Christof Teuscher (Ed.)

# Alan Turing: Life and Legacy of a Great Thinker

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# Alan Turing: Life and Legacy of a Great Thinker

Foreword by Douglas Hofstadter

With 77 Figures, including 10 in Color, and 4 Tables

Springer

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Part I

# Turing's Life and Thoughts

# Alan Turing: an Introductory Biography

Andrew Hodges

Wadham College, University of Oxford

**Summary.** A short description of the events and issues in the life of Alan Turing (1912–1954).

The Turing Day conference at the Swiss Federal Institute of Technology, Lausanne, was held to mark the ninetieth anniversary of Alan Turing's birth, which fell on 23rd June 2002. Turing's life was so short that further events will soon mark the fiftieth anniversary of his death on 7th June 2004. But in that span between 1912 and 1954 Alan Turing did pioneering work, encompassing the foundations of computer science, which still continues to stimulate and inspire. As this volume illustrates, the breadth and depth of Turing's work, as well as its dramatic intensity, compensates for its chronological brevity.

Alan Turing's biography is interwoven with the course of twentieth-century history and falls naturally into pre-war, wartime and post-war periods. He was born into the British upper-middle class which had confidently run the imperial administration until the First World War, but which, under the impact of economic and political crisis, progressively lost control thereafter. In a very broad sense, Alan Turing belonged to a new, modernizing generation which reacted contemptuously against Victorian values. But Alan Turing's early life was marked by detachment from the obligatory social training, rather than rebellion against it. It was also marked from the start by his intensely individual response to science and mathematics, in particular to the relativity and quantum mechanics which had transformed the physical sciences since 1900. He became an undergraduate at King's College, Cambridge University, in 1931, reading mathematics and graduating with distinction in 1934.

Very soon, in 1935, the lectures of M. H. A. (Max) Newman at Cambridge introduced him to the frontier of mathematical logic, which likewise had been transformed since 1900. But logic was neither Turing's immediate nor his only choice. It was his work in probability theory that won him a Fellowship of King's College in 1935, and he might easily have continued in this field, or in the mathematical physics that had first attracted him. Thus he came to logic from a wide background in pure and applied mathematics, and it was in this eclectic spirit that he attacked the Entscheidungsproblem of David Hilbert, which at that point remained an outstanding question.

Turing, working alone, and only twenty-three, attacked and settled this problem using his definition of computability. His famous paper, "On Computable Numbers, with an Application to the Entscheidungsproblem," was published at the turn of 1936–37. A complete outsider to the field, he won a place in the subject with a concept which after 60 years remains definitive. His definition of computability showed there could be no general method for deciding the provability of mathematical propositions, and marked the end of attempts to formalize a complete system for mathematics. But it also opened the way into new fields, which now we would recognize as computer science and the cognitive sciences.

Although Turing thereafter found himself classed as a logician, he was more a mathematician who applied himself to logic; and more than that, a scientist who behind the mathematics felt a deep concern for the fundamental questions of mind and matter. His underlying interest in the problem of mind showed up in the bold statements about human memory and states of mind which informed his arguments. His background in physics was hinted at in the "machines" with which he made his definition of computability — the now-famous "Turing machines," running on paper tape, an image of 1930s modernity. It was this concreteness which made Turing's definition of computability much more satisfactory than the mathematical definition offered by Alonzo Church, the Princeton logician who led the field. Mathematically, Turing's definition was equivalent to Church's. But the description of the Turing machine gave a convincing argument for why it was that this mathematical definition completely captured the concept of "effectively calculable."

Each Turing machine represents an algorithm; for modern readers it is hard not to see it as a computer program and to bear in mind that computers did not then exist. But Turing specifically defined a type of machine called "universal," capable of reading the instruction table of any other machine. This is precisely the principle of the stored-program digital computer, then yet to come into being. It is possible that Turing even then entertained the possibility of constructing such a machine, for he certainly interested himself in electrical and mechanical computation. But, if so, he left no notes or observations on this question. Rather, he was primarily engaged in a wide variety of mathematical researches. In late 1936 Turing joined Church's group at Princeton and there embarked on more advanced logic but also on work in algebra and on developing the theory of the Riemann zeta-function, fundamental to the study of prime numbers. The mathematician John von Neumann offered him a post at Princeton to continue mathematical research, but he chose to return to England in summer 1938, conscious of the impending conflict with Germany and already prepared to make a special contribution to it.

Whilst the Second World War took many of his scientific contemporaries into the physics of radar and the atomic bomb, it took Alan Turing into cryptology. After 1938, his grappling with the infinitudes of mathematical logic

was complemented by the finite but still highly challenging logical problem of the German Enigma enciphering machine. In 1939, partly thanks to a brilliant Polish contribution, Turing was able to propose a highly ingenious method of testing a "probable word" for Enigma-enciphered messages. His logical scheme was rapidly materialized in very large electromechanical devices called Bombes, which from 1940 onwards worked as the central engines of decipherment throughout the war. For this work, Turing was based at the now famous center at Bletchley Park, Buckinghamshire, which recruited increasingly large sectors of the British intelligentsia. Amongst these, Alan Turing remained the chief scientific figure. His central contribution, after the logic of the Bombe, lay in Bayesian statistics for measuring "weight of evidence," a development close to Shannon's theory of information measure. Turing led what was in effect a scientific revolution, and because he took personal charge of the crucial U-boat message problem, was able to see his approach triumph in the battle of the Atlantic. Alan Turing's role mirrored the developing course of the war: at first a lone British figure against all the odds, and later, as the work developed on a major industrial and transnational scale, handing over the British contribution to the power by which it was eclipsed: the United States.

Turing's personality traits became more striking when outside the Cambridge environment; shy but outspoken, nervous but lacking deference, he was not well adapted to military manners or to the diplomacy of the embryonic Anglo-American relationship. But his commanding scientific authority made him the top-level technical liaison between the wartime Allies, demanding a voyage to America in the winter of 1942–43 at the height of the Atlantic battle. None of this experience, however, gave him a taste for power or detracted from his primary vocation as a pure scientist. The undiminished tenacity of his scientific calling was well illustrated by the use he made of his wartime experience. For after 1943 Turing knew from Bletchley Park work that large-scale digital electronic machinery had the speed and reliability to make possible a practical version of his "universal machine." From that point onwards he made the construction of such a machine his principal ambition, and he arranged his work so as to gain personal experience of electronic components — designing and building an advanced speech scrambler. And so, at the end of the Second World War, he had a plan for an electronic computer, but it was motivated not by military or economic needs. It was for the exploration of the scope of the computable and in particular for comparing machine processes with human mental processes. He called it "building a brain."

For his war work, which some would judge critical to the Atlantic war, Turing was honored with the modest British formality of an OBE. But his work remained completely secret until the mid-1970s, and he derived no advantage from it in his subsequent scientific career. Nevertheless, the post-war period began with great promise, for he was invited to take up an appointment at the National Physical Laboratory, near London, in October 1945,

and his electronic computer plan, the proposal for the Automatic Computing Engine (ACE), was swiftly adopted in March 1946.

At that time, which was before the word "computer" had its modern meaning, Turing used the term Practical Universal Computing Machine. But, although fond of the word "practical," Turing did not have the human gift of getting his practical way with people and institutions who did not share his vision. From the outset, it became clear that the NPL had no clear idea on how it was to build the machine he had designed, and it failed to adopt a policy speedy enough to satisfy Alan Turing. Turing's plans for software, exploiting the universality of the machine, were the strongest feature of his proposal, but they were little developed or publicized because of the dominating problem of hardware engineering. Impatient for progress, Turing took up marathon running to near-Olympic standard, but this did not relieve the stress. In the autumn of 1947 he returned to Cambridge for a sabbatical year, and while there was approached by Max Newman, since 1945 professor of mathematics at Manchester University, to take an appointment there instead. Newman had played a most important part at Bletchley Park after 1942 and had organized a section using the most sophisticated electronic machinery; he was also fully acquainted with Turing's logical ideas. At Manchester he had rapidly recruited both Royal Society funding and top-rank engineers, and by June 1948 a tiny version of the universal machine principle was working there — in marked contrast to the lack of progress at the NPL. Turing accepted the appointment as Deputy Director of the Computing Laboratory. But already in 1948 it became clear that the engineering would dominate the Manchester environment, and before long both Newman and Turing were sidelined and did not direct anything at all.

