ALAN TURING

THE ENIGMA MAN

CODE BREAKER

NIGEL CAWTHORNE

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INTRODUCTION

Breakthrough at Bletchley Park

In 1940, Britain's Second World War codebreaking operation at Bletchley Park, Buckinghamshire, could claim some success in cracking the 'Red' code used by the German air force. Using a machine called a bombe, perfected by Alan Turing, Hut 6 could decode messages sent by the Luftwaffe, allowing the Royal Air Force to shoot German aircraft out of the skies. As a result, Adolf Hitler had to cancel his plans to mount a seaborne invasion of Britain, known as Operation Sealion, which would eventually be abandoned completely.

But Britain was still in dire peril. The Battle of the Atlantic was now in full swing. German U-boats, hunting in 'wolf packs', were sinking merchant shipping carrying the food, fuel, munitions and raw material on which Britain depended at such a rate that the British faced being starved into surrender. The submarines were being directed by messages written in a complicated German navy code generated by now-upgraded naval Enigma machines. These resembled typewriters and were battery-powered and portable.

Their operation was simple enough. When a letter key was pressed another letter lit up on the lamp board above. However, the connection between the keys and the lamp board passed through a series of rotors which moved with every keystroke, so that if the same key was pressed repeatedly a different letter would light up each time. Naval Enigma machines also had a plugboard where other connections were set up, further scrambling the code. Once the message was encoded, it was transmitted by Morse code. If the recipient had an Enigma machine set up in exactly the same way, the message could then be decoded simply by typing in the letters received and writing down those that appeared on the lamp board. Given the millions of possible combinations of rotors and plugboard connections, the Germans thought that the Enigma code was unbreakable. They had not counted on Alan Turing.

The brilliant young mathematician arrived at Bletchley Park at the beginning of the war and quickly designed the bombe, which rapidly ran through all the possible ways in which the Enigma machine could have been set up, but the ten listening posts that intercepted German Morse transmissions for Bletchley Park were producing so much material that it was impossible to handle it all. And when the Germans' code machines were upgraded, the decoding process took so long that it was too late to take action on the intelligence produced.

Turing at around the time he began working at Bletchley Park in September 1939

The British got lucky when some of the documentation that accompanied the German navy Enigma machines was captured. And then Turing worked out a way to narrow down the number of possible settings that could have been used to produce any coded message. This used ‘cribs’ – known or guessed stock phrases. One of the minor weaknesses of the Enigma machine was that no letter would be encoded as itself – if you pressed the ‘A’ any other letter apart from ‘A’ would light up.

German operators would transmit stock phrases. Weather ships routinely sent ‘weather for the night’ – rendered without spaces as ‘WETTERFUERDIENACHT’ – or ‘situation eastern Channel’ – ‘ZUSTANDOSTWAERTIGER-KANAL’. If such a phrase was run alongside a coded message it was sometimes possible to find a place where no letters matched, giving a possible translation for that part of the message and narrowing the number of possible settings used at the beginning of the message.

There were plenty of common phrases like ‘nothing special to report’ and ‘Heil Hitler’ or ‘Führer’ often appeared at the beginning or end of messages. Better still, from a captured German wireless operation it was discovered that if transmission had been broken off for whatever reason it resumed with ‘FORT’ – an abbreviation for *Fortsetzung* or ‘continuation’. This was followed by a number identifying the previous message, usually the time it had been sent. This would be spelled out in full, so 2300 would be ‘ZWEIDREINULNUL’. The Germans also transmitted map references. Turing studied letter sequencing in the German language as well. For example, ‘eins’ and ‘sch’ are common sequences of letters in German, but ‘jgt’ is not common, if it exists at all.

To exploit these weaknesses, Turing, who was in charge of Hut 8, tasked with breaking the German navy code, came up with a system he called Banburism. He had a workshop in Banbury, Oxfordshire, which produced special punched paper strips. When one section of text was run over another, it was possible to spot matches. These methods reduced the millions of possible settings of the Enigma machine down to hundreds of thousands, which Turing’s bombe could just about handle.

