CDMTCS
Research
Report
Series

A Life in Mathematics

Gregory Chaitin

University of Buenos Aires, Argentina

CDMTCS-555
July 2021

Centre for Discrete Mathematics and
Theoretical Computer Science

A Life in Mathematics

Gregory Chaitin
University of Buenos Aires, Argentina
https://uba.academia.edu/GregoryChaitin

August 31, 2021

Abstract

Gregory Chaitin's life in mathematics punctuated by some photographs taken during crucial episodes in his career.

1 New York, 1947–1965, Buenos Aires, 1966–1975

I was born in 1947 in Chicago and grew up in Manhattan, surrounded by books from the Museum of Modern Art (MoMA) and by issues of *Farm Journal*, *Theatre Arts Magazine* and *Scientific American*. My parents were involved with the theatre and with the United Nations. I practically lived in the Donnell branch of the New York City Public Library on 53rd street, in the MoMA across the street, and in Central Park a block away from our home between 68th and 69th street on Madison Avenue (819 Madison Ave. to be precise). I studied in P.S. 6, in the Bronx High School of Science, and in the Columbia University Science Honors Program for bright high school students, where I learned to program and was given the run of the Columbia University libraries.

Before leaving for Argentina I was briefly at the City College of the City University of New York, where I was excused from attending classes to write my first papers on program-size complexity and defining randomness, which would subsequently be published in the *Journal of the ACM*. The editor of the *Journal of the ACM* to whom I submitted these papers was Prof Martin

Davis, who had been a student of Emil Post and who is known for his work on Hilbert's 10th problem.

Furthermore, although I never graduated from City College because I left for Argentina, I was awarded the Nehemiah Gitelson award "for the student who in his undergraduate career best exemplifies the spirit of the search for truth," and the Belden Mathematical Prize (gold medal), both of which are usually only given to graduating students. And an article about me appeared in the *New York Times* containing praise by Prof Gian-Carlo Rota of MIT, who had been a student of Jack Schwartz (see below).

From 1966 through 1975 I lived in Buenos Aires, Argentina (BA), where my parents were born and where I enjoyed rowing in the Tigre river delta and attending ballet and light opera at the Teatro Colon opera house, not to mention the European style cafés and restaurants, and where I joined IBM before being transferred to the Watson Research Center in New York in 1975.

My return to New York was the result of a chance meeting in BA with the distinguished Courant Institute of New York University mathematician Prof Jacob T. ("Jack") Schwartz, who was impressed by my very simple proof that an N-bit formal axiomatic theory cannot provide individual examples of provably "elegant" programs greater than $N + c$ bits in size, an "elegant" program being one with the property that no smaller program can produce the same output that it does.

By the way, Jack Schwartz, like Martin Davis, had at City College been a student of Emil Post, who discovered incompleteness and uncomputability independently of Gödel and Turing, and who subsequently went deeper into these topics than either of these two more famous men, who had many other interests.

While living in Buenos Aires, I published five papers in the *Journal of the ACM* and two papers in the *IEEE Transactions on Information Theory*, and discovered information-theoretic incompleteness during a visit to Rio de Janeiro in 1970 and the halting probability during a visit to New York in 1974.

2 Visit to Rio de Janeiro, 1970

The photo on the next page was taken while I was visiting Rio de Janeiro in 1970. That is where I wrote my first paper on information-theoretic incompleteness, a Pontificia Universidade Católica (PUC) research report. I am dancing with the "porta-bandeira" (flag bearer) of the Salgueiro samba school before she enters the Carnival parade, which was then on Rio Branco avenue. This photo was taken in the vicinity of the Candelária church where the samba schools were assembling and waiting for their turn to parade. At that time I was twenty two, belonged to a rowing club in the Tigre river delta in Buenos Aires, and was very fit. This photograph is courtesy of the German numerical analyst Peter Albrecht, who was visiting Rio at the time.

