

**Giorgio Parisi with Piergiorgio Paterlini**

**Steps that never end**

**Daily life of a Nobel laureate**

Theseus' ship

© 2022 La nave di Teseo publisher, Milan

ISBN 978-88-346-1168-5

La nave di Teseo digital first edition November 2022

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## **100. Asteroid take me away**

### **Credits**

*To the memory of our parents,*

*Nunzia and Peppino,*

*Edda and Angelo*

***A randomly scattered pile of garbage,***

***the most beautiful order.***

***Heraclitus***

### 1. Letters and figures

I learned to read numbers first than the letters of the alphabet. When I was 3 years old - so my mother used to tell me - I recognized the number of the streetcar while it was still far away. "Here comes 53," "here comes 24."

Also when I was very young-my mother claimed before I even started elementary school, but maybe she was exaggerating or simply misremembering-there was the Game of 15, some will remember, a plastic board with 16 squares and 15 tiles numbered from 1 to 15 in random order and a blank space. You had to rearrange them from top to bottom in the correct order. A game, but one that had been invented as a puzzle as early as the mid-nineteenth century and which had an algorithm at its base, a kind of much simplified version of the Rubik's cube. (By the time the Rubik's cube came along, in 1974, I had already been a graduate student for four years, so I didn't care. Friends who were physicists were playing with it, studying it, getting into it. I must have had it in my hand three times to say a lot, then I didn't think about it anymore.)

There was a particular move you had to do to solve the Game of 15, and if you didn't understand it you couldn't put the numbers in order. I understood it. My mother used to tell me that adult people who tried it and couldn't figure it out would get very upset. Because it was frustrating to see a small child succeed where they failed.

On the other hand, I always wrote very poorly. As a handwriting I mean.

But really bad bad. In third grade the teacher had complained to my mother about this, and that the first graders wrote better than me. Even now my handwriting has remained bad, if I take notes quickly when I go to reread them I can't understand what I had written.

Growing up, a friend of mine said that I could have bad handwriting even when I was typing.

## 2. Mottled err

Anyone who has heard me speak knows that I have a lisp.

What you don't know is that the "r" I also misspell, not just pronounce.

A few years ago I was looking up "surgery" in the Treccani and looked it up as "chilulgia." I feel like writing "chilulgo" instead of "surgeon."

In words that contain both "r" and "l" sometimes I can't remember the order.

Had I gone to a good speech therapist, I would have learned the "r."

Newborn children perfectly distinguish all sounds from each other, then this ability, this skill is lost.

I have to say that fortunately, the moustache didn't give me much trouble. Some rare, good-natured teasing as a boy, but no big deal.

It certainly gives me a recognizable accent.

## 3. Old friends

My childhood and adolescence were very lonely. But for no particular reason - at least to my knowledge - and without suffering.

Perhaps I was one of those children of whom it was said "he is older than his age," which then meant with curiosities different from those of the majority of peers, children who were a bit lonely, who perhaps preferred the company of adults instead of the peer group, who did not like to run after a ball, more naive in things of sex and oblivious to any swearing (the two are always very closely related). Here, I was such a child. A little different from others and with interests certainly different from others, a world of my own a little different from others.

I liked to be alone and spend maybe whole afternoons reading. Or looking inside a microscope.

I was fond of my schoolmates, but friends I hung out with outside of school I had none, except at the beach, until I was 16-17 years old. Actually two, and they were both older people. One I had "inherited" from my father, although I then hung out with him on my own, and another I had sought out on my own initiative.

One of these two people, to whom I was extremely close, was a very dear friend of my father, Professor Nino Prato. He lived in our building on Via Salaria in Rome but for a while he and my father had only said hello to each other, then they had met in the summer at the same hotel in Chianciano and there they had made friends.

My father used to go to "Chianciano healthy liver," a famous slogan of the time, he didn't have any particular liver problems but he used to go before the war because it was common sense that the water was purifying and good for you anyway.

Good food was sure to be had in the hotels.

He also went to Fiuggi to "pass water." He suffered from kidney stones and would stay there two weeks. Usually alone.

But a couple of years we also went.

It was far too quiet a place and completely artificial. That is, it was not the actual country, but a place made up only of hotels. He would go in the morning like everyone else to the Fountain-there was an endless number of urinals-then he would pull himself together in the evening by playing board games. There were even auctions, with items ranging from pennies to even considerable sums.



It must have been my summer of 13 years when, during the two weeks in Fiuggi, I read Crime and Punishment, which had made a huge impression on me.

Nino Prato had been in the war, he was one of the "boys of '99," he was two years older than my father, he was Jewish and I think he had to go into hiding during fascism, but I know almost nothing about that. He was unmarried and lived with his sister whom I never saw, however, he used to visit us often at home both when we lived in the same building and later when we moved to Spontini Street. He lived on the second floor, we lived on the fourth, he played the violin and Dad said you could hear everything, but I don't remember. He liked poems, and he also wrote some.

We talked, he was very kind to us, he confided in my father some of his problems, I could hear him talking about a piece of land he owned near Cortona and that the sharecropper was stealing his money.

He was a chill guy and very formal, he cared about elegance. I always saw him in a jacket, tie and vest. He would take off his vest in the summer, but I remember once in Ostia, at lunch in a bathhouse, he was in a suit and tie.

He worked for a stockbroker.

He also often came to the Deer Park in Villa Borghese. In the moss-covered fountains there were a myriad of little animals (the infusoria) that were almost invisible to the naked eye. So he one day - I was in elementary school - gave me a microscope, and it was a very important thing for me. There was a drinking fountain completely covered with moss, I would go, take the moss, put it in a little bottle with some standing water, take it home, and you could see these little animals swimming around, one little animal that must have been a millimeter looked like a snake.

Nino Prato has been a very important and "familiar" figure for me.

I had also made friends with another gentleman about 65 years old. He said he had been an Italian checkers champion, I used to go to him often, play checkers, at checkers he always won, then at chess I won more. His last name was Balzi, he was bald with some white hair that came over his ears.

The friendship with Professor Prato I can also think had been a bit casual, he was a family friend, but this Mr. Balzi I had really sought him out, my father barely knew him and I don't even remember how our friendship started.

At home I was bored, I had a whole series of exciting readings, it is true, and the microscope, but they could not be enough. I didn't have enough stimulation either from professors or peers.

Math was also more of a pastime than the idea of an "investment" that would get me somewhere. And I was reading more about the history of mathematics than actual math texts, perhaps because - without knowing it - it was the research that I was passionate about, being in front of a problem and trying to solve it, having suggestions not pre-packaged solutions. Amazingly, it went on like that all the way through my freshman year of college.

In 1955 Uncle Totò, who had always stayed in Palermo and whom I had never met, died. At that point his widow, Celeste, moved to Rome, a guest of a nunnery. I would also visit her and play canasta with her.

An 80-year-old lady and a 10-year-old boy playing canasta in a nunnery.

#### 4. Villa Borghes

On the Salaria we lived at the height of Villa Albani. Villa Borghese was very close.

We would arrive at the small lake where the Temple of Aesculapius is, and I would have fun building small dams with stones and a bit of earth on the tiny stream that then plunges into the water.

It was also possible to rent a small boat and go around the lake.

We used to go there often, on foot. Bikes were rented on site, first with classic wheels then without.

Once while walking I had gotten distracted and bumped into a lamppost. Afterwards, when I walked past it, I would kick it and say, "Bluto lamppost."

Borges wrote, "Every time a child kicks something in the street, the story of soccer begins again."

It may be true, and certainly it is a very poetic phrase. But not to me.

I did not play soccer. I never played soccer or played any other sport.

## 5. Red of enchantment

One of the earliest memories I have comes from the house on Salaria Street. Which had a disproportionate and completely unnecessary entrance hall, with a large Persian rug in the center. There was the living room with the little golden armchairs (my father would later throw them away, he couldn't stand them anymore) and the dining room. A very long hallway led to the other side of the house, with the bedrooms.

I remember well this feeling of a "long" house, with one side facing the Salaria (living room and dining room) and a small balcony that I have no memory of but infer from my mother's stories, and the other side facing the back.

We were on the fourth floor, and the other buildings were lower than ours. The view could sweep. Seeing how the sun colored the walls of the houses red, I loved it.

Even today, looking at the houses reddened by the sunset, I feel that same very strong emotion as I did then.

## 6. The impossible interviews

When I was 10 years old in the summer I read issue 128 of *Urania*, *Cosmic Resonance*, signed N.H. Laurentix, which was then a certain Luigi Rapuzzi of Sacile, near Pordenone, who also signed under the pseudonyms L.R. Johannis and Louis H. Steyner. From there I then read 127 and practically little by little I won't say the whole collection but almost. Since I was a child I have read a lot of Verne, *From the Earth to the Moon*, *Around the Moon*, *Journey to the Center of the Earth*, *Twenty Thousand Leagues Under the Sea*, *Around the World in 80 Days*, and *Salgari*, the five books of the *Black Corsair* (*The Corsairs of the West Indies*), but it was Verne that I liked. *Captain Nemo*. Reduced versions, summaries printed in large print.

When I was 11, I spent a week in the hospital for groin hernia surgery. I read *The Boys on Pál Street*, *White Fang*, *The Last of the Mohicans*.

We had astronomy books in the house, about planets, satellites, how far they were from Earth, children's books with illustrations. The teachers had noticed that I knew the distance between Jupiter, Earth, the Sun, how big

Jupiter and Saturn were, they would ask me, and they would show me off to the other teachers: does the child know this...

I am not sure at what age, but still in my teens, I read *The Popular Astronomy* of Camille Flammarion (brother of the great French publisher), his best-known and best-selling book.

My father had a fairly large library, a thousand books, 25 meters of shelving. He had them all stamped and numbered, then the catalog was lost, and the more recent acquisitions were left unstamped and unnumbered.

During middle school I read a lot of books. Pirandello almost everything, a lot of Shaw's plays. My father also had one of the first editions of Moravia's *Indifferents* but I hadn't read that one.

I liked Sherlock Holmes. Which I still quote today because at a certain point in a novel there is a dialogue that is essential for those doing research. "What hypothesis have you made about the crime?" "None. I have too few facts, and it's extremely harmful to make assumptions with few facts because then if the assumptions are wrong and one falls in love with the wrong assumptions one can't make new ones, so I'm waiting until I have enough information and can make well-founded assumptions."

We had at home the famous UTET encyclopedia in the edition printed in the mid-1930s. It was getting outdated, and when the new UTET came in the 1960s, I learned a lot.

And then the comic books. We were full of Mickey Mouse, which was bought regularly, then the *Albi del Falco*, Donald Duck, the first Nembo Kid albums, Batman, and the ever-present "Corrierino," that is, the *Corriere dei piccoli*, and at home circulated *La Domenica del Corriere* and *La Settimana Enigmistica*. Every week Mickey Mouse, Donald Duck, *La Domenica del Corriere* would arrive at home... every day *Il Messaggero*, the Roman newspaper par excellence, and I would not miss the "Adventures in the City," often chronicles of people fighting and ending up in court.

When I was 12-13 years old I was given the history of World War II written by Churchill: six volumes of a thousand pages each, which Mondadori had published in 1951. Churchill recounts the war day by day, reports the letters he wrote. I had read the whole thing. History has always fascinated me.

When Linus was born in 1965, from the brilliant minds of Giovanni Gandini, Oreste Del Buono and Umberto Eco, I did not miss an issue. I still have the complete collection here at home.

The bulk, however, were the science fiction novels.

In elementary school I had a great passion for Hendrik Willem van Loon, a completely forgotten writer, very popular between the two wars, encyclopedic, illustrated books himself.

The book I had most enjoyed-read and reread several times-had been *The Lives of van Loon*, which was very strange. Van Loon was a journalist, a writer, a great traveler, a popularizer of history and geography. At first glance the book is completely crazy.

I also wrote about it later, as an adult, in that book. The plot is this. The author hosts Erasmus of Rotterdam for a year in his Dutch home. They decide to hold a dinner party every Saturday inviting famous people from different eras. Queen Elizabeth I of England with Empress Theodora of Byzantium, or St. Francis, Christian Andersen and Mozart, or Beethoven with Napoleon and the author's great-great-grandfather. Sort of like *The Impossible Interviews*, a famous Radio 2 program from the mid-1970s.

I realized later how much this book had marked me, how much weight it would have in my education. It was from van Loon that I absorbed the fundamental value of tolerance.

Even more impressed when I found out that Francesco Guccini had dedicated a whole long song to van Loon, titled just *Van Loon*.

One stanza reads:

Van Loon lived and I thought he was dead or (worse) useless,  
only because of the distance between its different myths and my youth  
And pride of that time, my ignorance;  
what did I know how much he had sailed  
With the courage of a Cabot among the foams  
Of each of his days, and that a shark  
Has become, day by day, a river fish.

Then Guccini himself says, "Van Loon is dedicated to my father, who used to read the works of this Piero Angela of his time, that is, the 1930s. Van Loon was a [...] popularizer of history, geography and various humanity, whose writings were frequently found in the homes of those who, like my father, had many interests but had not had the opportunity or the money to study. [...] An author therefore of the 1930s, 1940s, a writer of our fathers' generation: I identified him with that generation that when you are young you think is made up of losers. But as you grow up

you realize that your father was not a loser, he was simply someone forced to live like that. When you are young you think that you will never compromise, that no one can force you. In time you change your mind. [...] The older you get, the more you understand those fathers whom years before you had rejected or fought, especially since their defeats then became yours as well, and so did the small, long before unrecognizable, victories."

## 7. King's Avenue

My grandfather was Sicilian, his name was Francesco but to everyone he was Ciccio.

A wealthy family in Palermo.

Ciccio moved to Rome in the late nineteenth century, around the age of 30, perhaps less, and in Rome he married a lady of Turin origin, Maddalena De Matteis. Unfortunately, he died of cancer quite young, in 1928, while his wife survived him until the early 1940s.

On September 13, 1901, my father, Giuseppe aka Peppino, was born. He was born in Viareggio where his mother was vacationing.

They live on Viale Trastevere, which was then called Viale del Re. Famous enough to give the title and closing verse to a song by Nino Manfredi:

Every street in this city

It reminds me of someone

But one road I have to bypass.

Species under the moon

For if I walk down Viale Trastevere, Viale del Re

I'm going to die, Mari', I remember you sort of.

My grandfather was a builder, in partnership with one of the best-known building contractors of the time, Guglielmo Persichetti. In short, he built buildings and resold them, keeping some apartments for himself. My daughter Lorenza lived until a few months ago on the second floor of a building in Trastevere built by my grandfather around 1920, and I

remember when I was growing up we still had another apartment there, on the top floor, which my father then sold.

Uncle Mimmo was steward at the royal house, Quirinale. Once retired he used to tell about the court lunches: the king, Victor Emmanuel III, served first, would immediately start eating and eat quickly, and as he put down his fork everyone else had to stop eating as well. But those who were served last sometimes did not even have time to touch the first bite. Kings are like that.

It is with Uncle Mimmo that my father goes to Turin to buy a car, straight from the factory, FIAT. This is the late 1930s. They come back driving this shiny new car but they certainly don't have the Autostrada del Sole at their disposal, they have dirt roads, very dusty.

My father had started driving very early, he was taking lessons but was more familiar with sailboats, where you turn the rudder in the opposite direction to the one you want to steer the boat. So it had happened that when they had first told him to turn right he had turned the wheel to the left and crashed into a wall. As they were coming down the Pincio.

At some point my father began to think that Trastevere had become too confusing a neighborhood, and in the late 1930s he moved to the Salaria, just beyond Piazza Fiume. In 1954, when I was 6 years old, at the birth of my brother Valerio. Then we were evicted and moved a little further out of town, less than a kilometer, to Via Spontini, near Piazza Verdi, where the Poligrafico dello Stato is, also near the present Bioparco.

Memories of this move are beginning to be among the very sharp ones.

Also in order not to depend on the landlord, my father in 1963 bought a house at 10 Viale Parioli, one hundred and fifty square meters on the third floor, right next to Piazza Ungheria.

Fifteen years old, I had gone to the still empty apartment, drawn the whole house plan, the floor plan drawing to perfection. This house was a hundred meters from the school.

I would stay there until I was 27 years old, until 1975, when Daniella and I then went to live together on Via di San Basilio, a few meters from Piazza Barberini, right in the center.

## 8. Marriage with class

My father and mother met in the early 1930s. She lived in Rome on Via Monte d'Oro, which still exists in part, not far from Piazza di Spagna, in the area where they would later restore the Mausoleum of Augustus to its original state. His father was Umbrian, from the Gubbio area, had a farm and cared little for his family in Rome, coming to the capital just to sell his agricultural products, but his mother had been Roman for seven generations. This had been ascertained beyond a shadow of a doubt by *Il Messaggero*, in one of those investigations that readers liked so much.

My mother was the penultimate of nine children, two who died very young, and only one boy, who was a printer. She went to school with the nuns in Trinità dei Monti. She used to tell me that there was an elevator to go up, but it was very slow, and she - who always arrived late - preferred to walk the whole famous staircase.

My father starts dating this girl, but his mother, with her Piedmontese origins, strongly opposes: her son could not marry a woman of lower social class. And my father obeys. In the families of the 1930s, even the adult male children obey their parents.

He breaks off relations with his fiancée and hello. They would not see each other again until after his mother's death and could finally marry. The year was 1942.

They got married at the height of the war, decided to do it in Assisi, and in Assisi my wife Daniella's parents would also get married, in 1946.

My father had managed to narrowly avoid, without trying, serving in the military in the two world wars. The first because of a small age difference, the second because in 1940 he was already too "old" to be sent to fight.

## 9. Nine less

And perhaps a little too "old" he also felt to make children, both my parents had the complex of being old as parents. On the other hand, they had waited until the end of the war to bring creatures into the world.

My dad Peppino was born in 1901, my mom Annunziata, Nunzia to everyone, was 1910. They both took off nine years, to look younger, but keeping the age difference unchanged.

Married since 1942, I was born in 1948, August 4. Then comes my brother Valerius, six years later, April 13, 1954. As children a difference too great to play together. We slept in the same room, I used to tease him



a little, but in the end we always got along doing our own thing. When I was in sixth grade he was in kindergarten, there was no room for rivalry or jealousy but also no room for who knows what complicity.

He also later majored in physics, and I was a little surprised since he had a very strong interest in biology.

Valerio never married.

My father died in 1987, when I was 39 and my mother was 77.

My mother died at the age of 95, in 2005, when I was 57. A decade earlier she had fallen ill with meningioma, and we could not find a doctor to operate on her in Europe, despite the fact that her mental state was deteriorating fast. Better doctors had no desire to do risky surgery on an 85-year-old patient. Nothing to gain as fame, everything to lose if things went wrong. After six agonizing months we took her, my brother and I, to the United States.

The surgery was successful and gave her 10 years of life.

## 10. Totò and Petrolini

Italian was spoken in my father's house. With a mother from Turin and a father from Sicily, Italian was the only possible mediation. Only one phrase was said in Sicilian: *alzati chi tardu è*, get up who is late, which then from Italian does not deviate much.

Another curious and anomalous thing is that they were all very tall in the family. My father was close to six feet, as was I, the others exceeded him, which a century ago was really a good size.

He was a quiet and shy man, raising his voice little.

He had done one year early - also something that will be repeated - first grade and skipped fifth grade, then studied as a surveyor finishing high school at 16. He wanted to study engineering, even under pressure from his father, I think so he could take over his company. He took the supplementary exam necessary to enroll but failed because of a French subjunctive, something he never swallowed: French, he told me, he knew well. He therefore chose Business Administration and began working in a bank.

After his father's death in 1928, he will not do steady work for twenty years, buys and sells houses, and holds even important positions, for example as liquidator of two agrarian consortia, one in Avellino and one in Benevento.

He began to have steady employment again when I was born in 1948, because my mother was not working and there was a need to give more economic stability to the family. He is employed at the Cassa del Mezzogiorno, which at that time was where the CNR is now.

He told me that he used to go very often to the Casina delle Rose, now the House of Cinema, frequented the cafés chantants and had seen Totò, Petrolini, had even met Claretta Petacci.

My father and mother used to go out a lot at night, but when I was born they stopped and never started again.

My father liked music, opera, he had about 30 librettos that I also read and a not huge collection of 78s. Verdi essentially, and Donizetti's *L'elisir d'amore*. A few rare times we went to see opera.

When the 33 RPMs came out, my parents bought dozens of them. Beniamino Gigli, Enrico Caruso, Mario Lanza, Anna Moffo.

My mother really liked Ravel's *Bolero*, to the point that one night she thought she heard it at full volume, but it had been a hallucination.

I remember very vaguely, in the early 1950s, the domestic help, which was then called "maid," that we had in the house. There was also a governess who came to stay with me. For a time my father had also had a chauffeur. The governess was a certain Miss Vera whom I was very fond of. She came until I was 5 years old, and we called her "Miss Vera," not "governess," a term that was not part of the family lexicon, and "baby-sitter" was not yet said.

Then when I was 5 years old, I went to the first grade.

My parents passed on many things to me, my father especially. Although he spoke little and sent my mother ahead, a classic. But I don't remember major conflicts. As early as junior high school he would ask me, "How was school?" "Good." "Good? Why not great?" I would get angry but it wasn't serious. And a fairly meaningful exchange with him was there. He was sorry he couldn't be an engineer, so I would have to do it. Until it was time to choose a university, I never said no to him.