German soldiers communicate using an Enigma encoding machine, c.1942

He then used Bayesian statistics, first developed by 18th-century British mathematician Thomas Bayes, to work out the most probable initial settings, so that these could be tested first instead of churning through tens of thousands.

In April 1941, the team at Bletchley Park set about trying to decode messages as they came in. By June they were cracking them within a few hours of their interception. Prime Minister Winston Churchill's war planners had predicted that Britain would tip into starvation in that very month. But using 'Ultra' – as intelligence from the decryption of enemy ciphers was known – British shipping was

able to evade the wolf packs so successfully that for twenty-three consecutive days U-boats in the North Atlantic made not a single sighting of a convoy.

The following month Turing and his colleagues were summoned to Whitehall to be thanked officially. They received a £200 bonus, the equivalent of £6,000 in today's money, and Churchill paid a visit to Bletchley Park. He was taken to Hut 8 to meet Turing, who was 'very nervous'.

Churchill described the codebreakers there as 'the geese that lay the golden eggs – and never cackle'.

As the U-boats continued to scour the North Atlantic fruitlessly, there were fears that the Germans might realize that their codes had been broken, so information was leaked that the British had developed a new long-range radar that could detect submarines hundreds of miles away, even when they were under water. This was unnecessary, because in the paranoid Nazi regime it was assumed that some spy was passing details of the U-boat movements to the British.

The battle had been won, but the war continued. Intercepted messages were coming in at such a rate that the cryptanalysts at Bletchley Park were overwhelmed. In October 1941, Turing and others wrote to Churchill saying:

'Dear Prime Minister,

Some weeks ago you paid us the honour of a visit, and we believe that you regard our work as important. You will have seen that . . . we have been well supplied with the "bombes" for the breaking of the German Enigma codes. We think, however, that you ought to know that this work is being held up, and in some cases is not being done at all, principally because we cannot get sufficient staff to deal with it. Our reason for writing to you direct is that for months we have done everything that we possibly can through the normal channels, and we despair of any early improvement without your intervention.'

The sinking of the Empire Mica, *a British tanker, after a torpedo attack by the German submarine U-67 on 29 June 1942*

Churchill immediately responded with a memo which read:

> ‘Action this Day
> Make sure they have all they want on extreme priority and report to me that this has been done.’

Churchill later wrote: ‘The only thing that ever frightened me during the war was the U-Boat peril.’

With the wolf packs defeated in the North Atlantic and the United States joining the war on the Allies’ side in December 1941, not only was Britain saved from starvation, but it was possible to stockpile men and munitions in the British Isles ready for the invasion of Normandy

in 1944. And the man responsible for that was Alan Turing.

CHAPTER 1

Birth of a Genius

Alan Turing was a child of the Empire. His father Julius Mathison Turing was an assistant administrator and magistrate in the Madras province of British India. His mother, Sara, was the daughter of the chief engineer of the Madras Railway. Born in Madras and brought up in Ireland, she attended lectures at the Sorbonne in Paris before meeting Julius, a history graduate of Corpus Christi College, Oxford, on a cruise ship in the Orient. When they reached Japan, he asked her out. They married a few months later in Dublin in 1907. The following year their first son, John, was born in her parents' house at the hill station of Coonoor.

TROUBLED TIMES

In 1912, Sara was pregnant again. By then political unrest had made India a dangerous place for British administrators. The viceroy, Lord Charles Hardinge, was the target of a number of assassination attempts by militant Indian nationalists and that year he was wounded by a bomb during his state entry into Delhi.

Julius took leave and the family travelled back to England. They rented a house in Maida Vale, north London, and their second son was born in Warrington Lodge, a nursing home in Little Venice, on 23 June 1912. He was christened Alan Mathison at St Saviour's Church in Warrington Avenue two weeks later.

When Alan was nine months old, his father returned to India. Six months later, his mother Sara followed. She had intended to take Alan with her, but the toddler was suffering from rickets. So the two boys were left in the charge of Colonel and Mrs Ward in Hastings. Once the First World War had got under way, the colonel encouraged the boys to play with toy guns, cannons and battleships, but they rebelled.