Carnival in Rio

The PUC research report containing my first result on information-theoretic incompleteness actually consisted of two parts. The first part was called "Computational Complexity and Gödel's Incompleteness Theorem," and the second part was called "To a Mathematical Definition of 'Life'." It marked the beginning of a lifelong attempt to find the mathematical basis of biology, which was to culminate decades later in my book *Proving Darwin: Making Biology Mathematical* (2012).

And in Rio I was fortunately able to purchase a copy of the *LISP 1.5 Programmer's Manual* (MIT Press, 1962), thus beginning a lifelong infatuation with LISP and with inventing LISP dialects, programming LISP interpreters, and proving theorems about LISP program-size complexity.

3 Visit to New York, 1974

In the first few months of 1974 I traveled from Buenos Aires to New York as a "summer visitor" at the IBM T. J. Watson Research Center in Yorktown Heights. I lived in the White Plains YMCA—where I would swim—and commuted to the Watson Center by train and taxi.

It was during this visit that I discovered or invented the halting probability Ω. I remember the exact moment. I had been invited to give a lecture at a university somewhere in the United States—every week it was a different one—and was flying back to New York. At the precise moment that I realized that the halting probability was irreducible or algorithmically random, I was looking out the window and saw an unmistakable sight, the Pentagon in Washington, DC.

In Terry Fine's office at Cornell University

Due to the usual delays for refereeing and such, the halting probability did not appear in print until the next year, 1975, in my fifth *Journal of the ACM* paper, "A Theory of Program Size Formally Identical to Information Theory."

By the way, the halting probability was originally ω, but the set theorist Robert Solovay, who was visiting the Watson Research Center, suggested to me that Ω might be better because in set theory ω stood for the set of natural numbers $\{0, 1, 2, 3, \ldots\}$.

During this visit to the Watson Research Center I also corrected the proofs of one of my first publications on incompleteness, destined to appear later in the year, an invited paper "Information-Theoretic Computational Complexity" in the *IEEE Transactions on Information Theory*, with an appendix giving the mathematical details, which proofs I was to send to Gödel, as I will tell below.[1]

And I had two very interesting experiences.

The first was that I attended a lecture at the New York Academy of Sciences in Manhattan by a mathematician I admired, Mark Kac. The lecture was on randomness, and Kac's thesis was that randomness was an interesting but slippery notion that resisted precise definition. He concluded his lecture with the following words: "In spite of this, a definition of randomness has been proposed by Kolmogorov and by a young fellow in Argentina, Gregory Chaitin." I stood up and said, "No, I'm here now!" Pandemonium, over which Kac declared, "This was not rehearsed!"

After the talk a gentleman came up to me and said, "I'm Dennis Flanagan, the Editor of *Scientific American*." And he told me the following story about Gödel. At the time Flanagan was living in Princeton, New Jersey, and he had just published a wonderful article, "Gödel's Proof" by Ernest Nagel and James R. Newman (1956), later expanded into a small book (NYU Press, 1958) that completely obsessed me from the moment it appeared in the New York City public library (at that time I lived in Manhattan). Gödel was not known to the general intellectual public yet—that article and that book were to change that—and few people had seen a photo of Gödel and knew how he looked. However, Flanagan had sent the well-known portrait photographer Arnold Newman to Princeton in order to be able to include an image of Gödel in the article about him in *Scientific American*, resulting in a stark portrait of an angry-to-be-disturbed Gödel sitting in front of a bare blackboard that has been reproduced many times.

So Flanagan knew how Gödel looked. And one hot, humid summer day

[1] However, my best paper on incompleteness was probably "Gödel's Theorem and Information" published in the *International Journal of Theoretical Physics* years later, in 1982, and then reprinted in Tymoczko, *New Directions in the Philosophy of Mathematics* (Princeton University Press, 1986, 1998), together with the paper that I sent to Gödel.

Flanagan was walking down the street in Princeton, a small town, and saw Gödel approaching. He prepared to introduce himself as the publisher of the article about Gödel's proof. At that moment, however, a scantily clad beautiful young female student (we used to call them "co-eds" from the word "co-education") passed by, and Gödel stopped dead in his tracks to admire her. As they say in French, "La belle opportunité est perdu!" Flanagan did not dare to interrupt Gödel!

