubt,' Alan commented, 'on whether Euclid's axioms, when applied to rigid bodies, hold . . . . He therefore sets out to test . . . the Galilei-Newtonian laws or axioms.' He had identified the crucial point, that Einstein *doubted the axioms.* Not for Alan the 'obvious duties', for nothing was obvious to him. His brother John, who by now regarded Alan with a rather patronising, but not hostile amusement, held that

> You could take a safe bet that if you ventured on some self-evident proposition, as for example that the earth was round, Alan would produce a great deal of incontrovertible evidence to prove that it was almost certainly flat, ovular, or much the same shape as a Siamese cat which had been boiled for fifteen minutes at a temperature of one thousand degrees Centigrade.

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Cartesian doubt came as an incomprehensible intrusion into Alan's family and school environment, an intrusion that the English coped with more by laughter than by persecution. But doubt being a very difficult and rare state of mind, it had taken the whole intellectual world a very long time to ask whether the 'Galilei-Newtonian laws or axioms', apparently 'self-evident', were actually true. Only by the late nineteenth century was it recognised that they were inconsistent with the known laws of electricity and magnetism. The implications were frightening, and it had needed Einstein to take the step of saying that the assumed basis of mechanics was actually *incorrect*, thereby creating the Special Theory of Relativity in 1905. This then proved inconsistent with Newton's laws of gravity, and to remove these contradictions Einstein had gone even further, casting doubt even on Euclid's axioms of space to create the General Theory of Relativity in 1915. The point of what Einstein had done did not lie in this or that experiment. It lay, as Alan saw, in the ability to doubt, to take ideas seriously, and to follow them to a logical if upsetting conclusion. 'Now he has got his axioms,' wrote Alan, 'and is able to proceed with his logic, discarding the old ideas of time, space, etc.'

Alan also saw that Einstein avoided philosophical discussions of what space and time 'really were', and instead concentrated on something that could in principle be done. Einstein placed great emphasis on 'rods' and 'clocks' as part of an *operational* approach to physics, in which 'distance', for instance, only had meaning in terms of some well-defined measuring operation, not as an absolute ideal. Alan wrote:

> It is meaningless to ask whether the two p[oin]ts are always the same distance apart, as you stipulate that that distance is your unit and your ideas have to go by that definition. . . . These ways of measuring are really conventions. You modify your laws to suit your method of measurement.

No respecter of persons, he preferred a piece of working of his own to that supplied by Einstein 'because in this way I think it should seem less "magicky".' He reached the very end of the book, and gave a masterly derivation of the law* which in General Relativity would supplant Newton's axiom, that a body subject to no external force would move in a straight line with constant speed:

* Usually called 'the law of geodesic motion'.

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> He has now got to find the general law of motion for bodies. It will have, of course, to satisfy the general Principle of Relativity. He does not actually give the law, which I think is a pity, so I will. It is: 'The separation between any two events in the history of a particle shall be a maximum or minimum when measured along its world line.'
>
> To prove it, he brings in the Principle of Equivalence, which says that: 'Any natural gravitational field is equivalent to some artificial one.' Suppose then that we substitute an artificial field for the natural one. Now as the field is artificial there is some system at that p[oin]t which is Galileian, and as it is Galileian the particle will be moving uniformly relative to it, i.e. it has a straight world line relatively to it. Straight lines in Euclidean space have always a maximum or minimum length between two p[oin]ts. Therefore the world line satisfies the conditions given above for one system, therefore it satisfies it for all.

As Alan explained, Einstein had not stated this law of motion in his popular account. Alan might just possibly have guessed it for himself. On the other hand, he could very well have found it in another work which was published in 1928, and which he was reading by 1929 – *The Nature of the Physical World* by Sir Arthur Eddington. Professor of Astronomy at Cambridge, Eddington had worked on the physics of the stars and the development of the mathematical theory of relativity. This influential book, however, was one of his popular works, in which he set out to convey the great change in the scientific world-picture that had taken place since 1900. Its rather impressionistic account of relativity did state the law of motion, although without proof, and might have supplied its form to Alan. Certainly, in one way or another, Alan had done more than study a book, for he had put several ideas together for himself.

This study arose out of his own initiative, and Eperson did not know about it. He was thinking quite independently of his environment, which offered him little but nagging and scolding. He had had to look to his totally bewildered mother for a little encouragement. But then something new happened to put him into contact with the world.

There was a boy in another house – Ross's house, in fact – whose name was Morcom. As yet he was nothing but 'Morcom' to Alan, although later[23] he became 'Christopher'. Alan had first noticed

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Christopher Morcom early in 1927, and had been very struck by him, partly because he was surprisingly small for his form. (He was a year older than Alan and a year ahead in the school, but fair-haired and slight.) It was also, however, because he 'wanted to look again at his face, as he felt so attracted.' Later in 1927 Christopher had been away from school and then had returned looking, Alan noticed, very thin in the face. He shared with Alan a passion for science, but he was a very different person. The institutions that were for Alan such stumbling-blocks had been for Christopher Morcom the instruments of almost effortless advance, the source of scholarships, prizes and praise. He again returned late to school this term, but when he arrived Alan was waiting for him.

His utter loneliness was pierced at last. It was difficult to make friends with an older boy from another house. Nor was Alan good at conversation. But he found an *entrée* in mathematics. 'During the term Chris and I began setting one another our pet problems and discussing our pet methods.' It would be impossible to separate the different aspects of thought and feeling. This was first love, which Alan would himself come to regard as the first of many for others of his own sex. It had that sense of surrender ('worshipped the ground he trod on'), and a heightened awareness, as of brilliant colour bursting upon a black and white world. ('He made everyone else seem so ordinary.') At the same time, it was most important that Christopher Morcom was someone who took scientific ideas seriously. And gradually, though always with considerable reserve, he took Alan seriously. ('My most vivid recollections of Chris are almost entirely of the kind things he said to me sometimes.') So these elements were all present, and had the effect of giving Alan reason to communicate.

Before and after Eperson's classes Alan might talk to Christopher about relativity, or might show him other pieces of work. He had, for example, calculated π to thirty-six decimal places at about this time, perhaps making use of his own series for the inverse tangent function, and being much annoyed to find an error in the last decimal place. After a time, Alan found another opportunity to see Christopher. By accident he discovered that during a certain period on Wednesday afternoons set for private study, Chris went to the library and not to his house. (Ross did not allow boys to work unsupervised, fearing

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the sexual potential in unregulated associations.) 'I so enjoyed Chris' company there,' wrote Alan, 'that ever since I always used to go to the library instead of my study.'

Yet another chance arose through the gramophone society which the progressive Eperson had started. Christopher, a fine piano player, was a keen member. Alan had little interest in music, but sometimes on Sunday afternoons he would go to Eperson's lodgings with Blamey (who also had a gramophone and records in their shared study). There he could sit and steal glances at Christopher while the 78's played out their disjointed versions of the great symphonies. This was, incidentally, part of Blamey's noble effort to show Alan that there were other things in life besides mathematics. He also showed Alan how to make a crystal wireless receiver out of basic materials, having noticed that Alan had little pocket money for such things. Alan insisted on winding the coils for the variometer and was delighted to find that his clumsy hands had made something that actually worked, even if he could never aspire to rival Christopher's dexterity.

At Christmas, Eperson reported:

> This term has been spent, and the next two terms will have to be spent, in filling in the many gaps in his knowledge and *organising* it. He thinks very rapidly and is apt to be 'brilliant' but unsound in some of his work. He is seldom defeated by a problem, but his methods are often crude, cumbersome and untidy. But thoroughness and polish will no doubt come in time.

He would have found the Higher Certificate dull stuff, compared with the job of organising Einstein. But he cared more about his own failure to fit in with what was expected, now that Christopher had done 'hopelessly better' in the test at the end of term. In the new year of 1929 there was another shuffle, and Alan joined the sixth form proper, so that he did all his classes with Christopher. He made a point of sitting next to him in every class right from the start. Christopher, Alan wrote,

> made some of the remarks I was afraid of (I know better now) about the coincidence but seemed to welcome me in a passive way. It was not long before we began doing experiments together in Chemistry and we were continually changing our ideas on all sorts of subjects.

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The examiner for the mathematics of the Higher Certificate[24] commented that:

> A. M. Turing showed an unusual aptitude for noticing the less obvious points to be discussed or avoided in certain questions and for discovering methods which would at once shorten or illumine the solutions. But he appeared to lack the patience necessary for careful computation of algebraic verification, and his handwriting was so bad that he lost marks frequently – sometimes because his work was definitely illegible, and sometimes because his misreading his own writing led him into mistakes. His mathematical ability was not of a standard to compensate entirely for the cumulative effects of these faults.

Alan obtained 1033 marks in the mathematics papers, compared with Christopher's 1436.

The Morcoms were a wealthy, vigorous scientific and artistic family, with a base in a Midlands engineering firm. They had developed a Jacobean dwelling near Bromsgrove in Worcestershire into a large country house, the Clock House, where they lived in some style. Christopher's grandfather had been an entrepreneur in stationary steam engines, and the Birmingham company of Belliss and Morcom, of which his father, Colonel Reginald Morcom, had recently become chairman, now also built steam turbines and air compressors. Christopher's mother was the daughter of Sir Joseph Swan, who starting from a very ordinary background had become in 1879 the inventor, independently of Edison, of the electric light. Colonel Morcom retained an active interest in scientific research, while Mrs Morcom matched his energy in her own pursuits. At the Clock House she ran a goat farm; she bought and renovated cottages in the neighbouring village of Catshill; she was out every day on some project or county duty. She had studied in London at the Slade School of Art, and in 1928 returned there, taking a flat and a studio near Victoria, and producing sculpture of force and style. It was typical of her flair and zest that when back at the Slade she still pretended to be 'Miss Swan', but then invited other art students back to the Clock House, involving herself in absurd disguises when she doubled as Mrs Morcom.

Rupert Morcom, the elder son, had entered Sherborne in 1920, and had won a scholarship in science to Trinity College, Cambridge;

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he was now engaged in research at the Technische Hochschule in Zurich. Like Alan he was an avid experimenter, but one with the advantage that his parents had been able to construct a laboratory for him at home. His younger brother, who also had the use of the laboratory, now told Alan of all this, exciting great envy.

In particular, Christopher told Alan about an experiment that Rupert had taken up before going to Cambridge in 1925. It concerned a chemical effect which Andrews often used to draw the interest of the younger boys. By chance it involved Alan's old favourite, iodine. Solutions of iodates and sulphites, when mixed, would result in the precipitation of free iodine, but in a rather striking way. Alan later explained: 'It is a beautiful experiment. Two solutions are mixed in a beaker and after waiting for some very definite period of time, the whole suddenly becomes a deep blue. I have known it take a time, 30 secs., and then turn blue in 1/10 of a sec. or less.' Rupert had been investigating not the easy problem of working out the recombination of ions, but that of explaining this time delay. It required a knowledge of physical chemistry, and an understanding of differential equations, both beyond the school syllabus. Alan wrote:

> Chris and I wanted to find a relation between the time and the concentrations of the solutions and thereby verify Rupert's theories. Chris had already done some experiments upon it. We were looking forward very much to the experiment. The results unfortunately did not agree with theory and I made more experiments during the following holidays and invented a new theory. I sent the results to him and so we started to write to one another in the holidays.

