

Kunihiko Kodaira

All I could do
was arithmetic

Translator's note

The following is a translation and L^AT_EXitification of

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Jiewei Xiong

Preface

This book is an expanded version of *My Personal History* (私の履歴書), which was serialised in the *Nihon Keizai Shimbun* (日本経済新聞) in February of last year (1986). Since *My Personal History* is intended for general readers, I confined discussion of my own profession, mathematics, to the bare minimum required for the flow of the narrative. There is nothing quite as incomprehensible as talk of specialised mathematics.

When I look back and ask myself why I chose to specialise in mathematics and became a mathematician, I think that in the end it was simply because mathematics was the only thing I could do.

According to my mother, from a very early age I took an interest in numbers, and would repeatedly count beans as a form of play. When I was in primary school, I could do arithmetic, but I was hopeless at other subjects, a miserable pupil who disliked school. At middle school, too, I was no good at any subject other than mathematics: English, Japanese, and classical Chinese were all beyond me, and memorisation-based subjects such as history and geography were completely impossible. I remained, as before, a miserable pupil. I liked mathematics, and from my third year I was reading specialist mathematical books, but I studied simply because I found it interesting; it was not that I was studying with the intention of becoming a mathematician. I did not know that there existed a profession called a mathematician, in which one makes a living by writing mathematical papers. When I was in middle school, I aspired to become an engineer. In my fifth year, I sat the entrance examination for the First Higher School.

At that time, the entrance examinations for the old higher schools were formidable hurdles, equivalent to today's university entrance examinations, and the competition for the First Higher School was eight or nine to one. There were preparatory schools for candidates, but unlike today there was no regulation by deviation scores or anything of the sort, so anyone who wished to apply could sit the examination for the First Higher School. Had the entrance examinations been like those of today, I, who could do nothing but mathematics, would surely have been eliminated outright by my deviation score.

When I was a student at the First Higher School, the teachers all seemed wonderfully unhurried and to be enjoying themselves, and I thought I would like to become a secondary-school teacher. Even after entering the mathematics department at the University of Tokyo, all I did was study mathematics because I found it interesting – nothing more than that. After graduating from the mathematics department, I decided to have a go at physics as well, and enrolled in the physics department. In the autumn of the year after graduating from physics, I became an assistant professor at Tokyo University of Arts and Sciences. A few years later, I became an assistant professor in the physics department at the University of Tokyo, while continuing concurrently as an assistant professor of mathematics

at the Arts and Sciences University. Even at that point, however, I still had not settled on any particular field of specialisation. I simply read books and papers in mathematics and theoretical physics as my interests led me, and whenever I thought of something interesting, I wrote a paper – that was all. Once I had become an assistant professor, I had no worries about making a living. I intended to spend my entire life in Japan, happily studying mathematics and theoretical physics, writing papers, listening to records, and playing the piano.

Those plans were thrown into disarray by the Pacific War. My house, my records, and my piano were all destroyed in air raids, and after the war I lived in a makeshift hut built amid the ruins, with scarcely enough to eat. Far from living happily, I sank into a miserable existence.

Once the war began, foreign literature, of course, stopped coming in, and it became completely impossible to know what kind of research was being carried out abroad. Even if I wrote a paper, it might already be known overseas and therefore utterly pointless. Moreover, as air raids intensified, it became impossible to publish specialist journals in Japan, and even if one wrote a paper there was no means of publishing it. In spite of all this, I continued to write papers. Even looking back now, I do not really understand the psychology of those extreme circumstances. The military was shouting slogans of mass self-sacrifice, there was absolutely no sign that the war would end, and it was unclear whether one would even survive to see the post-war period – indeed, whether such a post-war period would come at all. Under such conditions, it is a mystery what I thought I was doing when I was writing papers.

The long paper entitled “Harmonic tensor fields on riemannian manifolds”, which I wrote from the wartime years through to the post-war period, had no prospect of being published in Japan and remained unpublished. In 1948 (Shōwa 23), however, thanks to the kindness of Shizuo Kakutani, it was submitted to an American specialist journal via the Occupation forces. This paper caught the attention of Professor Weyl, and in 1949 I was invited to the Institute for Advanced Study in Princeton.