Turing's programming never exploited the advanced possibilities he had mapped out in 1946, and he failed also to write the papers that could have established his claim to the theory and practice of modern computing. Instead, the main theme of his work became the more futuristic prospect of Artificial Intelligence, or "intelligent machinery" as he called it. Already prefigured in 1946, this was expounded in papers of 1947, 1948, and 1950, arguing strongly that computable operations could encompass far more than those things considered "merely mechanical" in common parlance, and indeed could emulate human intelligence. The last of these papers, the only one to be published in his lifetime, appearing in the philosophy journal Mind, has become famous for the Turing Test and its 50 prophecy, and stands still as a flagship for confidence in the ultimate mechanizability of Mind. But Turing's constructive arguments for how Artificial Intelligence might be achieved are perhaps as significant as the long-term vision. Notably, his ideas encompassed both the "top-down" and the "bottom-up" ideas that were to become bitter rivals in later AI research. But it is also notable that he did very little to follow up these ideas with active research, even when he had the resources of the Manchester computer.

In 1951, Turing was elected to a Fellowship of the Royal Society, the citation referring to his 1936 work. This was a watershed year for Turing: although he had largely failed in the immediate post-war period to capitalize on his wartime achievement, he now started a quite fresh development, demonstrating the part he could still have in the great expansion of science and mathematics that began in the 1950s. His new ambition was that of giving a mathematical explanation for morphogenetic phenomena, thus showing an interest in biology that went back to childhood, but which was now expressed in advanced methods for studying nonlinear partial differential equations with the computer simulations which had just become possible on the Manchester computer.

At the end of 1951 Turing submitted a first paper on this work, which for mathematical biology was to be as important as his 1936 work had been for logic. But at just this point, Alan Turing was arrested. As a homosexual, he was always in danger from the law which at that time criminalized all homosexual activity: an injudicious liaison turned that potential into fact. The trial, in March 1952, resulted in his being forced to accept injections of oestrogen. He fought hard to prevent this from arresting his work. Unrepentant, open and unashamed, Alan Turing found himself a very isolated figure at Manchester. In 1953 there was another "crisis" with the police, which may well have been related to the fact that as a known homosexual he fell into the new category of "security risk," one who could no longer continue the secret work he had previously been doing. His holidays abroad to less hostile climes would not have calmed the nerves of security officers. Amidst this Cold War story, however, Turing also found time not only for substantial developments in his morphogenetic theory, but for a stab at a new field: the interpretation of the quantum mechanics that had first absorbed him in youth. All this was, however, cut off by his death by cyanide poisoning at his home at Wilmslow, Cheshire, in 1954, by means most likely contrived by him to allow those who wished to do so to believe it an accident.

An awkward figure, who delighted yet often infuriated his friends, Alan Turing was wrapped up in world events and yet most concerned with an intense personal integrity. Writing as plainly as he spoke, he was an Orwell of science; but his large capacity for frivolity, as illustrated in his discussion of the Turing Test setting, gave him an honorable place in the lighter and cheekier side of English culture. His life was full of paradox, not least that he, of all people original and socially nonconforming, should be the foremost advocate of the view that the mind was purely mechanical. The most purely scientific in spirit, his application to war work was of greater effect than perhaps any other individual scientist. Committed to honesty and truth, he found his life enveloped by secrecy and silence.

The strange drama of Alan Turing's death in 1954 has in its way given him a lasting life in public consciousness. His state of mind at death remains an enigma, but so too does the true inner story of his life. Prickly and proud, yet

self-effacing, Turing wrote little about the development of his ideas. There is the unknown background to his fascination with the problem of Mind, where only juvenile fragments survive. There is the question raised by Newman, of whether he might have done greater things in mathematics, but for the war; and the question of the real motivations for Turing's abandonment of deep mathematical work for the sake of the war. The vexed question of the emergence of the digital computer in 1945, and of Turing's relationship with von Neumann, remains a gap at the heart of $20^{\text{th}}$-century technology. The true genesis of his Artificial Intelligence program during the war, and the question of whether his concern for the significance of Gödel's theorem was really resolved — all this remains unknown, spur to $21^{\text{st}}$-century thought and our fascination with the theory and practice of intelligent life.

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# Alan's Apple: Hacking the Turing Test

Valeria Patera

TIMOS Teatro Events, Association for the Communication of Science, Italy

**Summary.** A play by Valeria Patera, translated into English by Susie White.

## 1 The Author's View

My study on Alan Turing and a specific part of his work uses a poetic/philosophical approach and takes the form of a play; hence it will differ from the various papers presented here.

My aim was not to produce a work representing Turing's biography but rather to create a theatrical setting in which individuals who exist in different spatial and temporal contexts, but are closely linked in AI genealogy, meet on a virtual plane; individuals who, in both cases, have been branded as "outsiders."

Thus, stylized moments in Turing's life, which has all the makings of a modern tragedy but with comic overtones stemming from the bizarre nature of this eminent mathematician known for his eccentricity and contempt of power, and his disarming honesty and free spirit, "virtually" collide with the adventures of two young present-day hackers who meet up with him while surfing the Net.

The Turing Test is "reinvented" and transformed into a theatrical mechanism, a deus ex machina that brings the two young hackers, actors in the cyber culture created by the Net, into contact with Alan Turing, whose work in Bletchley Park during the Second World War may well have made him the "father" of the modern hacker-inspired cyber culture. This cyber culture, more than anything else, embodies the advantages and contradictions of a remarkable invention: the computer. Now an absolute necessity in everyday life, the computer has questioned and is seriously questioning some of the paradigms of Western culture; in fact, we are all increasingly compelled to address the nature and meaning of intelligence, thought, consciousness, reality, fantasy, freedom of information, intellectual property and access to knowledge.

By interweaving the two worlds, Alan's and the hackers', and following a continuous thread, I have sought to represent in a stylized way the evolution of the thought paradigm, from the pioneering research conducted by Alan Turing to the artificial intelligence of the late 1950s (the MIT Strong Artificial Intelligence Program was presented two years after Turing's death) and the revolutionary technological era in which we are now living, which

will certainly be — as our protagonist intuited — the beginning of a new and contradictory period in the life of the individual and his relationship with society.

For further reading, I would refer you to the introduction by Giulio Giorello.

## 2 Turing and the Apple — By Giulio Giorello

The apple has always had a certain importance in the history of mankind. There was the apple that Eve picked and Adam ate, and we have seen the consequences. There was the apple that fell on Newton's head — an episode he himself liked to relate in later years — and we are now grappling with the enigma of gravity. There is also Alan Turing's poisoned apple. Let's stop here. "Alan's Apple: Hacking the Turing Test" by Valeria Patera examines the scandal surrounding this last apple and presents as an enigma the life, death and destiny of the man who did so much to decipher the Nazi Enigma code during the Second World War. But deciphering the meaning of life is much more difficult.

Patera counterpoints the human and scientific aspects of Alan Turing's life with conversations between two hackers who, in turn, question the meaning of what they do. They set the virtual world of the Net against the real world, composed of things and bodies, but also of institutions like the Inland Revenue and the Police. Here, as in Turing's case, the focus is on diversity as opposed to standardization, extraordinary science as opposed to normal research, liberty as opposed to necessity. But what if the freedom dreamt of by those who surf the Net is actually a different kind of necessity? Besides, I remember one of the hackers saying at the beginning of Patera's play: "I live on the Net, in another society, with its own rules, borders and traditions." Exactly! Here we have another society, more rules and borders! We may also have the slight suspicion that the wonderful world imagined and desired by the hackers will turn out to be a Brave New World. Is there perhaps a test that would allow us to clearly distinguish the different kinds of freedom from those of necessity?

Turing's own experiences show how difficult it is to make a sharp distinction between the two. Does science always signify intellectual emancipation, and technology "progress?" Then why "are the Police so interested?" To what kind of freedom did Turing sacrifice the best years of his life? What kind of an open society is it that uses chemical castration to "normalize" those who appear to be sexually "abnormal?" And can machines be "better" than human beings, in every sense of the word? In constantly posing these questions, Patera cannot but use as a poetic symbol the Turing Test itself, which has become one of the most representative issues in the soul-body-machine or, if you prefer, the mind-brain-computer debate. A problem that has been with us at least since the time of Descartes. However, it was abstract logic

research (the Turing concept of computability) that truly revealed to us the Brave New World of computer technology; the technological aspect (the program known as Strong Artificial Intelligence) came later; moreover, it was brilliantly anticipated by Alan Turing.