He did more than write to Christopher – he invited him to Guildford. Ross, as housemaster, would have been horrified by this audacious step.[25] Christopher replied[26] (after some delay) on 19 August:

> . . . Before getting on to experiments I must thank you very much for your invitation to come and stay with you, but I am afraid I shall not be able to come as we are going away somewhere, probably abroad for about three weeks, just at that time . . . I am sorry not to be able to come; it is very kind of you to ask me.

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As for the iodates, new ventures at the Clock House had rendered them definitely *passé*. There were experiments to measure air resistance, liquid friction, another problem in physical chemistry with Rupert ('I enclose the integral which you might like to try'), plans for a twenty foot long reflecting telescope, and

> . . . So far all I have done is to make an adding machine for pounds and ounces. It works surprisingly well. I think I have given up Maths for these holidays, having just read a very good book on Physics in general including relativity.

Alan laboriously copied the ingenious experiment on air resistance that Christopher had devised and wrote back with more ideas about chemistry and a mechanics problem, only for Christopher to pour cold water on both in a letter of 3 September:

> I haven't studied your conical pendulum carefully but I can't so far understand you're [*sic*] method. Incidentally I believe you're equations of motion have a mistake in them. . . .
> I am now helping my brother analyse American plasticine for an artist. . . . The procedure is to boil with organic solvents. . . . I made a quite good plasticine and very nearly like the stuff we want, by mixing this iron soap with flowers of sulphur . . . and adding a little mutton fat. Hope you are having good holidays; see you on 21st, Yrs, C. C. Morcom.

But chemistry had now given way to astronomy, to which Christopher had introduced Alan earlier in the year. Alan had been given Eddington's *Internal Constitution of the Stars* by his mother for his seventeenth birthday, and had also acquired a 1½-inch telescope. Christopher had a four-inch telescope ('He never tired of talking about his wonderful telescope if he thought one was interested') and had been given a star atlas for his eighteenth birthday. Besides astronomy, Alan was also reading deep into *The Nature of the Physical World*, for in his letter[27] of 20 November 1929 there was a paraphrase of part of its account:

> Schrödinger's quantum theory requires 3 dimensions for every electron he considers. Of course he does not believe that there are really about 10^{70} dimensions, but that this theory will explain the behaviour of an electron. He thinks of 6 dimensions, or 9, or whatever it may be without forming

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> any mental picture. If you like you can say that for every new electron you introduce these new variables analogous to the coordinates of space.

This came from Eddington's description of that other change in fundamental physical concepts, one much more mysterious than relativity. The quantum theory had done away with the billiard-ball corpuscles and the ethereal waves of the nineteenth century, and replaced both by entities which had characteristics both of particles and of waves; lumpy but nebulous.

Eddington had a lot to say, for the 1920s had been a decade of rapid advance in theoretical physics, following up the spate of discoveries at the turn of the century. In 1929 Schrödinger's formulation of the quantum theory of matter was only three years old. The two boys also read books by Sir James Jeans, the other Cambridge astronomer, and here too there were entirely new developments. It had only just been established that some nebulae were clouds of gas and stars on the margins of the Milky Way, and that others were completely separate galaxies. The mental picture of the universe had expanded a millionfold. Alan and Christopher discussed these ideas and 'usually didn't agree', wrote Alan, 'which made things much more interesting.' Alan kept 'some pieces of paper with Chris' ideas in pencil and mine in ink scrawled all over them. We even used to do this during French.'

The date 28/9/29 appeared on them, and so did the official work:

> Monsieur . . . recevez monsieur mes salutations empresseés*
> Cher monsieur . . . Veuillez agréer I'expression des mes sentiments distingués
> Cher ami . . . Je vous serre cordialement la main . . . mes affectueux souvenirs . . . votre affectioné

but also there were generalised noughts and crosses, a reaction involving iodine and phosphorus, and a diagram which suggested doubting Euclid's axiom that for every line there would be exactly one parallel line passing through a given point.

Alan kept these pages, as *souvenirs affectueux*, although he could never express his *sentiments distingués.* As for *serrer cordialement la main*, or more – that was probably pretty firmly repressed in his mind, although soon he would write: 'There were times when I felt

* This piece of work was marked 'Nine wrong genders. 5/25. Very poor.'

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his personality particularly strongly. At present I am thinking of an evening when he was waiting outside the labs, and when I came too, he grasped me with his big hand and took me out to see the stars.'

Alan's father was delighted, if amazed, when the reports began to change their tone. His interest in mathematics was confined to the calculation of income tax, but he was proud of Alan, and so was John, who admired him for taking on the system and getting away with it. There had been a method in his madness all along. Unlike his wife, Mr Turing never claimed to have the faintest idea of what his son was doing, and this was the theme of a punning couplet that Alan once read out from his father's letter in his study:

I don't know what the *'ell 'e meant*
But that is what *'e said 'e meant* !

Alan seemed quite happy with this bluff and trusting ignorance. Mrs Turing, however, took the more accusing line of 'I told you so,' and made a good deal of the idea that her choice of school had been the right one. She had certainly paid a certain amount of attention to Alan, and it had not all been in the direction of moral improvement, for she liked to feel that she understood his love of science.

Alan was now in a position to think of winning a scholarship to university, a scholarship representing not only merit but a reasonable income, almost enough to live on as an undergraduate. An exhibition, awarded to second-class candidates, would mean significantly less. Christopher, now eighteen, was expected to win a Trinity College scholarship like his brother. It was ambitious of Alan to attempt the same at seventeen. In mathematics and science, Trinity held the highest reputation among the colleges of the university which was itself, after Göttingen in Germany, the scientific centre of the world.

The public schools were good at putting candidates through the daunting procedure for entrance scholarships to the ancient universities, and Sherborne also gave Alan a £30 per annum subsidy. But there was no automatic red carpet laid down. The scholarship examinations were distinguished by questions of an open-ended, imaginative kind, without a published syllabus. They gave a taste of future life. To Alan this was an excitement in itself, but there was more than this to stimulate his ambition. There was Christopher, who would so shortly be leaving Sherborne; there was some muddle

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The results were published on 18 December in *The Times*, just after term ended. It was a Great Crash. Christopher had won a Trinity scholarship, and Alan had not. Writing in congratulation, Alan had a letter in return with a particularly friendly tone:

20/12/29

Dear Turing,

Thank you very much for your letter. I was as sorry you did not get a schol as I was pleased that I did. What Mr Gow says means that you would have certainly got an Exhibition if you had put it down . . .

. . . Have had two of the clearest nights I have known. I have never seen Jupiter better and I could see 5 or 6 belts and even some detail on one of the large central belts. Last night I saw no. I satellite come out from eclipse. It appeared quite suddenly (during a few seconds) at some distance from Jupiter and looked very attractive. It is the first time I have seen one. I also saw Andromeda Neb. very clearly but did not stay out long. Saw spectrum of Sirius, Pollux and Betelgeux and also bright line spectrum of Orion nebula. Am at moment making a spectrograph. Will write again later. Happy Christmas etc. Yrs ever C. C. M.

Anything like 'making a spectrograph' was far beyond the resources Alan enjoyed at Guildford, but he got hold of an old spherical glass lampshade, filled it with plaster of Paris, covered it with paper (which made him think about the nature of curved surfaces) and set out to mark in the constellations of fixed stars. Typically, he insisted on doing it from his own observation of the night sky, although it would more easily and accurately have been done from an atlas. He trained himself to wake at four o'clock in the morning so that he could mark in some stars not visible in the December evening sky, thus waking up his mother, who thought she had heard a burglar. This done, he wrote to Christopher about it, also asking him whether he thought it would be advisable to try for a college other than Trinity next year. If this was a test of affection, he was again rewarded, for Christopher replied:

5/1/30

Dear Turing,

. . . I really can't give you any advice about exams because it is nothing to do with me and I feel it would not be quite write [*sic*]. John's is a very

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good College, but of course I should prefer personally that you came to Trinity where I should see more of you.

I should be very interested to see your star map when it is done but I suppose it is quite impracticable to bring it to school or anything. I have often wanted to make a star globe, but have never really bothered, especially now I have got the star atlas going down to 6th mag. . . .

Recently I have been trying to find Nebulae. We saw some quite good ones the other night, one very good planetary in Draco 7th mag. 10″. Also we have been trying to find a Comet 8th mag. in Delphinus . . . . I wonder if you will be able to get hold of a telescope to look for it with your 1½″ will be useless for such a small object. I tried to compute its orbit but failed miserably with 11 unsolved equations and 10 unknowns to be eliminated.

Have been getting on with plasticine. Rupert has been making horrid smelling soaps and fatty acids from . . . Rape Oil and Neal's Boot Oil. . . .

This letter was written from his mother's flat in London, where he was 'to see the dentist . . . and also to avoid a dance at home.' Next day he wrote again from the Clock House:

. . . I found the Comet at once in its assigned position. It was much more obvious and interesting than I had expected . . . I should say it is nearly 7th mag. It . . . should be obvious in your telescope. The best way is to learn the 4th & 5th mag. stars by heart, and move slowly to the right place, never losing sight of *all* the known stars. . . . In about half an hour I shall look again if it is clear (it has just clouded) and see if I can notice its motion among the stars and also see what it looks like with the powerful eyepiece (×250). The group of 5 4th mag. stars in Delphinus come into the field of the finder in pairs. Yrs. C. C. Morcom.

But Alan had already seen the comet, though in a more haphazard manner

10/1/30

Dear Morcom,

Thank you very much for the map for finding the comet. On Sunday I think I must have seen it. I was looking at Delphinus and thinking it was Equuleus and saw something like this [*a tiny sketch*] rather hazy and about 3′ long. I am afraid I did not examine it very carefully. I then looked for the comet elsewhere in Vulpecula thinking it was Delphinus. I knew from the

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> *Times* that there was a comet in Delphinus that day.
>
> . . . The weather really is annoying for this comet. Both on Wednesday and today I have had it quite clear until sunset and then a bank of cloud comes over the region of Aquila. On Wednesday it cleared away just after the comet had set. . . .
>
> Yours A. M. Turing
>
> Please don't always thank me for my letters so religeously. I'll let you thank me for writing them legibly (if I ever do) if you like.

Alan plotted the course of the comet, as it sped from Equuleus into Delphinus in the frosty heavens. He took the primitive star globe back to school to show to Christopher. Blamey had left at Christmas, and Alan now had to share another study, in which the inky sphere was poised. There were but few constellations marked in, but they amazed the younger boys with Alan's erudition.