During the 1950s, the theories of complex manifolds and algebraic geometry developed rapidly, and Princeton was one of the main centres of that development. When I went to Princeton, I discovered that the paper on harmonic tensor fields, which I had written simply because it interested me, with no prospect of publication, happened to fit perfectly into and contribute to those developments. At that point I became aware that I had at last become a fully fledged mathematician, and I joined the front line of research in complex manifold theory and algebraic geometry. I was thirty-four years old.

I was fortunate enough to meet a fine collaborator, Spencer, and our research progressed steadily. Then, in September 1954, at the International Congress of Mathematicians held in Amsterdam in the Netherlands, I was awarded something called the Fields Medal. After that, I continued to live in the United States, and returned to Japan in August 1967 for the first time in eighteen years. What had once been something I never dreamed of, back when I intended to spend my whole life living happily in Japan, had become reality.

Sometimes I wonder whether living in America was not all a dream, but since my daughters speak perfect English and have shaky Japanese, it must surely have been reality rather than a dream. Even while living in America, however, there were times – such as when my wife and I went shopping together at a supermarket – when I would lose sight of her for a while and think, “Oh? I’m here on my own in a place like this – is this a dream?”

Had I not written the paper on harmonic tensor fields, for which there was no prospect of publication, or had Kakutani not been kind enough, despite that, to ask the Occupation forces to send the paper to America, I would not have been invited to Princeton. And even if I had gone to Princeton, had I not happened to meet Spencer, the research would surely not have progressed in the way it did. Spencer had been a professor at Stanford University since 1942, and by chance moved to Princeton University in the same year, 1949, that I myself went to Princeton. That I was able to meet Spencer was entirely a matter of chance.

Because mathematical research consists solely in thinking with one's head, one has the feeling, while engaged in it, of acting autonomously. Yet when one looks back afterwards, one realises in the end that one was governed by fate.

I have continued my wandering journey through the world of mathematics, carried along by the current of fate. This book is a quiet record of the events that occurred along the way.

March 1987

At Naka-Ochiai
Kunihiko Kodaira

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Chapter I

An interest in numbers

My father was born in 1885 in Yonezawa Village, Nagano Prefecture, and my mother in 1894 in Kamisuwa Town. Both of my parents were from Nagano Prefecture. Perhaps for that reason, I have somehow come to be regarded as a native of Nagano myself, and even in *One Hundred Years of Mathematics in Japan*, published the year before last, it is stated that I was born in Nagano. In fact, however, I was born in Tokyo in March 1915, and am a Tokyoite.

When I was very young, there were rental houses everywhere in Tokyo, and it seems that my parents moved house frequently. My earliest memory is of living at Gotenyama in Shinagawa, and being taken by my grandfather to watch the trains.

My next memory is from after we moved into a rented house near Sugamo Station in Koishikawa. I do not know the exact details, but I think I was four or five years old at the time. We lived there from the year after the Great Earthquake until I was in the fourth year of primary school. In the middle of a fairly large garden there were several big stones with shrubs growing among them. In summer, dozens of lizards would crawl around there. They were beautiful lizards, their backs shining with a bluish silvery sheen. If you stepped on one's tail, only the tail would come off and the lizard would escape. The severed tail would go on twitching for a long time. In one corner of the garden there was a large persimmon tree, and in autumn it bore many persimmons. They were quite good persimmons.

At that time, it was rare for children to attend kindergarten. I did not go to kindergarten either, and at the age of six I entered the private Imperial Primary School. It was a small school, with only two classes in each year. Unusually for those days, it was co-educational, with each class made up of half boys and half girls. The headmaster was someone who had obtained a degree in education in America, and in American fashion there were sewing classes even for boys, who were made to sew things such as cleaning cloths. In other words, what would now be called home economics already existed. There was also, once a year, a funeral for dolls. Headless dolls brought in by the pupils were collected together, and a funeral was held for the poor dolls.

When I was four years old, my younger brother was born. Strangely enough, I remember the morning of that day. The night before, I had slept in the same room as my parents, but when I woke up in the morning I had been moved to another room. I got up and went into my parents' room, and when I tried to sit down on a bundle wrapped in a white cloth that was there, I was sharply scolded. That bundle was my brother, who had been born during the night.