The second amazing experience was that I somehow managed to make a phone call to Gödel's office at the Princeton Institute for Advanced Study (IAS), a cold call as they say in the world of sales, and Gödel himself picked up the phone. "Professor Gödel," I said, "I am extremely fascinated [obsessed would have been more accurate] by your incompleteness theorem, and I have a new proof based on the Berry paradox instead of the Epimenides paradox [the paradox of the liar, 'This statement is false']." He replied, "It doesn't matter which paradox you use!" In fact, he says this in the introduction to his famous 1931 paper, which I was familiar with. So I was prepared, and I immediately answered, "Yes of course, but this suggests to me a new information-theoretic view of incompleteness, which I would very much like to visit you and tell you about." He replied, "Send me a paper of yours on this subject, and I will take a look at it and decide if I give you an appointment." So I sent him the proofs of my as-yet-unpublished 1974 IEEE paper. Then I called him back, and he commented "Very interesting, your complexity measure is an absolute notion [like computability as contrasted with provability, which depends on the axioms]." And he gave me an appointment!

The great day arrived, and I had already figured out how to take the train from Yorktown Heights into New York City and from there to Princeton, New Jersey, and how long that would take. It was the week before Easter, and that weekend I was supposed to leave NY and fly back to Buenos Aires. There had been a Spring snowstorm, nothing serious, nothing that would stop me from visiting my hero, Kurt Gödel. I was about to leave my office at IBM for the train station, when the phone rang, and a voice, a terrible voice, that of Gödel's secretary, announced that Gödel was very careful about his health and because it had snowed he was not coming into his office that day and therefore my appointment was canceled!

So this is how I spoke to Gödel on the phone twice but never met him. In retrospect, I think this is a much more interesting story than if I had actually met Gödel. It illustrates the surreal quality of interactions with Gödel.

The next week I stopped on my way back to Buenos Aires to present

"A Theory of Program Size Formally Identical to Information Theory" at Stanford University.

However, the *annus mirabilis* 1974 was not yet over. Back in Buenos Aires, I was summoned by the head of IBM Argentina, Mr Benito Esmerode. The moment I sat down in Mr Esmerode's office, the phone rang. It was the head of IBM, Thomas J. Watson Jr. "Yes," said Mr Esmerode, "he is here in my office now, and yes, of course we will pay for his trip to the University of Notre Dame!"

What had happened? The IEEE was holding their 1974 International Symposium on Information Theory later that year at Notre Dame University, and the organizers wanted me to present "A Theory of Program Size Formally Identical to Information Theory" in their opening plenary session. But I had told them I couldn't travel to Indiana. So the president of Notre Dame wrote to Thomas J. Watson Jr. and asked for his help. Problem solved.

That was my second trip from Buenos Aires to the United States in 1974. I was transferred from IBM Argentina to the Watson Research Center in 1975, the year that my article on "Randomness and Mathematical Proof" appeared in *Scientific American*.[2]

With Cris Calude at Gödel's grave in Princeton, New Jersey

Years later my friend Cristian Calude from the University of Auckland

[2]To be followed by "Randomness in Arithmetic" in 1988 and by "The Limits of Reason" in 2006.

was visiting me at the Watson Research Center, and we decided to make a pilgrimage to Princeton. We found Einstein's former home near the IAS, Gödel's former home in a much poorer part of town, and Gödel's and John von Neumann's graves in the Princeton Cemetery. Einstein is not there. He was cremated and his ashes were scattered at an undisclosed location, as he had wished.

Furthermore, as we stood looking at Gödel's home, the couple who were renting it from the current owner came out and invited us in. It turns out that much remained exactly as it had been when Kurt and his wife Adele lived there, in particular the heavy sound-proofing so that Gödel could work undisturbed in his study, and a shrine to the Virgin Mary in the garden, but not Adele's infamous pink flamingo, which Gödel found "charming."