Three weeks into the term, on 6 February, some visiting singers gave a concert of sentimental part-songs. Alan and Christopher were both present, and Alan was watching his friend, trying to tell himself, 'Well, this isn't the last time you'll see Morcom.' That night he woke up in the darkness. The abbey clock struck; it was a quarter to three. He got out of bed and looked out of the dormitory window to look at the stars. He often used to take his telescope to bed with him, to gaze at other worlds. The moon was setting behind Ross's house, and Alan thought it could be taken as a sign of 'goodbye to Morcom'.

Christopher was taken ill in the night, at just that time. He was taken by ambulance to London, where he underwent two operations. After six days of pain, at noon on Thursday 13 February 1930, he died.

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2 The Spirit of Truth

I sing the body electric,
The armies of those I love engirth me and I engirth them,
They will not let me off till I go with them, respond to them,
And discorrupt them, and charge them full with the charge of the soul.
Was it doubted that those who corrupt their own bodies conceal
    themselves?
And if those who defile the living are as bad as they who defile the
    dead?
And if the body does not do fully as much as the soul?
And if the body were not the soul, what is the soul?

No one had told Alan that Christopher Morcom had contracted bovine tuberculosis from drinking infected cows' milk as a small boy; it had set up a pattern of internal damage, and his life had been constantly in danger. The Morcom family had gone to Yorkshire in 1927 to observe the total eclipse of the sun on 29 June, and Christopher had been taken terribly ill in the train coming back. He had undergone an operation, and that was why Alan had been struck by his thin features when he returned to school late that autumn.

'Poor old Turing is nearly knocked out by the shock,' a friend wrote from Sherborne to Matthew Blamey next day. 'They must have been awfully good friends.' It was both less and more than that. On his side, Christopher had at last been becoming friendly, rather than polite. But on Alan's side – he had surrendered half his mind, only to have it drop into a void. No one at Sherborne could have understood. But on the Thursday that Christopher died, 'Ben' Davis, the junior housemaster, did send to Alan a note telling him to prepare for the worst. Alan immediately wrote[1] to his mother, asking her to send flowers to the funeral, which was held on the Saturday, at dawn. Mrs Turing wrote back at once and suggested that Alan himself write to Mrs Morcom. This he did on the Saturday.

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15/2/30

Dear Mrs Morcom,

I want to say how sorry I am about Chris. During the last year I worked with him continually and I am sure I could not have found anywhere another companion so brilliant and yet so charming and unconceited. I regarded my interest in my work, and in such things as astronomy (to which he introduced me) as something to be shared with him and I think he felt a little the same about me. Although that interest is partly gone, I know I must put as much energy if not as much interest into my work as if he were alive, because that is what he would like me to do. I feel sure that you could not possibly have had a greater loss.

Yours sincerely, Alan Turing

I should be extremely grateful if you could find me sometime a little snapshot of Chris, to remind me of his example and of his efforts to make me careful and neat. I shall miss his face so, and the way he used to smile at me sideways. Fortunately I have kept all his letters.

Alan had awoken at dawn, at the time of the funeral:

I am so glad the stars were shining on Saturday morning, to pay their tribute as it were to Chris. Mr O'Hanlon had told me when it was to take place so that I was able to follow him with my thoughts.

Next day, Sunday, he wrote again, perhaps in more composed form, to his mother:

16/2/30

Dear Mother,

I wrote to Mrs Morcom as you suggested and it has given me a certain relief. . . .

. . . I feel sure that I shall meet Morcom again somewhere and that there will be some work for us to do together, and as I believed there was for us to do here. Now that I am left to do it alone I must not let him down but put as much energy into it, if not as much interest, as if he were still here. If I succeed I shall be more fit to enjoy his company than I am now. I remember what G O'H said to me once 'Be not weary of well doing for in due season ye shall reap if ye faint not' and Bennett* who is very kind on these occasions

* John Bennett was a boy in the house, who himself died later in 1930 on a lone winter trek across the Rockies.

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chairman of Powell Dyffryn, the Welsh mining company. Mrs Morcom wrote in her diary:

> . . . Sailed about noon. Wonderful day with bright sunshine until 3.30 when we began to come into mist and slowed down. Before tea we dropped anchor and remained just outside the mouth of the Thames until midnight. Ships all around us blowing fog-horns and sounding bells. . . . Rupert and Alan very excited about the fog and it really is rather alarming.

Alan shared a cabin with Rupert, who did his best to draw him out on Jeans and Eddington, but found Alan very shy and hesitant. Each night before going to sleep, Alan spent a long time looking at the photograph. On the first morning of the voyage, Alan began to talk to Mrs Morcom about Christopher, releasing his feelings in speech for the first time. The next day, after deck tennis with Rupert, was spent the same way, telling her how he had felt attracted to Christopher before getting to know him, about his presentiments of catastrophe and the moon setting. ('It is not difficult to explain these things away – but, I wonder!') On Monday, as they rounded Cape Vincent, Alan showed her the last letters he had received from Christopher.

They only spent four days on the Peninsula, driving over the hairpin bends to Granada where, it being Holy Week, they saw a religious procession in the starlight. On Good Friday they were back in Gibraltar and embarked on a homebound liner the next day. Alan and Rupert took early Communion on board ship on Easter Sunday.

Rupert was by now impressed with Alan's originality of thought, but he did not think of Alan as in a different class from the Trinity mathematicians and scientists he had known. Alan's future seemed unsure. Should he read science or mathematics at Cambridge? Was he sure of a scholarship at all? Somewhat in terms of a last resort, he spoke to Evan Williams about scientific careers in industry. Williams explained the problems of the coal industry, for instance the analysis of coal-dust for toxicity, but Alan was suspicious of this and remarked to Rupert that it might be used to cheat the miners by flourishing a scientific certificate at them.

They had done the trip in style, staying at the best hotels, but what Alan wanted most was to visit the Clock House. Mrs Morcom sensed this and gracefully asked him to 'help' her look through Christopher's papers and sort them. So on the Wednesday, Alan

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went to her studio in London, and then after a visit to the British Museum joined her on the Bromsgrove train. For two days he saw the laboratory, the uncompleted telescope, the goats (they had replaced the guilty cow) and everything Christopher had told him about. He had to go home on Friday, 25 April, but surprised Mrs Morcom by coming up to London the next day, presenting her with a parcel of Christopher's letters. On the Monday he wrote:

28/4/30

Dear Mrs Morcom,

I am only just writing to thank you for having me on your trip and to tell you how much I enjoyed it. I really don't think I have had such a jolly time before, except that wonderful week at Cambridge with Chris. I must thank you too for all the little things belonging to Chris that you have let me have. It means a great deal to me to have them . . . .

Yours affectionately, Alan

I was so glad you let me come on to the Clockhouse. I was very much impressed with the house and everything connected with it, and was very pleased to be able to help putting Chris' things in order.

Mrs Turing had also written:

27/4/30

Dear Mrs Morcom,

Alan got home last night looking so well and happy – He loved his time with you but specially precious to him was the visit to the Clockhouse: he went off to Town today to see someone but he said he would tell me of that part another day – and I knew he meant that it was an experience quite apart. We've had no real talk yet but I am sure it has helped him to exchange memories with you and he is treasuring with the tenderness of a woman the pencils and the beautiful star map and other souvenirs you gave him. . . .

I hope you won't think it an impertinence – but after our talk and your telling me how true to his name Chris was – and I believe is – in helping the weak – I thought how beautiful it would be to have a panel in his memory of S. Christopher in the School Chapel – a panel of your doing, and what an inspiration it would be for the boys who are so reminded that there are the followers of S. Christopher today and that genius and humble service can go hand in hand as in Chris. . . .

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Mrs Morcom had already put into effect a similar idea. She had commissioned a stained-glass window of St Christopher – not however for Sherborne, but for their parish church at Catshill. Nor was it the 'humble service' of Mrs Turing that it was to express, but the life that went on. Back at school, Alan wrote to Mrs Morcom:

3/5/30

> . . . I am hoping to do as well as Chris in the Higher Certificate this term. I often think about how like I am to Chris in a few ways through which we became real friends, and wonder if I am left to do something that he has been called away from.

Mrs Morcom had also called upon Alan to help choose books for the school prizes that Christopher was posthumously to receive:

> I think Chris would almost certainly have got *The Nature of the Physical World* (Eddington) and *The Universe around us* (Jeans) for the Digby prize and possibly one of *The Internal Constitution of the Stars* (Eddington), *Astronomy and Cosmogony* (Jeans). I think you would like *The Nature of the Physical World*.

The Morcom family endowed a new prize at Sherborne, a science prize to be awarded for work which included an element of originality. Alan had plodded on with the iodate experiment, and now he undertook to write it up for the prize. Christopher it was, even from the grave, who induced him to communicate and to compete. He wrote to his mother:

18 May 1930

> . . . I have just written to a Mellor the author of a Chemistry book to see if he can give me a reference about the experiment I was doing in the summer last year. Rupert said he would look it up in Zurich if I could get him a reference. It's annoying I couldn't get hold of anything before.

Alan was also interested in perspective drawing:

> This week's efforts in drawing are not on any better paper . . . I don't think much really of Miss Gillet's efforts. I remember she did once or twice say something in a vague sort of way about parallel lines being drawn concurrent, but she usually had the slogan 'vertical lines remain vertical' on the tip of her tongue. I wonder how she managed drawing things below

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> her. I have not been doing much by way of drawing bluebells and things like that but mostly perspective.

Mrs Turing wrote to Mrs Morcom:

> May 21 1930
>
> . . . Alan has taken up drawing which I was anxious for him to do long ago: I think this is quite likely an inspiration from you. He is quite devoted to you and I think he was just wishing for an excuse to pay you a call when he went up to Town the day after saying 'Goodbye' to you! You were all most awfully good to him, and in many ways opened up a new world to him . . . . Whenever we were alone he wanted to talk just of Chris and you and Col. Morcom and Rupert.

Alan hoped this summer to gain an improved mark in the Higher Certificate. His name was put down for Pembroke College, Cambridge, which awarded a number of scholarships on Higher Certificate marks alone, although he half-hoped to fail, so that he would have a chance of trying for Trinity. He did fail for he found the mathematics paper much more difficult than in the previous year, and his marks showed no improvement. But Eperson reported:

> . . . I think he has succeeded in improving his style of written work, which is more convincing and less sketchy than last year . . .

and Gervis:

> He is doing much better work than this time last year partly because he knows more but chiefly because he is getting a more mature style.

Andrews was presented with Alan's submission for the new Morcom science prize, and later said:[2]

> I first realised what an unusual brain Alan had when he presented me with a paper on the reaction between iodic acid and sulphur dioxide. I had used the experiment as a 'pretty' demonstration – but he had worked out the mathematics of it in a way that astonished me . . .