I do not remember it myself, but according to my mother, from an early age

I showed a special interest in numbers, and would repeatedly count beans as a form of play.

In arithmetic at primary school, at every lesson we were made to chant the multiplication tables like a Buddhist sutra, and were constantly drilled in calculation. Under the old shakkān-hō system of measures, one ri was thirty-six chō, one chō was sixty ken, and one ken was six shaku, so calculations of length were incomparably more difficult than calculations using today's metric system. Calculations with decimals and fractions were also practised repeatedly and at length. The most difficult were the so-called "cranes and tortoises" problems, while I think we did not learn very much that was geometrical.

When I was in primary school, I could do arithmetic, but I was no good at other subjects. On top of that, I had a quiet voice and stuttered, so I could not answer the teacher's questions properly. I was a miserable pupil, and I disliked school. Physical education was particularly dreadful. I was short, and my legs were especially short, so in races I would end up almost a full lap behind, to the point where it looked as though I were leading the race, which made me feel like crying. I also disliked composition, as I could never find anything to write about.

The year after the Great Earthquake, when I was in the fourth year of primary school, we moved to what is now our address in Naka-Ochiai. This time it was not a rented house: my father bought a plot of land in a residential development known as Bunka-mura and built a newly constructed two-storey house.

At that time, Ochiai was a suburb of Tokyo, with many vacant lots, and on both sides of the Seibu Shinjuku Line, from Tetsugakudō to near Nakai Station, there were wide open fields.

When I was in the fifth year, my younger brother entered the nearby Ochiai Daiichi Primary School. Around that time, we were given a puppy by a relative and decided to keep it. It was a brown mongrel, somewhat like a setter, and very good at catching rats. We named it "Cero". In those days, dogs were allowed to roam freely, wandering around the vacant lots in the neighbourhood, but when my brother called out loudly, "Cero, Cero", it would come running back, wagging its tail. One day, when my brother went off to school, Cero followed him. Wondering what had happened at school, we later learned that it had gone into the classroom and sat down next to my brother during the lesson.

Cero was a female dog, and twice a year, in spring and autumn, she would give birth to five or six puppies. If all six puppies were hidden away, she would run around everywhere, whining and crying as she searched for them. Strangely enough, however, if five were hidden and just one left behind, she did not seem to notice anything at all. From this, it became clear that dogs have no concept of number whatsoever.

Chapter II

My father, Gon'ichi

My father was a civil servant in the Ministry of Agriculture and Commerce, and was extremely busy. He usually returned home close to midnight, and it was not uncommon for weeks to pass without my seeing his face at all. When I was still very young, he once took me to the zoo on a Sunday, and I have the curious memory of thinking that he was some strange man I did not really know.

When an Economic Rehabilitation Bureau was established within the Ministry of Agriculture and Forestry as a measure to deal with the agricultural depression, my father became its first director (by then the Ministry of Agriculture and Commerce had already been split into the Ministry of Agriculture and Forestry and the Ministry of Commerce and Industry). The other day, at a gathering held in memory of Professor Gon'ichi Kodaira, I spoke with Mr Takeshige Ishiguro, who later served as the second director of the Rehabilitation Bureau. According to him, from morning until five o'clock in the evening my father was occupied dealing with delegations bringing petitions; only after five did he begin his regular office work, which often did not finish until close to eleven at night.

My father went from Suwa Middle School to the First Higher School, and then entered the College of Agriculture of Tokyo Imperial University (now the Faculty of Agriculture of the University of Tokyo). After graduating, he entered the College of Law of the same university (now the Faculty of Law), and completed his studies there in 1914, at the age of thirty.

Under the education system of the time, primary school consisted of a four-year lower course, followed by a four-year upper course. After completing the four years of upper primary school, my father entered Suwa Middle School at the age of fourteen. Since the upper course at the primary school in Yonezawa Village, where my father lived, only went as far as the second year, he attended Takashima Primary School in Kamisuwa Town for the third and fourth years. From Yonezawa Village to Kamisuwa Town was eight kilometres one way, crossing a mountain pass. My father walked sixteen kilometres every day. He used to say that if he was caught in a sudden evening shower on the pass on his way home, with lightning striking close by, it was terribly frightening.