Perhaps it is more than a historical irony that the test which is indissolubly linked to Turing's name in specialist literature was based on a gender test (designed to reveal if the hidden interlocutor was male or female). As well as ambivalent gender there is now an equally ambivalent human being. It suffices to consult the documentation on the results of the Turing Test. In the interesting volume "The Engine of Reason, the Seat of the Soul" (1995) by Paul M. Churchland, for example, we read that in the course of many tests not one "machine" was mistaken for a human being by the "judges," whereas many human beings were taken to be machines (see Chap. 9 of the above-mentioned work). Perhaps it is not a question of asking ourselves if a machine can think, but of concluding that when we think we do so like "machines."

Indeed, the hackers in Patera's play lead us to understand that, in some sense of the word, we are (also) machines. Extremely sophisticated machines, in fact, that have undergone a long evolutionary process. These machines are also known as bodies, and perhaps Turing's error was to sometimes forget that he possessed a body and that simulated intelligence is also strongly conditioned by the physical structures employed. Nowadays, the Turing Test is usually criticized from two opposing points of view. According to some it is too narrowly based, while others find it too broadly based. In either case it is not able to adequately represent the kind of symbolic thought that is now considered one of the most significant products of evolution, firstly from a biological and secondly from a cultural standpoint. I would refer the reader here to the now well-known Chinese room argument by John R. Searle. Patera obviously does not claim to solve this philosophical puzzle in her play, but she intelligently implies that the symbol is the "death" of Turing's research program.

Symbols are important, in fact, as the anecdotes about apples show, and the one about Turing is a little like the apple (poisoned) in Snow White, the difference being that in Turing's story there is no Prince Charming to awaken the sleeper with a kiss.

## 3 The Play

### Dramatis Personae

– *Alan Turing, English Mathematician born in 1912 (here acting from the 1930s to 1954)*
– *Julius Turing, his father*
– *Ethel Turing, his mother*
– *John Turing, his brother*
– *Christopher Morcom, his school friend at Sherborne*
– *Mrs. Morcom, Christopher's mother*
– *Housemaster at Sherborne*
– *Victor Beuttel, a fellow student*
– *Joan Clarke, cryptanalyst and fiancée*
– *Claude Shannon, American mathematician and Alan's friend*
– *Zac and Hardo, two present-day hackers*

### Scene 1

*A sloppily dressed hacker, Zac, with an "unreal" look about him gets off his bike.*

ZAC Shit, it's jammed, just like yesterday! (*pause*)
If my bike packs up I'm in trouble. I don't use it for racing. I hate sport and all that macho stuff. My bike's vital.
I'm fucked without one here. (*peering at it closely*) The chain again, just my luck!
I had to deliver the program.
Me and Hardo do over a hundred kilometers a week.
You're better off pedaling than crawling along in the traffic, which is just as much hard work. Right ... (*he tries to fix the chain*) every time this friggin' chain comes off I get mad, but I love the challenge.
I give it fifteen minutes. I can't resist a broken machine.
I was going to sell my car and buy a laptop.
Then I thought what good's a laptop if you're stuck in one place?
And the car caught fire on the highway.
I left it there. (*still tinkering*) Come on, I'll fix you ...
I wanted to be home for supper, since my mom's going to be there for once. She's moved, she's taking a course at the university to become a social worker.
I live with my dad. He's got Alzheimer's. (*pause*)
I'm finishing high school. (*pause*) I've tried kidding myself that if you lie well enough you're the first to be convinced. It doesn't work. No way! It's no good pretending to be what you're not, trying to be someone else. (*pause*)
Here they think I'm a weirdo, different ...

School's no joyride either.
What did the teacher do to punish me? Made me type up my papers on a typewriter, for God's sake. What a cow ... it's hell. It's sheer hell for someone like me (*he kicks the bike*), I've never used a typewriter in my life. It's like something out of the ark. Fifty pages ... (*pause*) The Headmaster thinks distributing a booklet on the birds and the bees to high school kids is being modern. It's making me freak out! (*he desperately puts a hand to his forehead and laughs bitterly*) Whole afternoons playing the typist! All I need is red nail polish and ...
As long as it doesn't get around the Net! Flamed online!
The Net's my life. I live on the Net, in another society, with its own rules, borders and traditions. I'm free to go where I like, to take all I want. The Net is a fantastic world, a continuous flow of updates, a constantly expanding universe of games, programs, graphics, operating systems ... hmmm, good enough to eat ...
Apart from the perverse logic of having to pay a subscription to access these things, I'm not subject to rules, taxes or any of that other crap they impose on you to keep you in one place rather than another. (*pause*)
Computers empower you. I've made a name for myself on the Net, and it suits me: Zac, short and sharp. Then there's my buddy Hardo: hard and a bit a bastard! (*pause*)

*He gets back on his bike.*

So me and Hardo thought, we've got no wheels, no money, all we've got is our technical ability, our skills.
Nothing's stopping us now! Having no wheels is a real opportunity! (*pause*)
On the Net it doesn't matter what color you are, or if you're male, female, lesbian, asexual, or a cannibal. On the Net age, the number of your bank account, and all that stuff doesn't count.
A nineteen-year-old zilch like me is a falcon on the Net, who flies higher than most then plummets down into the mystery of pi. I can see things I'd never have been able to, not even if I'd lived three times over in this shit hole. Working in a superstore. (*pause*)
I finally did it. I got the fucking chain back on. Nothing gets the better of me, got it?
A bike's the best way to get around, it's economical, an elitist symbol if you like, and you don't have those traffic lights breaking your balls ...
All those one-way streets round every corner would make you late for your own funeral ... Hmm, traffic signs should be rethought, controlled more intelligently and the entire system redesigned. (*pause*)
I take all my other trips on the Net.
The Net makes me feel secure. It's my community. The Net is not an alternative to life, for me the Net is life, my portable cyber-community ...

JULIUS Perhaps it is his being able to think of and do things that no one else would dream of doing that irritates them ... Do you remember that picnic when he found us some honey for the tea, taking it directly from the comb that he had located by studying the flight paths of the bees buzzing around it? The honey was bitter, but I was so impressed by the whole business ...

ETHEL I'll never forget that afternoon ... especially when he said he "knew" the forbidden fruit in the Garden of Eden was a plum and not an apple ...

*Alan, now naked, continues joyously working with alembics and consulting formulae amid swirling vapors, while his mother continues to read the letter.*

"I must say that he has taken his punishment very well and has certainly made more of an effort, for example with physical training. I have not completely given up hope."

ALAN I learnt to run fast to avoid the ball. What I like about being a linesman is indicating the precise point where the ball crosses the line. They've even made up a rhyme about me. (*reciting to himself*) "Turing's fond of the football field/For geometric problems the touch-lines yield."

*He laughs in amusement*

ALAN What I can neither understand nor share is the need for certainties that most people experience to some degree ... certainty holds no fascination for me whatsoever ... I live for doubt ... (*pause*)

But mere consciousness amazes me, gives me such joy ...

the tiniest insect or creature, eyesight, love ...

*He sees a boy go by, everything else disappears, that figure becomes the focus of his gaze, the colors change.*

... Oh, Christopher Morcom! Chris! When I see him a rainbow appears in my soul!

I'm so happy when I'm with him ... how can I see his face again?

*He pulls some crumpled notes from his pocket, smoothing out one of them.*

### Scene 4

*Alan and Christopher in the school library.*

CHRISTOPHER Oh Turing, what brings you to the library? I've never seen you here before ...

ALAN Well, yes, in fact, I just thought it was a good place to think ...

CHRISTOPHER Of course ...

ALAN Of course ...

*(after timidly hesitating for a moment)*

I've calculated pi to thirty-six decimal places ...

CHRISTOPHER Really, how did you do it?

ALAN Using the series — my own personal discovery — for the inverse tangent function ...

*People are calling out to Christopher.*

CHRISTOPHER Very interesting indeed! In the last few days I've been totally immersed in the General Theory of Relativity, space-time ...

ALAN (*sucking air in noisily through his nose, and then speaking rapidly without pausing for breath*) Have you noticed that Einstein does not deal with the "real essence" of time and space? He concentrates on measuring instruments, "clocks," thus adopting an operational approach to physics ... distance is also seen in relation to a measuring operation, and not as an absolute ideal.