The iodates won him the prize. 'Mrs Morcom is extraordinarily nice and the whole family is extremely interesting,' Alan wrote to Blamey. 'They have founded a prize in Chris' memory which I very appropriately won this year.' He also wrote:

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> I have started learning German. It is possible that I may be made to go to Germany sometime during next year but I don't much want to. I am afraid I would much rather stay and hibernate in Sherborne. The worst of it is that most of the people left in Group III nauseate me rather. The only respectable person in it since February has been Mermagen and he doesn't do Physics seriously or Chemistry at all.

The master who taught him German wrote: 'He does not seem to have any aptitude for languages.' It was not what he wanted to think about in his hibernation.

One Sunday that summer, the boys of Westcott House arrived back from their afternoon walks to find Alan, who was by now accorded a certain awed respect, engaged upon an experiment. He had set up a long pendulum in the stairwell, and was checking that, as the day went on, the plane of its motion would remain fixed while the Earth rotated beneath it. It was only the elementary Foucault pendulum experiment, such as he might have seen in the Science Museum in London. But it caused great astonishment at Sherborne, and made an impression second only to his arrival by bicycle in 1926. Alan also told Peter Hogg that it had to do with the theory of relativity, which ultimately it did: one problem that concerned Einstein was how the pendulum kept its place fixed relative to the distant stars. How did the pendulum know about the stars? Why should there be an absolute standard of rotation, and why should it agree with the disposition of the heavens?

But if the stars still exerted their attraction, Alan also had to work out his thoughts about Christopher. Mrs Morcom had asked him in April to write his recollections of her son for an anthology. Alan found this task very hard to fulfil:

> My impressions of Chris that I have been writing for you seem to have become more a description of our friendship than anything else so I thought I would write it as such for you and write something less to do with me that you could print with the others.

In the end he would make three attempts but every one of them strayed from manly detachment, too honest to disguise his feelings. The first pages were sent off on 18 June, and explained:

> My most vivid recollections of Chris are almost entirely of the kind things he said to me sometimes. Of course I simply worshipped the ground he

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> my companions were splitting our sides with laughter. What happened was Turing on his back stroke had knocked down some tea making crockery belonging to prefects, he did this on two consecutive strokes and from the noise we could all tell what was going on in the washroom, the third and final stroke did not connect with crockery as by that time it was lying shattered on the floor.

Much more upsetting, his diary,[4] which he kept under lock, was taken and damaged by another boy. There was, however, a limit to what Alan would take:[5]

> Turing . . . was quite a lovable creature but rather sloppy in appearance. He was a year or more older than me, but we were quite good friends.
>
> One day I saw him shaving in the washroom, with his sleeves loose and his general appearance rather execrable. I said, in a friendly way, 'Turing, you look a disgusting sight.' He seemed to take it not amiss, but I tactlessly said it a second time. He took offence and told me to stay there and wait for him. I was a bit surprised, but (as the house washroom was the place for beatings) I knew what to expect. He duly re-appeared with a cane, told me to bend over and gave me four. After that he put the cane back and resumed his shaving. Nothing more was said; but I realised that it was my fault and we remained good friends. That subject was never mentioned again.

But apart from the important matters of 'Discipline, self-control, the sense of duty and responsibility', there was Cambridge to think about:

> 2/11/30
>
> Dear Mrs Morcom,
>
> I have been waiting to hear from Pembroke to write to you. I heard indirectly a few days ago that they will not be able to give me a scholarship. I was rather afraid so; my marks were spread too evenly amongst the three subjects. . . . I am full of hope for the December exam. I like the papers they give us there so much better than the Higher Certificate ones. I don't seem though to be looking forward to it like I was last year. If only Chris were there and we were to be up there for another week together.
>
> Two of my books for the 'Christopher Morcom' prize have come. I had great fun yesterday evening learning some of the string figures out of 'Mathematical Recreations' . . . I have been made a school prefect this term, to my great surprise as I wasn't even a house-prefect last term. Last

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> term they started having at least two in each house which rather accounts for it.
>
> I have just joined a Society here called the Duffers. We go (if we feel inclined) every other Sunday to the house of some master or other and after tea someone reads a paper he has written on some subject. They are always very interesting. I have agreed to read a paper on 'Other Worlds'. It is now about half written. It is great fun. I don't know why Chris never joined.
>
> Mother has been out to Oberammergau. I think she enjoyed it very much but she has not told me much about it yet . . .
>
> Yours affectionately, A. M. Turing

Alan's elevation to School Prefect was a great comfort to his mother. But much more significant was a new friendship in his life.

There was a boy three years younger than Alan in the house, Victor Beuttell, who was also one who neither conformed, nor rebelled, but dodged the system. He also, like Alan, was labouring under a grief that no one knew about, for his mother was dying of bovine tuberculosis. Alan saw her when she came to visit Victor, himself in great peril with double pneumonia, and asked what was wrong. It struck a terrible chord. Alan also learnt something else that few knew, which was that Victor had been caned so severely by a prefect in another house that his spine had been damaged. This turned him against the beating system, and he never caned Victor (who was frequently in trouble), but passed him on to another prefect. The link between them was one of compassion, but it developed into friendship. Though at odds with the axioms of the public school, which normally would forbid boys of different ages from spending time together, a special dispensation from O'Hanlon, who kept a card index on the boys' activities and watched closely over them, allowed it to continue.

They spent a good deal of time playing with codes and ciphers. One source of ideas might have been the *Mathematical Recreations and Essays*,[6] which Alan had chosen as Christopher Morcom Prize, and which indeed had served a generation of school prize-winners since it appeared in 1892. The last chapter dealt with simple forms of cryptography. The scheme that Alan liked was not a very mathematical one. He would punch holes in a strip of paper, and supply Victor with a book. Poor Victor had to plod through the pages until he found one where through the holes in the strip appeared

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letters that spelt out a message such as HAS ORION GOT A BELT. By this time, Alan had passed on his enthusiasm for astronomy to Victor, and had explained the constellations to him. Alan also showed him a way to construct Magic Squares (also from *Mathematical Recreations*), and they played a lot of chess.

As it happened, Victor's family was also linked with the Swan electric light industry, for his father, Alfred Beuttell, had made a small fortune by inventing and patenting the Linolite electric strip reflector lamp in 1901. The lamp was manufactured by Swan and Edison, while Mr Beuttell, who had broken away from his own father's business in carpet wholesaling, acquired further experience as an electrical engineer. He had also enjoyed a fine life until the First World War, flying, motor racing, sailing, and gambling successfully at Monte Carlo.[7]

A very tall, patriarchal figure, Alfred Beuttell dominated his two sons, of whom Victor was the elder. In his character Victor took more after his mother, who in 1926 had published a curious pacifist, spiritualist book. He combined her bright-eyed, rather magical charm, with his father's strong good looks. In the 1920s Alfred Beuttell had gone back into research into lighting, and in 1927 had taken out patents on a new invention, the 'K-ray Lighting System'. It was designed to allow uniform illumination of pictures or posters. The idea was to frame a poster in a glass box, whose front surface would be curved in such a way that it reflected light from a strip light at the top exactly evenly over the poster. (Without such a reflection, the poster would be much brighter at the top than at the bottom.) The problem was to find the right formula for the curvature of the glass. Alan was introduced to the problem by Victor, and suddenly produced the formula, without being able to explain it, which agreed with Alfred Beuttell's calculation. But Alan went further, and pointed out the complication which arose through the thickness of the glass, which would cause a second reflection at the front surface. This made necessary a change in the curve of the K-ray System, which was soon put into application for exterior hanging signs, the first contract being with J. Lyons and Co. Ltd, the catering chain.

It was characteristic. As with the iodate and sulphite calculation, it always delighted Alan that a mathematical formula could actually work in the physical world. He had always liked practical

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demonstrations, even though he was not good at them, and although pushed into the corner as the intellectual 'maths brain', did not make the error of considering thought as sullied or lowered by having a concrete manifestation.

There was a parallel development, in that he did not permit the Sherborne 'games' religion to instil in him a contempt for the body. He would have liked to have been as successful with *corpus* as with *mens*, and found the same difficulties with both: a lack of coordination and ease of expression. But he had discovered by now that he could run rather well. He would come in first place on the house runs, when rainy weather obliged the cancellation of all-important Footer. Victor would go out with him for runs, but after two miles or so would say 'It's no good, Turing, I shall have to go back', only to find Alan overtaking him on the return from a much longer course.

Running suited him, for it was a self-sufficient exercise, without equipment or social connotations. It was not that he had sprinting speed, nor indeed much grace, for he was rather fiat-footed, but he developed great staying power by forcing himself on. It was not important to Sherborne, where what mattered was that (to Peter Hogg's surprise) he became a 'useful forward' in the house team. But it was noticed with admiration by Knoop, and it was certainly important to Alan himself: He was not the first intellectual to impose this kind of physical training upon himself, and to derive lasting satisfaction from proving his stamina in running, walking, cycling, climbing, and enduring the elements. It was part of his 'back to nature' yearnings. But necessarily there were other elements involved; he perceived tiring himself out by running as an alternative to masturbation. It would probably be hard to overestimate the importance to his life of the conflicts surrounding his sexuality from this time onwards – both in controlling the demands of his body, and in a growing consciousness of emotional identity.

In December it was the same arrival at Waterloo, on the way to Cambridge, but no trip to Mrs Morcom's studio. Instead his mother and John (now an articled clerk in the City) were there to meet him, and Alan said he would go and see Howard Hughes' aerial film *Hell's Angels*. At Cambridge he failed again to win a Trinity scholarship. But his greater confidence was not entirely misplaced, for he was elected

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to a scholarship at the college of his second choice, King's. He was placed eighth in order of the Major Scholars, with £80 per annum.*

Everyone congratulated him. But he had set himself to *do something*, something that Christopher had been 'called away from'. For a person with a mathematical mind, an ability to deal with very abstract relations and symbols as though with tangible everyday objects, a King's scholarship was a demonstration like sight-reading a sonata or repairing a car – clever and satisfying, but no more. Many had won better scholarships, and at an earlier age. More to the point than the word 'brilliant' which now came to schoolmasters' lips was the couplet that Peter Hogg sang at the house supper:

> Our Mathematician comes next in our lines
> With his mind deep in Einstein – and study light fines.

For he had thought deeply about Einstein and had broken the rules to do so.

Alan hibernated for two more terms – it was the usual thing. There was not much in the way of temporary employment in the conditions of 1931. By now he had settled upon mathematics rather than science as his future course at Cambridge. In February 1931 he acquired G. H. Hardy's *Pure Mathematics*, the classic work with which university mathematics began. He took the Higher Certificate for a third time, this time with mathematics as major subject, and at last gained a distinction. He also entered again for the Morcom prize and won it. This time it came with a Prize Record Book, which Alan wrote 'was most fascinatingly done and bears such a spirit of Chris in the clear bright illumination.' The Morcoms had commissioned it in a contemporary neo-mediaeval style, which stood out sharply from the fusty Sherborne background.