After graduating from the College of Law, my father immediately entered the Ministry of Agriculture and Commerce. After the ministry was divided into the Ministry of Agriculture and Forestry and the Ministry of Commerce and Industry, he served successively as Head of the Agricultural Policy Division, Director of the Sericulture Bureau, and Director-General of the Agricultural Policy Bureau. In 1932 he became Director of the Economic Rehabilitation Bureau, and in 1938 Vice-Minister of Agriculture and Forestry. The following year, 1939, he resigned as vice-minister and went to Manchuria (present-day north-eastern China). In 1941

he became a councillor of Manchukuo, but the following year he resigned from that post, returned to Japan, stood for election from the Third District of Nagano Prefecture, and was elected to the House of Representatives. He then became Director-General of the General Affairs Bureau of the Imperial Rule Assistance Association.

The Imperial Rule Assistance Association was an organisation intended to reflect the state of public opinion in government policy, and to ensure that the people were fully informed of the government's course of action. In reality, however, it was unable to convey to the public – indeed, even to much of the government leadership – the true situation of the Midway air and naval battle, or of the subsequent course of the war. All it could do was mobilise the people's energies under the slogan of "bringing the holy war to completion". Disillusioned by this, my father resigned as Director-General the following year, in 1943. After the war, in 1946, he suffered the misfortune of being designated as subject to the purge from public office because of his association with the Imperial Rule Assistance Association.

The other day, biographies of my father were published. They were *The Rural, Mountain, and Fishing Village Economic Rehabilitation Movement and Kodaira Gon'ichi* (農山漁村経済更生運動と小平権一, edited and written by Masahiro Kusumoto, Fuji Publishing, 1983) and *Kodaira Gon'ichi and Modern Agricultural Policy* (小平権一と近代農政, Nihon Hyōronsha, 1985). In fact, until I read these two biographies, I knew almost nothing about my father's career or achievements. The brief outline of my father's life given above is also based on these biographies.

Looking at the list of my father's publications included in *The Rural, Mountain, and Fishing Village Economic Rehabilitation Movement and Kodaira Gon'ichi*, one finds that he authored some forty books and around three hundred and fifty papers and other articles. I was deeply impressed by this. Someone like me does not come close to my father. I knew that he had written the substantial Treatise on Agricultural Finance, running to many hundreds of pages, and had obtained a doctorate in agriculture on the strength of it, but I had not realised that he had produced such an enormous body of work besides that. Of these, twenty-six books and some two hundred and eighty papers and other pieces were written in what little spare time he had amid his heavy official duties before he was designated for the post-war purge. The total number of pages of those twenty-six books alone comes to 4800. My father possessed a physical stamina that seemed never to know fatigue, but even so it is hard to imagine how, with the pressures of a life in which he returned home at midnight every night, he was able to produce such a vast quantity of writing.

My father's stamina was probably the result of the training he received as a child, walking sixteen kilometres every day for two years to and from Takashima Primary School. When I was a university student, I once said in front of him that I was tired and was scolded for it. His reasoning was that one might feel tired after walking a ri carrying a sack of rice on one's back, but otherwise there was no reason to be tired at all.

Chapter III

My grandfather, Kanai Kumikichi

At the end of every July, my mother would take my brother and me to her parental home in Kamisuwa Town, where we would spend the summer holidays, partly as a form of summer retreat. My mother's parents and her elder sister – that is, my grandparents and aunt – lived there. At that time, it took eight hours by train from Shinjuku to Kamisuwa.

My grandfather, Kanai Kumikichi, who was born in 1857, was a member of the first graduating class of Nagano Normal School. He became headmaster of Kamisuwa Primary School at a young age, and nurtured many able people. Later he served for many years as mayor of Kamisuwa Town and as a member of the Nagano Prefectural Assembly. He was a prominent and influential debater in prefectural politics, and his sharp, well-reasoned speeches in the assembly often made the prefectural authorities tremble. At the time, his reputation within Suwa District was also very high, to the extent that a popular ditty ran, "We cannot hope to be like Lord Kanai, but at least let us become village heads" (the above according to *Kodaira Gon'ichi and Modern Agricultural Policy*).