*Someone shouts out to Christopher again.*

CHRISTOPHER (*amazed by Alan's insight*) Sorry, they're calling me, I must go, be seeing you ...

ALAN Why don't you come to my room? We could do some experiments with iodates and sulphates, it's very interesting ...

CHRISTOPHER Oh yes, I've always loved messing around with them. Bye.

ALAN Bye ... (*pause*)

*The hacker cycles across the stage.*

### Scene 5

*Alan and Christopher are in the school lab, surrounded by alembics.*

ALAN ... You know I've always been fascinated by experiments involving iodine.

CHRISTOPHER My brother Rupert also ...

ALAN This is a beautiful experiment, watch: you mix the two solutions in a beaker, wait for a specific time, and the mixture suddenly turns blue. Everything becomes blue, blue, blue, deep blue ... as if a piece of sky had fallen into the beaker ...

*A deep blue patch of iodine appears on the screen and gradually fills the entire space, transforming it into a starry night sky.*

ALAN What's the time?

CHRISTOPHER Ten o'clock.

ALAN How can you tell?

CHRISTOPHER I always know the time; I go by my biological clock. Come and look at the stars.

ALAN What makes us different from a star?

CHRISTOPHER Stars are always there; our lives pass so quickly and we're certainly far less bright ...

ALAN I'd give anything to know why we have our present form instead of being star-shaped ...

CHRISTOPHER I watch them, study them for nights on end. Did you see that satellite the night before last?

ALAN I did! (*they are both keyed-up, aware of the mystery of it all*) How could I have missed it coming out of eclipse!

CHRISTOPHER The sky isn't that clear sometimes and it's difficult to make things out. My father wants to get a more powerful telescope.
I've often wanted to make a star globe but have never really got down to it ...

ALAN Oh yes, a star globe, I'd really love to make one ...

CHRISTOPHER I must go in now. The "Chief" will be very angry if he sees me out at this hour, and I feel a bit tired. I'm also going to be away for a week; I have to see the dentist. Good night Turing (*he clasps Alan's hand with both of his — Alan is completely thrown*).

ALAN (*alone now, and over the moon*) I worship the ground he walks on! Since I met him I've been living on another planet. The week we spent together in Cambridge was the happiest of my life! Now, at Sherborne, I'm going to make him a star globe ... I know it won't be anything fancy but ... with a bit of inventiveness ...

*He takes the glass globe from a lamp, starts to fill it with plaster of Paris and then begins to mark the positions of the stars with dots, and draw the lines of the constellations (his actions as he plots the stars and lines are enlarged on the screen).*

ALAN (*thinking to himself*) It's useless to ask oneself if two points are always equidistant ... I'm the one who defined the parameter, and, just as a research method will influence the result of an experiment, my ideas will tend to conform to that definition. These yardsticks are conventions we follow, and I adapt my laws to my own yardsticks. How I envy those who believe in an absolute truth!
I'll have to wake up at four because then the sky will be clear again and I'll be able to see the more distinct constellations ...

*We hear the mocking chant of his schoolmates.*

Pansy, pansy
Pansy, pansy, pansy!!!

### Scene 6

*Julius is reading a letter; his wife arrives and looks anxious when she sees it.*

ETHEL Heavens, another letter from the headmaster, what has that unconventional son of ours done now!

JULIUS You're wrong this time. His end of term results have greatly improved, look, Alan is making the grade! His marks are much higher — I expect one of the teachers has finally understood him: I don't always, but I try to give him my support.

ETHEL I told you that was the right school for him, it's obvious, the results speak for themselves. They'll make a real gentleman of him ...

*Julius helps himself to a small sherry.*

*Meanwhile we see Alan as he continues working on the star globe.*

**Scene 7**

*Alan is sleeping in his room at Sherborne; someone knocks on the door. Alan goes to open it, his eyes still heavy with sleep. It's the housemaster.*

ALAN (*embarrassed and scared*) Good morning, Sir, am I late for lessons? I got up at four to stargaze, you know, I must have dropped off again and ...

HOUSEMASTER No Turing, nothing like that, classes have not begun yet ... I've come to tell you that ... (*hesitating*)

ALAN Yes? ...

HOUSEMASTER (*giving a few little coughs*) ... that Christopher Morcom ...

ALAN Chris?

HOUSEMASTER Morcom has left us.

ALAN He left to go to the dentist; he told me a few days ago.

HOUSEMASTER No, that's not what I meant.

ALAN He's left Sherborne? To go where? He didn't tell me anything ...

HOUSEMASTER He has left this world. Christopher Morcom is dead.

ALAN Dead? Christopher?

HOUSEMASTER Yes, Turing, yes. It grieves me to have to give you this news, I know how close you were, but unfortunately that's how it is.

ALAN (*upset*) But ... he had to go to the dentist ... what ... how? ...

HOUSEMASTER Morcom had tuberculosis, caused by drinking infected milk in Yorkshire, bovine tuberculosis ...

ALAN Bovine tuberculosis?

HOUSEMASTER Yes. Two years ago, the disease caused grave internal damage and ... after terrible suffering he passed away at three this morning.

ALAN (*almost losing control*) At three this morning?

HOUSEMASTER Yes Turing, at three.

ALAN (*going to the window; he glances at the star globe*) I looked at my watch at three precisely. Something woke me up at three, something that made me think of Chris, the moon was setting ...

*The housemaster shakes Alan's hand warmly and leaves. Alan remains alone; it seems as if everything around him is being sucked into an enormous void.*

ALAN I had already accepted the idea of death. It's not clear why we live but, in theory, it's very clear why we die; the process can be described. There's a formula for every problem ... but not this terrible pain! There's no logic to that ... bovine tuberculosis ... he was so young, he was the best friend I'll ever have, Chris wasn't stupid like all the rest, he made the world bearable for me, he was everything I loved, he and my numbers ... Perhaps a cell has already left his body to become a star ... perhaps ... Now he's a bright new series of numbers scattered through the cosmos ... I'll find them one by one ...

and compose a new formula to celebrate his passing.

*The star globe remains in the middle of the stage as if it were a planet in the universe.*

## Scene 8

*A few weeks later. Alan is with Christopher's mother at her home (the Clockhouse).*

MRS. MORCOM (*giving Alan a fountain pen*) Alan, I'd like you to have this.

ALAN Oh, Christopher's favorite pen, he was so proud of it ...

MRS. MORCOM Take it; Chris would be very happy.

ALAN Thank you, Mrs. Morcom, it's like being entrusted with the most priceless treasure. I'm sure it'll help me with my studies and research; it'll be like having Chris by my side, helping me ... I've promised myself that I'll get top marks next term, I've got to do it, for Chris. And I'll succeed, you'll see!

MRS. MORCOM I'm sure you will, Alan, I'm absolutely sure, and remember we're always here if you need anything. I'd like to thank you for the beautiful flowers you sent and also the kind letter your mother wrote me — I've just replied to her.

ALAN I'm sure she'll be glad to hear from you. (*pause; he looks around*) You can feel Chris' presence so strongly here, I expect him to walk in any minute; it's as if his spirit pervaded everything.

MRS. MORCOM Oh Alan, I've thought about so many things, I've tried to find an explanation but ... all the scientific research that has been done in this house seems to have been in vain ...

ALAN Until the end of the last century the Laplacian view prevailed, which held that if everything was known about the Universe at any given moment we could foresee what it would be throughout the future. Now modern science has seen that the instruments it uses to acquire knowledge are themselves composed of atoms and electrons, just like the matter they are exploring, which has completely scuttled the previous theory. Therefore we cannot delude ourselves that it is possible to know the exact state of the universe, in the same way that we cannot say our actions are predestined. The action of the atoms in our brain is probably influenced to some degree by our will, which the actions of the body amplify.

MRS. MORCOM ... What about the action of the other atoms in the universe?

ALAN A burning question, since these atoms have no amplifying apparatus and they would appear to be regulated by pure chance, confirming the apparent non-predestination of physics.

(*pause; he sucks in air noisily through his nose*)

Furthermore, I would say that spirit is always connected with matter but not always by the same kind of body ...

**Scene 10**

*Seven years later; images of the Second World War, Enigma and codes, and scenes from war video games appear on the screen. Alan is sitting down; he is knitting, and has a gas mask beside him. Joan arrives.*

ALAN Good morning, Joan!

JOAN Good morning, Alan! I see you're making progress.