4 Interregnum, 1976–1986

Now there is a gap, during which I worked mostly on practical hardware and software engineering for IBM, which was a lot of fun. It was great to learn about hardware design and architecture issues, and to work on compilers and on some operating system components. I was part of a small, really terrific team, which was very educational.

After all, what do you do when you don't have a great new mathematical idea? I like to turn to practical engineering problems, which give one a feeling of accomplishment, while waiting for lightening to strike again.

We worked the way Elon Musk works at SpaceX, quickly lashing prototypes together, using them ourselves, and improving them as we went along. Theory was on a backburner.

This period of my career has been described in a perceptive essay by my former colleague, Rocky Bernstein, in his essay "Greg Chaitin, Computer Programmer" at `http://rocky.github.io/gjchaitin.pdf`.

In particular, I remember four projects.

The first was a timer for a proposed new processor design. It was a register-level simulator that we would run an instruction stream through to see how well the processor performed.

The second project I remember did register allocation via graph coloring for the back-end of an optimising compiler.

The third project was a binder that separated data and code, that attempted to re-order everything to minimize the working set, and that featured a garbage collector so that an entire run-time library could be bound with the output of the compiler and the unnecessary run-time routines would disappear.

Finally a project that was a hobby, to teach myself theoretical physics by programming simulations using the fundamental equations of theoretical physics. This included: (a) calculating and graphing the trajectory of a satellite orbiting a point mass according to Newtonian physics and according to Einstein's theory of general relativity; (b) a numerical verification of Einstein's field equations at a point near the event horizon of a Schwarzschild black hole; (c) showing the propagation of an electromagnetic wave according to the traditional formulation of Maxwell's equations and according to the more sophisticated vector potential formulation; (d) showing Schrödinger's equation in action by scattering the psi function probability wave for a solitary electron against differently shaped one-dimensional potentials; and finally (e) attempting to repeat the same calculations, as much as possible, using the Feynman path integral, sum over all histories reformulation of quantum mechanics.

To get these physics working models to function properly, I had to learn enough numerical analysis to do numerical solutions of partial differential equations. I fortunately could take advantage of the expertise of a member of the theoretical physics group who had learned numerical analysis simulating atom and hydrogen bomb explosions at one of the United States government national labs, Gordon Lasher, a very nice guy.

This then became my "Computer Gallery of Mathematical Physics" course, the idea being to teach fundamental physics by showing how to do the calculations instead of presenting the mathematics in the traditional way. Finally it morphed into my "APL2 Gallery of Mathematical Physics" course that took advantage of the fact that APL2 was an executable notation as concise as the equations of mathematical physics, but, it must be confessed, much more cryptic, because it employed so many special characters as one-character built-in mathematical functions (such as matrix multiply and matrix inversion). This APL2 Gallery also earned me my first trip to Switzerland and my first trip to Japan, an unexpected but most welcome bonus. And it was so concise that all the APL2 code for the course eventually ended up hanging, beautifully framed, as a single piece of conceptual art on the wall of our apartment in Rio de Janeiro.

Of course, now the right way to do all this would be to reprogram it in Stephen Wolfram's Mathematica, or, should I say, in the Wolfram Language.

As I said before, theory was on a backburner. I did of course accept invitations to lecture and to write some papers, but there was no fundamental new mathematical idea during this period. However, my understanding of incompleteness and its philosophical implications slowly advanced, helped by Martin Davis' suggestion that I take a look at Gödel's essay "What is Cantor's Continuum Problem?" The result was my best paper on incompleteness, "Gödel's Theorem and Information," published in the *International Journal of Theoretical Physics* in 1982, and then reprinted in Tymoczko, *New Directions in the Philosophy of Mathematics* (Princeton University Press, 1986, 1998), a collection of papers supporting a "quasi-empirical" view of math.

5 Visit to Vienna, 1991

In Gödel's classroom: Hier Wirkte Kurt Gödel von 1932–1938

Here I am in the small classroom at the University of Vienna where Gödel taught. The two lectures that I gave in Vienna in January 1991—one in this room and one at the Technical University of Vienna—are contained in my 1992 book *Information-Theoretic Incompleteness* (World Scientific). My 2002 book *Conversations with a Mathematician* (Springer-Verlag) also includes the Technical University lecture and provides additional background information.