My mother was completely apolitical, like almost all women at the time. My father was anti-communist, he felt close to the PLI but voted DC to make mass, the famous "useful vote" ante litteram. My mother went to mass on Sundays and took me with her; my father did not come.

My father did not eat in the evening, except when we stayed in the hotel, she said he got into that habit when he was young. Sometimes he would go out at night, come home at different times, and he didn't want obligations with his parents. The easiest solution was to never have dinner at home, so there was no need for justification, or having to give advance notice every time he went out.

The explanation was a little strange but I never investigated.

## 11. Anzio

Almost every year we went to Anzio from June 15 to September 15, umbrella in the front row, same place, the whole company of friends from Anzio since forever. I don't remember a time when we hadn't gone to Anzio, chosen initially for strategic reasons: my father didn't have three months off, but Anzio could be reached in an hour from Rome even if the train was an old wreck.

Around February-March of the second grade I got a whooping cough. At that time no antibiotics for whooping cough. I was taken out of school and taken to the beach in Anzio. I spent almost half the school year there, my mother made me do my homework so I wouldn't miss the year, and I didn't feel like it. I remember it well.

For some years we always went to the same house. It was close to the station. From the window at night I would look out at this downhill street to see when Father was coming.

On Sundays he would return to Rome. He would leave around seven o'clock in the evening from Nettuno where there was a seat. It was a bit of a ritual on Sundays in the square in Anzio to get an ice cream, then on one of the many horse-drawn carriages accompany him to Nettuno.

I must have been small, I had sugar-paper blue pants and jacket of the same color. I felt very elegant.

There was a small room at the end of the apartment, I used to go there to read, I was not with friends in the afternoon, only in the morning. I remember one year it had rained from September 1 to 15. I would look dejectedly at the water running down the downhill street and read all the time.

My father then bought a house, in Anzio, in the late 1970s, a house that has now passed to my family.

And Aunt Elide had also taken a house in Anzio, and now Daniella's brother Guido is fixing it up: his ex-wife will go there.

When I graduated from high school in the mid-sixties, I went there to study and prepare for the exam. Completely alone. I was studying for my baccalaureate and I didn't see anybody.

## 12. The Armando

Strange that my parents had chosen an elementary school run by nuns for me. The vast majority were girls. There were two boys. Armando and me.

The school was close by, a kilometer from home, very beautiful, with a large indoor garden, so much so that it has now been turned into a very upscale hotel on the road that runs alongside the Biopark.

Until the middle of third grade I went to school only in the morning, then my mother must have decided that it was much more convenient for her that I stayed in the afternoon as well (there was my little brother to pick up).

I didn't mind staying the afternoon. From home came the "schiscetta" with the second course of meat and a small glass bowl for the side dish, the pasta was made by the nuns but it was a plain pasta that I couldn't stand, unseasoned, sticky.

Apart from the pasta I liked going there, I would come home around 5:30 p.m., I had no homework to do. I became very fond especially of the teacher, whom I continued to visit for a few years.

After lunch we would play hide-and-seek or ball in the big garden, but more the typical games of little girls, tossed ball, captive ball, ball this, ball this other.

Once, in an attempt to catch the ball, I hit a piece of iron sticking out, one of those contraptions used to stop shutters. I got a big cut above my eyebrows. It had caught my eye....

### 13. St. Gabriel

Beginning in the sixth grade, the school of nuns no longer accepted boys, and I took junior high and high school science at San Gabriele High School. Priests, no, actually brothers of a lay congregation founded in the early eighteenth century.

In elementary school I had had only female classmates, from middle school to the end of high school only male classmates, quite a contradiction when you think about it.

Father wanted me to go to scientific, not classical, and I went to scientific. I had no objection to that.

Almost all male and almost all lay teachers as well. Who didn't really shine. No one who fascinated me. No real teachers. The chemistry teacher was nice but nothing more. The one in Italian and Latin, in middle school, had recently graduated, and some modest ambition of his to do something a little out of the ordinary—a more correct pronunciation, for example—was soon discouraged by the parents, who came in chorus to protest. The very low-level high school math teacher had his real business in the afternoons, buying and reselling apartments. He would take them in poor condition, renovate them, and resell them. Correcting homework annoyed him a lot. He had no time. A couple of times he made me go to his house to correct homework, obviously from another class not mine. The physics one was worth even less. There was a priest who did history and philosophy there, perhaps he was the best, the boys—with the naughtiness typical of the age—called him The Dry Death. Fortunately, he never knew it.

I was good with numbers, the best, and I made my classmates copy. I didn't like the Italian paper, I had my bad handwriting and it annoyed me to have to write on command on something chosen by others. I liked literature instead. I loved the texts, the poems, I liked the Iliad already in middle school, we did only a small part of it in school but I had gotten the full text as a gift and read it all, I had even memorized the first four hundred verses, the whole argument of Achilles with Agamemnon. Quite an effort for a young boy. And I liked philosophy and Latin. I had even noticed that the school version of the Iliad was missing verses from time to time. I didn't understand why. Then I realized that they were verses in which there were sexual references, something I had not grasped in sixth grade.

The curators had behaved like those who made Michelangelo's nudes in the Sistine Chapel put on their underwear.

14. The starry sky above me, and the mathematics within me.

Math in high school was all mundane math; I would look at it on my own. I found the passion and excitement of math within me around age 11-12. I started looking in encyclopedias. I had read a history of mathematics, I had become very good at algebra. There was a big private library open to the public next to the school, you could listen to music on headphones or read or do both.

At home we had an engineer's manual that had the table of numbers from 1 to 100 with the squares of the number and the square root next to it. I remember observing that if you subtracted one from the other, it came 3, 5, 7, 9, 11, that is, the odd numbers one after the other, in order. I was amazed, and that I had discovered this relationship made a great impression on me.

Many people, especially as children, feel an instinctive rejection of math. I don't remember what emotions I felt. I remember more a kind of natural ability, I would say innate. An early ability to do math. As early as junior high school I was always fiddling with numbers. I had been very impressed, for example, that you couldn't solve fifth-degree equations, I had been testing to see if I could find a system using school algebra. And I had come up with a completely balky idea. I was saying to myself, if you can't solve the fifth-degree ones maybe you can solve the sixth-degree ones.

I remember having a notebook in which I did large algebraic calculations.

By the time I was 13, I had learned a few concepts about derivatives, integrals, exponentials....

The discovery of the odd numbers one after another had left me filled with amazement.

The litmus test-which one learns as early as elementary school to quickly and easily check multiplication-also left me filled with wonder.

I think there were some important elements in this passion. The first was a magical aspect. What is magic? A huge disproportion between an act and its result. You move a wand through the air and a pumpkin turns into a carriage. Magic. Disproportion between act and result and also the fact that you don't know how it happens, that you have no idea of the

intermediate steps. The litmus test is not very different - come to think of it - from the magic wand.

And then there was the idea that all that stuff was somehow just mine. The thrill of the secret. A lonely, secret game. I mean, I was discovering things that other people weren't telling me and I didn't even know if they knew them. Because - that's the point - I wasn't talking about it. Deliberately. I had no desire to talk about these things with adults (with peers not even thinking about it). Nor with high school math teachers. They were my things, just mine.

The only time, around the age of 13, that I showed my notebook full of calculations was to an engineer friend of my father's who, moreover, had only been able to say that I had a real bump for math. Thank you, what insight. But I hadn't gotten a spider out of it.

Mathematics was a mysterious world that I was trying to get to know, to look at, but still a bit through the peephole. In retrospect, I wondered why I was avidly reading the history of mathematics and why it had never even crossed my mind to do the most simple and obvious thing: to pick up a real math book and set out to study it. It is strange that it should occur to you to spend your afternoons hunched over an encyclopedia in the library reading articles on mathematics, and not look in the same library for a book on mathematics. Even stranger that this went on until my freshman year of college.

From age 12 to 18 I studied piano, we had one at home and a teacher came once a week. I liked playing. But obviously not enough. Piano you have to do it at least an hour a day if you really want to learn, I was not going far enough. I was out of tune and remained so all my life, but I had learned to use the metronome well. I loved Latin, and Latin poems are based on long and short syllables. I controlled the reading of the hexameters with the metronome.

A strong passion for chess had also arisen. Around the age of 16-17 I had joined the only chess club in Rome. I had bought myself many books - all in English, only one magazine in Italian, *L'Italia scacchistica* - and spent a lot of time studying them.

I had participated in a couple of tournaments starting at the lowest level, then I had moved up in the rankings, I was very proud that I was able to win once against an opponent who was much better than me, starting from a little-known variant that took him by surprise.

I learned English in school from the seventh grade. In addition, my parents had an elderly native lady come once a week with whom I did some conversation but was very bored.

Piano and chess I completely abandoned them at the same time when I started college.

## 15. Azure

Some social adjustment problems I began to experience quite early on. I was playing football badly and I didn't like it, so I didn't play, but I was also discouraged by it.

The swearing jokes I did not understand. It was difficult after all to learn them from the nuns, and I certainly could not have heard them at home.

I had a lonely childhood and a lonely adolescence, the feeling I remember is that - at once unmistakable and hardly describable - of *Azzurro*, the Adriano Celentano song written by Paolo Conte.

I was cut off from many activities.

I knew I wasn't resourceful socially, but I didn't feel it was a problem to worry about.

It had to do with modesty, confidentiality, more certainly.

Soccer, as I said, basic element of socialization or exclusion. It wouldn't have taken anything to buy a ball and practice, with a little effort at 10 years old you can learn to walk by pushing a ball forward. Obviously, motivation was lacking.

I felt a little bit different, but then not even that much or at any rate not to the point that I suffered from it and seriously questioned changing.

Sporadically I would go to one or the other's house, but these "detours" did not even remotely fill the bulk of the time.

I had a whole range of interests of my own, and socializing was not among my priorities.

Then from the age of 17 something began to change. Not so radically. I deduce this more from the memory of my mother telling me "you don't have to go to this one and that one," and I would respond angrily "I'm going anyway." The usual tug and pull in adolescence when you start going out. "Where are you going with who are you going to what time are you going to be home," my mother always wanted to know everything. My father would leave it up to her.



Also when I was 17, there were chess tournaments, which were the rare instances when I went out in the evening in Rome. I would return with the circular around 11 o'clock.

During the last two years of high school I could now go out on my own, and I had older friends who would pick me up in their cars.

At school one morning a week there was Mass from 8 to 9 a.m. I used to go to it just like Sunday Mass. I took communion and confession occasionally, but - as the years went by - more and more rarely. Also in order not to be bored, I had begun to serve Mass (I did not dress as an altar boy): moving the Gospel from one side to the other, pouring water at the lavabo, giving the priest (who was the professor of history and philosophy) the small bottles with water and wine. I would often go back there on Sundays to meet a few classmates after Mass. I lived a hundred meters from the school.

But of girls not even a shadow. Except my friends' girlfriends.

Parties and parties ditto.

In Anzio there were of course girls, but again until age 16 or so the groups were rigidly separated, boys with boys and girls with girls.

I had been very surprised when, by now at the end of high school, I had seen that a large mixed company had formed. But that was only at the seaside, not in Rome.

## 16. What to do.

Hard perhaps to believe, but I never asked myself what I would do when I grew up.

My Aunt Assunta had told me, "Do you want to be an engineer to launch rockets like von Braun?" It may well be that I sometimes said yes to please her. But that I imagined myself launching rockets ...

Once always my aunt had asked me if I would like to be the first man to go to the moon, and I had replied, "No, the second one," typical of my character, because the second one risked less (then the 13th expedition would unfortunately disprove that calculation of probability).

My father wanted me to be an engineer, Aunt von Braun, I didn't think much, in fact not at all, about what I was going to do, I lived completely by the day, immersed in my books.

Books on the history of mathematics were ending with the nineteenth century, twentieth-century mathematics was harder to tell, it was becoming more and more abstract. But at that point, during high school, I had started reading books on physics and the history of twentieth-century physics. There was a narrative gap between what nineteenth-century and twentieth-century mathematicians were doing. I couldn't imagine what a twentieth-century mathematician was doing, what problems he was tackling, whereas twentieth-century physics is one of the things that has been retold and re-told: Fermi, the atomic bomb, the first particle accelerators, but always science popularization, not technical books. I had also started to read something on biology but it had not fascinated me and I don't understand why, the discoveries about the human body were and are fascinating. I recovered from the 1980s to the early 2000s by reading almost all of Stephen Jay Gould's three hundred biology essays as they were published in Italian. A biology thought of in close relation to society. And I must have read them really carefully if one evening -- finding myself having dinner with him, with Gould, of all people -- as he was talking I was thinking: this thing he wrote in such and such essay, this one in such and such other...

After high school graduation, back from summer vacation, there was no putting it off any longer. I knew I didn't want to do engineering, which for me moreover was identified with my father's and grandfather's construction engineering (electrical engineering for example I just wasn't thinking about), and just the idea of being a construction engineer caused me unbearable boredom and annoyance. I resolutely said no, even though my father was very disappointed. He didn't insist on it any longer; it was clear that there was nothing to be done and it was better for him to put his mind at rest.

At that point I was undecided between Mathematics and Physics, and I decided on Physics. Believe it or not, to this day I couldn't really explain why.

During my first year of college, apart from taking the algebra course taught by Lucio Lombardo Radice and the first classes, I had limited myself to reading course manuals, very thoroughly but only those, nothing more: physics mathematics geometry chemistry...

I remember very well that at the end of the first year a friend had said to me, "There is this book by Lev Landau (who unfortunately would die shortly thereafter, in the spring of 1968) that is very advanced, very good."

Over the summer I bought it, and then continued with the rest of Landau and Lifšic's famous Theoretical Physics Course, plus many other books. I studied things that corresponded to the syllabus of the following years.

Only after the first year did I get this whimsical idea-but what do you know-that I could buy myself books other than school books and study them on my own. Some of it was in English, the Editori Riuniti translated the Russian texts, but most of it was in French, so I started without knowing the language to read physics books in French: the formulas help you, then some of it was guessing, some of it was making sense, some of it was vocabulary...

That was the time-between my freshman and sophomore year of college-when I started studying professionally, no longer looking through the peephole: I started buying books, reading them, rereading them, reading them once quickly understanding only a small part and then rereading them in depth. And here is Paul Dirac's book on quantum mechanics, Erwin Schrödinger's book on statistical thermodynamics, Fermi's book, Morse and Feshbach's treatise of mathematical methods of theoretical physics, two big volumes of a thousand pages each.

At this point my personal, relationship life also changes, my social life undergoes a big acceleration. Well, let's say a beginning, because the real turning point will happen in Sixty-eight.

Mine was an experimental course, we did experiments in the laboratory divided into groups of three, notebooks, the report, contacts were obviously very numerous and close.

We were four hundred people enrolled in Physics, the lecture hall held less than three hundred, there were no microphones, the professor was forced to shout but basically you could hear very little anyway, the front seats were impossible to get, the middle ones not in the pigeonhole were coveted so you would make arrangements, the first one to arrive would take the seats for the others, and so you make friends, joke, discuss everything

I started hanging out with many classmates including Marcello Antichi (whom I later lost sight of and found again only a few years ago), Paolo Zampetti, Lucilla Sansonetti, Luca Peliti, Marco d'Eramo.

The problem of lonely afternoons was overcome.

There was an immense amount of books to read, study, people to work with, talk to, have fun with even, a huge opening on things to do, things to know, everything.

## 17. A good sixty-eight

As I recounted, until college I was in a situation where in Rome no girls, just a few at the beach, and then even there more in a manner of speaking than anything else.

With college, the companies naturally become mixed, except. in Physics there were practically only male students. While the few girls in Physics--obviously--were already pairing up with others.

Sixty-eight represents a huge reshuffling from all points of view. Analysts, historians, and commentators have always described those years as a complex phase: of political upheaval, anti-authoritarian, but also in the approach to science, for example, "against the neutrality of science," it was said, and in the absolute dissolution of interpersonal relations and relationships.

I used to go to meetings in Letters.

I, too, am beginning to keep mixed company.

The most frequent were Massimo Testa, Massimo Altarelli, Luca Peliti, Marco d'Eramo, Aurelio Grillo, Giovanni Lucano. People often went out in the evening, someone brought his sister, those who had girlfriends brought a friend of the girlfriend, and so female friendships increased. People went to pizzerias, to trattorias, to the movies, to the theater, to the Folkstudio, to classical music concerts. Even to the EUR amusement park. I was very uncomfortable on roller coasters (I suffer from vertigo), on the other hand I had a good aim at the shooting gallery (at least that was what I thought).

It was through Marco that I met what would become my wife, Daniella Ambrosino.

Mid-year occupations begin.

First Humanities. After a while, Physics as well.

Politically I was still influenced by my father, I was a liberal, the funny thing is that there were people in school who were definitely more right-wing than me if not outright fascists, and a friend who was a monarchist with whom I had very long discussions. I found myself sort of center-left being a liberal. But more than anything else I felt completely displaced.

At the very long assembly in Physics until nine o'clock in the evening to decide whether to occupy or not I was among those voting no, but the

point was that once you vote then I thought you have to respect the outcome of the vote. Either you decide not to vote ... but once you have voted you have to recognize the legitimacy of the decision, you can't say "if what I say comes it counts, if the opposite comes it doesn't count."

I was not among those who spent the night in the Faculty, but I participated in the assemblies, discussions, and study groups.

Sometimes I would stay all day in the occupied university, sometimes I would not, maybe I would avoid going there at the most dangerous times, you knew that on such a day the police would intervene -- going and then running away no -- I would avoid the times of major confrontation, but let's say that in the meantime I had become a sympathizer not particularly active.

On Almirante's famous day, all morning I stayed in Physics in the porter's lodge to watch who came in and who went out, I was doing security duty. I left later after the clashes under Law School when the fascists attacked Letters instead of Physics.

It was March 16, two weeks after Valle Giulia. Early morning. A large group of Missini, led by Giorgio Almirante, attempt an assault on the Faculty of Letters against the occupation. There are heavy clashes. To drive out the fascists, students try to enter despite entrances blocked by furniture and furnishings. I see chairs, desks, chairs flying. This is the day Oreste Scalzone is hit by the throwing of a desk and will end up with a fractured spine.

Marco d'Eramo was among the most active. At two o'clock in the afternoon the police intervened en masse, but the fascists barricaded in Jurisprudence managed to get out the back door, which the police, I don't know whether on purpose or out of naiveté, had not blocked. (I try to stick to the English proverb that says: never look for malice when the explanation may be stupidity.)

I was beginning to notice the big difference between how the events really happened and how they were told by newspapers and television.

And extreme impression had made on me to see clearly in front of the courthouse that students were being truncheoned by policemen while standing still and peaceful, without any provocation, ten meters away from them.

This, just as a liberal, had outraged me deeply. How could the state, which represented and protected the law, violate it so shamelessly and in the public eye?

What happened for me happened for so many, and to say it today seems trivial but it was not trivial at all then. My shift to the left that

skipped the PCI completely. All my friends were either in the extra-parliamentary left or had remained in the PCI in critical positions. I knew Claudio Petruccioli's brother, Sergio, who was then very involved in the Student Movement, and who would become a historian of physics with whom I would long later collaborate at Treccani. There is a story that today we can perhaps call funny, Claudio himself, then secretary of the FGCI (Italian Communist Youth Federation), tells it. Right after Valle Giulia, the FGCI organizes a conference. Claudio gives the introductory report, Sergio takes the floor and begins his speech like this, "I do not agree with Comrade Petruccioli."

1969 was a year politically more shifted to the left by the students, and I was less enthusiastic; I had never been an extremist, although I went to occupations and discussed everything with everyone. At the same time I realized that it was precisely in 1969 that I had abandoned liberalism and was now in agreement with Marxist ideology.

How do I explain, today - I didn't wonder then, I was too busy living - this radical and all in all sudden transition?

I had taken an active interest in politics by the age of 14. I avidly read all the politics that was in the *Messaggero*, the newspaper that arrived at home. I remember very well the birth of the center-left, the government led by Amintore Fanfani in March 1962 (DC-PRI-PSDI with the external support of Nenni's PSI), the general elections of 1963, the Moro government at the end of 1963 (DC-PRI-PSDI-PSI), the program of the nationalization of the electricity industry, the death of Togliatti in 1964, all things that today seem - and are - very distant, but we are talking about just four years before 1968. Just as I remember well always in 1964 - I was 16 years old - the election of Giuseppe Saragat as president of the Republic.

We had television in the house but we listened to the radio, a pre-war radio of the big cabinet type. I remember the sounding of the name in the counting of the votes: Saragat Saragat Saragat.

But liberalism for me then-and perhaps not only for me-was essentially an economic ideology. In college I would hear my comrades talk instead about values, about the duty to give everyone equal opportunities, and that inequalities were not only wrong but immoral. So my transition from liberalism to communism was mostly an ethical question, the values that the left, and more so the radical left or extra-parliamentary left as it was then called, represented were already my lifelong values. Seen this way, the change was not traumatic. Huge yes but not shocking. More than a shift from one ideology to the opposite one, it was a "paradigm shift." From economics to ethics. The discovery of politics as a "moral issue."

Nor was it the late adolescent rebellion against the father. No, this aspect never had anything to do with me. In fact, I would come home from

college and try to convince my father of my new ideas. With little or no success, of course.