In 1915, their mother risked the journey through submarine-infested waters to pay a visit. She found Alan disturbed. Writing home to her husband, she said:

> 'Alan will in a moment cry with rage and attempt to hold his breath, and in the next moment he will laugh at his tears, saying, "Look at my big tears," squeeze his eyes and say, "Ah" with his mouth wide open trying to squeeze out more tears for fun.'

However, he was a pretty, outgoing and engaging boy, quite free of the shyness that would afflict him later at public school. His mother said: 'I was not alone in my opinion when I wrote that he was "a very clever child, I should say, with a wonderful memory for new words".'

After three months in her care, his mother wrote: 'Alan has improved greatly. He has many charming traits. He misses nothing.' He had a lively mind and that summer, she noted, he made his first

attempt at experimenting.

‘One of the wooden sailors in his toy boat got broken,’ she recalled. ‘He planted the arms and legs in the garden, confident that they would grow into toy sailors.’

When his mother returned to India that autumn, she asked Alan to be a good boy while she was away. He said: ‘Yes, but sometimes I forget.’ Even John, something of a rebel himself, said: ‘Alan was quite a nuisance.’

In March 1916, Julius and Sara braved the U-boats again, wearing life-belts all the way from Suez to Southampton. They took a holiday in Scotland before Julius returned to India. Given the U-boat menace, it was decided that Sara should stay in England with the boys. By then John was at prep school, so Alan lived with his mother in rooms in St Leonards-on-Sea.

EARLY SIGNS OF BRILLIANCE

From an early age, Alan was interested in figures. Even before he could read he would study the serial numbers on the lampposts around Hastings. At first, he did not know whether to read the numbers from right to left or vice versa. However, he noticed a red spot on his left thumb which he called the ‘knowing spot’. When he came across a number he would pull back his glove and look for the spot, then he would know which way to read the figures.

It was clear that he had an unusual mind. At five, he announced that rhubarb made his teeth feel as if the white had come off. Later, when his father was back in England again, he told young Alan off for having the tongues of his boots twisted. ‘Those tongues should be as flat as a pancake,’ said Julius.

‘Pancakes are usually rolled up,’ Alan shot back.

He also made up words. ‘Quockling’ was his word for the noise made by seagulls fighting over food, a ‘greasicle’ was the rivulet of wax down the side of a candle when it is caught in a draught and ‘squaddy’ was Alan’s word for being squat and square.

However, Alan lagged behind when being taught to read. Then he came across a book called *Reading Without Tears* and taught himself to read in three weeks. This self-reliance when it came to problem solving would become a trademark.

In 1918, he went to St Michael’s Primary School where he began to learn Latin. When he left at the age of nine, the headmistress there said: ‘I have had clever boys and hard-working boys, but Alan is a genius.’

Outside school, Alan was precocious. He pounded up dock leaves to make a cure for nettle stings, precisely recording the formula, and began compiling what he called an ‘encyclopaedio’. Waking early he would write down sundry facts such as the width of England. Geography held a special appeal and he asked for an atlas for his

birthday. Later, when Alan arrived at his prep school, Hazelhurst, he beat older brother John in a school-wide geography test.

Alan's other passion was reading nature-study books and at the age of eight he began writing a book called *About a Microscope*. That summer, the family took a holiday in Scotland where Alan carefully observed the flight of bees and tracked them to their nest to get their honey. In the evenings Sara read *Pilgrim's Progress* to the two boys, but when she decided to skip some of the heavier theological discussion Alan was indignant. Shouting 'You spoilt the whole thing', he dashed from the room and stamped up and down in a huff.

That autumn Julius and Sara returned to India once more. Alan wrote to them regularly, talking of his newest concoctions including the recipe for his 'gobletoe drink', which contained grass roots, radish leaves and nettles. He then wrote an advertisement for Dunlop in the hope that they would send him free tyres for his bicycle. But Mrs Ward wrote to his parents, complaining of Alan's continued stubbornness and disobedience. He rode round and round the lawn on his bicycle and refused to come in, saying: 'I can't get off until I fall off.'