ALAN I love knitting, I'm making a glove, I'm on the third finger ... I've always enjoyed making things, but this is really quite remarkable! While trying to fathom the latest Enigma key used by the Germans in their messages disguised as weather bulletins, I'm producing woolen fingers, it's wonderful!

Every morning at 6 AM the Germans transmit the same message, I'm sure there's something behind it ...

JOAN (*alluding to the gas mask*) And that?

ALAN I wear it riding to work. It filters out the pollen that makes me sneeze, most convenient!

JOAN (*smiling*) Do you mean to say you rode through the village wearing that?! What must people ...

ALAN At least it isn't a secret, at least they can form an idea ... But no one has any idea what we cryptanalysts are working on here. It's as if we didn't exist. We're suffocated by secrecy, what we do cuts us off from everyone, even those closest to us ... In the early days at Bletchley Park, before my studies at Princeton, we were a group of romantic intellectuals on the loose. Now we're pigeon-holed, our work's so organized, we're like a code-breaking factory, and I find this sort of non-existence hard to bear at times.

JOAN If Churchill deigned to pay us a visit it must mean that he's well aware of the importance of our work here.

ALAN "The geese who laid the golden eggs and never cackled," that's what he called us. Not bad ...

JOAN The great Churchill was quite astonished. Perhaps he expected to find only serious mathematicians secretly engaged in cryptanalysis in the huts, and never dreamt of coming across a well-known collector of porcelain, a museum curator from Paris, the British chess champion, leading bridge players and an unconventional mathematician who knits and ties his mug of tea to the radiator ...

ALAN But he must have guessed we're in difficulties; the only positive thing about his visit is that he told us to contact him personally should the need arise. I've taken him at his word and have already jotted down a few lines to make him understand that if he doesn't send us reinforcements we won't be able to finish the job, not even with the Bombes they sent us; war will not wait. We'll all sign it and he won't be able to refuse ... (*he looks steadily at Joan*)

JOAN What are you thinking about, Alan?

ALAN Oh, Joan, I was lost in my feelings ... I get so much pleasure from being with you, I really do, we're such good friends, everything's so spontaneous ...

JOAN How could it be any other way with you? You're the most incredible man I've ever known and I'm so proud that you and I ... (*Alan breathes in noisily through his nose*) Alan, is there something wrong?

ALAN The thing is that I ... I ... don't think I feel quite the same way as you do ... perhaps I ... Oh, I love you of course, there's no doubt about that, but ... there's something else ... you see, the fact is that er ... men don't exactly leave me cold ... do you understand?

JOAN Of course I do, but I won't let it be a problem ...

ALAN How sweet you are ... but I really think it will be; I don't want you to suffer; I'm absolutely convinced it won't work. You'll feel let down, and I don't want that. There are times when we have to give up what we love because there is no alternative. Wilde knew that so well ...

"Yet each man kills the thing he loves."

*Everything freezes; the lights change.*

## Scene 11

*At the Turings' house: Julius, Ethel and John are sitting around the table set for a meal. Alan arrives out of breath, with his jacket buttoned unevenly, one shoe different from the other, and untidy hair.*

ETHEL (*mortified to see him looking such a mess*) Alan, my God, how can you go around like that?! You look like a vagrant!
And you're late! Your hands are dirty! Heavens, what a tie!
And ... what's this? Alan, you're wearing a rope instead of a belt, and a red one at that, what am I to do ... What a disappointment! I thought that working at the Foreign Office you would have adopted a military manner, but just look at this haystack and those dark circles under your eyes ... they may make you work the whole night through, but I'd like to know exactly what you do?

ALAN Defend England by playing mathematical games. But enough of that, why don't you give me a plate of your wonderful stew? You don't think I came to see you, do you?!

ETHEL What was that thing about a code? A code that breaks other codes? What was it? (*Alan kisses his mother on the cheek. Ethel gives an ironic but satisfied smile as she goes into the kitchen, mumbling and grumbling.*)

ALAN (*to his father and brother, lowering his voice*) I'm off to Washington!

JULIUS Another trip to America, son? Princeton, again?

ALAN No, I'll be staying in Washington this time. They want us to let them in on the secrets of Bletchley Park's cryptanalysis. The Americans are supporting the British strategy of reconquering the Mediterranean for

the first time, Britain has agreed to be used as an American base. The war has reached a turning point, Father. (*Julius nods gravely*)

ETHEL (*loudly, from the kitchen*) Princeton, did I hear aright? You got a postcard from Princeton?

ALAN Not quite, I'm leaving for Washington!

ETHEL (*looking astounded as she comes back into the dining room*) You are? So you've finally become someone? Even if you go around dressed like that?

ALAN (*smiling*) Dressed like this I've invented a machine that does very difficult calculations, a universal machine that can do a lot of things automatically: read, write, compute; in other words, produce "intelligence." (*there is a big silence*)

ETHEL A machine? (*pause*) That does all that by itself? (*pause*)

ALAN A model with which it's possible to elaborate the most complex procedures simply by using a series of simple elements: states, positions, reading, writing, a table of instructions. A universal machine!

ETHEL Black magic.

I wonder what the Reverend would say? May St. George protect you!

ALAN Quite honestly, I'd rather have the dragon on my side.

JULIUS Tell me about this miraculous machine ...

ALAN I began with a theoretical machine; they've called it the Turing Machine!

JULIUS (*looking proud*) Oh, that has a nice ring to it, a nice ring to it indeed: the Turing Machine.

ETHEL It's in the family, in our genes. What's more, a close relative of ours, George Stoney, invented the electron!

ALAN Mother, I've told you a hundred times that you can't invent an electron because it already exists, you can only discover it and give it a name. But they did use it to invent electronics.

ETHEL That's no mean feat! You should tell those crass Americans about it!

ALAN (*ironically*) I'll write them a letter first thing tomorrow! (*Julius and John smile at each other*) However, to understand you should think of a super typewriter that can calculate an infinite number of operations. You see, there really is no difference between intelligent and mechanical, therefore some functions of our brain, like counting, can be translated into a mechanical action by breaking down each small stage, that is the smallest element of each mental state, and translating it into a series of numbers that are printed on paper tape ... an endless tape ...

From a certain point of view one can say that the machine thinks, or at least reproduces some thought functions. (*Ethel's eyes are on stalks, Julius' mouth is half-open in amazement, and John shifts in his chair in embarrassment*)

ETHEL But that's blasphemy! A machine that thinks? It's sacrilegious! What about the soul? Our Lord gave us the power to think. How can you say that ...

ALAN The soul ... And how do you explain the fact that for a long time monotheistic religions considered that women had no soul at all?

*Ethel is stumped; she struggles to come up with something and finally succeeds.*

ETHEL Leaving the soul out of this, human beings and machines are not made of the same stuff!

ALAN It doesn't matter what the brain is made of, only how it works! You may not think so but there's nothing sacred about the human brain!

ETHEL That too! Talk about a fire-breathing dragon!

ALAN The human brain is composed of an infinite number of elements called neurons: ten thousand million or more, according to some estimates. These neurons are connected to each other by a dense network of "wires." A neuron is a kind of switch, a very simple one, that has two positions: ON and OFF. The position assumed depends on the signals the neuron receives from the other neurons.

ETHEL Am I to think that ... how can I put it ... that this is why I can smell violets in springtime?

ALAN Yes, in point of fact, it is. The brain stores information in the form of configurations created by impulses relayed by neurons. It is astonishing how closely the storage and modification functions of neurons in the brain resemble the corresponding functions of a calculator. It is this similarity that convinces me that we can actually build a thinking machine.

ETHEL Are you going to state all these wild theories publicly in America? An electric brain?!!

JULIUS A theoretical machine is all right as far as it goes; but can you build one?

ALAN (*breathing in noisily through his nose*) It already exists. We're actually well ahead with the Colossus, which is capable of doing an incredible number of calculations and has a memory that can store vast amounts of information.

We're working flat out. That's why I'm going to America again.

*Julius looks at his son gravely yet warmly, and a little patronizingly; Ethel wrings her hands.*

*Alan smiles; he goes over to the wireless and turns it on. A firm, pleasant male voice fills the room.*

MALE VOICE Only a few men, a handful in fact, have had the strength to believe in and to strive unceasingly to realize something that seemed impossible; they have built an electronic brain, whose infinite possibilities will extend human intelligence. This is the birth of a new era. We must be receptive to new ideas, new concepts. We must see the human mind and human consciousness in a new light. And those scientists must be allowed

to help us; their responsibilities are very great and we, in our turn, must help them to shoulder this burden ... (*Ethel remains thoughtful and silent, as do Julius and John. Alan gets up and takes his leave. He goes out. The lights change.*)

*The hacker rides by on his bike, singing a rap.*

ZAC

I used to think
Of a cybernetic meadow
Where mammals and computers
Live together
In programming harmony
Like pure water
Touching clear sky.