What I did not experience-assuming there was continuity with Sixty-eight, and in my opinion there was not-was the Seventy-seven movement. There were many reasons, but one is enough: I was not in Italy, I was in New York, I was in Paris, two years with Daniella and doing more than serious research, living one of the most intense phases of my work as a theoretical physicist.

Italy was really far, far away.

## 18. Physics of youth

I had taught myself so much math and physics that the 1968-1969 classes were so boring. I had completely stopped going. I found it much more useful to study at home or in the libraries, both very large, of Physics and Mathematics.

I was only taking the required courses and tutorials.

In the second half of 1968 an American, Israel Herstein, had arrived and taught a very advanced course in algebra. Only three of us were left to follow him, two professors and myself.

I remember a beautiful feeling, though. An incredible air of youth. At the Institute of Physics, the oldest person-a legend whose name was Edoardo Amaldi-was not 60 years old, and the reference people who would be the older ones-Giorgio Salvini, Giorgio Careri, Marcello Conversi-were in their 45s and 50s; theoretical physics was led by Nicola Cabibbo, who had just returned to Rome and was only 33 years old. And it was precisely Nicola who was, so young, an international star (together with Tullio Regge), they were the first Italian theoretical physicists after Enrico Fermi to enjoy worldwide fame, which was also a strong element of attraction with respect to us students and those who were considering which faculty to enroll in.

On exams I had almost all 30s and 30s and honors, 28 only on one experimental course. Not by accident. I have always been a theorist, not an experimentalist, although I have sometimes deviated from this very clear line.

The day before the Mathematical Methods exam I just looked at the chapter titles of the texts: this I know this I know this I know, then I went

to take the exam, answered all the questions and the professor gave me 30. What, 30? With the cheekiness that one sometimes has, I ask him, "and why not 30 cum laude?" Answer, "Because I had the impression that I was making up the demonstrations on the spot instead of having studied them." Which was true, but then he should have given me 40, not 30. I must confess, however, that decades later when, on the other side of the desk, I faced a student who gave the same impression I felt the same sense of annoyance. The professor was Carlo Bernardini, one of the builders of AdA (Accumulation Ring), for a five-year term a PCI senator, with whom I would later become close friends and whom I also greatly esteemed for his social commitment.

In physics I had gone very far in studying frontier topics. And a recent friendship with Massimo Testa was growing. In my third year - he was in his fourth - I helped him do his thesis. We would discuss, look for new ideas and test them by calculating, as I would have and would have done all my life, because that's what a theoretical physicist does. The computers were there but they were certainly not advanced, we didn't use them much, partly because we hadn't learned the language of programming yet. There was a small Olivetti, the Program 101, programmable up to 120 instructions, in a little room on the third floor of Physics. An absolutely revolutionary computer, small, the first desktop computer designed as a personal tool. We used to use that.

By the end of my third year, I was able to read and study the latest articles that were gradually coming out all over the world.

## 19. In memory. Marcello Cini

Another star, though of a very different kind from Nicola Cabibbo, was Marcello Cini.

Ten years ago I wrote a recollection of Marcello Cini in which I still find myself today, if not even more than yesterday, word for word.

During 1968 Marcello Cini was not in Rome: he was spending a sabbatical year in a Parisian university. At that time I often heard about this fellow professor, who was quoting Marx and had been in North Vietnam under American bombing.

I met him on his return to Rome; I was supposed to take one of his physics classes, but between occupations and other events the lectures I went to could be counted on the tips of my fingers. But I still have imprinted in my mind the effort Marcello made not to separate the results



of quantum mechanics from how a small number of men had succeeded in making these marvelous discoveries, formulating at first nonsensical and contradictory hypotheses that over the years were modified and became more and more sensible and coherent. It was not at all easy to bring the two discourses together: the story of an adventure spanning a period of some thirty years (1900 to 1930) and the description of the resulting theory. It was a different way of telling the story of science, one that made a remarkable impression on those of us accustomed to seeing only the final product, nice and shiny, without realizing the effort that had been required to get there.

It was a transitional period in Marcello's life. In the early postwar period he had become a brilliant theoretical physicist in the then leading discipline, high-energy physics, and at the age of only 33 in 1956 he had won a professorship at the University of Catania. He had continued to work, published papers in prestigious journals, and was invited to speak at important international conferences, but theoretical physics was becoming narrow to him.

At that time, Marcello was ceasing to work in the main strand of physics: he would resume his research activities several years later, fascinated by one of the most intriguing and never well resolved problems in physics: what is "the meaning" of quantum mechanics, what is physical reality, what is in this context the relationship between the observer and the observed object, how much the observation of a phenomenon necessarily changes the phenomenon itself. Marcello was beginning to reflect on the relationship between science, history and society, to see science as one of many human activities that becomes "comprehensible only if it refers to the totality of the workings of men." Science is no longer neutral, but carries with it the marks of the ideologies of the scientists who produced it.

These are the theses that converge in the book *The Bee and the Architect*, published in 1976 and collecting essays written in previous years by Giovanni Ciccotti, Marcello Cini, Michelangelo De Maria and Giovanni Jona-Lasinio. They were doubly heretical theses with respect to the dominant orthodoxy, both politically and scientifically, and provoked a furious reaction. The book, which had enormous notoriety and was reprinted (even with a short essay by me), had, however, as the years went by, a very strong influence on the way we conceive the relationship between science and society, and many of the outrageous theses became common feeling.

Marcello was one of the few great intellectuals who sought to understand the world thoroughly, not just in the technical aspects of a scientific discipline, but in its entirety, filling his life with both political commitment and the effort to arrive at a greater understanding and control of nature. He was one of the few reference points we had, always ready to discuss and help you understand.

After he left the university, it was exciting that it was my turn to take over his room at Sapienza.

## 20. Doubts about the Higgs boson

Since 1969 Nicola Cabibbo, the one who was my teacher, had returned to Rome from abroad.

He was studying the most interesting topics of the moment and writing about them, and he had involved Massimo Testa and myself in his work.

By June of my fourth year I had taken all the exams and was ready to graduate in the very first session, in July 1970.

The best students aspired to do a research thesis, the others just needed a compilative work. And always the best students would go and ask the most scientifically known professors for it.

Many of these trajectories are conditioned by the environment. Once you enroll in physics you either think about a "normal" career outlet (going into high school teaching, being a lab technician, the possibility of working in a company back then was very remote) or you stay in the research environment.

The most ambitious thing was to get right into the research environment.

In the collective imagination of the time, the ultimate was particle physics. And theoretical physics was considered the first choice. Were we or were we not the heirs of Enrico Fermi and Ettore Majorana? There was a lot going on in the world in theoretical physics, but at the time of the dissertation I was not aware of it.

Massimo Testa does his thesis with Cabibbo, who had decided to take only one undergraduate per year to follow him well.

The next year I asked him about it and he said he would gladly assign it to me. At this point Nicola could not make up his mind about the topic, he could not find the right one for me. Gianni Jona told me there was a very interesting one, a problem related to what would later be called the Higgs boson. We chose that one.

A few years earlier a series of papers done by François Englert, Robert Brout and Peter Higgs had been published. Higgs points out that in Brout and Englert's theory there had to be a boson. This theory presented some difficulties from a theoretical point of view. This often happened when faced with sensational news. The first reaction was always: this can't be done, it's not right, it's not here it's not there, you can't. Then talking, discussing ...

In 2013 Englert and Higgs would take the Nobel Prize for this discovery (Brout, who was the eldest of the three, had meanwhile died).

Higgs met him in person at Casa Nonino in 2012. He had confided in me that when he gave seminars they would interrupt him in the middle to say: this statement cannot be made, it contradicts this and this mathematical principle. Then slowly people were a little convinced but remained with doubt, they thought: sometimes arguments that appear sensible hide unsuspected flaws. Physicists often do not prove theorems, and in the absence of a theorem some perplexity remains.

Therefore, in the thesis, it was first necessary to test the consistency of the theory with other quantities that they had not considered.

Jona insisted that this was important, that we had to be sure that the various steps were consistent, that there were no wizards in the theory that had slipped through. The final demonstration that everything was consistent came the following year, with the work of Tini Veltman and Gerard 't Hooft, who would take the Nobel Prize in 1999.

It would have been really resounding if you found that the theory didn't hold up. If you find an error in something like that you go straight into history. Instead it held up, so ...

The work was original but gave a result that was not unexpected, a small piece, one of many works that removed some doubt, nothing more.

I did everything very quickly with the help of Massimo Testa. We then published the results together.

## 21. Summary

It may help to make the point. In the sense that this is the easiest thing I've done in my whole life. And look at this.

My thesis-done with relative ease and fairly quickly-was 112 typed pages, including about ten at the bottom of bibliography and notes (56 entries).

The title page read: UNIVERSITY OF THE STUDIES OF ROME - SCHOOL OF MATHEMATIC, PHYSICAL AND NATURAL SCIENCES - Academic year 1969-70 - Graduating student: Giorgio Parisi, Matr. 02693 - Advisor: Prof. Nicola Cabibbo

Title: BA THEsis - GOLDSTONE BOSONS AND GAUGE FIELDS.

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APPENDIX II - Ward's Identity

BIBLIOGRAPHY AND NOTES

But what was my thesis more specifically about?

In 1966 two very good young Soviet physicists, three years older than me, Sasha Migdal and Sasha Poljakov, had written their first paper in which they verified that under a certain formalism (Fermi gauge) the theory was correct. Gianni Jona proposed to redo their calculations under a different formalism (Landau's gauge) to verify that the results did not change, as it should have been.

It must be said that this issue was not exactly in fashion. So much so that when the two Sashas presented their results at one of the usual Moscow afternoon seminars they were mercilessly attacked by the senior professors for wasting their time studying useless stuff like gauge theories. Let them rather deal with important and fashionable matters like Regge poles.

The great disappointment was immediately drowned in alcohol, then the two physicists changed the subject but, from the highly intelligent people they were, they switched from Regge's poles to phase transitions. When

the year after the dissertation I began to work on phase transitions, I found their work in front of me, very interesting and a source of great inspiration to me and not only to me.

We finally managed to meet (it was not easy with the Iron Curtain) and made great friends, especially with Sasha Migdal, who also came to visit me two months with his family in Rome around 1990. Their teenage daughter was studying piano and came to my house in the morning to do her daily three hours at the keyboard. I was in college, but in any case I was no longer using the piano.

## 22. Predictions

"Daniella, this is Giorgio Parisi who will one day win the Nobel Prize."

That's how I met my wife. I first saw her in front of the Faculty of Physics. I have forgotten this presentation, but she remembers it well. It was my classmates who had spoken like that, and for them it was not a boutade.

For a while we hung out only as friends and only in a group, about 15 people who saw each other relatively often usually after dinner.

In the fall of 1969 we decided to get together. Quite naturally, without one saying it first, without much declaration.

I was in my fourth year of Physics, she had to do her thesis in Humanities. That winter we went between Christmas and New Year's to Bad Gastein, a resort town in Austria perfect for skiing. It wasn't exactly a romantic vacation. We weren't exactly alone. Half the physics institute was there. Skiing and even climbing seemed to be a tradition for Italian physicists. Even Edoardo Amaldi had been a big mountain enthusiast, an accomplished rock climber.

In Bad Gastein those who skied, skied well. I was a beginner.

With Daniella it was my first serious engagement experience and I was tight with it, not convinced. I decide to break it off. Daniella feels terrible about it. Perhaps Heaven decides to punish me. Soon after, while skiing, I stupidly break my leg. Stupidly because I had not bothered to take bindings on good skis. They were old-fashioned and inadequate for safety: in case of an accident, the foot would slip out only from the heel, not the toe. Not that I couldn't afford better ones, it had just been ignorance, recklessness.

Result: fracture of the tibia and fibula, six screws in the tibia, forty days without being able to put my foot on the ground, long cast, all the way to the groin, I was afraid to walk around the house with my leg elevated forward, on crutches. I had preferred the wheelchair.

I took advantage of this time to read the whole Recherche. I had read A Love of Swann and had decided to read the rest.

I had broken my leg but I had not completely broken relations with Daniella within our group of friends.

The interlude was not short. It was not until I returned from the United States in 1974 that I started looking for her again, seeing her more and more often, trying to see her every day. She was reluctant, burned by my abandonment, but I had become persistent in the meantime.

We decide to try again. So our story starts again, in July 1974, in Rome, and soon after we spend the vacations first in Pantelleria then in Paris.

It went well, I had definitely matured. In 1975 we decided to move in together. We rented a house on San Basilio Street, quite expensive but very comfortable for both Daniella and me. She had become secretary to a judge of the Constitutional Court, Edoardo Volterra, son of the mathematician Vito Volterra. Jurist. Who had met Daniella's dad. He wanted to have a secretary at the Court who was not from the circle of jurists because he was afraid that someone from that circle would not maintain the necessary confidentiality. And he had thought of his friend's daughter, who was his daughter Virginia's classmate at Tasso High School. Daniella had entered on contract as a "special secretary," meaning she was not to type, but to do responsible work in close cooperation with the judge: following up correspondence, making phone calls, reading and summarizing texts in foreign languages, going to the library to do research. She later became a court official.

In Rome at that time there was little or no possibility of going to university to teach in the Humanities, in return this opportunity had come along that would guarantee-just temporarily, we thought-economic independence.

That we had moved in together without being married represented a big break with my father and mother, which was inconceivable to them. Then we healed the breakup. For a few months they had refused to come to our house but slowly realized it was a standoff, while from Daniella's family there had been some grumbling but not such strong resistance.

Things were going well. Daniella wanted to go to Paris to get her doctorate, and I had arranged accordingly. It had turned out that there was a researcher position for me in Paris as well. We decided to move

there together. The initial plan was for her to quit her job, then we thought that if we got married she would be entitled to leave as a wife accompanying her husband. We got married for this. To get this right. Like so many others in those years-there had also just been the resounding victory in the divorce referendum-we were not passionate about the idea that our love had to be "validated," approved, registered by state authority. The idea that we had to marry to make society happy. But at that moment the game, an extra right, was worth the candle. (We would in any case have married when the children arrived).

A few days before we left for Paris we were in the Capitol. August 1976. Only twenty to twenty-five guests.

### 23. À la carte

We were married on August 26 in a very simple ceremony-and much to my parents' relief and satisfaction-but for me much more emotional than I would have expected.

Daniella was wearing a light blue Indian canvas dress she had bought a few days earlier. Not one of those elegant, formal dresses but one that I liked very much. I was in light blue too, a shade just slightly different from hers. I was, however, in a suit and tie. We arrived in our car, and afterwards we went to lunch at Gigetto the Fisherman, which had a big garden. A la carte menu, so everyone could order what they preferred, not the classic wedding lunch.

A few days later we left for Paris. A beautiful city for a honeymoon, but we were going there to work. We were expected on September 1.

The departure had been adventurous to say the least.

We had to leave the apartment on St. Basil's Street, a few things we had disposed of, the rest in the car.

We started in the morning to load the recently bought mustard-colored 850 and only managed to leave at seven o'clock in the evening.

What shall we do? Do we leave now or in the morning?

Now.

At the first motel we stopped. The next morning we left again. In the evening we were in Geneva where we had dinner at a starred restaurant that I knew well.

The next day finally in Paris.

## 24. On the mother's side

Daniella was born in Rome but her family on her maternal side was originally from Falvaterra, a small town of five hundred inhabitants on a hilltop near Ceprano, Frosinone province, three hundred meters above sea level. Her maternal grandparents, Luigi and Maria, both from Falvaterra, had moved to Rome as soon as they married.

At that time there was no running water in the village, and the girls would fetch water from the spring, a little lower down, and carry it home in amphorae balanced on their heads. In the little central square, old people sat on stone benches commenting on who was passing and who was not passing; the mayor had a house overlooking the square itself. Daniella's mother's brother would later marry the podesta's daughter.

The family home was-there still is-at the center of the village, but Grandfather had come to Rome-half the inhabitants of the rest had left-he had been in the Royal Guard for public safety and was mad at Mussolini for disbanding it. He had reconverted as a railway police officer, something like that.

The paternal relatives, on the other hand, were originally one from Abruzzo (daughter of landowners) and the other from Naples (naval officer). Daniella's father was born in Naples but grew up in Rome. Many of that branch were dead by the time we married, or there was virtually no relationship; Daniella's relatives were almost all maternal, except for her father's sister, Aunt Lia, and a cousin, Uncle Giulio, a magistrate. Grandfather Zeno, however, enjoyed in memory a certain fame, linked alas to the fact that he had died in the famous sinking of the Leonardo da Vinci in Taranto harbor on August 2, 1916.

Rodolfo, Daniella's father, belonged to the middle class, although when his father died the family had come to financial hardship and had pulled through thanks to his mother Linda's iron determination to deprive herself of everything to provide a future for her children.

Rodolfo had studied law, was a professor of Roman law. Daniella's mother, Emilia, Roman but of Ciociara origin as mentioned above, still



lives, is from 1920, 102 years old. She was the oldest of sisters, Elide and Benedetta. Then there was a brother, Augusto.

Emilia was the one who cared the most about social uplift. They wanted to send her to vocational schooling, but she had strongly opposed it, had insisted, had wanted to study Latin, and had attended the magistral school, then graduated with a degree in Humanities. She had played the devil's advocate by managing to get her sisters to escape the infamous start-up as well.

After the war Emilia meets Rodolfo. Who tells her, "First you graduate then we get married, if not, you'll never get your degree again."

They marry, with some grumbling here too from Rodolfo's mother about the social difference between the two, but without serious opposition. Rodolfo becomes interested in politics, joins the Liberal Party, will play an important role in the Constituent Assembly, secretary general of the Assembly.

Soon after marriage Daniella was born, in 1947, father won a teaching position in Trieste and moved there. Alone. The family remains in Rome. In 1953 Daniella's brother Guido is born, father - in his early 40s, young for that position - becomes rector at the University of Trieste, at which point the whole family is reunited.

He gets a heart attack, which was practically a death sentence in those days. After the first one came a second one and there was nothing you could do about it. He was aware of that, and against the advice of the doctors he stayed in his post. Perhaps he had done it on purpose, generously and foresightedly. Had he died on the job, the widow would have been entitled to a more dignified pension than she would have received for the few years her husband had accrued.

One day neo-fascists plan to hold a demonstration inside the university. Tensions run high the night before, he does not want to call the police, and during the night comes the second shot, the fatal one. He dies in 1958, at just 48 years old.

Daniella-who was 11 years old-would later tell me several times how much she had suffered. She was very attached to her father who, in the family, was the more playful one, her mother the more rigid one, all caught up in her role as educator.

Daniella thus lived in Trieste from 1954 to 1959, from second grade to sixth grade. Upon her father's death, the family returned to Rome.

Emilia-who until then had not worked because her husband did not want to-began substitute teaching then would be a literary teacher until retirement.

## 25. At Balduina

A very peculiar thing happens in Rome.

Daniella's whole family, mom aunts uncle cousins, go to live in a condominium on San Cipriano Street. A co-op house, which was paid for in twenty years, as was done particularly in the 1950s and 1960s.

On the first floor my mother-in-law with Elide, the second sister, who had the complex of being neglected. On the second floor Augustus, on the second Benedetta. Elide moved only later into the apartment building, and she normally stayed there only in the winter months, the other six months she spent at the beach in Anzio.

This "fellowship" went on for sixty years, closeness, mutual aid, "I made pasta with clams, I'll bring you some," things like that, an experience that I know is unique.

A few years ago Daniella's uncle and aunts died; her mother remained.

In the condominium at Balduina everyone knew each other, they were very longtime friends, on the top floor for example lived the four Rocchetti sisters, also called "aunts" by Daniella and Guido, the ones with whom relations were closest.

Guido's daughter, Lea Schlude Ambrosino, in 2018 dedicated her first feature film (which won several awards) - Via San Cipriano - to this very experience.

And writer Luce d'Eramo, in her novel *They Will Leave*, was inspired by Ilia to sketch the character portrait of Bibiana Fasetti.

Elide never married, she was an elementary school teacher, she liked the work very much, she was very fond of the children, she was very very gigantic, and she owned a puppet theater. When there were parties at our house for the children and their little friends she would come and do puppet shows. She was also famous for the large nativity scenes she built and the living nativity scene she had her grandchildren perform every Christmas.

Benedetta was employed at the Treasury and had married a very nice Sicilian civil servant.

Augusto worked at the Railways as a technical expert and was married to Maria, a girl from Falvaterra who, however, had grown up in Rome, raised by her uncles.

## 26. Christmas Eve.

I remember the early years when I went there with Daniella, we would have Christmas lunches with about 20 people. When the children in turn had children we no longer stood around the table and each floor had its own Christmas Eve and Christmas lunch.

Last Christmas, too, we went to Daniella's mother's house for dinner. There was my daughter's family with her 4-year-old son Martino and our former domestic helper, Gabriella, who is now almost 90 years old. After dinner we drove her back home to Trastevere, and on the car ride-because from Balduina to Trastevere is quite a drive-she briefed us on pretty much everything and everyone from many years here, relatives home this and that. She was and has remained a very kind and very good lady. Of great intelligence even though as a child she had been sent to tend turkeys rather than to school and had started working at 13.

We had hired her in 1978, just back from Paris. Abruzzese, very fond of children. When my son Leonardo introduced her to newborn Giaïro she started crying.