In the Easter holiday, on 25 March, he went on a walking and hitch-hiking trip with Peter Hogg (a keen ornithologist) and an older boy, George Maclure. On their way from Guildford to Norfolk they spent one night in a working men's hostel, which suited Alan, indifferent to anything more fancy (though it shocked his mother). One day, rather typically, he walked on by himself while the other

* For comparison: a skilled worker earned about £160 per annum; unemployment benefit ran at £40 per annum for a single man.

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whenever he chose. His room could be as muddled and as untidy as he liked, so long as he made his peace with the college servants. He might be disturbed by Mrs Turing, who would scold him for the dangerous way he cooked breakfast on the gas ring. But these interruptions were very occasional, and after this first year Alan saw his parents only on fleeting visits to Guildford. He had gained his independence, and was at last left alone.

But there were also the university lectures, which on the whole were of a high standard; the Cambridge tradition was to cover the entire mathematics course with lectures which were in effect definitive textbooks, by lecturers who were themselves world authorities. One of these was G. H. Hardy, the most distinguished British mathematician of his time, who returned in 1931 from Oxford to take up the Sadleirian Chair at Cambridge.

Alan was now at the centre of scientific life, where there were people such as Hardy and Eddington who at school had been only names. Besides himself, there were eighty-five students who thus embarked upon the mathematics degree course, or 'Tripos' as Cambridge had it, in 1931. But these fell into two distinct groups: those who would offer Schedule A, and those who would sit for Schedule B as well. The former was the standard honours degree, taken like all Cambridge degrees in two Parts, Part I after one year, and Part II two years later. The Schedule B candidates would do the same, but in the final year they would also offer for examination an additional number – up to five or six – of more advanced courses. It was a cumbersome system, which was changed the following year, the Schedule B becoming 'Part III'. But for Alan Turing's year it meant neglecting study for Part I, which was something of a historical relic, hard questions on school mathematics, and instead beginning immediately on the Part II courses, leaving the third year free to study for the advanced Schedule B papers.

The scholars and exhibitioners would be expected to offer Schedule B, and Alan *par excellence* was among them, one of those who could feel themselves entering another country, in which social rank, money and politics were insignificant, and in which the greatest figures, Gauss and Newton, had both been born farm boys. David Hilbert, the towering mathematical intellect of the previous thirty years, had put it thus:[9] 'Mathematics knows no races . . . for

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mathematics, the whole cultural world is a single country', by which he meant no idle platitude, for he spoke as the leader of the German delegation at the 1928 international congress. The Germans had been excluded in 1924 and many refused to attend in 1928.

Alan responded with joy to the absolute quality of mathematics, its apparent independence of human affairs, which G. H. Hardy expressed another way:[10]

> 317 is a prime, not because we think so, or because our minds are shaped in one way rather than another, but *because it is so*, because mathematical reality is built that way.

Hardy was himself a 'pure' mathematician, meaning that he worked in those branches of the subject independent not only of human life, but of the physical world itself. The prime numbers, in particular, had this immaterial character. The emphasis of pure mathematics also lay upon absolutely logical deduction.

On the other hand, Cambridge also laid emphasis on what it called 'applied' mathematics. This did not mean the application of mathematics to industry, economics or the useful arts, there being in English universities no tradition of combining high academic status with practical benefits. It referred instead to the interface of mathematics and physics, generally physics of the most fundamental and theoretical kind. Newton had developed the calculus and the theory of gravitation together, and in the 1920s there had been a similar fertile period, when it was discovered that the quantum theory demanded techniques which were miraculously to be found in some of the newer developments of pure mathematics. In this area the work of Eddington, and of others such as P. A. M. Dirac, placed Cambridge second only to Göttingen, where much of the new theory of quantum mechanics had been forged.

Alan was no foreigner to an interest in the physical world. But at this point, what he needed most was a grip on rigour, on intellectual toughness, on something that was absolutely right. While the Cambridge Tripos – half 'pure' and half 'applied' – kept him in touch with science, it was to pure mathematics that he turned as to a friend, to stand against the disappointments of the world.

Alan did not have many other friends – particularly in this first year, in which he still mentally belonged to Sherborne. The King's

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scholars mostly formed a self-consciously élite group, but he was one of the exceptions. He was a shy boy of nineteen, who had had an education more to do with learning silly poems by rote, or writing formal letters, than with ideas or self-expression. His first friend, and link with the others of the group, was David Champernowne, one of the other two mathematical scholars. He came from the mathematical sixth form of Winchester College, where he had been a scholar, and was more confident socially than Alan. But the two shared a similar 'sense of humour', being alike unimpressed by institutions or traditions. They also shared a hesitancy in speech, although David Champernowne's was more slight than Alan's. It was and remained a rather detached, public school kind of friendship, but important to Alan was that 'Champ' was not shocked by unconventionality. Alan told him about Christopher, showing him a diary that he had kept of his feelings since the death.

They would go to college tutorials together. To begin with, it was a case of Alan catching up, for David Champernowne had been much better taught, and Alan's work was still poorly expressed and muddled. Indeed, his friend 'Champ' had the distinction of publishing a paper[11] while still an undergraduate, which was more than Alan did. The two supervisors of mathematics at King's were A. E. Ingham, serious but with a wry humour, the embodiment of mathematical rigour, and Philip Hall, only recently elected a Fellow, under whose shyness lay a particular friendly disposition. Philip Hall liked taking Alan, and found him full of ideas, talking excitedly in his own strange way, in which his voice went up and down in pitch rather than in stress. By January 1932 Alan was able to write in an impressively off-hand way:

> I pleased one of my lecturers rather the other day by producing a theorem, which he found had previously only been proved by one Sierpinski, using a rather difficult method. My proof is quite simple so Sierpinski* is scored off.

But it was not all work, because Alan joined the college Boat Club. This was unusual for a scholar, for the university was stuck with the polarising effect of the public schools, and students were

* W. Sierpinski, a prominent twentieth-century Polish pure mathematician.

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supposed to be either 'athletes' or 'aesthetes'. Alan fitted into neither category. There was also the other problem of mental and physical balance, for he fell in love again, this time with Kenneth Harrison, who was another King's scholar of his year, studying the Natural Sciences Tripos. Alan talked to him a good deal about Christopher, and it became clear that Kenneth, who also had fair hair and blue eyes, and who also was a scientist, had become a sort of reincarnation of his first great flame. One difference, however, was that Alan did speak up for his own feelings, as he would never have dared with Christopher. They did not meet with reciprocation, but Kenneth admired the straightforwardness of his approach, and did not let it stop them from talking about science.

At the end of January 1932, Mrs Morcom sent back to Alan all the letters between him and Christopher which he had surrendered to her in 1931. She had copied them out – quite literally – in facsimile. It was the second anniversary of his death. Mrs Morcom sent a card asking him to dinner on 19 February at Cambridge, and he in turn made the arrangements for her stay. It was not the most convenient weekend, he being engaged with the Lent boat races and obliged to be abstemious at dinner. But Alan found time to show her round: Mrs Morcom noted that his rooms were 'very untidy', and they went on to see where Alan and Christopher had stayed in Trinity for the scholarship examination, and where Mrs Morcom imagined Christopher would have sat in Trinity chapel.

In the first week of April, Alan went to stay at the Clock House again, this time with his father. Alan slept in Christopher's sleeping bag. They all went together to see the window of St Christopher, now installed in Catshill parish church, and Alan said that he could not have imagined anything more beautiful of its kind. Christopher's face had been incorporated into the window – not as the sturdy St Christopher fording the stream, but as the secret Christ. On Sunday he went to communion there, and at the house they held an evening gramophone concert. Mr Turing read and played billiards with Colonel Morcom, while Alan played parlour games with Mrs Morcom. Alan went out one day for a long walk with his father, and they had another day at Stratford-upon-Avon. On the last evening, Alan asked Mrs Morcom to come and say goodnight to him, as he lay in Christopher's place in bed.

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The Clock House still held the spirit of Christopher Morcom. But how could this be? Could the atoms of Alan's brain be excited by a non-material 'spirit', like a wireless set resonating to a signal from the unseen world? It was probably on this visit[12] that Alan wrote out for Mrs Morcom the following explanation:

NATURE OF SPIRIT

It used to be supposed in Science that if everything was known about the Universe at any particular moment then we can predict what it will be through all the future. This idea was really due to the great success of astronomical prediction. More modern science however has come to the conclusion that when we are dealing with atoms and electrons we are quite unable to know the exact state of them; our instruments being made of atoms and electrons themselves. The conception then of being able to know the exact state of the universe then really must break down on the small scale. This means then that the theory which held that as eclipses etc. are predestined so were all our actions breaks down too. We have a will which is able to determine the action of the atoms probably in a small portion of the brain, or possibly all over it. The rest of the body acts so as to amplify this. There is now the question which must be answered as to how the action of the other atoms of the universe are regulated. Probably by the same law and simply by the remote effects of spirit but since they have no amplifying apparatus they seem to be regulated by pure chance. The apparent non-predestination of physics is almost a combination of chances.

As McTaggart shews matter is meaningless in the absence of spirit (throughout I do not mean by matter that which can be a solid a liquid or a gas so much as that which is dealt with by physics e.g. light and gravitation as well, i.e. that which forms the universe). Personally I think that spirit is really eternally connected with matter but certainly not always by the same kind of body. I did believe it possible for a spirit at death to go to a universe entirely separate from our own, but I now consider that matter and spirit are so connected that this would be a contradiction in terms. It is possible however but unlikely that such universes may exist.

Then as regards the actual connection between spirit and body I consider that the body by reason of being a living body can 'attract' and hold on to a 'spirit', whilst the body is alive and awake the two are firmly connected. When the body is asleep I cannot guess what happens but when

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seemed no way of predicting the path that any particular electron would follow, not even in principle. Einstein, who in 1905 had made a very important contribution to the early quantum theory with a description of the related photo-electric effect, was never convinced that this was really so. But Eddington was more readily persuaded, and was not shy of turning his expressive pen to explain to a general audience that determinism was no more. The Schrödinger theory, with its waves of probability, and the Heisenberg Uncertainty Principle (which, formulated independently, turned out to be equivalent to Schrödinger's ideas) gave him the idea that mind could act upon matter *without* in any way breaking physical laws. Perhaps it could select the outcome of otherwise undetermined events.

It was not as simple as that. Having painted the picture of mind controlling the matter of the brain in this way, Eddington admitted that he found it impossible to believe that manipulating the wave-function of just *one* atom could possibly give rise to a mental act of decision. 'It seems that we must attribute to the mind power not only to decide the behaviour of atoms individually but to affect systematically large groups – in fact to tamper with the odds on atomic behaviour .' But there was nothing in quantum mechanics to explain how *that* was to be done. At this point his argument became suggestive in character, rather than precise – and Eddington did tend to revel in the obscurity of the new theories. As he went on, the concepts of physics became more and more nebulous, until he compared the quantum-mechanical description of the electron with the 'Jabberwocky' in *Through the Looking Glass*:

> *Something unknown is doing we don't know what* – that is what our theory amounts to. It does not sound a particularly illuminating theory. I have read something like it elsewhere:–
>
> The slithy toves
> Did gyre and gimble in the wabe.