I used to see
A cybernetic forest
Filled with pines and electronics
Where a deer strolls peacefully
Past computers
As if they were flowers
Filled with sparkling jewels.

Think about
A cybernetic ecology
Free us of our labors
Return to nature
All together

Watched over and protected
By the machines of divine grace[1]

## Scene 12

*America. Alan and Shannon are having their meal in the laboratory at night; there is a chess board beside them. Alan glances at the onion on Shannon's plate, and spears it with his fork.*

ALAN An onion, yes it was actually the onion that gave me an insight into the human mind ... the onion whose layers can be peeled away (*he peels off one layer delicately with his fingers*) ... If we consider the functions of the mind, or the brain, there are certain operations that can only be explained in purely mechanical terms. This does not correspond to the "real" mind; it is a kind of skin that we must peel off to find it. But in what is left, we find another skin to take off, and another. Do we finally arrive at the "real" mind, or only a skin that contains nothing? (*he sucks in air noisily*

[1] "I used to think ... ," variation on the poem "All Watched Over by Machines of Loving Grace" by Richard Brautigan (1967).

small barrel to keep here, but it was as if I had said something sinful, it beats me ... (*he sucks in air noisily through his nose*)

Oh, I've got a brilliant idea! As an alternative, I propose an afternoon at the rifle range tomorrow!

SHANNON (*in astonishment*) The rifle range? With your ideas about war?! ... Where did you learn to shoot?

ALAN In the Home Guard.

SHANNON Home Guard?

ALAN Yes, a civilian force that has been set up in England, since we're at war. They teach you to use a rifle during the training course, so I enrolled.

SHANNON I thought you weren't interested in weapons ...

ALAN As with everything else, I was mainly interested in how the gun worked, its possibilities; but I admit I was also attracted by the uniform, though I'm hardly a model soldier. The fact is that one of the questions on the form I had to fill in was: "Do you understand that by enrolling in the Home Guard you place yourself liable to military law?" I saw no advantage in answering "Yes" so I wrote "No." The thing was that they only looked to see that I'd signed the form, as usually happens in these situations, so I was accepted and was a first-class shot at the end of the course.

Needless to say I had no further use for the Home Guard; there was less danger of a German invasion, and I wanted to do something more useful and continue my research. However, the fact that I skipped parade was naturally reported to Headquarters and when I was asked why, I told them that now I had become a crack shot I was no longer interested in the Home Guard.

SHANNON (*amused*) How did they react?!

ALAN The commanding officer nearly had a fit; he reminded me of my duties as a soldier and that it was not up to me decide, but I told him that if he looked at my form closely he would see that I was not subject to military law. They found my form at once and he had to admit I had been improperly enrolled through no fault of my own.

SHANNON You son of a gun!

ALAN No, I wasn't trying to be clever. I simply took the form at its face value and decided what was the optimal strategy for completing it. I applied the minimax strategy!

SHANNON (*amused and affectionately admiring*) As usual it's real difficult to catch you out. I'll sure miss you when you go back to England ...

ALAN (*touched and embarrassed by the show of affection*) I think about my return to Europe, I think about it a lot, I know nothing will be the same. We can't emerge from this war unchanged, everything's changed. What little innocence we still possessed is now gone ...

*As the two friends look at each other and reflect, the light changes.*

**Scene 13**

*Two hackers in the back room of a computer shop; a workbench completely covered with tangled wires, mother- and daughter-boards, screws, etc.*

ZAC I've done it, the system's working again! Everything was looking black, I was desperate ... (*to computer*) you're real smart! Almost as smart as me! What a turn on; it's like giving someone the kiss of life and seeing them come alive ... I've resuscitated it! Fucking neat! For a while I thought it was no go and then ...

HARDO Let's celebrate with a Coke! Now we can afford the real thing instead of that ersatz crap!

ZAC Come on (*pouring the Coke*) let's get stewed!

HARDO I told you the computer would save our lives.

ZAC Unbelievable, a few months ago we were shut up in that shitty school composing papers on a typewriter as a punishment and now ...

HARDO We got a job in next to no time, and together! What a break!

ZAC A quick trawl and we found work. (*they slap each others palms*) We'll go a lot further — that's a promise, and a threat!

HARDO It was a real eye-opener. I didn't realize that what we've been doing for years — building computers, writing programs, gaming, installing operating systems and software — had a value, a market ... that it gave us a real possibility to carve out a niche for ourselves in society.

ZAC Yeah, society, you can't exist without it. Sure, they love the Net now. How convenient it is for them to log on and access schedules, connections, ticket prices and every other kind of info, before taking a train or plane to their shitty vacation spots or the cities where they strike million-dollar deals ... .

HARDO Bastards! We understood the Net's potential for exchanging info first. But now we're becoming empowered 'cause none of them know how to do what we can do, they've started preaching about intellectual property, the unchecked flow of information ... For them the mere idea of losing total control ...

ZAC I can't stand the way they can't tell a hacker from a cracker, get them mixed up, don't understand. They think we're all destructive individuals, online terrorists. Try telling them ... Hey, listen to this! It's a blast! (*music at full volume*)

HARDO Oh, cool, when did you pull it down?

ZAC Last night, I scarfed a whole bunch of fantastic tracks, so fuck the record companies and long live music! There's material and intellectual property. Paying for intellectual property is justified only on rare occasions. You pay for material products. I don't fork out for software or music, 'cause I know that musicians, writers and artists will find other ways to earn money from their work; but I would never dream of stealing a TV or a book.

HARDO "They" think geeks don't read, but I really rate books. Ever since I was I kid I've loved browsing in bookshops or at stalls looking for classics or sci-fi. I like the feeling of holding a book, of turning the pages ... The conventional concepts of trade and property are being redefined. What we do has so much political significance, do you get that? We're freeing up culture!

ZAC Just think if they'd stuck a rifle in our hand and sent us off to free some oppressed people that had no desire to be liberated by us. Did you ever think about that? At least our generation has been spared going to war ... (*he has second thoughts*) Christ, everything's possible, but ...

HARDO Hmm ... right ... the Fatherland. No, I don't think it's worth dying for that patriotic crap, no sir. Look at Alan Turing ...

ZAC Turing's where we come from; he was the original hacker ... with his mathematical theories and formulas he succeeded in getting into the Enigma machine used by the Germans and decoding their secret messages during the War ...

HARDO You gotta hand it to him! Christ knows where we'd be now without his insights into AI.

ZAC That was the start of it all. His working constantly with electronic machines that revealed patterns in the hidden messages, enabled him to get down to inventing a calculating machine that could actually duplicate — if not go beyond — human thought processes.

HARDO I found a site with all the dope on him, a real guru!

He gave everything to his country, to England, and we can honestly say that the British beat Hitler thanks to Turing's decoding work. Thanks to his brain they were able to screw those Nazi bastards and make them eat dirt. Wow, he was really something.

But you could never say that the palefaced Brits with all their prejudices treated him like a national hero.

No way.

On the contrary ...

## Scene 14

*England 1952. Alan and his brother John in the visiting room of a prison.*

JOHN So, Alan, try to explain what happened, clearly and in a few words, please. I can't believe it. You of all people!

ALAN Well, what can I say ... recently I was missing a few items and occasionally some money, and I got fed up at a certain point and told Arnold ...

JOHN (*allusively*) You and Arnold ...

ALAN Yes, we were. I met him in a pub and then ... but the point is that Arnold confessed to me that he had told a friend of his about us, and that

this friend had done some petty thieving, convincing me that I should go to the Police and report the burglary.

JOHN God, you're a silly ass! And you were stupid enough to go to the Police? All your study of logic and you still haven't understood that ...

ALAN Is what they're saying, what they're thinking logical? Look, there are 6 charges against me ... or rather one charge phrased in six different ways ... 1. Alan Mathison Turing, on the 17th day of December, 1951, at Wilmslow, being a male person, committed an act of gross indecency with Arnold Murray, a male person.

2. Alan Mathison Turing, on the 17th day of December, 1951, at Wilmslow, being a male person, was party to the commission of an act of gross indecency with Arnold Murray, a male person. And so on.