When his mother returned to England in 1921, she found Alan had changed. Formerly outgoing, he was now withdrawn and dreamy. She took him out of school and taught him at home for a term. They spent the summer in Brittany. In London that autumn, he spent his time collecting bits of metal from the gutters with a magnet and he was full of questions. At nine, his mother recalled, he asked: 'What makes the oxygen fit so tightly to the hydrogen to make water?' She had no answer.

After a skiing holiday in Switzerland, Alan began at Hazelhurst where he spent his spare time making paper boats and, to start with, getting into fights. He was soon unpopular at school. Poor at games, he preferred to play chess – though few would play with him – and he spent hours working out complex chess problems on his own. Later in life he became an accomplished runner and said he got his start at school, fleeing from the ball. Teachers considered him both lazy and insolent. He complained that his algebra teacher 'gave a quite false impression of what is meant by x'.

That summer, while holidaying with his family in the Highlands, he went climbing and after hearing a lecture on Everest expressed an interest in joining the next expedition to the as yet unconquered peak. In the evenings, the family dined in the garden and competed to see who could spit gooseberry skins the farthest. Alan won by applying scientific methods. He inflated his skins so they would be more aerodynamic.

At school, he was always building gadgets, including a far from successful fountain pen, and the library records show that he never borrowed fiction. In the holidays, he cycled out to the nearby woods where he experimented, once returning covered in soot and with his

eyelashes singed after firing clay pipes he had made. There were experiments with baking soda and muddy jam jars in the coal cellar. Archdeacon Rollo Meyer and his wife, who looked after the boys in the school holidays, wrote to their parents complaining that Alan was always doing dangerous things.

In 1922, he came across the American book *Natural Wonders Every Child Should Know* by E.T. Brewster which, he told his mother later, opened his eyes to science – particularly biology, which became a lifelong interest – and after a holiday in Rouen he began writing to his parents in halting French. Climbing in Wales, he drew maps of the places he had visited. He also took an interest in family trees. Then the gift of a chemistry set afforded new opportunities for experimenting. In the basement, he extracted iodine from seaweed. But his mother fretted, telling a friend: 'I am sure that he will blow up himself and the house one day.'

A schoolmaster gave him private tutoring. He also tutored himself using the form's encyclopaedia. At the age of twelve-and-a-half, he wrote home: 'I always seem to want to make things from the thing that is the commonest in nature and with the least of waste energy.'

PROBLEM PUPIL

In 1924, his father retired, but to avoid heavy taxation on his pension he did not return to England. He and Sara settled in France. By then, though, Alan was used to his parents being some way away. He even took himself to school by taxi, tipping the porter and the driver.

His clear aptitude for science and mathematics did not stand him in good stead in a school that specialized in teaching Latin, Greek, literature and the classics in preparation for public school. Turing's spelling and grammar were poor – and remained so throughout his life. Nevertheless, he passed his Common Entrance examination and seemed to be destined to follow his brother to Marlborough College. But John warned: 'For God's sake don't send him here. It will crush the life out of him.'

Instead Alan was sent to Sherborne, a 300-year-old public school in Dorset where the husband of one of his mother's friends was science master. Travelling to school from his parents' new home in France, Turing took the ferry from St Malo to Southampton. But when he arrived back in England, it was the first day of the 1926 General Strike and no buses or trains were running. His only option was to cycle the sixty miles to Sherborne, stopping for the night in a hotel on the way and keeping detailed accounts to justify the outlay to his father.

Alan Turing did not excel at his new school. Even his mathematics was 'not very good'. His report said: 'He spends a great deal of time in investigations in advanced mathematics to the neglect of his elementary work.' In his science lessons, which occupied just two

hours a week in the classical curriculum, ‘his knowledge is scrappy’, while his housemaster complained that he was ‘trying to build a roof before he has laid the foundations’. However, knowing Alan’s aversion to games, his father had requested that Alan substitute golf for cricket. This gave him the opportunity to walk around thinking out problems. As a result he won the school’s Plumptre Prize for mathematics. His maths teacher, Mr Randolph, declared him to be a ‘genius’ after being shown an algebraic exposition. Randolph at first thought Turing must have copied it from a book, but he had worked it out from first principles. But this counted for little at a school that valued the humanities and classics. Generally, his work was so poorly presented that it was thought he ought to be sent down. As his headmaster remarked: ‘It is only the shallowest of minds that can suppose . . . scientific discovery brings us appreciably nearer the solution of the riddles of the universe.’ He considered Turing ‘anti-social’ and said that he was ‘the kind of boy who is bound to be a problem in any kind of school’, though the headmaster did concede that Turing had ‘special gifts’.