Eddington was careful to say that in some sense the theory actually worked, for it produced numbers which agreed with the outcome of experiments. Alan had grasped this point back in 1929: 'Of course he does not believe that there are really about 10^{70} dimensions, but that this theory will explain the behaviour of an electron. He thinks of 6 dimensions, or 9, or whatever it may be without forming any

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mental picture.' But it seemed no longer possible to ask what waves or particles really were, for their hard nineteenth-century billiard-ball concreteness had evaporated. Physics had become a symbolic representation of the world, and nothing more, Eddington argued, edging towards a philosophical idealism (in the technical sense) in which everything was in the mind.

This was the background of Alan's assertion that 'We have a will which is able to determine the action of the atoms probably in a small portion of the brain, or possibly all over it.' Eddington's ideas had bridged the gap between the 'mechanism' of the body, which Alan had learnt from *Natural Wonders*, and the 'spirit' in which he wanted to believe. He had found another source of support in the Idealist philosopher McTaggart, and added ideas about reincarnation. But he had in no way advanced upon or even clarified Eddington's view, having ignored the difficulties which Eddington had pointed out in discussing the action of the 'will'. Instead, he had taken a slightly different direction, one fascinated with the idea of the body amplifying the action of the will, and more generally concerned with the nature of the connection between mind and body in life and death.

These ideas did, in fact, show the shape of things to come, though in 1932 there was little outward evidence of future development. In June he had found himself placed in the second class in the Part I of the Tripos. 'I can hardly look anyone in the face after it. I won't try to offer an explanation, I shall just have to get a 1st in Mays* to shew I'm not really so bad as that,' he wrote to Mrs Morcom. But more significant, in reality, was the fact that he had ordered as his last prize from Sherborne a book that promised a serious account of the interpretation of quantum mechanics. It was an ambitious choice of study, a book only published in 1932. It was the *Mathematische Grundlagen der Quantenmechanik*, the Mathematical Foundations of Quantum Mechanics, by the young Hungarian mathematician John von Neumann.

On 23 June it was his twentieth birthday, and then on 13 July what would have been Christopher's twenty-first. Mrs Morcom sent Alan a 'Research' fountain pen, such as Christopher had shown off, as a present. Alan wrote from Cambridge, where he spent the 'Long Vacation Term':

* 'Mays' were the semi-official second-year examinations.

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14/7/32

Dear Mrs Morcom,

. . . I remembered Chris' birthday and would have written to you but for the fact that I found myself quite unable to express what I wanted to say. Yesterday should I suppose have been one of the happiest days of your life.

How very kind of you it was to think of sending me a 'Research' pen. I don't think anything else (of that kind) could remind me better of Chris; his scientific appreciation and dexterous manipulation of it. I can so well remember him using it.

But if he was twenty, and preparing to confront the work of European mathematicians, he was still a boy away from home, away from Sherborne. The summer holidays were spent much as those of the previous year:

Daddy and I have just been to Germany, for just over a fortnight. We spent most of the time walking in the Schwarzwald, though Daddy of course was not up to much more than 10 miles a day. My knowledge of the language wasn't altogether of the kind that [was] most wanted. I have learnt nearly all my German by reading half a German mathematical book.* I got home somehow or other . . .

Yours affectionately, Alan M. Turing

Alan had another holiday camping with John in Ireland, where he amazed his family by turning up at Cork in a pig-boat. Then for the first two weeks of September he joined O'Hanlon for a second and last time on Sark. Alan was 'a lively companion even to the extent of mixed bathing at midnight,' wrote[14] O'Hanlon, who had struck a modern note by allowing two girls on the party. Alan had taken some fruit-flies with him, as he was studying genetics in a rather haphazard way. Back at Guildford the *Drosophilae* escaped and infested the Turing home for weeks, not at all to Mrs Turing's pleasure. O'Hanlon was sufficiently detached from the 'nation in miniature' to write[15] of Alan as 'human and lovable', saying:

I look back on holidays in Cornwall and Sark among the great enjoyments of my life: in all his companionship and whimsical humour, and the diffident shake of the head and rather high pitched voice as he propounded some

* Not the von Neumann book, however, which he only received in October 1932.

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> question or objection or revealed that he had proved Euclid's postulates or was studying decadent flies – you never knew what was coming.

The all-encompassing system still allowed some moments of freedom. And Sherborne had also left Alan with one friendship that lasted – with Victor. Alan's younger friend had been obliged to leave school at the same time, his father suffering from financial loss at what was the worst of the Depression. He had failed his School Certificate (telling Alan that it was because of too much time spent on chess and codes) but quickly caught up by passing it at a London crammers, and began what Alan called 'his grim life as a chartered accountant'. At Christmas 1932 Alan stayed with the Beuttells for two weeks and worked in Alfred Beuttell's office near Victoria. The visit was overshadowed by the fact that Victor's mother had died on 5 November. The deep shadow was a link, for both boys were having to deal with the fact of early death. The link was close enough to break Alan's usual reserve as to his beliefs – just as Mrs Morcom had broken it – and rather grudgingly to discuss his ideas about religion and survival. Victor believed very strongly, not only in the essential Christian ideas, but in extra-sensory perception and in reincarnation. To him, Alan appeared as one who wanted so much to believe, but whose scientific mind made him an unwilling agnostic, and who was under great tension as a result. Victor saw himself as a 'crusader', trying to keep Alan on the straight and narrow, and they had fierce arguments, the more so as Alan did not like being challenged by a boy of seventeen. They talked about who had rolled the stone away, and how the five thousand had really been fed. What was myth and what was fact? They argued about the after-life, and the pre-life too. Victor would say to Alan, 'Look, no one has ever been able to *teach* you any mathematics – perhaps you have remembered it from a previous life.' But, as Victor saw it, Alan could not believe in such a thing 'without a mathematical formula'.

Victor's father, meanwhile, had thrown himself into research and work to overcome his bereavement. Alan's work in his office was concerned with calculations required for his commission as lighting consultant to the Freemasons' new headquarters in Great Queen Street. Alfred Beuttell was a pioneer in the scientific measurement of illumination, and the development of a lighting code[16] based on 'first principles' as part of the 'reduction of the physiology of vision

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to a scientific and mathematical basis'. His work for the Masons involved elaborate calculations to estimate the illumination at the floor level, in terms of the candle power of lights installed and the reflecting properties of the walls. Alan, who was not allowed into the Masonic building, had to work from imagination to check Mr Beuttell's figures.

Alan became friendly with Mr Beuttell, who told him about his success in Monte Carlo as a young man, when he had managed to live for a month on his winnings. He showed Alan his gambling system, which Alan took back to Cambridge and studied. On 2 February 1933 he wrote back with the result of his analysis, which was that the system yielded an expected gain of exactly zero, and that accordingly Mr Beuttell's winnings had been entirely due to luck and not to skill. He also sent a formula he had worked out for the illumination of the floor of a hemispheric room lit from its centre – not, admittedly, an immediately useful result, but a very neat one.

Standing up to Mr Beuttell's ideas about his gambling system took some courage, as he was a forceful man, whose heart of gold was buried deep, with strong opinions on many subjects. An eclectic Christian tending to Theosophy, he was a great believer in the unseen world, and told Alan that his invention of the Linolite electric lamp had been sent to him from beyond. This Alan found too much to swallow. But he also had ideas about the brain, which he had formed since the early 1900s, according to which it worked on electric principles, with differences of potential determining moods. An electric brain! – there lay a more scientific idea. They had long discussions on these lines.

Alan and Victor also went down to Sherborne together for the house supper, and after Christmas Alan wrote to Blamey, saying:

> I still haven't quite decided what I am going to do when I grow up. My ambition is to become a don at King's. I am afraid it may be more ambition than profession though. I mean it is not very likely I shall ever become one.
>
> Glad you had a good beano for your coming of age. Personally when my time comes I shall retire into a corner of England far from home and sulk. In other words I don't want to come of age (Happiest days of my life at school etc.)

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with such tawdry problems solved, people could start to think about something important. It was an attitude very different from the cult of duty, which made a virtue out of playing the expected part in the power structure. King's College was very different from Sherborne School.

It was also part of the King's attitude to life that it regarded games, parties and gossip to be natural pleasures, and assumed that clever people would still enjoy ordinary things. Although King's had only gradually moved away from its original role as a sister foundation to Eton, there were among its dons those who made a positive effort to encourage candidates who did not come from public schools and tried to make them feel at home. There was great emphasis on the mixing between dons and undergraduates in what was a small college, with less than sixty students in each year. No other college was like this, and so Alan Turing gradually woke up to the fact that by chance he had arrived in a unique environment, which was as much his element as any institution could be. It corroborated what he always knew, which was that his duty was to think for himself. The match was not perfect, for a number of reasons, but it was still a great stroke of fortune. At Trinity he would have been a lonelier figure; Trinity also inherited the moral autonomy, but without the personal intimacy that King's encouraged.

The year 1933 only brought to the surface ideas which in King's had a long history. Alan shared in the climate of dissent:

26/5/33

Dear Mother,

Thank you for socks etc. . . . Am thinking of going to Russia some time in vac but have not yet quite made up my mind.

I have joined an organisation called the 'Anti-War Council'. Politically rather communist. Its programme is principally to organize strikes amongst munitions and chemical workers when government intends to go to war. It gets up a guarantee fund to support the workers who strike.

. . . There has been a very good play on here by Bernard Shaw called 'Back to Methuselah'.

Yours, Alan

For a short time, Anti-War Councils sprang up across Britain and united pacifists, communists and internationalists against a 'national' war. Selective strikes. had, in fact, prevented the British government

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from intervening on the Polish side against the Soviet Union in 1920. But for Alan the real point lay not in political commitments, but in the resolve to question authority. Since 1917 Britain had been deluged by propaganda to the effect that Bolshevik Russia was the kingdom of the devil, but in 1933 anyone could see that something had gone completely wrong with the western trading and business system. With two million people unemployed, there was no precedent for what was above all a *baffling* situation, in which no one knew what should be done. Soviet Russia, after its second revolution of 1929, offered the solution of state planning and control, and there was great interest among intellectual circles in how it was working. It was the testing-ground of the Modern. Alan probably enjoyed riling his mother with a nonchalant 'rather communist': the point lay not in this or that label, but in the fact that his generation were going to think for themselves, take a wider view of the world than their parents had done, and not be frightened by bogey words.