I was invited to Vienna because of my 1987 Cambridge University Press monograph *Algorithmic Information Theory*, the subject of a highly visible and very favorable review in the prestigious journal *Nature* ("The Ultimate in Undecidability," 1988). And I was greeted in Vienna by a full-page article in the newspaper *Der Standard* entitled "Gödeliger aus Gödel," Out-Gödeling Gödel.

I think of this as my "Randomness in Arithmetic" episode, which was the title of the *Scientific American* article that I published in 1988 summarizing the results in my 1987 Cambridge book. With it I got out of my system the fascination with Hilbert's 10th problem that I inherited from Martin Davis and, actually, from Emil Post, who had told Martin that Hilbert's 10th problem "begged for an undecidability proof."

After this "Randomness in Arithmetic" episode, I spent years programming out algorithmic information theory in LISP for my three Springer-Verlag textbooks,[3] and further years absorbed in studying Leibniz, who had also fascinated Gödel.

And then I attempted to write the kind of book that as an adolescent had inspired me to become a mathematician. The result was *Meta Math!: The Quest for Omega* (2005), which I summarized in my 2006 *Scientific American* article on "The Limits of Reason." In both of these publications Leibniz figures prominently.

Why did I embark upon a serious study of Leibniz? In fact, it was completely fortuitous. I had long been aware of a reference in one of Hermann Weyl's works on the philosophy of science to Leibniz's reflections on complexity in the *Discours de métaphysique* (1686). But I did not follow this up until an invitation arrived for me to give a talk at a September 2002 meeting of the German Philosophical Society in Bonn. So began my Leibniz phase, which continued until the tricentennial of Leibniz's death in 2016, when I give lectures on Leibniz in Turin, Kraków and Singapore. Furthermore, Ugo Pagallo, who had just published *Leibniz—Una breve biografia intellecttuale*,

[3] *The Limits of Mathematics* (1998), *The Unknowable* (1999), and *Exploring Randomness* (2001).

happened to visit Brazil in 2016, so my wife and I organized a Paquetá island Leibnizfest with Ugo and friends at our weekend home there and at a fine restaurant on the island at the Casa de Artes.

I must confess that it had not been easy for me to study Leibniz. I amassed a considerable collection of Leibniz books, a number of them out of print and hard to obtain. But it was all worth it, and was reflected not only in my talks but also in a series of papers such as "Leibniz, complexity, and incompleteness," which I published in the *APA Newsletter on Philosophy and Computers* in 2009.

I should say more about the genesis of *Algorithmic Information Theory*, my first book. In 1986 I received a letter from Cambridge University Press. They informed me that they were launching a new series, *Cambridge Tracts in Theoretical Computer Science*, with the goal of showing that there is intellectually significant theory behind computer science. And to make this point as clearly as possible, they were asking me to write the first book in their series!

I took this letter to Ralph Gomory, at that time the head of research. He had started his career as a mathematician, and I admired him and felt that he could have been minister of science and technology for a nation. He had given me a helping hand several times, at crucial junctions in my career at IBM. I was supposed to be working on practical problems, but Ralph picked up the phone, called the head of the physics department, and I was given a one-year internal sabbatical to write my book!

And I am proud that Jack Schwartz wrote the foreword for *Algorithmic Information Theory*. Jack was a spectacular mathematician, and a workaholic. He had studied with Emil Post, who had recognized his talent, and he was the co-author (some people said practically the sole author) of Dunford and Schwartz, *Linear Operators*, an exhaustive and massive three–volume masterpiece, the likes of which we shall probably never see again.

To indicate the kind of man that Jack was, I will repeat a story that his student Gian-Carlo Rota tells in the *AMS Notices*. There is a certain important theorem that appears in Dunford and Schwartz that is usually credited to a well-known mathematician. Gian-Carlo was, however, surprised that in Dunford and Schwartz it was not so credited. Then he noticed that Dunford and Schwartz was published before that well-known mathematician's paper! Jack had proved the theorem, but had not bothered to claim credit. For Jack, what counted was doing the mathematics, not who got the credit. I have tried as best I could to follow his example.