She was a force of nature at making sweets, at Christmas she did not give gifts, she would lock herself in the house for days and make all kinds of sweets, she used hundreds of eggs...

Those meals on St. Cyprian Street were completely according to tradition.

Eve eel, fish, clams.

For Christmas lunch cappelletti in broth, a four-pound stuffed turkey that my mother-in-law had learned to cook I don't know how, Abruzzo ricotta cake (a kind of Neapolitan pastiera without the wheat).

As the years passed, Christmas lunch had been moved to the restaurant and turkey was eaten on Christmas Eve.

Emilia until a few years ago did not need the caregiver, then the time came for her too when she could no longer be alone.

Daniella has always been very close to her cousins and cousins, and when our two children were small just two of Daniella's cousins came to baby-sit. It was a great advantage that they knew each other so well, it happens that you see cousins once in a while, but they were upstairs.... They were in college and needed to supplement.

Grandma Emilia also helped with the children for years, and both Leonardo and Lorenza are very fond of her. My mother would have liked to, but shortly after Lorenza was born she had an eye problem, she could see very little.

She was also ten years older than Emilia, and keeping up with young children having sixty or seventy makes a big difference.

My parents attended relatives very sparingly. Consequently, so did I.

My mom had six brothers and sisters. She mostly saw her older sister, Giulia, and her daughter Lia, who was more of an aunt than a cousin to me, while I was the same age as another sister's children, Assunta, Paola and Franco.

Lia today is very old but still very lucid and loving. After my mother's death she is the one who told me many things about our family. Her daughter Silvia, whom I had lost sight of, I had the surprise of seeing her pop up one day as a chemistry professor at Tor Vergata.

I used to meet occasionally a nice cousin of Dad's, Giannino, who had a daughter the same age as me, Loretta Parisi, who later moved to Canada.

Of the grandparents, unfortunately, I have the regret that I only knew Agata. The only son, Neno, was a printer in Paese Sera while his daughter Maria Grazia is an avid archaeologist.

## 27. The soul of the pocket

As for my brother-in-law Guido, he had enrolled in Philosophy. He planned to graduate with a fundamental thesis on Rosa Luxemburg, but in the end that thesis was never written.

With the help of Marco d'Eramo he had joined manifesto as a young man, a newspaper for which he had long been a correspondent from Germany, first in Bonn then in Berlin. When manifesto decided to do without-or could no longer afford-to have permanent correspondents from foreign capitals, he, instead of returning to Rome as they had asked him,

preferred to detach himself from the newspaper and remain in Germany, where by two different partners he had two children, Anton and Lea, who have dual citizenship and both speak Italian very well as well.

Lea and Anton came to do a year of high school in Italy and preferred to stay with us instead of at their grandmother's already very elderly home.

Guido had acted in Nanni Moretti's first film, the 1973 short film *La sconfitta*.

In the room that had been our son Leonardo's, Anton has lived for five to six years. After university in Berlin he decided that his true calling was to be a tailor. Italy was the ideal place to learn this trade. He took a three-year course and now, at 29, is self-employed with his own workshop. Niche tailoring, for particular clients, everything is done not only custom but by hand. I used to think that tailors now work with sewing machines, but instead he tells me that the result is very different. Even a very elegant breast pocket, beautifully made but not by hand, he is able to recognize it immediately and says it "has no soul."

I do not have the ability to see the soul of a pocket.

## 28. Bagagillion Risk.

Daniella had graduated in Humanities with a thesis on Aristophanes. To celebrate the graduation of our friends Marco d'Eramo and Luca Peliti, in the last useful session, spring 1971, she proposed to stage *Lysistrata* by Aristophanes, precisely. A comedy, like all Greek theater, precursor, topical, acute. A comedy, simplifying but not even too much, anti-militarist and feminist. The Athenian *Lysistrata*, involving women from other cities as well, organizes a sex strike to dissuade men from war (we are in the heart of the Peloponnesian War). In one scene she allows Myrrhine to meet her husband Kinesias but only to make him think she will give herself to him and then leave him high and dry.

Daniella had done the theatrical reduction of the text, the directing, the casting, and of course she was impersonating *Lysistrata*. I played Cinesia, *Mirrina*'s husband, the one who gets the solemn catch.

Laboriously keeping the two celebrants in the dark until the very end, we had done quite a bit of rehearsal at Daniella's house, then rented the Teatro Tordinona, opposite the Court of Cassation, the famous Palazzaccio across the Tiber, crossing the Umberto I bridge.

We had managed to put together a nice stage setup: costumes, dry ice to make fire smoke when you throw it into the water. We had even found a 4-year-old boy who just had to make an appearance on stage.

At one point I was supposed to utter this line, "That woman loves me clearly." But my floppy "r" had slightly altered the sentence. The whole theater snickered, in rapture. My friend Gianni Battimelli, a historian of physics and particularly of twentieth-century Italian physics, was still remembering it a few months ago and still laughing.

And it had ended with a great throwing of vegetables at us actors who generously threw them back at the spectators.

People from the Roman scene, the real one, were also running around in the theater. A couple of them had come up to me and told me that I had natural comic talent and wanted to cast me for Bagaglino. I confess that the compliment had pleased me. Not to the point of tempting me, though.

There were a hundred people to attend. But Marco's mother, Luce d'Eramo, had not been able to come. So a few days later we repeated the play directly at her home.

And Ignazio Silone had also come to assist.

## 29. Silone's mourning

When I won the Nonino Prize ("Maestri del nostro tempo," 2005) in my speech I began like this, "I am very honored to receive the prestigious Nonino Prize, also because this prize is a sign that in Italy the separation between the two cultures, the humanities and the sciences, is diminishing."

I actually had a great deal of luck. The two cultures in my life were not only an intellectual problem, a theoretical reflection, but I lived them in my daily life. Daniella was very familiar with classical culture, Greek above all; later in life I would discover and experience intensely the popular culture of the beloved Greek islands. But above all I enjoyed the closeness and friendship of two great Italian writers of the last century, Ignazio Silone and his most important scholar Luce d'Eramo, for friends Lucetta, herself a writer.

Silone frequented Lucetta's house, and vice versa, I often went to Marco d'Eramo's house and had seen him many times, Silone.

He was a fairly closed person but we chatted lightly, and I remember, in his eyes, those flashes of intense and at the same time disenchanted irony that I think represented his deeper nature.

But - interestingly, or perhaps not - we were not talking about politics. By the late sixties and early seventies, that is, the years when we saw him often, everything had already been consumed. His political story, but also his personal story, and even his literary story (which I had learned from Lucetta's book on Silone). His membership on behalf of the young socialists in the founding of the Communist Party in Livorno in 1921, his leading role in the PCI, together with Camilla Ravera, after Gramsci's arrest and the party's entry into hiding, his exile, the trips to Moscow from 1921 to 1927 with Togliatti, the early denunciation of Stalinism and the Soviet model, the death in Fascist jails of his brother Romolo in 1932, the expulsion from the PCI together with Angelo Tasca, Alfonso Leonetti, Pietro Tresso, and Paolo Ravazzoli, the consumption that kept him between life and death in a sanatorium in Davos, the return to Italy after the war, literature "as a continuation of the struggle," years of fierce attacks by both communists and Catholics, on him who called himself a "Christian without a church and a socialist without a party," participation in the Constituent Assembly, the editorship of *Tempo presente* with Nicola Chiaromonte, the scandal of the exclusion of *Uscita di sicurezza* from the Viareggio Prize in 1965, so sensational as to produce the first mea culpas of critics.

A beautiful piece of history not only Italian, and not only literary. Here, all of this seemed to have completely consumed him and to have been consumed. Also because he - unlike others - had never really healed from the wound of the "ex." He had never really overcome the grief-he confesses this clearly in *Exit to Safety*-of leaving the party and the disappointment-existential, deep, not just political-of the drift of real socialism and the PCI's long complicity with the Soviet regime. He had written, "The truth is this: the exit from the Communist Party was for me a very sad date, a serious mourning, the mourning of my youth. And I come from a district where mourning is carried longer than elsewhere."

It struck me-and at the same time I could understand him-how everything seemed distant, almost foreign to him, as if it no longer concerned him. I was struck by his seeming indifference as he saw the themes that he had anticipated for forty years and that had marked his entire life taking hold-with the youth protest, the libertarian movements, and the expulsion of the manifesto group from the PCI. Surely he was the last person in the world who would claim any primogeniture, who would ever utter phrases like I said it, I said it first, I understood it before anyone. For him, this was not a victory, but the confirmation of an excruciating, painful defeat. Personal and collective, therefore even more tragic.

But he was sick again, spending periods in a Swiss clinic, and he didn't talk to me about these things.

He preferred silence, albeit an affectionate silence; he greatly enjoyed telling jokes, or telling us about Gustav Jung, from whom he had been in treatment in the early 1930s.

One night that he had invited us to dinner something had gone wrong. The main course was a huge turkey, but it had not been put on to cook by his wife Darina until nine o'clock in the evening. I remember that at midnight we began to set our teeth on the half-raw turkey. Also to pass the time, and perhaps get over the embarrassment, he had told us a very curious story, a paranormal episode he had happened to witness, about which he had not drawn any conclusions, but it had certainly impressed him.

In the Jungian circle he attended in Zurich there was a lady who claimed to be a medium. So Jung decides to test her. He takes a letter from the wife of one of his patients, hands it to her, a letter that has never been opened, the medium starts shaking all over and saying "get that green glass away from me." They take the letter away from her, she calms down then they open it and the wife wrote that her husband had committed suicide by drinking a green poison.

Coming back to me, in addition to the best-known books-from Fontamara to *Avventura d'un povero cristiano*, from *Una manciata di morei* to *Seme sotto la neve* to *Uscita di sicurezza*-I had been particularly impressed by *La scuola dei dittatori*, a true essay on dictatorships written, however, in the form of a highly sarcastic and even humorous dialogue. An aspiring American dictator-Mr. Double Vu-wants to figure out how to establish dictatorship in his country. He arrives in Zurich with his advisor, Professor Pickup, an ideologue inventor of pantautology. They meet - this is 1939 - the official figures of fascism and Nazism, but from them, supposedly true experts, they learn nothing. Instead, they will understand everything from an Italian political émigré, Tommaso called the Cynic, an anti-fascist exile. It is not difficult to catch Silone himself in Tommaso and especially the moral to be drawn from this "manual for aspiring dictators."

I had always been a history buff, and I had a strong interest in the history of the Russian Revolution. I had read a little bit of everything, from Giuseppe Boffa's history of the Soviet Union to Trotsky's three-volume history. It was 1973-1974, I was in New York City, reading on the subway, in the half-hour it took me to go to the Village.

In those years I was also very intrigued by the American political situation, and the American left in particular. There was an old-fashioned communist party and there were as many as two Trotskyist parties, quarrelsome-look at that-one more right-wing and one more left-wing, as it were. The "right-wing" one was holding conferences at Columbia



University where I was staying. I had missed the one with Jane Fonda (only two hundred attendees, there were no masses) and went to the one with one of the Chávez brothers. They had founded the first farm workers' union, the Huelga, which had been making tough fights for years to get the possibility of collective farm contracts. Despite the character's notoriety, there were about 20 participants in all. With him and some of the others in attendance we had then gone to dinner. I don't know how it had come out that I knew Silone. Chávez had gotten excited. He had told me that Fontamara had been an extremely important book for him to understand and organize peasant struggles.

I wanted to tell Silone about it when I returned to Italy, but then I never did. Those were his last years, going to and from the Swiss hospital where he would die on August 22, 1978.

We were going to the seaside with Lucetta. We stop at a truck stop and see a newspaper announcing the death of the writer. Lucetta wants to send a telegram, but she cannot make up her mind to send it to his widow, Darina, with whom she did not have a good relationship. In the end she addresses the telegram directly to Ignazio Silone, Via di Villa Ricotti 36, Rome.

### 30. Spy?

Daniella and I then followed the controversy that erupted several years after his death, with books accusing him of being the worst double agent, a filthy spy for the fascists. A theorem we never believed, moreover ably debunked by other books by other historians.

Silone during the imprisonment of his brother Romulus-an affair that marked him all his life-had certainly had contact with this commissario Guido Bellone mentioned: there is a handwritten letter in the archives that is certainly his in which Silone declares that he is breaking off "a long period of loyal relations." But the earlier documents attributed to him are summaries made by the police from informants with different names; there is no evidence that they go back to him. Although the nature of "loyal relations" is not at all clear, I am absolutely convinced that Silone never passed on any really relevant information. He had headed the Inner Party Center; if he had really passed on vital information, fascism would have had an easy time dismantling everything. Instead, nothing ever happened. It is also hard to believe that a party as well-organized as the PCI had never noticed anything and that, despite fierce attacks (Togliatti himself had called him a "renegade"), no one had ever said a word or raised even the slightest suspicion about this. The curiosity to know how

exactly things played out is great, but we will never be able to ascertain for sure.

After his death Luce d'Eramo had continued to deal with that very important piece of political-literary-human history of our twentieth century. She had sent Daniella to do a long interview with Camilla Ravera, and I had gone with her. A small, petite old woman who remembered everything and spoke very quietly. She did not look like the woman who had held such delicate and important positions. She had practically gone into oblivion, as unfortunately often happens, and that was how it would be until 1982 when President Sandro Pertini named her a senator for life, the first woman to be honored with this office.

Luce d'Eramo, on the other hand, had interviewed Alfonso Leonetti. And this time, too, Daniella and I had accompanied her, to the suburban neighborhood of Rome where he lived. Leonetti was completely forgotten and cut off from official politics. He lived toward the Olimpica in the Aurelia direction, in a small, modest house; he had health problems. But he was still lively, curious, and very glad we had gone to talk to him, albeit about the past. He had connections with a group of young Trockists who had put us in touch and who will publish the interview in their newspaper.

It interested Lucetta, it interested Daniella, it interested me to get a closer, more direct idea of these people who had had such a strong relationship with Ignazio Silone during the crucial period when he had been a communist.

### 31. A Great Light

Daniella had been Marco d'Eramo's classmate since high school. So she had known his mother. But Lucetta sought and had direct relations with us apart from her son. She was working on the world's first and most important and richest Sionian monograph, seven years in the making (it would come out from Mondadori in October 1971, a year after my graduation, to understand). Daniella had given her a hand, and so had Luca Peliti. The acknowledgments read, "Daniella Ambrosino collaborated in sorting the material. We also thank [...] Luca Peliti, Mario Siragusa and again Daniella Ambrosino for some of the research and translations from English." All of us then had very carefully reread the text before it was given to print.

They were already very close friends by the time I came along. There was a period when they saw each other very often, and when they didn't see each other they talked on the phone every day.

We were among her closest friends until her death in 2001, and she for us of course.

She lived a few hundred meters from Silone's house, practically on either side of Piazza Bologna, Silone in a small side street of Viale XXI Aprile, Lucetta on Villa Koch Street. She was staying on the sixth floor, then an apartment on the third had become vacant in the same building and she moved in, placing the furniture in the identical arrangement as before.

Volunteering in Germany at age 19 to uncover the truth about fascism and Nazism, she had then experienced prison and attempted suicide. Repatriated by the Nazis out of regard for her father (an undersecretary in Salò), because of her extraordinary intellectual honesty and courage instead of returning home she had allowed herself to be deported and ended up in Dachau. From there she had managed to escape, and one day in May 1945, at the age of 20, in Mainz, while digging through the rubble looking for bombing casualties, a wall had collapsed on her, reducing her to death and leaving her paralyzed in her legs. She was in a wheelchair.

This extraordinary story she would only manage to tell more than thirty years later, in the novel *Detour*. And in *Detour* in a corner there is me too, and there is Daniella and her and our dear friend Corinne Lucas. In the book we talk about a vacation in Spain with some friends. Those friends were us. We took many vacations with her. Paris, the châteaux of the Loire. Then when the children were born we all went to the mountains together in the winter.

She was a meticulous organizer, a quality perhaps indispensable for living a life as full and intense as hers given the situation she was in. Sometimes it was necessary to lift her with the whole wheelchair. Marco and I at that time did it easily, even when she was on the sixth floor and the elevator was not working, Marco carried her, I carried the wheelchair. Everything was adventure for her, intense, fun, exciting. She continued to be the witty, dragging fighter she had always been. Very independent, she traveled by train, by plane, drove a special car with controls on the steering wheel, had an easily disassembled, sturdy and relatively light wheelchair built, sized so that it would fit in an elevator and in the trunk of a car. Every morning she had to devote a couple of hours to her own "maintenance," joking that she squeaked, in fact it was the wheelchair that squeaked, but it was her way of accepting this situation without being dominated by it, this joking of being almost one with the wheelchair, "a robotic."

A woman who was striking for the enormous intensity she put into all things and who spoke very directly to people. "But what do you really want to do, what do you care about, what are you willing to suffer for?" Questions that few people ask and that were difficult to answer because they required self-reflection, when you talked about them with her it made you think a lot. She wanted to know what I was doing in physics, and I had to explain it to her in an understandable way. Especially at that time I was not used to doing that. In turn she was generous in her self-telling, she did not deny herself. On certain things she was stubborn. Certainly she would never say this is not my problem, I don't have to deal with it, if she thought you were doing something wrong she would tell you openly, it might bother you but in the end it was certainly a helpful thing. Her relationships with people, even when they were limited, were never superficial.

We would discuss at length the books he wanted to write or was writing. And because his novels all dealt with very deep themes (right-wing terrorism, left-wing terrorism, old age, mental illness, the existence of other worlds...) these discussions became insights into politics, science, human reality.

He said--and I think he was quoting Moravia, whom he knew very well personally--that when randomly opening a page of a book, the reader should always know where the action is taking place, because, what is being talked about, the reader had to be helped to understand what was happening and where, without forcing him or her to the effort of remembering what he or she had read before.

She often asked me what I was doing; she wanted explanations of quantum mechanics. And when she then decided to write Partranno-one of her most beloved books by me (and which will finally be reprinted in 2023, with a preface by me)-we talked a lot, for her it was crucial that the scientific part of the novel be unassailable. Since we were dealing with aliens, I discussed with her at length how to describe the movements in space and time. She liked science fiction books as a device for expressing ideas about the current world by seeing it from a strange, unusual perspective. She also had a great interest in the relationship between humans and animals; she had read a number of essays on animal behavior and had wanted to study biology so that she could immerse herself in her protagonist Paola Rodi, a biologist. Even the places where she set her stories, she wanted to know them perfectly. She was the opposite of Salgari, who enjoyed telling about places he had never been.

In 1983 we organized a trip to New York, Daniella Lucetta and I, a week driving around the metropolis just so we could then describe places and feelings.

So it had been for Japan, where a piece of the novel Last Moon is set. Two weeks with Corinne and Daniella, I had not been able to go.

In *Si prega di non disturbare* she had tried to empathize with what might have been a black terrorist. She had experienced very intensely-I remember it well-the attempt to empathize with people and characters so distant from her. But she had done so-she said-because Nazism was essentially dehumanizing opponents, and so humanizing Nazis for her was a way of fighting Nazism itself.

He loved Silone's writing very much. And like Silone she used literature to explain the world. And still like Silone she was an isolated writer, isolated literarily also because of her estrangement from salons and as a consequence of political isolation, a leftist woman outside the PCI and every other party. She frequented Moravia, but not his circle, however, she had become friends with Dario Bellezza.

Unforgettable for me remains the New Year's Eve of 1979 when, to celebrate his return to writing after years with *Detour*, he had thrown a party at his own home with Moravia, Dario Bellezza, Elsa De Giorgi, Elio Pecora and a part of the leftist intelligentsia of the time.

In any case, I had taken care of the beverages.

## 32. Physics of summer

Even before I graduated I had started a little bit, my first steps into the world of theoretical physics. Sometimes I would go to the Frascati Laboratories-where I would later work for about ten years-for seminars.

Nicola Cabibbo had asked me to go with him to a School of Physics in Crete at the end of my third year. I remember that very advanced, new, cutting-edge topics were being addressed there. I don't have a precise idea of what I understood, it's likely that much still eluded me, but it was important to begin to smell that atmosphere, to come into contact not only with the most relevant problems but also with the people ahead of us who were working on them, to learn to make the effort to understand the most difficult things in a professional way.

The school was in Chania, or Chania, Crete's second-largest city, with the old Venetian harbor and castle.

After school I had stopped three days in Athens to visit the city even though I already knew it. Starting from my 15th birthday with my family we had done a few trips: Venice, France, Athens precisely. Now I felt at home.

I was 21 years old. It was my first trip abroad alone. One night at dinner we were chatting, me and a gentleman who was also dining in the same restaurant alone. Those things that arise in situations like that. After dinner he invites me for a drink at his house. Gladly, why not? Some more small talk then I make to leave. And that's when I realize her astonishment, her disbelief then her disappointment. He had assumed that I had gone to his house to spend the night together. He had been correct but insistent, I had to tell him that he had misunderstood, that I just wasn't attracted to people of the same sex.

I had not felt any annoyance or scandal or what. I had just felt sorry for him, for that disappointment of his so strong.

On the way back to the hotel I had thought that in Italy such a thing might not happen. But who knows. And on the other hand, at 21 in Rome, it wasn't like I was going to dine alone in a restaurant. And then there I was a foreigner, a vacationer....