According to records at hand, my grandfather became a primary school teacher at the age of nineteen in 1876, and at twenty-seven resigned as a headmaster to become a member of the Nagano Prefectural Assembly. That would mean that he became headmaster when he was about twenty-three or twenty-four.

The Kanai family were said to have been of the samurai class of the Suwa domain, so the house in which my grandfather lived was probably a former samurai residence. In the front garden there was a large pond, and beyond the back garden stood an earthen storehouse. The entrance hall was a spacious doma, with a reception room to the right, and beyond that, in modern terms, what would be called a dining kitchen. In the middle was a large irori hearth, from which a kettle was hung on an adjustable hook suspended from the rafters, with firewood burned beneath for cooking. This room had no ceiling, and the thick beams and the attic above were blackened with soot from the smoke of the firewood. There were several other rooms as well, and in the front garden there was a newly built detached house. In addition, there was a separate bathhouse, and since hot spring water welled up there, one could bathe at any time.

My grandfather lived a rigorously regular life. Every morning he rose at six o'clock, took a bath, and then did physical exercises there for an hour. After supper he would go out for a walk, covering four kilometres from one end of Kamisuwa Town to the other. On rainy days, instead of going into town, he would walk back and forth repeatedly along the engawa veranda of the house until he had covered four kilometres.

Well versed in Chinese studies and deeply knowledgeable about Chinese his-

tory, my grandfather would sit me on his knee and tell me all sorts of stories about China's past. I listened to them as though they were fairy tales.

My grandfather was eleven years old in the first year of Meiji, and as a child he probably attended a terakoya or similar school, where he learned classical Chinese by sodoku of hakubun. Hakubun refers to classical Chinese texts without reading marks, and sodoku means reading them aloud without any explanation of their meaning. There is a saying, "Read a book a hundred times and its meaning will become clear of itself", and it seems that through repeated sodoku the meaning naturally came to be understood.

Later, when I was in the third year of middle school, during the summer holidays I was having trouble because I could not understand the classical Chinese texts. My grandfather said that he would teach me. Thinking this was a blessing, I took my textbook to him, but after glancing at it he merely said, "Oh – so you can't read something like this?" and in the end did not explain the meaning of a single sentence. Having learned classical Chinese through sodoku of hakubun, it probably never occurred to him that "teaching" might mean explaining the meaning of the text.

My grandfather had interests in many fields besides Chinese learning. Among the materials I have at hand is a fragment of a notebook in which he copied out an English book on volcanology. Writing out English sentences by hand with a brush, and even reproducing detailed illustrations such as coral reefs with a volcano at their centre, must have required tremendous effort. He seems to have been particularly interested in zoology, and there were many specimens of insects and birds that he had collected while walking through the mountains and fields, all stored in wooden boxes of various sizes. On one occasion, I watched as he prepared a stuffed specimen of an animal shaped rather like a mouse. As he peeled off the skin step by step and finally pulled out the bones of the tail, the skin of the tail came off, turning inside out like a sock, which impressed me greatly.

My grandmother was a quiet, small woman. Even when something displeased her, she would merely mutter under her breath, and I never once heard her raise her voice. Every evening after nine o'clock, she would bring the notebook in which she had written that day's shopping details, together with the remaining cash, and sit formally before my grandfather to undergo an accounting inspection. If the figures were off by even a single sen, my grandfather would scold her severely, but she would do nothing more than bow her head and say, "Yes, yes." She truly lived a life of patience, obedience, and virtue.

Chapter IV

The Fifth Middle School years

After graduating from primary school, I entered the Fifth Middle School (Tokyo Prefectural Fifth Middle School, the predecessor of what is now Koishikawa High School). There was an entrance examination, but since there were no such things as cram schools for primary school children, it was enough simply to revise what we had learned at school.