Pupils in a science class at Sherborne School

As a boy, Turing was also scruffy and unkempt. This was a particular problem when it came to the Officer Training Corps parade on Fridays. His failure to bond with other boys, and his general ‘slackness’ in gym, meant that he was considered a ‘drip’ and was teased for his shyness, his high-pitched voice and his hesitant delivery that almost amounted to a stammer. A classmate said that Turing was ‘an example of how a sensitive and inoffensive boy . . . can have his life made hell at public school’.

What annoyed his teachers the most was his ability to pay no attention to them during lessons and then cram at the last minute and score high marks in the final exam. As it was, most of his work in his new obsession, mathematics, was done outside the classroom.

Turing's greatest *bête noire* was his English and Latin teacher A.H. Trelawney Ross, who believed that Germany had lost the First World War because it thought 'science and materialism were stronger than religious thought and observance'.

'As democracy advances, manners and morals recede,' he said. Scientific subjects were 'low cunning' and when Turing was around he would sniff and say: 'This room smells of mathematics. Go out and fetch a disinfectant spray.'

Turing simply ignored Ross and when the teacher caught him doing algebra during a study period set aside for religious instruction he failed Turing in both taught subjects. Nevertheless, Ross conceded: 'I like him personally.' And, despite Turing's slovenliness, his housemaster remarked that he had a 'saving sense of humour'.

As well as being a fount of odd scientific facts, the young Turing made a joke of his own inadequacies in a way that most found endearing. Nevertheless, Turing did not make life easy for himself at school and did not go out of his way to make friends.

At fifteen, Turing wrote a précis of Albert Einstein's *Relativitätstheorie* (Theory of Relativity), recently published in English, to explain the principles to his mother. For Turing Einstein's work was intoxicating. It overthrew the axioms of Euclid and Newton which until then had been the bedrock of mathematics and science. Turing's brother John remarked:

> '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.'

FIRST CLOSE FRIENDSHIP

Sherborne had been the setting for old boy Alec Waugh's controversial semi-autobiographical novel *The Loom of Youth*, published in 1917, which openly mentioned homosexual relations between boys. And at some point in Turing's first two years there, he began to discover that he, too, was attracted to his own sex. *The Loom of Youth* was, of course, a banned book at the school and the masters tried to deal with the problem through cold showers and preventing boys studying together without a teacher being present. Turing tried to cope with his growing desires by going on long runs.

His affections became fixed on fellow pupil Christopher Morcom,

who became his one school friend. He was a year older than Alan and an outstanding student. They shared an interest in science and mathematics.

Their relationship was innocent enough. Turing wrote that Morcom had some very definite ideas of right and wrong and avoided ‘dirty talk’, though he was not ‘in any way silly or priggish’. Turing and Morcom spent time creating and deciphering codes. They particularly liked codes that used a template – a carefully cut pattern that, when placed over a specific page in a specific book, revealed a secret message. Among youngsters, code making and breaking was all the rage. Codes and ciphers were used by the heroes of comic books and by the 1930s manufacturers of breakfast cereal were promoting their products with ‘decoder rings’ and other codebreaking devices.

Morcom was an accomplished pianist and introduced Turing to classical music. He also helped Turing improve his social skills and smarten up his appearance and his handwriting. As a result Turing’s work improved and he was not picked on so much by the other boys, even attracting some admiration for his long-distance running. In the school’s inter-house races, he could beat all-comers.

As Turing began, finally, to fit in at school, his parents’ worries were quelled and at home they enjoyed his obvious talents.

‘We regarded Alan as the family encyclopaedia,’ his mother wrote. ‘He seemed to have the answers to all our scientific queries.’

Turing now relished the competition with Morcom in their scientific work.