Between the delivery and discussion of the thesis I had gone to the School of Physics in Erice, the one named after Ettore Majorana and founded by Antonino Zichichi. I took great advantage of this experience, beginning to meet people with whom I would later interact strongly. Guido Altarelli (Massimo's older brother), Luciano Maiani from Cabibbo's "Roman school," and other physicists such as T.D. Lee (Tsung-Dao Lee, the first Nobel Laureate I met in life), Sidney Coleman, Richard Brandt.

At other schools I would have met Kurt Symanzik, Ken Wilson, Daniel Amit.

Schools of Physics were born in the early 1950s. The pattern is more or less the same for all of them. Someone gives away land, or they are bought, in large and beautiful spaces, the schools are initially summer-only then will operate year-round, they are born spartan then are gradually modernized, renovated, equipped with amenities.

Two, actually three, are the ones I have loved most and frequented most assiduously: Cargese in Corsica, fifty kilometers north of Ajaccio, and Les Houches, a small town a few kilometers from Chamonix, the last town in the valley.

Sea and mountains, skiing and swimming, the two things I enjoyed most (actually swimming for a long time is boring, I used to spend time in the water mentally reciting long poems learned by heart).

In Cargese the sea was thirty meters away, you could swim in the mid-morning interval. If the class was boring I would escape to swim even earlier, and there I would find other escapees and the secretaries, who had gone before me.

In Les Houches, the school was at an elevation of one thousand two hundred meters, halfway up the coast, the village one hundred meters below. A couple of chalets, one for cooking and classes, the other as housing for the teachers. The participants in camp. Then they built more chalets, put in heating, private bathrooms, and now the school can comfortably accommodate up to seventy participants.

I went there so many times in both winter and summer. In winter there was free time from 12 noon to 5 p.m. so I could ski (but often worked after dinner). I used to go alone, except once I took my daughter Lorenza. In the summer we went with Daniella and the children, who had a great time. The free time was quite a lot. We would stay as long as a month.

Another school was in Varenna-every time I pronounced it my mother understood Ravenna-on the shore of Lake Como opposite Bellagio, in the Villa Monastero where the Italian Physical Society every summer has organized schools since 1953.

Very serious and important schools, the greatest physicists passed there, there had been Enrico Fermi and many other Nobel Laureates.

In 1973, when I was only 25 years old, I had taught a physics course to people almost all older than me.

In Cargese with the whole school we had gone to a disco, Kurt Symanzik really liked the twist, which he danced-he said-because it was good for his health.

With Richard Brandt I would be in New York for a month before spending a whole year at Columbia with T.D. Lee (but "recommended" initially by Richard).

T.D. Lee was one of those people who liked to talk and tell to make himself look good. But someone like him who had won the Nobel Prize at only 31 years old (along with Chen Ning Yang, in 1957) could also afford it.

He once gave me this talk, "When you have a new idea you run the risk of thinking that this thing cannot work. The person who makes a great discovery runs into two possibilities: either he is so good that he realizes right away that the arguments why that thing can't work are wrong, or he doesn't know those arguments well and doesn't have the perception that they can't work. In short, one can make a great discovery even out of unconsciousness. You can make a great discovery because you are too experienced or too little."

I had not had the courage to ask him which of the two categories he belonged to.

### 33. In memory. Daniel Amit

Daniel - one of the first great neural network theorists, he had studied in detail many aspects of brain memory, he came from studying particle physics, then statistical mechanics and neuroscience - I met him in Cargese in 1973, I was 25 he was 35. The same year when somewhat naively some of us boycotted the lectures of Curtis Callan, a physicist who was part of "Jason," a group of high-level American scientists who did mostly confidential consulting for the U.S. government on "sensitive" topics including climate change, but also the Vietnam War. In retrospect, their input was extremely useful: they had written a highly influential Report in 1967 in which they argued strongly against the use of tactical atomic bombs in Vietnam. But I couldn't know at the time; the Report was secret.

Our friendship began with a swim. The first two hours of the morning were very boring. So Daniel and I had thought it was much more productive to meet on the rocks and swim. We chatted about politics and many other things I don't remember. Not about physics, however.

Daniel was a naturalized Italian and taught at Sapienza University since 1991. He died in Jerusalem in 2007, and I will never be able to forget his passion, his sense of justice, his always being willing to pay his own way, his great determination and at the same time his unfailing self-deprecation.

Daniel was not only a great physicist, but also a great activist for peace between Israelis and Palestinians. The words "Jerusalem, capital of two states" stood out on his website.

Had he not been missing at even 70, I would have proposed him for the Nobel Prize, along with John Hopfield.

### 34. On the bus to Frascati

With these beginnings together with Nicola Cabibbo I had begun to be an active scientist.



Two CNR fellowships were available immediately after graduation, one in Rome and one in Frascati at the National Laboratories.

Nicola decided that Massimo Testa would take the one in Rome, I would take the one in Frascati.

That was fine with me.

It was the first job, the first salary. I was then hired permanently in 1973, although in the same year I went to the United States. Not my first scholarship. I had also won scholarships during my college years. Some money that emancipated me from asking for "pocket money" at home.

Frascati was, in those years in Italy, the best place I could have happened upon. There were these big laboratories that at the time were from CNEN (now ENEA) and partly from the National Institute of Nuclear Physics (INFN). And there were the two biggest particle accelerators in Italy. An electron accelerator and under the impetus of Bruno Touschek, an Austrian genius who arrived in Italy in the 1950s, of Jewish descent, and a Holocaust survivor-the world's first large electron-positron accumulation ring that allowed these particles of opposite sign and moving in opposite directions to collide within the same ring, offering very important and unexplored scientific results and observations. They had named it Adonis because its miniature prototype bore the name Ada (Accumulation Ring). Adonis, at thirty-five meters in diameter, was a large AdA, which was only five feet in diameter.

I would go two-three days a week. In the morning at the faculty in Rome, then at noon I would take a bus, have lunch with friends in Frascati, discuss with them, come back. I used to walk around with a school bag full of photocopies of articles.

Since 1979 I had lived in Trastevere and had gotten into the habit, when I went to Frascati, of catching the bus at Viale Trastevere at 7:40 in the morning, although I did not have, unlike other employees, time constraints, I would arrive at 8:20, the bus would leave again at 5:40 and drop me off at Viale Trastevere, I could use the time to read. Various times I would get in the back where I would do low-voice practice of Chinese, which I studied for eight months before I went to China and then continued for another year, learn to recognize and pronounce the ideograms. I had also enrolled in a Chinese course at the Italy-China Association near the Pantheon in Rome.

I went to China in 1980. Before that I had been one year in America between 1973 and 1974, and two years in Paris in 1976-1978. In those years I was working frantically on different subjects, with different people, in different places. At that time it was difficult to work by correspondence, or at any rate at a distance.

Just one example. In February-March 1980 I go twice to Paris for a week, then to the Erice School of Physics in Sicily and to Les Houches near Chamonix. From there I spend a few days at CERN in Geneva and, not to miss anything, I go to Pisa to give a seminar. After a month in Rome I leave again in mid-April for Beijing, stopping in Paris for a couple of days both on the outward and return journeys for a series of scientific discussions. Returning from Beijing in late June I go for a week to the International Conference on High Energy Physics in Madison Wisconsin where I speak before more than a thousand scientists.

I would return to Paris for two months in 1982. But in the meantime in 1980 my first daughter, Lorenza, had been born, and in 1981 I had begun teaching at Tor Vergata. Since 1982 I have not made any long trips related to my work.

I had come to teach theoretical physics at Tor Vergata after a fleeting transition to engineering at Sapienza, and at Sapienza I returned in 1992 and remained until my retirement in 2018, when I took over the presidency of the Accademia Nazionale dei Lincei (since 2021 I have been the vice president). In 2018 I am appointed Professor Emeritus.

### 35. Field choice

Immediately after the dissertation I started working on problems in statistical mechanics but, not only because I was at Frascati, I was also continuing to work on high energy physics, later in the vulgate to become particle physics (classical nuclear physics was called low energy physics). That was one of the things it was useful for me to do, useful for learning the craft, understanding the experiments well, learning how to interpret the data. In short, see things up close but also begin to make theories. Nothing fundamental and even less highly original, on the other hand I was just starting out. I was beginning to think, to reason.

For me the important thing about those beginnings was getting to know and hang out with people who were doing particle physics and others who were doing certain material properties of statistical mechanics. In Rome as in Paris as in New York there was a huge flow of information coming through, people coming to give lectures, and long and fruitful discussions.

Over the years a little bit all over the world there has been this fruitful exchange between particle physics and statistical mechanics, in the two directions. I, too, oscillated between statistical mechanics problems and particle physics problems for a very long time. I liked the feeling that I was one of the few who could successfully transport ideas from one field to the

other. I felt that I was helping to restore the unity of theoretical physics, which was often fragmented instead: physicists in the two fields were making discoveries relevant to each other and didn't realize it. I also liked to pursue research on very different topics at the same time. Perhaps I was a bit vain, shallow, in fact it seemed to me that by moving away from a topic and picking it up again after some time, this "distance" allowed me to see it in a new light and helped me to identify where the snag was and solve it. Perhaps this is also why I wrote nearly a thousand articles, often on completely different topics and many in the same year.

In particle physics everything revolved around the question of what the infinitely small looked like. What determined the properties of the proton. It was not known. As early as the early 1950s, a series of collisions could be made that produced very short-lived particles at high energy. Order of magnitude: one millionth of a billionth of a billionth of a second. "Very short" means really short.

And there were two schools: whether to consider the individual parts or the balance of the whole. Said another way: some people thought you had to reason about the individual components of matter, matter made of molecules, molecules made of atoms, and so on to smaller and smaller particles, because matter had essential components and you had to determine the laws of motion of these components.

The other point of view was more confusing: the behaviors of the particles were seen as a construction that all held together, and the puzzle lay in seeing how the properties of the particles fit into each other, so this universe of particles was not to be considered individually but as a self-consistent whole comprehensible in its entirety. Whether by influence of much of the Roman milieu or by personal taste, I was definitely with the first school. What were these mythical constituents of particles? Some conjectured quarks but why weren't quarks observed?

I was beginning to rack my brains about which way was right and how to figure it out. And to pose the problem of how to make accurate predictions, what experiments to observe. The complicated object to control was the proton, while the electron was something simpler whose behavior was well understood. Fortunately, significant experiments had been done in those years on high-energy collisions of electrons with protons, which were much simpler to interpret theoretically than collisions of one proton with another proton. One theoretical physicist, comparing the two types of collisions, said that to understand the nature of a clock there are two methods: take an X-ray of the clock or have two clocks slam into each other and observe the fragments of the collisions (electrons make it possible to take a precise "X-ray" of the proton).

Like many others, I too set out to study these electron-proton collisions, trying to deduce what the various theories predicted. For reasons that escape me, probably extrascientific, I disliked quarks, and did not

contribute to the very early work on quantum chromodynamics, which I could have done very well had I not been too presumptuous.

### 36. New York New York

In 1972 I try to arrange to go to the United States. I talk to Richard Brandt who offers me a chance to stay for a year at New York University. By the way, a beautiful place, fifty meters from Washington Square. Then funding suddenly blows up and I say patience, I'll stay in Frascati. My scholarship was over, I wasn't getting paid but I had kept the room, I was getting my mail there.

The mail, indeed. In January-February 1973 I got a letter from T.D. Lee in which he asked if I wanted to go to Columbia University for a year. Do you want me to say no?

I inform Giorgio Salvini, who had directed the construction of the first accelerator at Frascati, and he is most impressed. A month later in Frascati they hire me, a regular hire with a fixed-term researcher contract for two years, not a fellowship. How had they thought: a Nobel Prize winner said he was "delighted" (that was the formal language) to have him at Columbia and we not even a position?

I don't get hired in time that I take a leave of absence for a year, then come back.

I had found out later that Brandt had gone to T.D. Lee to tell him that I was very good, having also heard the positive opinion about me from Sidney David Drell, a very important physicist with whom I had interacted in Rome for a couple of months.

Things worked that way. Sometimes formal calls sometimes informal things, word of mouth about who was good, whirlwind of letters of introduction, but don't think about the patronage recommendations that we are unfortunately used to. There, your face was on the line. If you said someone was good and he wasn't, you were finished, word immediately spread that you were untrustworthy, and what you wrote no longer mattered. Just as letters of compliments circulated so could skin-crawling critiques. No one could afford light, wrong, self-interested judgments. It was the triumph of merit and comparison among scientists. Even now, if I avoid explicit critiques, I am, however, very careful about what I write.

And here I am at Columbia, in Manhattan, upper part of Broadway, last white outpost before Harlem. It ended the Columbia area, and immediately Harlem began.

The theoretical group at Columbia was headed, of course, by T.D. Lee. There were three lectures a week with guests from outside, and it was good manners if nothing else to go and listen to them, on Mondays, Wednesdays and Fridays. On Mondays and Fridays we would go with the guest on duty in a dozen or so to the Chinese restaurant, where everyone ate with their plates placed directly on the glass tables. But we were entitled to the tablecloth.

I lived in a building that was not dilapidated but quite dirty. And I had a house full of little cockroaches. When I complained about them they would say, "Don't mind them, it's normal here, there are them everywhere." A few mice would also come to visit me.

In the Village there was a fairly important bookstore. But it was raining in some places.

### 37. Surrealism

Of New York I got to know the violent part, which curiously presented itself to me in its most surreal aspect.

In 1973 to save money, I had taken a two-room apartment with a friend whom I had known since childhood and had become a mathematician, Francesco Zirilli. One evening Francesco came home quite shaken. "What happened to you?" And he tells me this story.

"This morning I was walking down the street, a gentleman comes running up and with a shove knocks me to the ground, and before I could get up he pulls out a knife. Along comes another one who gets into a terse argument with the one with the knife, I don't understand anything they are saying, and they leave. A little later I see the same gentleman who had knocked me down coming toward me on the same sidewalk with a half smile on his face. I would have wanted to run away but he was much more athletic than me, he would have caught up with me in a few meters. So I decide to wait for him and try to talk to him, protect myself with words. And he says to me, 'Look, I have to apologize enormously to you, I made a terrible mistake, my friend explained to me that I had made a mistake, you see I have to kill a man and I was convinced it was you, then my friend explained to me that I was mistaken person, I am enormously sorry, I would be glad to buy you a whiskey at the bar.'"

Francis had politely declined the offer.

One day I had been chatting about chess with a gentleman about 75 years old in Washington Square in the center of the Village. He had told me that twice he had been stabbed in the ribs while walking quietly down the street and had had all his money taken.

They had also explained to me that I could walk around with no more than \$20 and no less: no more than \$20 because they could rob you then kill you to prevent you from going to the police, no less than \$20 that would not be credible and also impractical.

It was clearly stated in the Columbia guidebook: if on the subway you find you have made a mistake, do not get off at the Harlem stop to cross, continue to the next stop, and from there go back, do not exit and walk back.

I had this Trockist friend who used to go to Harlem to leaflet and hand out copies of their newspaper. He was one of the very few white people who could get into Harlem without risking it. I accompanied him once and actually except for the two of us all the others were black. Harlem was off limits to whites, considered very dangerous.

A few years later Nicola Cabibbo goes to New York with his wife Paola landolo and their son Andrea, who must have been about 12-13 years old. One day he comes home and finds the little boy tied to a chair and gagged. The thieves had come. And luckily they had merely tied him up.

Paola was once at Café Reggio, also in the Village, a quiet area. She heard a hissing sound and then saw the gentleman sitting at the small table next to hers slump down. He had been shot from the street. He had died instantly.

But the truly surreal story related to New York would happen to me years later in the most unthinkable way. I was on the Palatino, the famous train that connected Rome-Paris for forty years, from 1969 to 2011. In the 1970s, no one in my circle of friends took the plane to Paris. The Palatino would leave Termini around seven o'clock in the evening, and by ten o'clock the next morning you were in Paris at the Gare de Lyon. You'd have dinner on the train, sleep in the second-class berth (six in the same compartment), have breakfast again on the train. I must have taken it a billion times. Often with Daniella and also with Lucetta.

It so happens that once I had started chatting with my neighbor and we had fraternized because he was from Frosinone and I had mentioned that my wife's family also had Ciocian origins. He told me that he was retired. But he had lived all his life in New York, he was a driver for the Gambino family. In the evenings he would drive a couple of people to different

places in the metropolis, they would get out and shortly afterwards get back in, he would stay in the car. It was clear that these were going to collect protection money for one of the most notorious and probably the most powerful Mafia family in New York. He had once attended a lunch with two hundred people in Sicily. But he felt like an ordinary wage earner. An ordinary immigrant who had saved some money and eventually returned to Italy to invest it. Regularly employed, he had taken his severance pay and was planning to open two pizzerias in Frosinone. He was going to Paris to sound out that square as well.

The normality of crime, Lucetta often repeated.

The banality of evil, Hannah Arendt would have said.

### 38. In memory. Kurt Symanzik

In 1973 while I was in New York one afternoon Kurt calls me, he has a night off. We're going to Brooklyn to see a ballet that ends at midnight. Said and done.

Kurt was an outstanding physicist. And we felt a strong liking for each other. He was twenty-five years older than me. We never wrote papers together but we collaborated a lot, we compared a lot, he had found a math error I had made on a published paper, I learned a lot from him especially in terms of method, how to study things in a certain way. I am very grateful to him.

He lived alone, had been to New York, hated teaching, loved New York, but his hatred for teaching was so strong that he was convinced to return to Germany, to a German laboratory (Desy) in Hamburg with no teaching obligations.

When he spent in New York he would try to catch up with frantic activities. This I learned later. So I was stunned when, after the ballet was over, he asked, "What do we do now?"

In the theater was one of the first performances of *The Life and Times of Joseph Stalin* by the great director Robert Wilson. It started at 7 p.m. and lasted 12 hours, 7 acts. We arrived at 1 a.m., wanting there was still a good chunk of the play to follow.

The first act we see was strange. Hard to describe. So many characters on stage on what could have been a farm. Every now and then the displacement of a person. A girl crawls across the stage and after an hour

is on the other side. In fact by the end of the act all the characters had changed places. Seeing it I had thought it was extremely boring, but it actually made a great impression on me. In retrospect, it seems to me to be a metaphor for life.

We get a cheeseburger during intermission, come back in and see an actor in a chair suspended in midair held up by two ropes. A palm tree to his right and a few people below, and him reciting passages from Hegel or maybe Marx, I wasn't literate enough to understand exactly the origin of the quotes. We watched a long piece, then another. But I was falling asleep, falling out of sleep. Only later did I realize the importance of the opportunity we had been given. Unfortunately for me, it was not the right time. At the end of the act I told him, "You do what you want, I'm going." I was supposed to leave for Italy the next day, so I hadn't packed my bags yet. We found something open at four o'clock in the morning in Manhattan, had an omelet with sausages, who knows if it was supposed to be considered dinner or breakfast. Of course, the subway in New York was open and running all night.

I'm going to visit him in Hamburg. We go to see Mozart's The Magic Flute, an actually beautiful edition, and I had liked this one unconditionally.

I walk into the house and see a huge poster of Sophia Loren, the most stripped-down Loren I had ever seen, I don't have prudery but it was hanging on the wall, it must have been three feet by two feet, not exactly what one would use to hang on the walls of a house.

He ate lunch normally, but at dinner he could not go out all the time also so as not to waste time. He did grocery shopping once a month, bought galettes, cans of mackerel, concentrated milk which he strengthened with powdered milk. We had dinner with that.

I made up for it once when we went to a scenic restaurant where during happy hour you could eat all the desserts you wanted. I downed six different slices of Bavarian cakes.

### 39. In memory. Giorgio Salvini

If Giorgio Salvini had not been there, there might not have been the Frascati Laboratories. Which have certainly not represented little to Italian physics.



Giorgio Salvini directed the laboratories still in their construction phase. He had been entrusted with this role at a very young age because besides being an excellent physicist he had the right character to carry out that very difficult task in postwar Italy. Then he was president of INFN (1966), president of the Accademia dei Lincei, and finally minister of University and Technological Research in the Dini government (1995-1996).

When he returned to Italy from the United States, he was 31 years old. He had surrounded himself with even younger collaborators to build the laboratories. For him, merit was paramount; he wanted only the best, and he did not misjudge. He would later recount, "I went looking for collaborators, from university to university, who were top of the class. It didn't matter to me whether or not they knew how an electrosynchrotron worked, character or ideology. It mattered to me that they were good." He had a tremendous challenge before him; he had been given *carte blanche* and could not fail. The obsession with merit in these cases is natural, if you're going to sail around the world you're very careful in choosing who you sail with.

To say that he had an adventurous life is an understatement. He is born into an initially wealthy family that later becomes very poor. He attends master's school, is a teacher and enjoys teaching, thinking he will do it forever. Instead, he enrolls in medicine, then physics. And he becomes one of Italy's leading physicists. But his passion for teaching will drag on for the rest of his life; his lectures in the great Physics lecture hall, the historical lecture hall, the one that could hold two hundred to four hundred students, were masterful even from the point of view of teaching ability.

In 1949 he went two years to the United States, to Princeton University, and when he returned he began the Frascati adventure, with Italy's first major accelerator machine, the electrosynchrotron, in 1953.

He was the one who got me hired, who made me the first INFN employee in Frascati.

He said, "I can confess one thing: I am in love with the universe. An unrequited love certainly, the universe is mute to our questions but my love is there."