The Fifth Middle School was founded on the educational philosophy of its headmaster, Mr Chōshichi Itō, who believed that “education is the effort to enable a human child truly to become a human being; it is the endeavour to allow the innate gifts with which a young person is born to grow freely and to their fullest extent, and to provide every favourable condition for the development and unfolding of mind and body”. It was a school with an extraordinarily free atmosphere.

At that time, the standard uniform for middle-school students was a stand-up collar jacket, but at the Fifth Middle School the uniform was a Western-style suit with a necktie. There were also two female teachers: one taught English, and the other classical Chinese. I have heard that at a parents’ meeting Headmaster Itō remarked, “How cold it is with only men”, but among the middle schools of the time (middle schools were for boys, while schools for girls were called girls’ schools), the Fifth Middle School was probably the only one to have female teachers.

Every morning, all the pupils were gathered in the schoolyard for an assembly, at which the headmaster gave a talk. His talks ranged from everyday matters to politics and economics, but I particularly remember how he often urged us not to shut ourselves up in narrow Japan, but to go and pioneer new lands in Brazil, preaching the spirit of pioneering. “Pioneering and creation” were the motto of the Fifth Middle School.

It was also revolutionary that there was no Imperial Portrait (a photograph of His Majesty the Emperor) at the school. On ceremonial days such as National Foundation Day, instead of paying respects to the Imperial Portrait, Headmaster Itō would gather all the pupils in front of the Nijūbashi Bridge at six o’clock in the morning and lead us in three cheers of *banzai*.

From my first year through to my third, my homeroom teacher was Ms Michiko Monoi, who taught English. I remember that at the end of each term she would ask each pupil in the class how many days they had been absent that term, and write the answer into the attendance register. Daily attendance was probably not taken. The school respected pupils’ autonomy and was consistent in maintaining a free atmosphere, but regrettably Headmaster Itō passed away when I was in my fourth year.

In the middle schools of that time, mathematics consisted of arithmetic in the first year, algebra and plane geometry from the second through the fourth years, and solid geometry in the fifth year. The fifth year of middle school corresponds in age to the present second year of high school, but there was neither calculus nor probability and statistics.

The plane geometry taught in middle school at that time was traditional Euclidean plane geometry, and through plane geometry we middle-school pupils learned logic. Euclidean plane geometry is probably the ideal teaching material for learning logic. In recent years, Euclidean plane geometry has been almost entirely expelled from elementary and secondary mathematics education, and as a result the opportunity to teach logic has been lost, which is regrettable.

Both algebra and geometry were taught using a single textbook each, used continuously from the second through the fourth years. When I was in the third year at the Fifth Middle School, my classmate Shin'ichi Nishitani and I decided that we would study the algebra and geometry textbooks thoroughly and solve every exercise from beginning to end. Once we started, it took less than half a year to reach the end of the fourth-year material.

So I went out and bought *Algebra* by Matsusaburō Fujiwara and began to read it. It was a specialist work on algebra, with the first volume running to six hundred pages and the second to eight hundred. I no longer remember clearly how far I read, but I do remember very well studying the proof of the law of quadratic reciprocity with great determination. I also recall reading about determinants and continued fractions. I then read about Galois theory, but in the end I did not understand it. Galois theory appears at the beginning of the second volume. There is no way a middle-school student could read all the way through the second volume, so it may have been after I entered higher school that I read the part on Galois theory.

There was no reason why I chose *Algebra*. I must simply have happened to notice it when I went to Sanseidō in Kanda or somewhere of the sort. In the Fifth Middle School library there was *Advanced Differential Calculus* by Tanzō Takeuchi, but I avoided it, thinking it must be a highly advanced and difficult book. Had I known that it was “differential calculus for higher schools”, I think I would have read that before *Algebra*.

After that, I tried to read Hilbert’s *Foundations of Geometry* in the translation by Tsurukazu Hayashi, but I could not make any headway. However, it said there that certain theorems concerning equal angles and equal lengths, which can be proved using proportions, can in fact be proved without using proportions. Once, in a geometry lesson at school, I demonstrated how to solve a proof problem – one that could easily be done using proportions – without using proportions at all, by drawing numerous auxiliary lines. All the teacher said was, “You’re a fellow who likes auxiliary lines,” and he did not praise me in the slightest.