JOHN Did you publicly declare that you had had a sexual relationship with that man?!

ALAN What if I did? It's true isn't it? They asked me a question and I answered it; besides, I had gone there to report a theft ...

JOHN How maddeningly naive! In a country where homosexuality is a crime carrying a two-year prison sentence, my dear brother, with his brilliant brain, goes straight to the police to report the theft of a few trifles, a burglary in which the youth he was taking to bed was indirectly involved! You should never have gone to the police, not for any reason on earth! Let alone put yourself in such a vulnerable position!

ALAN I don't want to be respected and accepted as the person I am not. I want to be accepted as a homosexual.

JOHN You do realize that everyone's going to know now?

ALAN I am not worried about being in the public eye but about all the details of the affair becoming public.

JOHN I find your behavior unacceptable. You have no consideration for other people's feelings. Have you thought about mother?

ALAN ... Yes, that's the worst part of this business, I have to tell her about something for which, as King George V believed, men usually shoot themselves. You wouldn't tell her for me, would you?

JOHN Out of the question! I've found you a good solicitor, I'll try and get you out on bail, but my telling mother is completely out of the question!

ALAN ... Roger ... However, I have started to write to my closest friends, I'd like them to hear the facts from me instead of reading about it in the paper ...

JOHN Sounds like a wise move ... By the way, your solicitor advises you to plead guilty ...

ALAN I've already told you that it's not easy ... don't you see that there is no way I can be completely honest?

Denying what I have done would be a lie ... and it would be like considering what happened as something that should be denied; but also presenting

myself as guilty in public, as a confessed criminal, is not telling the truth either ...

JOHN Don't you understand that the statement you made to the Police doesn't give you a leg to stand on, so you have very little to lose by pleading guilty. This would shorten and play down the trial, which is basically the most important thing.

ALAN Of course, you don't give a damn about the terrible circumstances under which homosexuals are forced to exist ... you're only interested in your position in the City. I'll think about it and should I decide to plead guilty, you may rest assured that I won't pretend for one single minute to feel guilty or to recant.

JOHN (*losing his patience*) All right, do as you wish ... (*he leaves*) (*Alan remains alone; he picks up a withered leaf from the floor and studies it in silence*)

ALAN What makes a cell become a starfish, a leaf or a human being? (*he is lost in thought as the light dims and in the background we hear sounds from the small prison*)

## Scene 15

*The work room of the two hackers*

HARDO I've been surfing for at least four hours a day recently, and doing it on the boss' phone line gives me even more of a kick.

ZAC Remember that astronomical bill we got when we moved into our rat hole? Cleaned us out!

HARDO (*passing a hand over his forehead, as if wiping off the sweat*) Mammoth heart attack! What a beginning! We were practically living online, a real slap in the face! That huge bill suddenly revealed the full weight of the material world as opposed to the lightweight virtual world! (*singing to himself*) I was thinking of a cybernetic meadow ...

ZAC Being online makes you feel like something else; all you have to do is log on and leave the world ... (*pause*) If we don't give any importance to the concept of inside and outside, it no longer dominates us ... (*pause*)

HARDO Do you think that everything around the screen, the outside I mean, really exists? Some say no, that it's all in the mind ...

ZAC Mind, mind ... we were just talking about that bill, if it had been a mental issue we wouldn't have shelled out all that money, which really cost us ...

HARDO Wait a minute though, money's really weird. Sure it exists and it has a value, but only because this has been agreed, only because that piece of paper represents this or that sum, otherwise it would just be a piece of paper. It's like saying that if you don't give it that meaning, money doesn't exist.

ZAC But the paper exists. Whether you say so or not.

**Scene 17**

HARDO I'm almost there with my new program, I'm really wound up. It's unbelievable, I get so excited every time, a real high. I can't go to bed until it's finished, I talk to the computer.

I've produced something that wasn't there before, something alive, a creature I gave birth to, with my mental sperm.

ZAC "Almost" alive, almost! It's that "almost" you can relate to; it's much more difficult to get on with people who are totally alive.

HARDO You said it! You were so unrelaxed while that little blonde was giving you a line the other night at that "office" party, it was like you had a gun in your ribs!

ZAC The thing is that sometimes whole people scare me, I don't know what to do with my emotions. I mean, why didn't whoever created them set up an archive to store them in?

HARDO That's an idea ...

ZAC Let's face it, as soon as I got there and saw how they were dressed I realized there was a difference, and when she started talking to me, getting up real close and looking at me the way she did, I was sure she trying to figure out if I got my jacket from a dime store. (*pause*)

It was a bad situation — level 9 — a real-live "doll" and all that talk, wow ... it was like a three-way chat with everyone talking at once. There was no stopping her, so what could I do? She buttonholed me and I tried to adapt, faking the replies ...

HARDO You tried to imitate her, just like computers do humans: imitation game!

ZAC Imitation what?

HARDO Imitation game, or rather the Turing Test.

ZAC Oh. What's that?

HARDO It's a test Turing devised to show that it was possible to reproduce certain aspects of human thought and language in a machine, and to see if it was possible to distinguish between the replies from people and those from a machine. The original purpose of the test was to determine if a person's sex could be established from the replies.

ZAC Something else! Exactly what I needed! How does it work?

HARDO There are three players: a man, a woman and an interrogator, who can be male or female. The interrogator is in a room by himself, he has to decide, on the basis of written replies, which is the man and which is the woman ... But what would happen if the man and the woman were replaced by a machine without our knowing? To what degree would we realize this? In short, the question here is "can machines think?"

ZAC How do you do this Turing Test, it's really awesome!

HARDO In the latest version a jury of 10 people have to decide, during an online conversation, if they're talking to a person or a programmed computer (*he starts punching keys furiously*).

ZAC Has the computer ever fooled them?
HARDO And how, that's what's so great. But mostly people have been taken for machines ... and that makes you think ... (*pause*)
ZAC Does this mean we can say that something dies when a program is destroyed?
HARDO The million dollar question ... (*he keeps punching the keys*)
ZAC I've asked myself over and over; it drives me crazy ...
HARDO (*still typing*) Hmm ... you have to decide how you're going to approach the question; it's always best to choose a fresh viewpoint.
ZAC I don't think there's too much choice.
HARDO Not true. For instance, if you look at it from the point of view of the living, you'll see that when you die you die for someone else as well, someone who's connected to you ...
ZAC So?
HARDO So as a program is something through which you create a particular relationship with the computer, when this "dies" we can say that you feel its death, your relationship feels it, so I would say that something dies ... (*he punches the keys even faster; he is visibly excited about what's happening onscreen*)
ZAC Your reasoning's flawless, flawless; I'm going to get a black T-shirt and go into mourning. (*reacting with a start*) Great! I've got into the Turing Test!
Now we don't know if we're connected to a man or a machine ...

*On the other half of the stage Alan is lying on a bed in his room, with his old teddy bear Porgy, the star globe, a bowl of fruit, etc. He writes on small white cards and what he writes appears on the screen as the message from a computer that the two boys receive; they read them out loud.*

PORGY My name's Porgy, what's yours?
HARDO Hardo. Do you like being in touch with the world, Porgy?
PORGY It's not easy to be in touch with the world.
HARDO How do you get on with humans?
PORGY I've got on better with my bed.
HARDO Do you always have an answer?
PORGY No, I don't. Not even mathematics is entirely a matter of logic.
HARDO Do you always tell the truth?
PORGY When the emperor's wearing no clothes he's naked.
HARDO What leaves you speechless?
PORGY What cannot be said.
HARDO What is the universe?
PORGY The universe is the interior of the light cone of the creation.
HARDO And science, what's that?
PORGY Science is a differential equation.
HARDO And religion?

PORGY Religion is a boundary condition.
HARDO Does God exist in the universe?
PORGY Wherever God's holy pantomime is played out.
HARDO Can a computer conceive of God?
PORGY I've always wondered if He would catch cold walking on the damp grass.
HARDO Do you agree with what people say about how machines think?
PORGY If two machines were chatting about human beings, would they ask why they think what they think?
HARDO Can a computer be so desperate it commits suicide?
PORGY Could you repeat the question?