#### 40. In memory. Nicola Cabibbo, the Master

A great friendship had developed with Nicola Cabibbo, even with the family. We used to go in the summers to their house in the Castelli where there was a large cherry tree from which we would greedily pluck fruit.

It was the whole Roman physics environment that was my teacher, if you will, but the most important relationship was definitely with him. He was thirteen years older than me, not such a great distance, after all, as to force a somewhat formal awe-inspiring relationship.

In Physics, everyone was on first-name terms right away, except with older people. The only ones I did not call "tu" after I graduated were Edoardo Amaldi (who was from 1908) and Giorgio Careri (from 1922) who did not give confidence. New graduate student or professor, when discussing physics in a professional manner he was the tu for everyone. The day after I won the professorship competition, Amaldi and Careri also started to call me tu; I was a professor like them, so...

Nicholas was one of the most brilliant postwar theoretical physicists: in the 1960s he had formulated a fundamental theory of weak forces between elementary particles (one parameter of which is commonly referred to as the "Cabibbo angle").

While I was doing my thesis - I remained cold, Massimo Testa, on the other hand, was passionate about it - he had been building, for months, a thirty-centimeter telescope mirror, which he hand ground to perfection, one small piece at a time. He had also built with his own hands, together with two other physicists, a mini-computer that made it possible to see at a very high speed on a television screen the figures of a game called Life, which would later be important for the Ape project, our first supercomputer.

He had also bought a sailboat whose entire electrical system he had redone. He had gone there a couple of times and that was it. His wife was seasick, some tension had built up, but I suspect he had bought it just to do those jobs in it.

At home he had a workshop with an impressive amount of tools and had hobbies--let's call them that--of various kinds, working with early chips, early games with programming language...

Very recently I had noticed some very colorful abstract paintings on the walls of his house. Proudly he had told me that he had done them. He had developed a digital technique for transforming photographs in a way that created those images that had impressed me so much.

He used to say, "Why do we have to study this problem if we don't enjoy doing it?"

It was almost unanimously deemed a scandal and an injustice that he was not awarded the Nobel Prize in 2008.

## 41. White Rabbit

Daniella and I stayed in Paris for two years, from 1976 to 1978.

We lived on the Rue des Saints-Pères, on the first floor of a house overlooking the courtyard of an eighteenth-century mansion. Little light came in; to tell if the sun was shining you had to open the window and lean out. But it was in a very central location, next to the Saint-Germain-des-Prés neighborhood near the medieval abbey of the same name. There were famous cafes like the Flore, where Sartre, Simone de Beauvoir and Cioran used to go. Only later did I find out that those had also been Hemingway's places, with the cafes he frequented with Francis Scott Fitzgerald and with Joyce: at Polidor's, or the Brasserie Lipp, which the writer mentions in *Movable Feast*, his memoir published posthumously and which I recently reread, and then again *Les Deux Magots* right in front of the church.

I was doing research exactly as I did at Frascati or Columbia. That is, in a serious way but also with great freedom of schedule and topics and contacts. I had quickly made friends with many physicists, with whom it was a pleasure to collaborate and from whom I learned a lot.

I was the first year at the Institut des Hautes Études Scientifiques in Bures-sur-Yvette, in a park outside Paris, and the second year at the École Normale Supérieure, in central Paris next to the Pantheon and the Sorbonne.

The first year I went to this distant suburb, forty minutes by train. Inside a chestnut grove of about ten hectares were three buildings: a library that looked like the little marzipan house-big windows, floor-to-ceiling glass windows-then a restaurant and offices, and the studios of the few permanent researchers. You could go chestnut picking in the fall. And mushrooms. But the secretaries even there arrived earlier in the morning and knew the best places.

I often went to work and discuss with my friends at the Saclay Physics Center. We would drive into the Parisian countryside in the midst of rapeseed fields, in a blaze of bright light yellow.

Sometimes I went by my 850, sometimes by train, but then you risked having to wait for a bus for twenty minutes and then walk another ten minutes.

Fortunately, almost immediately I had learned that Jean-Bernard Zuber, a friend with whom I had started working, had a "cunning" technique for

getting to the workshops. He would drive the children to school then board the 8:48 train. I would leave the house at 8:35 and take the same train. At the arrival station, in that suburb, we would find a very old Renault that Jean-Bernard would purposely leave parked there. We would get in and thus avoid both the bus and the last ten minutes on foot. Jean-Bernard would return to Paris very early to pick up the children from school, so I had to make other arrangements. I was also coming back relatively early by Italian standards. As early as four o'clock in the afternoon, when we would meet in the discussion room, I would begin to inquire about the possibilities of a ride, which, however, was almost never to Paris directly, but to a suburban station from which to take the train.

I would leave the house in the morning and Daniella would ask, "What are you doing?" and I would look like White Rabbit from Alice in Wonderland, "It's late, it's late!" I'm in a hurry I'm in a hurry. Sometimes I would do the runs, and in the winter it was still dark. I would see the light in the country, half an hour later.

Daniella meanwhile was studying for her Ph.D., doing preparatory work, taking courses at the Maison des sciences de l'homme (École des Hautes Études en Sciences Sociales) with Pierre Vidal-Naquet, a very important historian mainly, but not only, of classical Greece, his parents deported to Auschwitz when he was 15, committed to exposing human rights violations by the French in the Algerian War and of course against Holocaust deniers.

It was a very interesting group of structuralists, the best known being Marcel Detienne and Jean-Pierre Vernant, applied an anthropological approach, influenced by the structuralism of Claude Lévi-Strauss, to the study of classical and archaic Greece.

One year Daniella also took a Roland Barthes course, struggling each time to find a place.

Every now and then he would look for things in the library for his judge or make a trip to Rome.

We would meet at home in the evening.

After two years we returned to Rome, as we had planned.

## 42. Hard-boiled eggs

I like to cook.

I cooked mostly for friends who came for dinner, in New York as in Paris as in Rome.

Before, when I was still living with my parents, I had made some attempts but without much success, my mother was controlling and kept her breath on my neck, not the ideal condition to learn how to do anything.

In New York one evening I had decided to make risotto alla milanese following the classic recipe that calls for ox marrow. I had checked the vocabulary to be sure how to say it in English but the butcher had looked at me strangely and replied that they only sold edible things.

In Paris so many people would invite us to dinner, we would reciprocate, but to be on their level was impossible. Those who know French haute cuisine know what I mean.

I once asked one of these friends who looked like real chefs: when you invite, how do you count the bottles? He had replied: one each plus one for the tablecloth.

Abroad, the problem was - we are talking about the 1970s - finding certain raw materials. One day I needed pine nuts to make pesto alla Genovese. At the market I had found everything except pine nuts. I persisted and bought some Algerian pastry that had pine nuts on it, took them out one by one and used them to make pesto.

Daniella helps in the kitchen, takes care of the preparatory part, washing vegetables, things like that, then both the theoretical and experimental part is up to me.

The fact is that Daniella leaves things on the fire and makes them burn.

Burning hard-boiled eggs is not easy. She succeeds at it. She has succeeded more than once. And this is one of the physics experiments that can be repeated again and again with the same result: the smell of the burnt hard-boiled egg is one of the worst.

Daniella also manages to burn the broth.

43. High energy

Today, high-energy physics is based on chromodynamics. Quantum chromodynamics (QCD) is the quantum theory that describes the interaction between quarks and gluons, the constituents of the proton. As early as 1972, two years after graduation, I had set out to study how fundamental particles interacted at higher and higher energies. Precisely because of the nature of QCD it turned out that the higher the collision energy, the more accurate predictions could be made (this counterintuitive property of QCD goes by the name of asymptotic freedom).

I persevered the initial phase of QCD, beginning in New York in 1973 to use the techniques I had previously developed to the study of interacting quarks and gluons. Returning to Rome from New York in 1974, I devote myself to this subject, beginning to work with a young former graduate student of Nicola Cabibbo, Roberto Petronzio. I do this with a little ringworm, partly because it gnawed at me that I had missed the initial phase of QCD, despite the preparatory work I had done, and I was keen that at least the experimental verification of the predictions be linked to my name.

Roberto died in July 2016 at the age of 67. He had a rich personality and many interests outside physics. A good reader, music lover-he played guitar and saxophone-he loved the mountains and the sea. He was a great skier and an excellent sailor. The only person I knew capable of sailing in force nine seas. In the ocean, with waves reaching fifteen meters.

We had made friends right away. Just in 1974 I had gone with him and other friends on a camping trip to Calabria for a couple of weeks. And with Daniella we had seen him often, together with his whole family. Then, as sometimes happens, by the instances of life, we had lost sight of each other.

In 1974 we started working very intensively until the early 1980s.

But it is with Guido Altarelli-who was also in Paris in 1977-that I conclude all this work that I started in Frascati.

We had started working together with Petronzio always on QCD. One day I walked into Altarelli's room at the École Normale Supérieure, an old red-brick building in the center of Paris, and he said, "You know Giorgio, those equations you had written are very interesting but not clear enough. Let's do pedagogical work and derive them in the simplest way, following the method of Nicola Cabibbo."

Guido talked about how the particles inside the proton evolve, how they change their distribution and shape as the energy increases.

You "x-ray" the proton with electrons of a certain energy and find two pairs of quarks and antiquarks. You increase the energy and find three pairs.

In fact, the more you increase the energy, the more the constituents of the proton change. For example: low energy, three quarks; high energy three quarks plus a gluon. Increase the energy again and you find two gluons plus a pair of quarks and antiquarks. The problem was to predict how this change happened and whether it agreed with the experimental data, then write the relevant equations.

In one particular case I had written the equations almost four years earlier. Indeed, the complete equations I had published in the proceedings of a conference, which was very little read, and also contained some errors in the printed formulas (I am a bad proofreader, especially for formulas).

We set to work, actually Guido does almost everything himself, and we rewrote correctly (Guido was of absolute precision), extended the previous equations arriving precisely at the Altarelli-Parisi equations. The simple derivation, traced back to Nicholas' method, had made the work extremely clear and transparent from a physical point of view.

It was a fundamental contribution to theoretical physics, which gave rise to a myriad of subsequent works that used these ideas.

Certainly, Altarelli and I changed the techniques and language that were being used to describe these kinds of phenomena. And by changing techniques and language, it was possible to make a whole series of predictions that were not possible before. But how come? The equations were the same, so where was the progress? someone might have asked. But in a physics paper, the words that accompany the equations are fundamental. The fact that these equations could be derived in a simple way made it possible to extend the same methods (suitably modified) to the calculation of a whole range of other processes and in particular to events that occurred in high-energy proton-proton collisions. It was then possible to verify the correctness of QCD predictions in myriad different experiments, reaching the certainty that QCD was the right theory.

Guido jokingly said that ours was the most cited French work in high-energy physics because both authors were employees of French research institutes, and therefore French by scientific affiliation.

My commitment to ultrahigh energy physics I can say began with Nicola Cabibbo at the end of college and ended with the Altarelli-Parisi equation of 1977.

Guido passed away in 2015. The last time I met him was in Vienna, where we had gone to collect an award for the equation bearing our last

names. He was already ill, but I foolishly did not see him, we hugged, we talked for a long time, we also had dinner with Monica, with whom he formed a very solid couple.

Guido left a deep imprint on modern understanding of the laws of our universe. And he was not a solitary scientist, one who cared about the personal prestige that research might bring him. He felt part of a large community, the scientific community, and CERN in particular. I don't want to write the usual obituary, but unforgettable to me are his always slightly ironic look at himself and life, his kindness, his intellectual honesty, the joy he took in understanding new things. And that unmistakable gentle laugh of his.

#### 44. The world through the looking glass

Back in Rome in the summer of 1978, I thought I would continue on the high-energy ground. I was always interested in the behavior of quarks inside the proton. At the same time I had discovered that, in a field hitherto unknown to me, there was a way that was used to solve the so-called "replication method," which, however, gave wrong results in certain cases. I remember before the Christmas vacations of 1978, I went to the library and photocopied quite a few articles that were about this method of replications, these strange systems that I did not know about that were spin glasses, and I took them home. The feeling that I still remember sharply today is that I didn't care about spin glasses, what I found unbearable was that there was a method that worked in some cases and didn't work in others and you couldn't understand why.

Presumptuously or naively I had said to myself, I can solve this rebus in a fortnight, they must have made a trivial mistake, some oversight in the calculation.

I check the calculations, carefully, and see that they are correct instead.

The error then had to be far more complicated, a conceptual error.

I'm going to jump in. I spent a few months trying to figure out what this conceptual error was, even I had then seen that it had already been identified by others but I had come to the same conclusions on my own, and in any case what mattered most was that if you discover the error you have to be able to correct it if you don't, you don't go anywhere.

It was months of groping in the dark and working hard, and even a bit obsessively, but I finally did it. To find the result I needed to introduce a



whole series of new mathematical concepts that did not exist at the time. It was equally very strange: on the one hand it was a stretched mathematics, there were unproven hypotheses that stood only on intuition, on the other hand I could not understand - let's say - what I had done, let alone what it would then produce in an avalanche. I didn't understand myself what interpretation to give to what I had found.

Between 1979 and 1983 I publish about ten papers in scientific journals as I refine the theory, and the most relevant papers are the first and the last, those from 1979 and those from 1983.

When you send a paper to a physics journal there are reviewers who judge it and decide whether it is interesting or not. I remember the reviewers' judgment was, "You don't understand anything, however, since the results are interesting it should be published." They added that a final part was to be cut out because "it was not worth the paper it was written on."

I had worked on this problem in 1979 almost full time, then I had left it alone for a while. In 1982 I went back to Paris and there we finally untied the knot. I say "we" because I worked with Marc Mézard, Miguel Ángel Virasoro, Gérard Toulouse and Nicolas Sourlas, understanding among other things that this whole thing was connected with the problem of complex systems.

In 1983 with Virasoro, who had moved to Rome for two years, I work precisely on statistical mechanics of complex systems.

In 1985 with Mézard and Virasoro we gave a rearrangement to my 1979 theory and crystallized it, so to speak, in the book *Spin Glass Theory and Beyond: An Introduction to the Replica Method and Its Applications*, which came out in November 1986. In that *Beyond* there was already an intuition that there were possible applications, as it turned out, from optimization problems to neural networks (to which Virasoro himself would devote himself, who from 1988 onward became passionate about studying how one can understand the workings of the brain and some of its high-level capabilities, for example that of classifying objects into categories).

I remember this period as one of the happiest in my career.

I soon realized that the one on spin glasses was my most original contribution to physics. And I still think so today. This field I really took care of. And this is really the most interesting thing I did, there were very, very difficult logical leaps to make.

Yes, this "field" I had been watering for forty years (doing many other things in the meantime). And I had found it by accident, unlike others that were more natural for me to study. But said in this way it can explain only a small part of the deep emotion I feel, it can explain at best why I am

attached to it, how you get attached to an object you have carried with you for a lifetime. Instead, I happen to wonder what would have happened to physics if I had not existed.

There are unsolved scientific problems on which there is great competition, a competition that often lasts for years, or decades. Arriving first at the solution of one of these problems is a great satisfaction, no doubt, and I know it well: how many races I have had, sometimes arriving first, but also losing them miserably. But these are problems that "must" be solved and are not forgotten. Spin glasses, on the other hand, were a relatively marginal problem, even though two Nobel laureates were working on it at the time. So it is possible that no one would come up with the solution or that a very partial outcome would be reached, but deemed satisfactory, and the problem would go out of fashion and be abandoned. Instead, I manage to solve the problem by finding a solution that is extremely imaginative and mathematically meaningless, but which has had and continues to have applications in a very large number of fields, and above all serves a paradigmatic function, something that goes far beyond spin glasses. Here and only here do I feel that I have added territory to physics that could perhaps have remained unexplored.

On a different plane the feeling is that of Frank Capra's 1946 masterpiece starring James Stewart, *Life is Wonderful*. George spends his life giving up everything to help others. A disaster happens that is unacceptable to him, and George decides to end it all by going into the river. It is Christmas Eve night. But here comes an angel who shows him what would have happened (a sea of disasters) if he had never been born. George never commits suicide again and makes peace with "life (which) is wonderful." It's a fairy tale, I know that. But, like, an existentialist fairy tale. Which has nothing to do with pride or feeling superior or the race to the top of the class. It's just the question, astonished, that we can all ask ourselves when faced with something that, because of us, has really radically changed the course of a little piece of history: of science, of a person, of a group of people, of an important event... A question about the world and our place in the world. How would it have been if I had not been born?

Back on earth, my construction had immediately attracted the attention of mathematicians who were experts in probability to try to see if the final formula I had written could be proved, and this was work that engaged a whole series of mathematicians (including the Italian Francesco Guerra) for some 20 years, from 1981 to 2001. Confirmation later came in particular from Michel Talagrand.

The theory on spin glasses was the first mathematical description of a complex system.

## 45. Thunderbolts

It is rare in theoretical physics to have real "eureka" moments because many of the things you build up slowly, not by a bolt of lightning. You can have the lightning bolt on initial intuition - it happened to me several times - but then you get the result with months or years of calculations.

On the spin glasses, however, I remember two very particular moments when I felt the excitement, the thrill of discovery, the feeling, almost the certainty, that I had found the tangle.

We are talking about a handful of months in the summer of 1983.

I was going to Varenna, I was on the train between Rome and Milan, I liked traveling by train, it didn't take three hours like today but almost seven. I had set to work, I had started to write formulas and I had come to see a conclusion. But I said to myself, this is the strangest thing, if my theory predicts nonsense like this it must be all wrong. It was actually right, in fact that formula was fundamental to the theory. I was elated and bewildered at the same time.

Of the second electrocution I easily remember the date. It was August 3; I also remember it because it was the day before my birthday.

I was in the house in Falvaterra.

A very hot summer.

The house is vertical: first floor, first and second floors, terrace on the third with tiles that were red-hot in the sun. Around noon I would go up and water the tiles in the hope of mitigating the heat that was spreading throughout the house. Always a lot of stairs to climb.

Falvaterra was a perfect place for children.

On August 3 just after lunch I finally manage to put them to sleep, which is not easy, and I stay in the living room almost in the dark, with the blinds ajar.

I stood there doing the math and eventually got this result, this property that would later prove to be accurate (only in 2011, to be precise, almost 30 years later).

I didn't quite get it all, but I remember the excitement, how impressed I was to have gotten something that had the flavor of a resounding and entirely new solution, unexpected even for me.

#### 46. In memory. Miguel Ángel Virasoro

Miguel was not only an extraordinary colleague but also a great friend. He greatly influenced my studies and my personal life. He taught at Sapienza since 1982 for 30 years, so he was there when I started teaching at Tor Vergata and I found him again at Sapienza when I arrived in 1992.

Miguel's son Diego was my daughter Lorenza's age. One day Miguel invited us home and proposed that we enroll Lorenza and Diego in the same elementary school. We struggled not a little to even put them in the same section but eventually succeeded. Besides school, our children participated together in many other activities. A choir, for example, and I even keep the film of a soccer game where they all played together, including my other son Leonardo, almost two years younger. When we bought a house in the hills in 1990 for vacation together with other friends, among them would be Miguel and his first wife Sylvia.

Miguel had once told me that after giving a seminar on a cognitive disorder of face recognition, he had been asked if he was the son of the inventor of "Virasoro algebra." He was both amused and proud.

His deep curiosity drove him to change the subject matter of his studies, which ranged from particle physics (from which string theory originated) and statistical complexity mechanics to brain function and economics.

He was a profound, visionary man with great humor. And yes, his life had not been easy.

While writing his doctoral dissertation in Buenos Aires comes the 1966 coup d'état. The Faculty of Science becomes one of the main sites of opposition; one night police raid and massacre the occupiers. Virasoro goes into hiding then flees to Israel.

When democracy returns to Argentina in the early 1970s, Virasoro also returns. He becomes dean of the Faculty of Science in Buenos Aires. During a period in the United States, another coup in his country, this time by Videla. Virasoro is fired and threatened with death if he returned.

He will take refuge for a year in Paris then go to Turin, then to Sapienza University, then to direct the UNESCO ICTP physics center in Trieste. Finally back to Argentina at the Universidad Nacional de General Sarmiento.

#### 47. Wells and cities

After the work on spin glasses, around 1985 I began to study, again with Marc Mézard - because Virasoro as I mentioned had taken other paths - problems that we could here in a first approximation call optimization, but also combinatorial and satisfiability, disordered systems in which randomness played a central role but with respect to which I was increasingly able to find explanations, laws, mathematical descriptions, predictability. Different problems but which continued and intertwined with the vast field opened by spin glasses, and with the same intuition at the origin and the same mathematical framework, only gradually more complex. Problems many of which carried one over the other. Simple questions and more complicated questions. Systems that were sometimes conceptually simple but mathematically very difficult. And it should be said right away that from here we are and always will be in the field of complex and messy systems. It was always complexity that was gradually emerging as the macro-interest of my theoretical research.

Suppose you have 4 cities and 4 wells, you know the distance between a well and each city, not necessarily in a straight line. Each city you want to connect it to a well so that the total distance is as short as possible, there are 24 possible scenarios.

If there are 40 cities and related wells instead of 4, you cannot examine all possible connections; there are cunning methods that allow you to find the shortest path with a computer.

With 100 cities and 100 wells it gets nice and complicated.