6 Greg and Virginia in New York, 2008

At Bear Mountain Bridge

This photo shows us just before we got married in August, 2008. We are on Bear Mountain, and in the background you can see the Bear Mountain Bridge and the Hudson River—actually a glacially-cut fjord with excellent hiking trails. This photo was taken by Karol Jałochowski for *Polityka* magazine, who later filmed the *Against Method* documentary—on creativity in mathematics and in biology—at our Paquetá island weekend home near Rio de Janeiro.[4]

The week before we got married I was reading David Berlinski's *The Devil's Delusion: Atheism and Its Scientific Pretensions* (2008), which has a critique of Darwinism, and I had the idea of trying to model evolution as a random walk in software space ("metabiology"). In *Proving Darwin: Making Biology Mathematical* (2012), I credit Virginia as my muse, and I refer to metabiology as "our child," as indeed it was at that time because our two

[4]Available from Amazon Prime Video at https://www.amazon.com/dp/B07M5VLJS2.

children had not yet been born, and in fact the prospect of having children, although desired by both of us, unfortunately seemed rather remote.

Jack Schwartz also played a role. In our numerous dinners in hole-in-the-wall ethnic restaurants in Greenwich village in Manhattan, he would talk to me about molecular biology, which he was studying with his usual intensity, thoroughness and omnivorous intellectual appetite. "DNA," he said, "is just a digital programming language!" He encouraged me not to give up and to continue thinking about biology. Unfortunately he passed away in 2009, so I was never able to show him *Proving Darwin*.

I had been searching for this idea—random walk in software space!—my entire life, but I was only able to come up with my mathematical theory of biology after retiring from IBM and moving to Brazil. And it was also in Brazil that Virginia and I finally resorted to *in vitro* fertilisation treatments, becoming parents later in life than is usually the case. That story will be told in Virginia's forthcoming book *Maternidade Tardia: Contextos e Caminhos*.

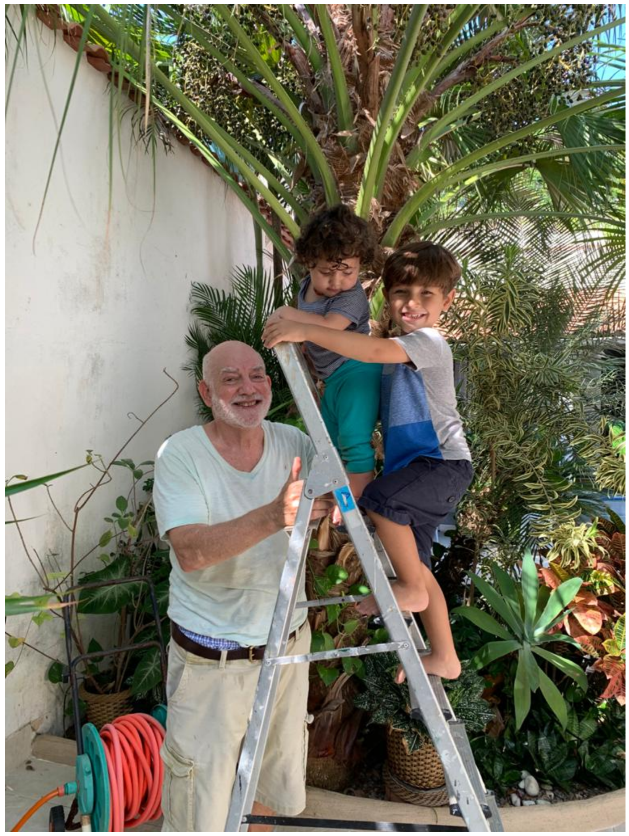
Strangely enough, all the technical tools needed for metabiology were already in my 1975 paper "A Theory of Program Size Formally Identical to Information Theory," but in 1975 I lacked the necessary sophistication.[5]

Nor did I have Virginia to provide a philosophical perspective on several crucial issues:[6] (a) the oracle in metabiology corresponds to the environment; (b) the global algorithmic mutations used in metabiology instead of SNPs and indels are a key contribution, not an embarrassment, and in fact have been picked up by Hector Zenil and his collaborators[7] and may explain the major transitions in evolution; and (c) metabiology, in emphasizing open-ended creativity instead of adaptation to the environment and selfish genes, goes beyond Darwinism as it is currently understood—and provides us with a different and more flattering human self-image.