‘Chris’s work was always better than mine,’ he said. ‘He was very thorough. He was certainly very clever but he never neglected details, and for instance very seldom made arithmetical slips. He had a great power in practical work of finding out just what was the best way of doing anything.’

To impress his friend, Turing calculated the value of π to thirty-six decimal places. Teachers described him as ‘brilliant’, saying that he thought rapidly. But he found schoolwork dull compared to relativity and his grades were low compared with Morcom’s.

Morcom also involved Turing in laddish pranks. They dropped stones from a railway bridge down the funnels of passing trains. One bounced off and hit the stoker, nearly getting them into serious trouble. They sent gas-filled balloons across the field to Sherborne Girls’ School. And, with another boy, they wrote a sketch ragging a science master, which Morcom intended to set to music.

Turing at Sherborne, aged about fifteen

But Morcom suffered from frequent illness and was often out of school. As a result they wrote long letters to one another, addressing each other as ‘Dear Morcom’ and ‘Dear Turing’ and discussing problems in physics, chemistry, maths and astronomy – their new passion.

In the summer of 1929, the boys took their Higher School Certificate. Morcom got high marks in the mathematics paper; Turing did not do so well. The examiner commented:

> ‘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 is definitely illegible, and sometimes because his misreading his own writing led him to mistakes.’

Now eighteen, Morcom had set his sights on a scholarship to Trinity College, Cambridge, the top scientific college at England’s leading scientific university. Though a year younger, Turing followed suit. They travelled up to London together where Turing was introduced to Morcom’s mother, a sculptor who had a studio there. Then they were driven to Cambridge to sit the entrance examination. Morcom passed; Turing didn’t.

Soon they were parted for the Christmas vacation. Resuming their correspondence over the holidays, Morcom wrote that he was making a spectrograph, a scientific instrument to study light. From a poorer background, with fewer means at his disposal, Turing made a map of the cosmos, sticking paper around an old spherical glass lampshade. He rose each morning at four o’clock to mark the positions of the stars and constellations on it.

The two of them followed the path of a comet, which Turing then plotted on his star chart. At the beginning of the next term, he took the resulting map to show Morcom. Three weeks into the term, Morcom fell ill again. This time he was rushed to a hospital in London by ambulance. After two operations and six weeks of pain, he died of tuberculosis. Turing had lost his only friend.

He wrote to his mother:

> ‘I feel that I shall meet Morcom again somewhere and that there will be some work for us to do together 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.’

He said that it never occurred to him to make other friends – 'Morcom . . . made everyone seem so ordinary.'

Turing also wrote to Morcom's mother, who said that his letter helped her in grief more than anyone else's.

CHANNELLING GRIEF

In memory of their son, the Morcoms instituted the Christopher Morcom Prize for Natural Science, which Turing won in 1930 and 1931. Science master A.J.P. Andrews said of his 1930 award:

> 'I first realized 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 . . . I have always thought Alan and his friend Christopher Morcom were the two most brilliant boys I have ever taught.'

Turing continued punishing his body with his athletic endeavours. He won the house steeplechase and leapt the Tregudda Gorge while on holiday in Cornwall that summer. And in his grief he continued to channel his energies into science and mathematics. He began to learn German, though his teacher said: 'He does not seem to have any aptitude for languages.' But he was doing this for a reason. The next time he won a school prize, he asked for *Mathematische Grundlagen der Quantenmechanik* (The Mathematical Foundations of Quantum Mechanics), by John von Neumann.

Nor was he content with book-learning. On a sunny Sunday, he assembled a replica of Foucault's pendulum in the stairwell, a device that Jean-Bernard-Léon Foucault had used to demonstrate the rotation of the earth in 1851. Teachers and members of staff flocked to see it.

Turing was eventually made a prefect, though he soon turned against administering corporal punishment to younger boys. He then won the school's King Edward VI Gold Medal for Mathematics and a scholarship to study mathematics at Cambridge, which gave him £800 a year, twice the amount received by the unemployed in those years of the Depression. But first, he took an Officers' Training Corps course at Knightsbridge barracks. Excelling at drill and tactics, he demonstrated that he had the necessary strength and endurance to qualify as a reserve officer.

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