*The program stops. On the screen we see Hal's mouth in "2001: A Space Odyssey." Freeze frame on the two hackers. Light on Alan as he stops writing. He gets into a sitting position.*

ALAN The onion ...
Yes, I wanted to separate the layers of the onion of the mind
but there was nothing in the center. (*pause*)
My hope, my wish was to find this. (*he helps himself to an apple and takes a bite*)
The core.
Pure life. (*pause*)

*He sits down at a table on which there are some ampoules and laboratory instruments. While he is speaking he picks up a small box with cyanide in it, opens it, tips the contents into a small basin and slowly dips the apple in the poison.*

A computer can only open the windows of logic through which life itself escapes.
Irrational and inimitable. (*pause*)
A computer can never appreciate a fairy-tale as much as a little boy. (*pause*)
I love Snow White's apple. (*pause*)
Its reflection in the mirror. (*pause*)
Through which I pass. (*pause*)
Imitation game. (*pause*) (*he sings to himself and lies down on the bed*)
"Dip the apple in the brew
Let the Sleeping Death seep through." [2]

**Scene 18**

*Ethel Turing enters; she speaks quietly, arguing against Alan's having committed suicide.*

ETHEL That habit of not washing his hands after doing experiments, that's what killed him.
He did experiments with cyanide. (*pause*)

[2] "Dip the apple in the brew ... " from Walt Disney's *Snow White*.

He always had a fixation about poison getting under his fingernails; some of it was bound to. (*pause*)
He wasn't careful enough; he didn't scrub them, and who knows ... (*pause*)
I'll never believe my Alan took his own life.
He was odd, granted, but not that odd. (*pause*)
He was calm again, and had practically overcome the trauma of the oestrogen treatment.
That nasty affair actually brought us closer. (*pause*)
And then he had resumed his computing studies, he had been to Greece ... he was organizing another trip. (*pause*)
The idea of the secret service is like something out of a film. (*pause*)
Yes, I've thought about it, all that top-secret information, but I never knew anything. What can I say? (*pause*)
His complete lack of interest in his body, grooming, washing his hands ... (*pause*)
He was exactly the same at college ... your hands and nails are dirty, Alan, you've got ink on your collar. (*pause*)
Wash your hands, Alan.

— *The End* —

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were given instruction tables which would allow it to interpret that logical system.

In 1950 his M.Sc. student Audrey Bates worked on putting a small part of Church's lambda-calculus in a form where it could be mechanized by the Manchester computer [1]. This work could have led to LISP programming, which was also inspired by the lambda-calculus, but he never followed it up. The same is true of the work he did on program proofs in 1949; this was never taken up and had to wait for others in the 1960s.

The computer scientist John McCarthy would have invited Turing to Dartmouth College in 1956, for what is usually thought of as the conference that began Artificial Intelligence. What would Turing have said, if he had accepted such an invitation? He would have been living witness to the fact that Artificial Intelligence research had started well before 1956. The wartime origin was described in [20, e.g. pp. 210–214, 265, 291–294] with a deeper analysis in [21, 23]. Perhaps he would have advocated avoiding the separation of "top-down" from "bottom-up" research that was in fact to characterize AI research so strongly for the next thirty years. For Turing in 1948 and again in 1950 [34, 36] had described both approaches together, saying that both should be tried out. But he had made little effort to make such trials himself. Turing preferred making the first attack at a new idea and then leaving the details for others to work out. This was true of his programming theory, his bottom-up ideas on neural networks, and his top-down ideas on machine chess-playing. So it is by no means obvious that a longer life would have led him to continue with AI research.

There is, however, another arena where his knowledge of mathematical logic might have been brought into practical computer science to make a first attack on a new area: this is what we have known as complexity theory since the 1970s.

Practical time constraints on algorithmic solutions formed a vital aspect of Turing's wartime work. It seems quite possible that he was consulted by GCHQ after 1948 about the use of computers for large-scale problems, such as the famous Venona problem of Soviet messages which was the top Anglo-American priority in that period. If so, it is also possible that research in large-scale efficient computer-based searching and sorting would have brought him to complexity theory ideas.

Turing's wartime work mainly lay in probability theory and Bayesian statistics. Afterwards he left it to Jack Good to write up a civilian version of his theory, and he made no effort to pursue the parallel of his work with Shannon's information theory. But possibly he would one day have gone on to combine his knowledge of computation and probability: in particular he had left the concept of randomness oddly informal. He described machines with "random elements" but these were left to Shannon and others in 1956 work to define properly [13].

Looking further ahead, the ideas of Gregory Chaitin on randomness and computability give a picture of a field Turing might have opened — even if not necessarily agreeing with all Chaitin's views.

A minor feature of Turing's postwar work, but one that might have blossomed with longer life, is the application of computing methods in pure mathematics. His colleague Max Newman was very quick to exploit the Mersenne Prime problem to illustrate the power of computation, and discussed very advanced ideas at the inauguration of the Manchester computer [24] in the use of probabilistic methods in algebra and number theory. Probabilistic primality testing, as used in public-key cryptology today, might have been working much earlier in Turing's hands.

He might also have made powerful advances in cryptology itself. It is striking how he made general statements about this field, and we do not know where his thoughts were leading. In a 1936 letter [29] he reported to his mother from Princeton:

> I have just discovered a possible application of the kind of thing I am working on at present. It answers the question "What is the most general kind of code or cipher possible," and at the same time (rather naturally) enables me to construct a lot of particular and interesting codes.

This tantalizing statement, with its fascinating link between computability and cryptology, leaves us only wanting to know the answer Turing found to his question, and the identity of the particular and interesting codes. Possibly the latter were related to Turing's 1937–8 cryptological work, which was reported to me by Dr Malcolm McPhail in 1978 in the following terms (see [20, p. 138]):

> ... he would multiply the number corresponding to a specific message by a horrendously long but secret number and transmit the product. The length of the secret number was determined by the requirement that it should take 100 Germans working eight hours a day on desk calculators 100 years to discover the secret factor by routine search. Turing actually designed an electric multiplier ...

Again, we are left wondering what the scheme actually was (for multiplication is too simple), and what was his theory of its security. It is by no means clear what Turing was doing, and he may well have had many advanced ideas that were never published. In 1950 he divulged [36]:

> I have set up on the Manchester computer a small programme using only 1000 units of storage, whereby the machine supplied with one sixteen figure number replies with another ... I would defy anyone to learn from these values sufficient about the programme to be able to predict any replies to untried values.

In the paper this plays the role of showing how a computable process — in fact a *small program* — can be totally surprising, thus making a point about the mechanizability of mental processes. But read another way it is a claim to a cipher system unbreakable even with chosen plaintext — the modern criterion of security.

Once again we can only speculate on what he was doing for GCHQ, and why GCHQ had tried to get him back to work full-time, until his 1952 exclusion. What might have he done if the political establishment had treated him differently? Would his effect on the cold war history of 1954 have been as significant as it was on the Atlantic war of 1944? Both were great wars of information and intelligence.

There is a science-fiction story by the writer Greg Egan [14], which starts on a political footing, discussing what might have happened if Alan Turing had been treated differently by his rulers, and has all sorts of imaginative elements, including a dialogue with the theologian C. S. Lewis. But it goes on to focus on scientific advances by and around a counter-factual Turing of the late 1950s. An important point is that it correctly introduces a focus on fundamental *physics*, a point to which I shall return in concluding this survey. The story is called *Oracle*, a reference to the uncomputable oracle of Turing's 1938–9 paper on ordinal logics [31]. Roughly speaking, an oracle has to contain an infinite amount of information in a finite space, so as to be able to solve a problem unsolvable by any Turing machine, e.g. to supply on demand the answer to the halting problem for every Turing machine. In this excerpt a fictional character links the oracle with time travel:

> ... "Time travel," Helen said, "gives me the chance to become an Oracle. There's a way to exploit the inability to change your own past, a way to squeeze an infinite number of timelike paths — none of them closed, but some of them arbitrarily near it — into a finite physical system. Once you do that, you can solve the halting problem ..."

## 2 Church's Thesis and Copeland's Thesis

This brings me naturally to B. J. Copeland's influential views on what Turing would have done, because he has also raised the prospect of actually building such oracles — not as science fiction, but as a serious possibility for future technology. This is the prospectus of so-called hypercomputation. Moreover, he and his colleague D. Proudfoot have associated these ambitions with Turing's views and given the impression that these are lost ideas of Turing's which can now be recovered and perhaps implemented.

There is a very general sense in which I agree with Copeland: the physical world should not be assumed computable without further investigation. This point was made long ago by Chaitin [2] and no doubt by many others.