[5] It took me many years to understand what mathematical methods could or could not achieve, and to free myself from the formulation in John von Neumann's posthumous notes, *Theory of Self-Reproducing Automata*, edited and completed by Arthur W. Burks (University of Illinois Press, 1966).

[6] See Virginia's paper "Metabiology, Interdisciplinarity and the Human Self-Image" in Wuppuluri, Doria, *Unravelling Complexity: The Life and Work of Gregory Chaitin* (2020).

[7] Please see the article in *Quanta* magazine at `https://www.quantamagazine.org/computer-science-and-biology-explore-algorithmic-evolution-20181129/`



With Maria Clara and João Bernardo in Paquetá, 2021

7 Coda

I offer this story of a life in math as food for thought. Why is one period of a person's life more fertile than another? Why is one particular decade in the life of a nation or of a city more creative? Where do new ideas come from? What kind of stimulus is necessary? Why did it take me so many years to come up with a simple model of evolution?[8]

Nations, individuals and corporations seem to have periods of youthful vigor and periods of decline. Maybe I am fooling myself, but the postwar

[8]Fortunately for my self-esteem, Jacques Hadamard, in his book *The Psychology of Invention in the Mathematical Field* (Princeton University Press, 1945), gives many examples of mathematicians, including himself, who failed to see more or less obvious consequences of their own work. I believe this is sometimes referred to as "tunnel vision."

United States in the 1950s seemed particularly optimistic and energetic—as evidenced by the large families and the thick issues of *Scientific American*—a period captured in my father Norman Chaitin's 1962 feature film *The Small Hours*—preserved in the MoMA film library—an Argentine intellectual's depiction of struggling artist types in postwar Manhattan.

Corporations also go from dynamic, energetic, can-do beginnings into bureaucratic decline.

The mystery of creation is evident in my little story, but even more so in the lives of Leonhard Euler and Srinivasa Ramanujan, two spectacular cases of overflowing creativity, of overabundant gifts. And then there are mathematicians like John von Neumann or Jack Schwartz—or even my friend the physicist Stephen Wolfram—who seem to be mutant life forms, aliens more or less capable of pretending to be human beings. How do such minds function? How is the human spirit capable of such achievements? Will we be able to create artificial intelligences at that level?

Gregory Chaitin is an Argentine-American mathematician living in Rio de Janeiro, and a lifetime honorary professor of the University of Buenos Aires with an honorary doctorate in philosophy from the University of Córdoba, the oldest university in Argentina and one of the oldest in South America. He was formerly at the IBM Watson Research Center in New York, where he was part of a small team that developed the Power processor architecture and its associated software.

On the theoretical side, Chaitin is best known for his discovery of the remarkable Ω number, a concrete example of irreducible complexity in pure mathematics, and which shows that mathematics is infinitely complex. For this he was awarded the Leibniz Medallion by Wolfram Research in 2007. He has also proposed modeling evolution as a random walk in software space ("metabiology").

Among his books are: *Algorithmic Information Theory*; *Conversations with a Mathematician*; *Meta Math!*; and *Proving Darwin*.

Festschriften: Cristian S. Calude, *Randomness and Complexity, from Leibniz to Chaitin*, World Scientific, Singapore, 2007; Gregory Chaitin, *Thinking about Gödel and Turing: Essays on Complexity, 1970–2007*, World Scientific, Singapore, 2007; Shyam Wuppuluri, Francisco Antonio Doria, *Unravelling Complexity: The Life and Work of Gregory Chaitin*, World Scientific, Singapore, 2020.