This was the first work on optimization done with Mézard in 1986, and we found that when the number of cities (and wells) becomes very large the optimal distance tends to be 1.6449 times the average distance between cities and wells, where 1.6449 is actually  $\pi^2$  divided by 6.

When you do a complicated calculation, with so many unproven assumptions, you want to make sure everything fits, so we did a thousand different tests with 100 cities and 100 wells and it always came out to a number very close to 1.64. We had not only the analytical element but

also the empirical evidence: the analytical calculation matched the numerical result.

This greatly intrigued mathematicians. And in 2001 one of the greatest probabilists, David Aldous, proved the result to be correct, introducing a whole series of mathematical concepts to prove it perfectly.

This work was very important because the amount of optimization problems we can face is endless, and these problems became analytically accessible only after this work.

#### 48. A Chinese man on a roll

In the mid-1980s, the smartest and most enterprising Chinese man I have ever met arrived in Rome: Zhang Yicheng.

He was a Ph.D. student, in a country so far away and different from his own, a foreigner, theoretically with no money and no experience. In two days he found a house a hundred meters from the Pantheon. Free of charge. After a few days he was speaking in Romanesco. He wrote and wrote in perfect Italian. And he was capable at the first "Cuccia!" of paralyzing very bad dogs.

I had begun to wonder about situations that had elements of randomness. One could not arrive at a clear theory of a phenomenon called DLA (Diffusion-Limited Aggregation).

Take a coffee stain on a paper towel. The shape of the stain will change each time, even if the paper towel is the same and the amount of coffee identical. It is common experience: there is nothing to be done, the stain will change every time.

Question: why? Why is the shape of the stain different with the same amount of coffee? On a qualitative (i.e., narrative, discursive) level, you can say that the paper towel is made of many fibers that are not put in the same way, some let the coffee through more easily and some less. You don't see the irregularities with the naked eye, but pour coffee on it and you can see them, either with the naked eye or with a simple magnifying glass.

A theoretical physicist wants to understand what is going on. Above all, he wants to have a quantitative theory, not just a qualitative observation.

Same thing when you have cells that grow irregularly (think of tumors).

You have to get to writing equations in which there is a normal, deterministic part, as for an equation about propagation in a homogeneous system, and a part that accounts for irregularities in the material, a random part, in a situation that evolves over time. The coffee spot and the cells change over time, little or a lot.

Can you predict how a coffee stain evolves? Figure out which things depend on the random part and which don't?

And if the paper towel has gradually larger sizes, can I understand and predict how the oscillations of the jagged surface of the spot will change? What is the law that tells me how and why the size changes? A qualitative description could be given, mathematically it was a whole different ballgame.

Zhang and I started from a simplified situation of the problem, but even then we couldn't arrive at a model that worked. And we had almost put a stop to it. Then Zhang had left for the United States, and while he was there I wrote the equation. But I leave it there. I don't really know what to do with it, I can't understand what it implied.

In November 1985 Zhang and Iranian-born physicist Mehran Kardar proposed that I send the journals a complete paper, in the sense that they had gone ahead and found what my equation led to, and what the testable predictions were. A whole new line of thought was being introduced into the surface growth models. This equation had never been written before, and it would be called by our three initials: the KPZ equation.

I was also a little embarrassed; I felt like they had done it all and it was not right for me to sign it too. I tended to value more the part they had done, and I had failed to do, than the initial impetus I had given, writing the equation and doing a very first analysis. However, each of the three of us had made an essential contribution to the work, without which it would never have been written. So it was only fair that we all three sign off.

Almost forty years later, I had forgotten the details. A few months ago - I really didn't remember this - Zhang told me that he had passed through Tor Vergata in July 1985 - he also remembered the day - and I had written the equation down for him on a napkin in the cafeteria, then he had made me rewrite it on a piece of paper so he wouldn't forget. That piece of paper he had kept, and today I have it too in photocopy.

The example that can also be given is that of a cigarette map burning and the burns proceeding in an irregular (disordered) way. We now had an equation for such a system and a new physical law describing it.

The equation comes out in 1986.

And it would prove to be another wildly successful work. A plethora of applications had been found to which this theory was useful.

Thirty years later, in 2014, mathematician Martin Hairer would prove that the KPZ equation was well defined mathematically and would win the prestigious Fields medal reserved for mathematicians under 40 and considered the Nobel Prize in Mathematics for that very reason.

This scientist had had to resort to a whole series of techniques new in mathematics to prove that what we had written made sense.

#### 49. The noise of ice ages

The Nobel motivation mentions the "discovery of the interplay between disorder and fluctuations in physical systems from the atomic to the planetary scale." But to my knowledge the only thing done by me on a planetary scale is a paper on ice ages, ice ages are indeed on a planetary scale.

There are precise measurements of Earth's temperature going back as far as a million years. We know that the Earth fluctuates between cold and warm periods. These are two relatively stable situations: when the Earth is cold there are large amounts of ice, the Earth is white, and the energy coming in from the Sun is largely rejected. When the Earth is hot it is black and it is warm because it absorbs a lot of energy from the Sun. Hot and cold periods last tens of thousands of years. A Serbian astronomer - Milutin Milanković - has explained the complex astronomical reasons why the amount of sunlight reaching Earth varies by one per thousand at certain times and has proposed that this small variation can cause temperature differences of ten degrees.

We are all rightly terrified at the fact that in the last fifty years the temperature has increased by almost one degree. Ten degrees is therefore an enormous change, while the change in the amount of light causing it, if it is one per thousand, is tiny, one would think insignificant. Strictly speaking, doing a simple calculation--on the back of an envelope, the British say--the variation in light of one thousandth should cause variations of half a degree, one degree, nothing so dramatic as ten degrees. The time in which the solar variation returns to the previous situation is one hundred thousand years, which is the same period of time



between one great ice age and another, and the warm and cold periods correspond to Milanković's.

So the problems were: how the one per thousand could shift the climate by so much, and why and how-if these two states are quite stable-we move from one to the other.

One afternoon in 1979 I am at the university. My friend Roberto Benzi tells me: go and listen to Alfonso Sutera's seminar, you will find it interesting.

I was not doing climatology, but I went, I was curious. The randomness at that juncture was total. I might not have been at the university, I might not have met Benzi, I might have declined his proposal, I can easily imagine a thousand other situations where I would not have attended that seminar.

Sutera's theory was that everything was random, sequences of cold years accumulating ice and sequences of warm years melting it. The cause: rare weather events. And he had shown some models according to which it was not inconceivable that on average the passage times would take a hundred thousand years round trip.

Immediately I think: but if ice ages depend on random timing, how come they always occur at the same time interval? This Sutera did not explain.

When the seminar was over he took what was then called the "red circular," and I went with him and we continued to discuss the streetcar. I told him that things were not exactly as he had explained, or rather it had to be explained how a small variation caused such large effects. Add something to his theory.

I was on other business but then meeting Benzi in Physics - I bumped into him coming out of the elevator - I said to him before even saying goodbye (he remembers it as "the elevator speech"), "Ice ages happen with Milanković periods because small variations change the tunnel effect."

I had worked in other contexts on these so-called "statistical tunnel effects," which are the transition from one state to another, going through an unlikely state, so I had experience in calculating these transition times, and I realized immediately that with small perturbations, with a small solar effect, the change could become enormous.

I had the initial insight, however, that I would never have had in my life without those coincidences. But why did this guy get into studying climatology? One would think from reading the scientific journals. And in fact I was not particularly interested in studying climatology. I had gone to

a seminar that I was told was interesting: a good physicist my age a little younger, let's hear what he says. The curiosity of scientists.

The idea was communicable in two minutes, in one minute ... but then comes the real work. You manage to do the extra step that those who gave the seminar couldn't do, but then you have to work at it and a lot.

At that point, in fact, Benzi, Angelo Vulpiani, and Sutera himself started making calculations and writing programs that ran even at night because the computer was freer. (They were stopped in the middle of the night by the police: what are you doing here at this time?)

But eventually the calculations were done and it turned out that my hypothesis was reasonable. There was a small effect that would normally cause half a degree instead produced a huge variation because it controlled the transition from one state to another, in one direction or the other.

We have called all this stochastic resonance. But "stochastic" is synonymous with "random." The point was to establish that there was a need to insert, to add some randomness in the system that was neither too big nor too small, and only when it is so you have the effect we are talking about.

And here we must also introduce the so-called "noise" element.

An example: when you listen to a recorded voice the normal canon says that if there is noise on it it is harder to hear, but it also happens-counterintuitively, but it may be a common experience-that by putting a small amount of noise on it you understand better what the recorded voice is saying.

So sometimes if you want to perceive a signal more sharply, you have to add a little bit of noise. Not too much. Not too little.

There are two ingredients in all of this: a little variation that you wonder how it can have big effects and overlapping randomness. The point was to figure out how all this could amplify the effects, "amplification" being the right word.

We submitted the theory to scientific journals, many rejected it to us because climatologists did not like it. Eventually it was published in a climatology journal called Tellus.

Gradually this became very important, absorbed by climatology automatically, but then it became very successful in different contexts: biology, electronics... We didn't expect it at all. We were not doing signal theory. We had started with ice ages, and for years I was convinced that what we had discovered was limited to ice ages. There and then, in the

very early 1980s, Stochastic Resonance had not struck the imagination. Then it ramped up. The real boom-even experimentally-was in the mid-1990s after work on crayfish tail sensory receptors. From ice ages to crayfish...

Neurons are a good example. They receive a series of inputs and if the signal is not strong enough the neuron does nothing, but if it is strong enough the neuron fires. It is clear that you can have an input that would not be enough to activate the neuron but if you add the right amount of "noise" to it you have a good chance that the neuron will fire.

I am amazed every time when I think how *Escherichia coli*, a bacterium of the intestinal flora only a couple of microns long, can notice that there is a little more sugar on the right instead of the left, an infinitesimal variation, and move in the correct direction. These hosts of our gut would not survive if they could not pick up the signal of extremely small variations and move effectively.

In general: extracting signals from the environment and making them readable for use is a fundamental thing for all living things, starting with microbes.

Stochastic Resonance-born absolutely by chance (talk about chance)-of all the work I have done is one of the most cited. On Google you can find 500,000 results. The famous article in *Tellus* is cited by almost 2,000 scholars.

## 50. The fastest computer in the world

By the 1970s physicists, beginning with the work of Ken Wilson, had developed a formulation of lattice gauge theories that were suitable for numerical calculations. However, it was not clear how to turn this idea into an effective method. By dint of thinking about how the interacting quarks formed the proton and other particles, by the early 1980s, together with other physicists, we had arrived not only at a concrete proposal, but had also made the first calculations, which were very approximate. Then, as the decades passed and with the work of several hundred people around the world, the techniques we had introduced evolved into a precise computational tool capable of obtaining results with great precision.

But in the early days, the consequence of this new point of view was that we could no longer limit ourselves to analytical calculations (the ones you do with pen and paper) to which small-scale numerical calculations had been added since the 1960s-1970s, but we had to move to large-

scale numerical simulations (the ones for which you need the computer and have to deal with the computer's capabilities, cases in which the formulas to be used involve billions of billions of operations). Just to say one: if we wanted to—as we wanted to—measure the mass of the proton with greater precision than we had obtained, we needed computers that were not only more powerful than those that were on the market, but possibly different, better suited to the calculations we wanted to do. We needed the fastest computer in the world. And the only way was to build ourselves a parallel computer at home that could run relatively simply, so many computing units, however, centrally controlled.

Nicola Cabibbo, who had some experience in electronics, was gnawing that the Americans had started and we couldn't get going. We talked about it with great uncertainty from 1982 to 1984 then we decided -- with a good deal of risk -- to do it ourselves.

A U.S. company had made small chips, one for addition and one for multiplication. We bought 64 of one type and 64 of the other.

Many of us had never done anything electronic before, and here it was all the way from designing the machine to building the hardware to the control software.

We were a bit of an Armata Brancaleone, a bit of a formidable team of people who were in charge of various parts of the project.

By a lucky combination, two undergraduates, Pier Paolucci and Simone Cabasino (Daniella's cousin by the way), were experts in electronics and were and are very good programmers. Gaetano Salina, another student, was our hardware expert.

So many of us were on this project. The ones I personally worked with the most were Paolo Bacilieri and Ettore Remiddi in Bologna; Fabio Costantini, Gianni Fiorentini, Maria Paola Lombardo and Lele Tripiccione in Pisa; Donatella Pascoli in Padua, Adolfo Fucci at CERN in Geneva. In Rome Cabibbo, Enzo Marinari, Silvano Petrarca, Federico Rapuano, myself, and the three undergraduates I mentioned above. Various groups, each of which was responsible for a piece, literally. The assembly of the various components was done in Rome.

We organized a presentation seminar in Geneva with Nicola. A great programmer, a supercomputer expert told us: you may be able to make the hardware work, but you will never be able to make decent software that works. He advised us to give up, we persisted, certainly underestimating the difficulties, but in the end it worked out well for us.

In 1986 the machine was capable of doing a billion operations per second, and it was all for us, whereas before you had to struggle to get ten times slower machines assigned to you for four days.

Nicola Cabibbo was the moral head of the project but at the same time he was chairing INFN (they were finishing the construction of the Gran Sasso Laboratories). He had incredible responsibilities and workload (more than a thousand employees, a very significant budget, institutional, bureaucratic obligations, following the budget law, the European Parliament, we always talk about funding and contiguous territories). I was in charge of the project, we worked during the week and on Saturday mornings we would meet with Nicola to discuss and take stock of everything.

From 1986 to 1992 we used this machine to do I don't know how many calculations. However, we realized that our computer-which we christened Ape-was beginning to be old, outdated.

Ape 100 project starts, that is 100 times faster, and it is implemented, but I worked a little bit on the initial design part, then it was not so interesting for me anymore and I left.

An Ape Mille and an Ape Next were also built in 2005, but then it stopped there. Commercial computers were improving so fast that they were unreachable; they had also learned the trick of parallel computing. Lattice gauge theories continued to grow because of the most modern computers. We are now at the thirty-ninth annual international conference with hundreds of participants.

I was satisfied with what I had accomplished in particle physics. Altarelli and I had succeeded in obtaining precise predictions for very high-energy collisions and, in the next decade, for the properties of particles at rest. In less than two decades I had contributed to the fact that accurate predictions were possible in many regions of particle physics. My attention at that point shifted to other problems, and I no longer worked in that area. I transferred the techniques of scientific programming and numerical simulations that I had learned at that time to the study of spin glasses.

## 51. Beware of the gorilla

I had proposed to call it Ape because in Italian it means both the insect and the famous van, and in English "big anthropomorphic ape," gorilla, or gorillone, as an acronym for Array Processor Expansible.

There were AdA and Adonis in Frascati, which is quite hilarious as a couple.

I mean, we physicists have a lot of fun with names, with acronyms, with puns. Usually self-deprecating, not to take ourselves too seriously.

Gluone in English comes from glue (glue), so it is a "collon."

Not to mention the Unified Theory, the unobtainable (for now) Theory of Everything. In Italian the pun is not understood but it is called Theory of Everything because the English acronym is TOE (Theory of Everything). But toe (big toe) in English means big toe.

The Theory of Everything would, in the end, be but a little toe.

## 52. These children

The birth of children was the greatest emotion of my life. So much so that the arrival of Lorenza - the first moreover, whose gender we did not know until the birth - caused the memory of the chilling images of the Bologna massacre, August 2, 1980, to be removed from my memory. The dates overlapped with incredible precision. It was the last days of Daniella's pregnancy and it is as if all memories and emotions were sucked up by that event. On August 4 - my birthday - in Anzio Daniella begins to have the first signs of childbirth. On August 4 there is the oceanic demonstration in Bologna after the massacre. Back in Rome, Lorenza is born on August 6. On August 6 in Bologna there is the equally oceanic funeral of the victims, in Piazza Maggiore, attended by President Sandro Pertini. While all of Italy watches those images moved on television, I, moved, cannot take my eyes off Daniella and my newborn daughter.

Leonardo would arrive eighteen months later, on January 29, 1982.

So, we had just returned to Anzio from San Felice Circeo, we are having lunch at my parents' house on August 4. I was sitting in an armchair and Daniella's water breaks. We went back to Rome, the next day, the 5th morning, and we went to the hospital together. It was decided that if the birth did not occur spontaneously as early as the 6th it would be stimulated with oxytocin.

On the 6th as expected they do oxytocin, contractions come. At 1 p.m. we are in the delivery room, yes, I was there too, not really in the delivery room but in short I could see what was going on. I was so excited. I see the little head pop up and for a moment it gets stuck, a cut is quickly made and Lorenza is born.

And with Leonardo it will be the same, a very, very strong emotion.

### 53. Names

Names have always been very important to me.

So, in both cases there were very long discussions with Daniella about what to call our children.

Until the birth, as I said, we did not know Lorenza's gender, so we waited to discuss the name. The names Daniella liked were Irene and Viola. I retorted that Viola reminded me of the color of Lent and so no, to Daniella it reminded her of violets instead. Irene I did not want because I had recently read the Secret History, a booklet by Procopius of Caesarea against the Emperor of Constantinople, Justinian, and he had a very naughty wife named Irene. It was a slip of the tongue, but I realized it later. The empress's name was Theodora, who knows why in my head it was Irene.

I didn't have any particular preferences, more like vetoes. Eventually we agreed on Lorenza, Delia, Viola. With commas, so that the name would in fact turn out to be just Lorenza. To both Daniella and me, Delia did not remind me of the most beloved soubrette of my childhood days, Delia Scala, but of the island of Delos.

Several names were in the mix for Leonardo. One was Giacomo, but we had to take note of the very strong objection of our domestic helper, whom we were so fond of that we considered her for all intents and purposes part of the family and therefore had a say. I just liked the name Leonardo; I wasn't thinking of the author of the Mona Lisa. But my name is-this nobody knows and you can't even find it on the net, no use looking it up-Giorgio, Leonardo, Renato. Always with commas.

I don't like dynasties, I didn't want to call my son by my middle name. We got to the last one, to the registry office, like Lorenza. And the name Leonardo won the race.

### 54. Removals

With two children so close in age, you don't have to do too different things with one and the other.

Around the age of 2 they went to daycare, we chose a Montessori daycare, we liked it, and then until they were 3-4 years old you couldn't send them to public ones and we wouldn't get on any ranking list.

Upon returning from Paris Daniella and I had moved back to live in Trastevere, on Via dei Fienaroli, where there was also the famous Bibli bookstore, now unfortunately permanently closed, for many years an important literary and cultural gathering place.

Then, in 1984, with two small but fast-growing children-Lorenza was 4, Leonardo 2 1/2-we began to feel cramped in the house in Trastevere. We moved a little bit outside again, heading north, between the Salaria and Viale Libia where we still live today.

Residential construction, a big enough house, almost too big now that they no longer live with us (there is one room we never use), a bright house, not very bright, five-story buildings, we are on the third.

We sent Lorenza from age 2 to 4 to a Montessori, then to public kindergarten. Leonardo to a Montessori until age 3 then public kindergarten also, the same as his sister. An elementary school also Montessori. With very good teachers, with whom we kept in touch for a long time.

We both worked, Daniella had stayed at the Constitutional Court and would remain there until retirement, although for a long time in Rome she had done a lot of work on her doctoral dissertation. In French. Eight hundred typewritten folders. A huge amount of work, first all in Italian, then translated with the help of a professional translator.

I was also a typist. I spent a lot of time typing his thesis.

55. Calvin (in the sense of Italo)

On what time to put them to bed, Daniella with our children was more conciliatory. I tended to put them to sleep earlier.

Once they were settled in their respective beds, I sat in a chair in the hallway near their open door and read a fairy tale. They in the dark room, me in the lighted hallway. Reading Calvino.



I had been very struck by a book, *Morphology of the Fairy Tale*, by Russian semiologist Vladimir Propp, which Calvin himself quoted. I was interested in his discussion of the structure of fairy tales. Likewise, I greatly appreciated Marcello Bernardi, his illuminating *The New Child*.

I mean, I thought fairy tales conveyed values, and the child then needed to reflect on them. So I was not reading more than one fairy tale a night. And I had chosen the two hundred Italian fairy tales of the folk tradition -- as the title accurately stated -- collected and transcribed "in language" by Italo Calvino. Being two hundred, after less than a year you could start again as if they were new.

Some are popular versions of many fairy tales we know, ranging from *Beauty and the Beast* to the *Three Little Pigs*, from *Little Red Riding Hood* to *Cinderella* but also echoing Greek myths, such as the story of *Perseus and Medusa*, or *Ulysses and Polyphemus*.

I infinitely loved this concluding reflection by Calvin:

Now that the book is finished, I can say that this was not a hallucination, a kind of occupational disease. Rather, it was a confirmation of something I already knew in the beginning, that something I alluded to earlier, that one conviction of mine that drove me on the journey through the fairy tales; and that is that I believe this: the fairy tales are true. They are, taken all together, in their always repeated and always varied case histories of human events, a general explanation of life, born in remote times and preserved in the slow rumination of peasant consciences down to us; they are the catalog of destinies that can be given to a man and a woman, especially for the part of life that is precisely the making of a destiny: youth, from birth, which often carries within itself an omen or a condemnation, to separation from home, to the trials of becoming an adult and then a mature one, of confirming oneself as a human being. And in this summary design, all: the drastic division of the living into kings and the poor, but their substantial equality; the persecution of the innocent and its redemption as terms of a dialectic internal to every life; love encountered before knowing it and then immediately suffered as a lost good; the common fate of being subject to spells, i.e., of being determined by complex and unknown forces, and the effort to liberate and self-determine understood as an elemental duty, together with that of liberating others, indeed the not being able to liberate oneself by liberating oneself, the liberating by liberating; fidelity to a commitment and purity of heart as basic virtues leading to salvation and triumph; beauty as a sign of grace, but which can be hidden in the guise of humble ugliness like a frog's body; and above all the unified substance of the whole, men beasts plants things, the infinite possibility of metamorphosis of what exists.