Alan did not in fact go to see Russia for himself. But even if he had, he would have found himself ill-disposed to become an enthusiast for the Soviet system. Nor did he become a 'political' person in the Cambridge of the 1930s. He was not sufficiently interested in 'mere power'. Buried in the *Communist Manifesto* was the declaration that the ultimate aim was to make society 'an association, in which the free development of each is the condition for the free development of all.' But in the 1930s, to be a communist meant identifying with the Soviet regime, which was a very different matter. Those at Cambridge who perceived themselves as members of a responsible British prefect class might well identify with the Russian rulers as with a sort of better British India, collectivising and rationalising the peasants for their own good. For products of the English public school, apt to despise trade, it was but a small step to reject capitalism, and place faith in greater state control. In many ways the Red was a mirror image of the White. Alan Turing, however, was not interested in organising anyone, and did not wish to be organised by anyone else. He had escaped from one totalitarian system, and had no yearning for another.

Marxism claimed to be scientific, and it spoke to the modern need for a rationale of historical change that could be justified by science. As the Red Queen told Alice, 'You may call it "nonsense" if you like,

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but *I've* heard nonsense, compared with which that would be as sensible as a dictionary.' But Alan was not interested in the problems of history, while the marxist attempts to explain the exact sciences in terms of 'prevailing modes of production' were very remote from his ideas and experience. The Soviet Union judged relativity and quantum mechanics by political criteria, while the English theorist Lancelot Hogben sustained an economic explanation of the development of mathematics only by restricting attention to its most elementary applications. Beauty and truth, which motivated Alan Turing as they had always inspired mathematicians and scientists, were lacking. The Cambridge communists took upon themselves something of the character of a fundamentalist sect, with the air of being saved, and the element of 'conversion' met in Alan Turing the same scepticism as he had already turned upon Christian beliefs. With his fellow sceptic Kenneth Harrison he would mock the communist line.

On economic questions, indeed, Alan came to think highly of Arthur Pigou, the King's economist who had played a slightly earlier part than Keynes in patching up nineteenth-century liberal capitalism. Pigou held that more equal distribution of income was likely to increase economic welfare, and was an early advocate of the welfare state. Broadly similar in their outlook, both Pigou and Keynes were calling for increased state spending during the 1930s. Alan also began to read the *New Statesman*, and could broadly be identified with the middle-class progressive opinion to which it was addressed, concerned both for individual liberty and for a more rationally organised social system. There was much talk about the benefits of scientific planning (so that Aldous Huxley's 1932 satire *Brave New World* could treat it as the intellectuals' already dated orthodoxy), and Alan went to talks on progressive ventures such as the Leeds Housing Scheme.* But he would not have seen *himself* as one of the scientific organisers and planners.

In fact his idea of society was that of an aggregate of individuals, much closer to the views of democratic individualism held by J. S. Mill than that of socialists. And to keep his individual self intact,

* This gave him a tenuous link with his mother, who had shares in a Bethnal Green housing association. Alan's reaction was approval that they planned the flats for the families who needed them rather than *vice versa*.

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self-contained, self-sufficient, uncontaminated by compromise or hypocrisy,* was his ideal. It was an ideal far more concerned with the moral than with the economic or political; and closer to the traditional values of King's than to the developing currents of the 1930s.

Like many people (E. M. Forster among them) he found a special pleasure in discovering Samuel Butler's *Erewhon*. Here was a Victorian writer who had doubted the moral axioms, playing with them in Looking-Glass fashion by attaching the taboos on sex to the eating of meat, describing Anglican religion in terms of transactions in ornamental money, and exchanging the associations of 'sin' with those of 'sickness'. Alan also much admired Butler's successor Bernard Shaw, enjoying his light play with serious ideas. For the well-read sophisticate of the 1930s, Butler and Shaw were already out-worn classics, but for one from Sherborne School they still held a liberating magic. Shaw had taken up what Ibsen† called 'the revolution of the Spirit', and wanted to show true individuals on the stage, those who lived not by 'customary morals' but by inner conviction. But Shaw also asked hard questions about what kind of society could contain such true individuals: questions highly pertinent to a young Alan Turing. *Back to Methuselah*, which Alan thought 'a very good play' in May 1933, was an attempt at what Shaw called 'politics *sub specie aeternitatis*'. With its science-fiction view of Fabian ideas, treating with contempt the sordid realities of Asquith and Lloyd George, it suited Alan's idealist frame of mind.

One subject, however, did *not* feature in Bernard Shaw's plays, and only very rarely in the *New Statesman*.[19] In 1933 its drama critic reviewed *The Green Bay Tree*, which was about 'a boy . . . adopted for immoral purposes by a wealthy degenerate,' and said it was 'well worth seeing for anyone who finds a pervert a less boring subject for the drama than a man with a diseased liver.' In this respect, King's College was unique. Here it was possible to doubt an axiom which Shaw left unquestioned and Butler skated over nervously.

It was only possible because no one breached the line that separated the official from the unofficial worlds. The consequences

* 'Regarding Aunt J's funeral', Alan wrote in January 1934 to his mother, 'I am not v. keen on going, and I think it would be consummate hypocrisy if I did. But if you think anyone will be the better for my attending I will see whether it can be managed.'

† Alan also considered Ibsen's plays 'remarkably good'.

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of being found out were the same in King's as anywhere else, and the same double life was imposed by the outside world. It was a ghetto of sexual dissent, with the advantages and disadvantages of ghetto life. The internal freedom to express heretical thoughts and feelings was certainly of benefit to Alan. He was, for instance, helped by the fact that Kenneth Harrison derived from his father, himself a graduate of King's, a liberal understanding of other people's homosexual feelings. But the world of Keynes and Forster, the parties and comings and goings of Bloomsbury people, lay far above Alan's head. There was a glossiness about King's, whose greatest strength lay in the arts, and drama in particular, in which he had no share. He would have been too easily deterred and frightened by the more theatrical elements in expressing his homosexuality. If at Sherborne his sexuality was described in terms of 'filth' and 'scandal', he now also had to come to terms with that other kind of labelling that the world found so important: that of the *pansy*, an affront and traitor to masculine supremacy. He did not find a place in this compartment; nor did the King's aesthete set, flourishing in its protected corner, reach out to a shy mathematician. As in so many ways, Alan was the prisoner of his own self-sufficiency. King's could only protect him while he worked out the problems for himself.

It was the same with regard to religious belief, for while agnosticism was all but *de rigueur* in King's, he was not the person to follow a trend, only to be stimulated and liberated by the freedom to ask hitherto forbidden questions. In developing his intellectual life, he did not form the social connections that a less shy person could have made. Unlike most of his close acquaintances, he was a member neither of the 'Ten Club' nor of the Massinger Society – two King's undergraduate societies of which the first read plays and the other discussed far into the night, over mugs of cocoa, papers on culture and moral philosophy. He was too awkward, even uncouth, to fit into these comfortable gatherings. Nor was he elected to the exclusive university society, the Apostles, which drew much of its membership from King's and Trinity. In many ways, he was too ordinary for King's.

In this respect he had something in common with one of his new friends, James Atkins, who was the third mathematical scholar

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small village school near Liverpool, and he had not been through the public-school training. A rather small, rather young classics scholar, he had been cox of the boat in which Alan rowed, but their acquaintanceship developed as Fred became aware of Alan as someone whose sexuality seemed to be made no secret, either by himself or by others.

Fred was very interested in an exchange of views and emotional experiences, feeling himself very puzzled by sex, and confronted by ex-public schoolboys much more conscious of homosexual attraction. He had taken advantage of the King's freedom of discussion, and had been told by a Fellow that he 'seemed a pretty normal bisexual male'. But it was not as simple as that, and nothing was ever simple for Fred Clayton.

Alan told his friend about how much he resented having been circumcised, and also of his earliest memories of playing with the gardener's boy (presumably at the Wards' house), which he thought had perhaps decided his sexual pattern. Rightly or wrongly, he gave Fred, and others too, the impression that public schools could be relied upon for sexual experiences – although more important perhaps was that schooldays continued to loom large in his consciousness of sexuality. Fred read Havelock Ellis and Freud, and also made discoveries in the classics which he would convey to his mathematical friend, not noted otherwise for an interest in Latin and Greek.

Puzzlement was an entirely reasonable reaction, in the conditions of 1933, when even in King's there was so little to go on for those outside the most chromium-plated circles. These conversations were whispers in a crushing, deafening silence. It was not the effect of the law, whose prohibition of all male homosexual activity played but a tiny part in the Britain of the 1930s, in direct terms. It was more as J. S. Mill had written[20] of heresy:

> . . . the chief mischief of the legal penalties is that they strengthen the social stigma. It is that stigma which is really effective, and so effective is it, that the profession of opinions which are under the ban of society is much less common in England than is, in many other countries, the avowal of those which incur risk of judicial punishment.

Modern psychology had made a twentieth-century difference; the 1920s had given to the *avant-garde* the name of Freud to conjure

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with. But his ideas were used in practice to discuss what had 'gone wrong' with homosexual people, and such intellectual openings were outweighed by the continual efforts of the official world to render homosexuality invisible – a process in which the academic world played its part along with prosecutions and censorship. As for respectable middle class opinion, it was represented by the *Sunday Express* in 1928, greeting *The Well of Loneliness* with the words, 'I had rather give a healthy boy or a healthy girl a phial of prussic acid than this novel.' The general rule remained that of unmentionability above all else, leaving even the well-educated homosexual person with nothing more encouraging than the faint signals from the ancient world, the debris of the Wilde trials, and the rare exceptions to the rules supplied by the writings of Havelock Ellis and Edward Carpenter.

In a peculiar environment such as Cambridge, it might be a positive advantage to enjoy homosexual experience, simply in terms of the opportunity for physical release. The deprivation was not one of laws but of the spirit – a denial of identity. Heterosexual love, desire and marriage were hardly free from problems and anguish, but had all the novels and songs ever written to express them. The homosexual equivalents were relegated – if mentioned at all – to the comic, the criminal, the pathological, or the disgusting. To protect the self from these descriptions was hard enough, when they were embedded in the very words, the only words, that language offered. To keep the self a complete and consistent whole, rather than split into a facade of conformity, and a secret inner truth, was a miracle. To be able to *develop* the self, to increase its inner connections and to communicate with others – that was next to impossible.

Alan was at the one place that could support that development. Here, after all, was the circle round which Forster passed the manuscript of his novel *Maurice* which conveyed so much about being 'an unmentionable of the Oscar Wilde sort'. How to *complete* the work, that was one problem. It had to have its own integrity of feeling, yet be credible as a story of the real world. There was a fundamental contradiction, which was not resolved by having his hero escape into the 'greenwood' of a happy ending.

There was another contradiction, in that this attempt at communication remained secret for fifty years.[21] But here at least

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was the place where these contradictions were understood, and although Alan's self-contained nature placed him on the edge of King's society, he was protected from the harshness of the outside world.

If Alan enjoyed *Back to Methuselah*, it would also have been because Shaw dramatised his theory of the Life Force, which raised the same questions as the 'spirit'. One of Shaw's characters said 'Unless this withered thing religion, and this dry thing science, come alive in our hands, alive and intensely interesting, we may just as well go out and dig the garden until it is time to dig our graves.' This was Alan's problem in 1933, although he could not accept Shaw's easy solution. Bernard Shaw had no compunction about rewriting science if it did not agree with his ideas; determinism had to go, if it conflicted with a Life Force. Shaw fixed on Darwin's theory of evolution, which he discussed as if it were an account of every kind of change, social and psychological change included, and rejected it as a 'creed': he wrote[22] that:

> What damns Darwinian Natural Selection as a creed is that it takes hope out of evolution, and substitutes a paralysing fatalism which is utterly discouraging. As Butler put it, it 'banishes Mind from the universe.' The generation that felt nothing but exultant relief when it was delivered from the tyranny of an Almighty Busybody by a soulless Determinism has nearly passed away, leaving a vacuum which Nature abhors.

Science, for Shaw, existed to provide a hopeful 'creed', which revealed religion no longer did. There *had* to be a Life Force, of which the super-intelligent Oracle of A.D. 3000 could say 'Our physicists deal with it. Our mathematicians express its measurements in algebraic equations.'

But for Alan, science had to be true, rather than comforting. Nor did that mathematician and physicist John von Neumann have anything to say that lent credence to a Life Force. His *Mathematische Grundlagen der Quantenmechanik* had arrived in October 1932, but perhaps Alan had put off tackling it until the summer, when he also obtained books on quantum mechanics by Schrödinger and Heisenberg. On 16 October 1933 he wrote:

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> My prize book from Sherborne is turning out very interesting, and not at all difficult reading, although the applied mathematicians seem to find it rather strong.

Von Neumann's account was very different from Eddington's. In his formulation, the *state* of a physical system evolved perfectly deterministically; it was the *observation* of it that introduced an element of absolute randomness. But if this process of observation were itself observed from outside, it could be regarded as deterministic. There was no way of saying where the indeterminacy was; it was not localised in any particular place. Von Neumann was able to show that this strange logic of observations – quite unlike anything encountered with everyday objects – was consistent in itself, and agreed with known experiments. It left Alan sceptical about the interpretation of quantum mechanics, but certainly gave no support to the idea of the mind manipulating wave-functions in the brain.

Alan would not only have found von Neumann's book 'very interesting' because it was tackling a subject of such philosophical importance to himself. It would also have been because of the way in which von Neumann approached his scientific subject as much as possible by logical thought. For science, to Alan Turing, was thinking for himself, and seeing for himself, and not a collection of facts. Science was doubting the axioms. He had the pure mathematician's approach to the subject, allowing a free rein to thought, and seeing afterwards whether or not it had application to the physical world. He would often argue on these lines with Kenneth Harrison, who took the more traditional scientific view of experiments and theories and verification.

The 'applied mathematicians' would have found von Neumann's study of quantum mechanics to be 'rather strong' because it required a considerable knowledge of recent pure-mathematical developments. He had taken the apparently different quantum theories of Schrödinger and Heisenberg, and by expressing their essential ideas in a much more abstract mathematical form, shown their equivalence. It was the logical consistency of the theory, not the experimental results, that von Neumann's work treated. This suited Alan, who sought that kind of toughness, and it made a

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beautiful example of how the expansion of pure mathematics for its own sake had borne unexpected fruit in physics.

Before the war, Hilbert had developed a certain generalisation of Euclidean geometry, which involved considering a space with infinitely many dimensions. This 'space' had nothing to do with physical space. It was more like an imaginary graph on which could be plotted all musical sounds, by thinking of a flute, or violin, or piano tone as made up of so much of the fundamental, so much of the first harmonic, so much of the second harmonic, and so on – each kind of sound requiring (in principle) the specification of infinitely many ingredients.* A 'point' in such a 'space', a 'Hilbert space', would correspond to such a sound; then two points could be added (like adding sounds), and a point could be multiplied by a factor (like amplifying a sound).

Von Neumann had noticed that 'Hilbert space' was exactly what was needed to make precise the idea of the 'state' of a quantum-mechanical system, such as that of an electron in a hydrogen atom. One characteristic of such 'states' was that they could be added like sounds, and another was that there would generally be infinitely many possible states, rather like the infinite series of harmonics above a ground. Hilbert space could be used to define a rigorous theory of quantum mechanics, proceeding logically from clear-cut axioms.

The unforeseen application of 'Hilbert space' was just the kind of thing that Alan would produce to support his claim for pure mathematics. He had seen another vindication in 1932, when the positron was discovered. For Dirac had predicted it on the basis of an abstract mathematical theory, which depended upon combining the axioms of quantum mechanics with those of special relativity. But in arguing about the relationship between mathematics and science, Alan Turing found himself tackling a perplexing, subtle, and to him personally important aspect of modern thought.

The distinction between science and mathematics had only been clarified in the late nineteenth century. Until then it might be supposed that mathematics necessarily represented the relations of

* The analogy is not intended to be exact; Hilbert space and quantum mechanical 'states' differ in an essential way from anything in ordinary experience.

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always down-to-earth, liked to say: 'One must always be able to say "tables, chairs, beer-mugs", instead of "points, lines, planes".'

In 1899, Hilbert succeeded in finding a system of axioms which he could prove would lead to all the theorems of Euclidean geometry, without any appeal to the nature of the physical world. However, his proof required the assumption that the theory of 'real numbers'* was satisfactory. 'Real numbers' were what to the Greek mathematicians were the measurements of lengths, infinitely subdivisible, and for most purposes it could be assumed that the use of 'real numbers' was solidly grounded in the nature of physical space. But from Hilbert's point of view this was not good enough.

Fortunately it was possible to describe 'real numbers' in an essentially different way. By the nineteenth century it was well understood that 'real numbers' could be represented as infinite decimals, writing the number π for instance as 3.14159265358979. . . . A precise meaning had been given to the idea that a 'real number' could be represented as accurately as desired by such a decimal – an infinite sequence of integers. But it was only in 1872 that the German mathematician Dedekind had shown exactly how to define 'real numbers' in terms of the integers, in such a way that no appeal was made to the concept of measurement. This step both unified the concepts of number and length, and had the effect of pushing Hilbert's questions about geometry into the domain of the integers, or 'arithmetic', in its technical mathematical sense. As Hilbert said, all he had done was 'to reduce everything to the question of consistency for the arithmetical axioms, which is left unanswered.'

At this point, different mathematicians adopted different attitudes. There was a point of view that it was absurd to speak of the axioms of arithmetic. Nothing could be more primitive than the integers. On the other hand, it could certainly be asked whether there existed a kernel of fundamental properties of the integers, from which all the others could be derived. Dedekind also tackled this question, and showed in 1888 that all arithmetic could be derived from three ideas: that there is a number 1, that every number has a successor, and that

* There is nothing 'real' about 'real numbers'. The term is a historical accident, arising from the equally misleading terms 'complex numbers' and 'imaginary numbers'. The reader not familiar with these expressions could think of 'real numbers' as 'lengths defined with a hypothetical infinite precision.'

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a principle of induction allows the formulation of statements about *all* numbers. These could be written out as abstract axioms in the spirit of the 'tables, chairs and beer-mugs' if one so chose, and the whole theory of numbers could be constructed from them without asking what the symbols such as '1' and '+' were supposed to mean. A year later, in 1889, the Italian mathematician G. Peano gave the axioms in what became the standard form.

In 1900 Hilbert greeted the new century by posing seventeen unsolved problems to the mathematical world. Of these, the second was that of proving the consistency of the 'Peano axioms' on which, as he had shown, the rigour of mathematics depended. 'Consistency' was the crucial word. There were, for instance, theorems in arithmetic which took thousands of steps to prove – such as Gauss's theorem that every integer could be expressed as the sum of four squares. How could anyone know for sure that there was not some equally long sequence of deductions which led to a contradictory result? What was the basis for credence in such propositions about all numbers, which could never be tested out? What was it about those abstract rules of Peano's game, which treated '+' and '1' as meaningless symbols, that guaranteed this freedom from contradictions? Einstein doubted the laws of motion. Hilbert doubted even that two and two made four – or at least said that there had to be a reason.

One attack on this question had already been made in the work of G. Frege, starting with his 1884 *Grundlagen der Arithmetik*. This was the *logistic* view of mathematics, in which arithmetic was derived from the logical relationships of the entities in the world, and its consistency guaranteed by a basis in reality. For Frege, the number '1' clearly meant something, namely the property held in common by 'one table', 'one chair', 'one beer-mug'. The statement '2 + 2 = 4' had to correspond to the fact that if any two things were put together with any other two things, there would be four things. Frege's task was to abstract the ideas of 'any', 'thing', 'other', and so forth, and to construct a theory that would derive arithmetic from the simplest possible ideas about existence.

Frege's work was, however, overtaken by Bertrand Russell, whose theory was on the same lines. Russell had made Frege's ideas more concrete by introducing the idea of the 'set'. His proposal was

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that a set which contained just one thing could be characterised by the feature that if an object were picked out of that set, it would always be the same object. This idea enabled one-ness to be defined in terms of same-ness, or equality. But then equality could be defined in terms of satisfying the same range of predicates. In this way the concept of number and the axioms of arithmetic could, it appeared, be rigorously derived from the most primitive notions of entities, predicates and propositions.

Unfortunately it was not so simple. Russell wanted to define a set-with-one-element, without appealing to a concept of counting, by the idea of equality. Then he would define the number 'one' *to be* 'the set of all sets-with-one-element'. But in 1901 Russell noticed that logical contradictions arose as soon as one tried to use 'sets of all sets'.

The difficulty arose through the possibility of self-referring, self-contradictory assertions, such as 'this statement is a lie.' One problem of this kind had emerged in the theory of the infinite developed by the German mathematician G. Cantor. Russell noticed that Cantor's paradox had an analogy in the theory of sets. He divided the sets into two kinds, those that contained themselves, and those that did not. 'Normally', wrote Russell, 'a class is not a member of itself. Mankind, for example, is not a man.' But the set of abstract concepts, or the set of all sets, would contain itself. Russell then explained the resulting paradox in this way:

> Form now the assemblage of classes which are not members of themselves. This is a class: is it a member of itself or not? If it is, it is one of those classes that are not members of themselves, *i.e.* it is not a member of itself. If it is not, it is not one of those classes that are not members of themselves, *i.e.* it is a member of itself. Thus of the two hypotheses – that it is, and that it is not, a member of itself – each implies its contradictory. This is a contradiction.

This paradox could not be resolved by asking what, if anything, it *really meant*. Philosophers could argue about that as long as they liked, but it was irrelevant to what Frege and Russell were trying to do. The whole point of this theory was to derive arithmetic from the most primitive logical ideas in an automatic, watertight, depersonalised way, without any arguments *en route*. Regardless

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