I tried other stories but liked them less. We went on in Calvin. Until three fairy tales - only three and only for them - I had even written them. One in

which the sister saves her little brother from the wicked witch, another again with two little brothers as protagonists (The Children, the Fly and the Wolf), the third about the grass I want that doesn't even grow in the king's garden, and ends with the king no longer saying "I want" and "becoming kind to everyone."

I didn't read Calvino's fairy tales in order, some were very short, as the children grew up a little friend was born: "How many pages does this fairy tale have?" "Three pages." "Oh no, it's too short." They wanted long fairy tales, and I agreed.

This went on for quite a while.

After Calvino read and reread a million times, I made the experiment of reading the Odyssey in Rosa Calzecchi Onesti's translation; I reversed the cantos, beginning with Ulysses' tale to give a chronological order (had I used the classic, in every sense, Pindemonte's translation it would have been a disaster, with the children). For several months I read, with a few tweaks, that one. Sometimes Leonardo would fall asleep in the middle.

At the time Calzecchi Onesti was the best, in an Italian that was neither courtly nor archaic. Today the new translations are beautiful; I would read the one by Dora Tomasono Marinari, a high school teacher who, once retired, thought it best to use her spare time to translate the Iliad and the Odyssey. Interestingly, her son, Enzo Marinari, later became first my student then my friend and colleague.

Lorenza and Leonardo had made a habit of coming in the middle of the night to our big bed. Often it was just Leonardo, and then I would pick him up and take him back to his room, many times falling asleep then myself lying on his bed waiting for him to get back to sleep. As we got a little older, when they came I would sometimes leave. This must have lasted about ten years.

Philosophically, I used to tell myself: sooner or later they will stop.

## 56. Ladybugs and Cub Scouts

Daniella as a girl had had a very important experience in the AGESCI scouts. So we also enrolled Lorenza and Leonardo in scouts, at ages 10 and 8. In spite of everything, the Catholic scouts seemed to us to be more open than the lay CNGEI scouts. The values they conveyed were solidarity, things like that, and we were more than okay with that.

We were not married in the church, the children had not been baptized, and so the agreement with the scouts was that they would not make any demands with respect to religious faith and practice, the only thing was that when there were communal activities they would participate, including Mass.

Lorenza continued until she was 18 and would have gone on again, but at that point, at the highest levels of responsibility, one needed to be Catholic.

Leonardo, on the other hand, left when he was 16. He had told me that they had kicked out all his most important friends; his had been an act of protest and at the same time an act of solidarity with his classmates, regardless of the fact that at that point he no longer had any friends his own age. Then he liked the outings, but of going there every Thursday he had begun to get tired.

Same with skiing. While Lorenza continued to come skiing with us, teenage Leonardo decided that he was much better off in Rome a week or two without his parents than in the snow.

## 57. The New Life

The birth of children changes life completely, it's a whole new thing, once you bring them into the world it's not like you can get distracted and say now I have something else to do. It is a huge assumption of responsibility, also an act of optimism towards the future, and making sure that their future is good becomes your main commitment.

I think I was a very present father.

The children I kept so much, I took care of them on so many occasions.

I was from the beginning very involved in their upbringing and the new family organization. After breastfeeding, I was the one who prepared the bottles, and the first feedings.

I used to take them for long walks.

I accompanied them to school, from kindergarten to elementary school. In middle school they went alone, they were old enough and the school was very close to home. From the balcony you could see all the way from our front door to the school.

In elementary school they would eat lunch at school then from middle school they would come home instead. Daniella always stopped by the office, we had a domestic helper, but I was sorry not to be with them. Partly because of that in 1992 from Tor Vergata - very far away, off the Raccordo Anulare - I moved to Sapienza. I could stay with my children at lunch then go back to the university.

There was also the fact that I had been working away from home for 20 years. Frascati first, Tor Vergata later. I thought basically I've already given, maybe I can afford now not to spend almost an hour and a half in the car every day.

I admit I was particularly pleased that Leonardo in a video interview immediately after the Nobel as the first thing he told reporters, "My father has always been very present, think he would run away from the university to have lunch with us then return to the university after lunch."

Of course, when they grew up they were the ones who were never home.

## 58. Rites of passage

Accompanying Lorenza in growing up was quite easy. She seemed to have none of the typical anxieties of adolescence or at any rate not to use parents as the classic punching ball.

Leonardo, on the other hand, was a textbook child and teenager.

It quickly became clear that Leonardo was not Lorenza.

We got him into first grade early, but it had gone badly, he had no desire to study, to do his homework. When we asked the teachers to send him to second grade, they told us, "Look, it's not really appropriate, he has to repeat first grade."

He was stubborn, if something didn't amuse him there was no way, you can imagine the school problems he encountered. Starting with the great struggle we had to make him learn to read and write.

I used to try to get him to read Verne's books, one piece I would read and one he would read, but even for those pages that had enthralled me he felt very little interest. He loved to hear about reading, but he didn't want to know about reading. Daniella on this was very insistent, I a little less so. The more you insist the more the boys do the opposite. And how

many battles during the summers to get him to repeat the multiplication tables he didn't learn.

I mean, this business that he didn't like school so he was doing badly went on for quite a while, clash after clash until maturity, which turned out to be a real liberation for everyone. For him and for us. And of course, as soon as he got a little bit older, he would go out at night, come back at two or three o'clock in the morning, and except that the next day school was out of the question, there were already cell phones and I would start calling at two o'clock in the morning, trying to find out where he was, who he was with, what he was doing...

At some point, all of a sudden, he started reading Bukowski. He didn't like made-up stories, Bukowski conveyed an air of real life, then reading became a pleasant thing for him as well.

Today the relationship with him is good, as is the relationship with Lorenza.

Leonardo left home permanently when he was 30, but by 23 he was also doing in-out for long periods. Lorenza left when she was a couple of years younger, in a rented house with another girl.

I admit that I was very sad, I missed them. But I could understand him, or at least understand-especially in Leonardo's coming-going-that this was one of the possible paths of the autonomy and detachment essential to becoming an adult. I could see my struggle but also his, though so different, both inevitable.

## 59. Seas and mountains

Vacations have always been an important time in Daniella and mine's relationship with our children.

At the Cargese and Les Houches Schools of Physics, for example. I used to teach, then listen to others a little bit, but I had a lot of free time. In Les Houches we had this little house, our own floor of a chalet and around the garden and the forest. Leonardo was 6 months old the first time. There was a little kitchenette where we prepared lunch for him. I didn't get paid for lessons, I paid a token amount for the children.

A trip to the mountains in 1986 has remained famous in our family, with Lorenza who was 6 years old and Leonardo 4. By the time we returned, we arrived that the cable car was already closed and we had to endure a

descent (fortunately not an ascent) of almost a thousand meters. A young student of mine helped me carry Leonardo down on his shoulders.

Once we rented a house near Trieste, a city where Daniella had lived a few years as a child.

We went many times to the sea in Greece (in this case often just Daniella and I).

Of Anzio I have already mentioned, a permanent fixture of our summers.

As our children got older, we got into the habit of taking them skiing at least a week in the winter, possibly even two, at first near Rome, at Prati di Tivo, on the Gran Sasso towards the Adriatic, for two years we also went with Lucetta. Then we switched to skiing in the Alps.

One of the problems, with all these fairly long vacations, was that Daniella had more limited vacations. While we were in Anzio a little bit she stayed in Rome, a little bit she commuted back and forth. In the morning, at the beach, I had to take care of the children.

In 1990 we rented a house together with other families of friends in Ponticelli on the Salaria towards Rieti, fifty kilometers from Rome. The children stayed permanently there and we parents took turns, obviously taking care of our own children but also those of our friends. Now it is just us left but mostly Lorenza and Leonardo go there with their families. A very nice place, in the middle of olive trees. We buy our oil there.

Then there were the long trips, mostly to North America, carefully planned, long periods away from the cities: in 1994 (Lorenza 14, Leonardo 12) to Monument Valley, between Utah and Arizona, in 1996 to Death Valley National Park in California, then to Yosemite National Park famous for giant sequoias and to see Petrified Forest Park in Arizona, in 1998 to Yellowstone and Grand Teton National Park in Idaho.

In 2005, when I won the Dannie Heineman Award, we drove with the whole family from Los Angeles to San Francisco along the beautiful coast at the suggestion of Marco d'Eramo.

In 2012, we toured a dozen canyons for almost a month, including Black Canyon in Colorado, both with the children and with Anton, Guido Ambrosino's son, and with a cousin also from Daniella, Cristina.

In 2014 we went three weeks just Daniella and I from Calgary to Vancouver Island, Canada.

We would rent a car and go.

## 60. Still the two cultures

Lorenza went to classical, Tasso, the same high school as Daniella even though it was not exactly close to home. Leonardo the scientific.

Even with school, everything went smoothly for Lorenza. Except with the sympathetic but utterly incompetent math teacher-he had studied geology and taken only one math exam in college, got the certificate but got the exercises wrong, they didn't come to him, the better ones corrected him while he was at the blackboard. An educational disaster.

In college Lorenza chose Communication Sciences, unfortunately in the year of the enrollment boom, from a thousand the year before to four thousand. The faculty had to rent the cinemas around there for classes, the next year they went to a closed number system, and the enrollment went back to a thousand. He did several interesting things, collaborated with Giovanna Melandri when she was minister for youth policy and sports activities in the second Prodi government, oversaw social pages for Gambero Rosso, then three months at MIT in Boston, a few months at a Finnish university. She taught at John Cabot University in Rome and is now an associate professor in Sociology of Cultural and Communicative Processes, her specific field of research being Internet studies.

Leonardo's path, given the premise, was more surprising. He did Computer Science, he was into computers, we had a small Apple at home that I used for work but they could play games on it. In college he gradually got better and better. The exams he didn't like he took forever to give them, as always, but then everything went well. An experimental thesis after the three-year degree, then a 110-plus for the master's degree, then the Ph.

He got into starling work as I was leaving it, fascinated by the thing itself and also by my former students Irene Giardina and Andrea Cavagna. And he worked with them. Andrea was very strict, giving him lectures that mine by comparison were compliments. Today he is permanently employed at CNR as a researcher at the Institute of Complex Systems.

Two very accomplished people, professionally. And also personally.

## 61. It is Francesca

Lorenza told her mother. Then her mother told me. That she loved a woman. It was 2007, our daughter was 27 years old.

It was a surprise to both of us; she had been in a long relationship with a boy since the age of 18. We didn't expect it at all.

Daniella is the one who took a little longer to get used to it; she was doubtful that it was a definite inclination.

The thing that scared me the most, however, was the difficulty I saw in becoming a grandfather. The lack of children in short, for her first of all, because she loved children very much. You could see it in the way he behaved with the little ones when he was in the scouts.

We got used to it, especially seeing his confidence and the clarity of his life plan.

With her we then talked about it several times, quietly, and I must say that now everything is good, very good, everything is clear, even publicly, everything in the light of day, as it should be.

Certainly I had no objection, it was just that thought of children. I knew that for a person to have children is an important thing, I was afraid for her that this could not be realized.

Then the children came.

Thanks to artificial insemination. Abroad, of course.

We were very much in agreement with this choice, very happy and participated, followed along with the procedures, travel, and pregnancies, all the tests, and so on.

The children are now two. Brothers also biologically because they were born from the same donor. Martino who is almost 5 years old and Teo who has to turn one.

We also have a wonderful relationship with the parents of Lorenza's partner of eight years, Francesca, who is a business development manager in a company. They live in Alghero, and unfortunately with Covid we have not been able to hang out either by going to them or them coming to Rome as much as we would have liked. But we saw each other, we had lunch together, we exchange gifts at Christmas.

The things you do as a family. The things a grandfather does. So many times I went to Lorenza and Francesca's house to hold their grandchild, play with Legos and wooden train set. At his request I just gave him a children's microscope.



I have also told him some of Calvin's fairy tales, now it is his turn to listen to Calvin.

But we were not too lucky. The first few months that I was president of the Academy of the Lynxes, time was really short, soon after that came Covid, and I don't need to remind you how everything became more difficult. Many fewer meetings, the masks ...

Martino is doing very well in kindergarten, he has many classmates with whom he has made friends, he socializes easily, he is overjoyed at school which is a good school. That he has two moms does not create any problem.

Martino is always very happy when we are able to visit him. He is not only very affectionate. At school they taught him to reflect on his emotions, even associating them with colors, so he is a child who says, "I am happy," "I am sad."

The last time we saw him, and it had been a while since we had gone, he said, "Ah, I'm so happy that grandparents came."

## 62. Seeing the mountains

Leonardo and Susanna have been together for about ten years. They lived a little out of the way in the middle of the countryside, but Leonardo longed for a house closer to work and with a terrace from which they could see the mountains. They finally found it, near the Nomentana, not too far from Piazza Bologna.

When they moved in together permanently, Leonardo told me: this is the landline number, I turn off my cell phone at night, so if there is a need... It was understood that that was an official communication without being official. I replied to him -- again not to give it solemnity -- that hopefully I would not need it, and anyway the Nobel communication always came during the day...

Susanna majored in Philosophy, then worked for years in film productions, and finally decided to get her master's degree to teach, which she did, with a research thesis in English.

He wrote it while expecting Jairus, the last born in our family, in January 2022. Jairus, with the accent on the "i" not the "a" as in the Gospels,

where it is told that a certain Jairus, a notable of Capernaum, goes to Jesus to ask him to resurrect his daughter.

I don't know why specifically Jairus. For fifteen years Leonardo had said his son would name him Zeno, he insisted so much. Zeno Zeno Zeno. He had even threatened his sister not to steal that name from him, I mean, he had optioned it. Zeno was Daniella's great-grandfather anyway, that naval officer who died in the famous sinking of the Leonardo da Vinci in Taranto harbor in August 1916. Then Giàro popped up. Ya'ir, I was told, means "enlightens" or "rejoices."

We are also very friendly with his family. Mother Antonella and her partner Alfredo are two very nice, hospitable people, younger than us but we get along well. We have known each other for a relatively short time because the boys, who are rather reserved, took a few years to "introduce" their respective parents to each other. They have a house in Ladispoli near the beach where Leonardo and Susanna often go. Together with Ludovica, Susanna's younger sister, they take great care of Giàro.

We also recently met Susanna's dad, Mom's first husband, who lived many years in Africa and now lives in Bracciano with his wife Teresa. They too are excited about their grandchild.

### 63. A great party done, and one to be done

Lorenza celebrated her civil union with Francesca in 2018 (there is no egalitarian marriage in Italy, you know). Martino was a year and a few months old, beautiful party.

A sunny day, in the unique light of certain late September days. A green clearing in the woods, with trees as backdrops, in the Viterbo countryside. White chairs and tables. A friend of Lorenza and Francesca's officiating the ritual.

From Alghero had arrived Francesca's parents-Mom Claudia and Dad Nanni-and a whole busload of relatives and friends. In all, we were about 100 people.

At noon the brides make their entrance into the park, Martino in the middle, held by the hands of both. Long, all-white dress that of Francesca, white with flowers that of Lorenza.

So many people wanted to say a few words, I didn't think to speak but after Nanni had spoken I said something too. We were and are very close friends with the in-laws.

There was music and we danced. Even a Sardinian dance, in a circle, the way I like it. I also danced with Daniella, while Nanni danced with his wife Claudia.

I recently reviewed the photographs. I found that light and color reflected in our eyes again. There is not a single face from which joy and cheerfulness did not emanate.

Instead, Covid prevented us from properly celebrating Leonardo and Susanna's wedding in November 2021. Even I had come in contact with a positive person and was quarantined.

It was simply bureaucratic, a minimalist ceremony, stripped down to the bone: just the two of them and the witnesses in a City Hall office. No parents, relatives, friends. We then saw the photos, and the bride and groom, who to celebrate at least a little, had both dressed in a mustard yellow, sunny jacket. Susanna with a very original bouquet of flowers in her hand. Toast with a bottle in the street.

In short, an unforgettable wedding in its own way, in the heart of a pandemic, spartanly cheerful.

Leonardo and Susanna promised that as soon as possible they will have a real big party with us and all the friends.

#### 64. China was far away

Invited by the Chinese Academy of Sciences, agreed upon a year in advance, I go to China with much hesitation, from April 20 to June 20, 1980. Leaving Daniella alone in the last months of her pregnancy did not please me too much. But it was hard to give up that trip, and she certainly could not accompany me, besides the fatigue, think if our firstborn had been born in Beijing....

The Chinese scientist chaperoning me was physicist Wu Yongshi, with whom I wrote a paper during my stay.

I'm in Beijing and I say to myself, let's leave a trail. I was sure that by doing a certain calculation a certain result would come, and I said to this Chinese guy who was with me: why don't we try it? It was a paper on

perturbation theory, it didn't seem that deep, but it was actually a major conceptual breakthrough. It was published in Scientia Sinica, both in Chinese and Italian, and also cited in the Nobel motivation.

I, rather than knew, "smelled" the China that was then beginning to open up to the West, the China of impressive economic growth, the China of Deng Xiaoping. Unfortunately, it was also the China that only nine years later would experience the tragedy of Tiananmen Square. The Chinese people I met seemed very open, willingly discussing politics after a period of very little foreign contact. I was talking to professors, physicists, researchers. When I returned a few years later, for a shorter period, the atmosphere had completely changed. They were not the ones who started talking about politics. If you asked, they would answer, without difficulty. But I felt clearly that the need, the urgency, the necessity that I had perceived on the first trip had disappeared, was no longer there.

In 1980, communication difficulties with Italy were still great. I used to write a letter by airmail every two to three days to Daniella, but it would take forever to arrive. And for a phone call you had to book days in advance. Things unimaginable today.

I spent most of my time in Beijing, then went to visit the famous buried statues of terracotta warriors in Xi'an.

Then on to Shanghai.

Then to the "golden city" of Lanzhou.

Then to West Lake near the city of Hangzhou, a lake cited for its beauty by so many Chinese poets.

The Chinese dressed in what was called the Mao jacket, blue for civilians, green for the military. When they came to the West, however, they were all in suits. So in "retaliation" as soon as I arrived in China I bought myself some Chinese clothes, jacket and pants, one light suit and one heavy suit. Then I went to a barber to get a Chinese haircut.

I used to walk around dressed as a Chinese person.

And I was being mistaken for Chinese.

It is the dress that makes the man, more than that.

I was relatively comfortable in Tor Vergata even though getting there was an adventurous journey, terrible traffic jams on the Raccordo Anulare (then the situation improved when they built the Bretella, but I would leave shortly to go back to Sapienza).

In the first two years (1982-1984) we were still four cats, four cats of professors and four cats of students.

I used to go only to teach classes, three days a week.

The university was not so much a place to work in the strict sense as a place to talk. I would tell what I was doing, listen to other people's comments and what they were doing. Discussing, comparing was and is an essential part of the work. But the main thing, the most important thing was to spend a great deal of time staying absolutely up to date with what was going on, reading the scientific literature, knowing and understanding what others were doing.

You have to consider that a lot of time passes between the writing of an article and its publication, four, six months, a year for some journals.

Before the advent of the Internet, texts were cyclostored in universities, two hundred to four hundred copies were pulled out and sent by mail to various libraries around the world. And there were shelves where pre-prints were displayed and changed every week, you could browse both journal articles and those not yet published. This exchange, I would say, is the very essence of scientific research. But let alone how the Post Office worked....

There were two to three institutions around the world that sent around the list of pre-prints to thousands of other institutions, even the small ones, and so you could request the ones you were interested in or send the ones that were requested. Cards like business cards would arrive saying, "Dear Sir, can you send me the pre-print from the title..."

I would sit in the library and spend two or three hours reading.

Very often I had to come home at 4:20 p.m. to pick up the children from school; Daniella would return much later.

Even before that, in the 1970s, when I was not in Paris or New York, I was often at home all day "doing the math" or thinking or reading all the articles I had photocopied for myself.

I used to work often even after dinner; now I have more difficulty doing so.

## 66. Winter countryside

Every now and then it would happen that Daniella and I would pass through the Prati district in the evening, we would see starlings above our heads in the Roman sunset sky, and Daniella would ask me: but wouldn't it be possible to understand how they form those figures with such sharp contours? Don't you physicists have a system to figure it out?

Even with the group that had built Ape we had started talking about it in the late 1980s. And the crucial point was to be able to have a three-dimensional reconstruction of it to understand what was going on.

We began to reflect, a friend took a beautiful artistic picture of starlings flying over St. Peter's. We were getting more and more engrossed.

But on the nose you needed at least 40,000 shots; each photo could fit thousands of birds whose positions you had to take. Managing such an undertaking was impossible: because of the time, the amount of funding, the number of people to be employed.

It was not possible at that time.

We did it 15 years later, in late 2005, and in hindsight even the computers of that time would not have been able to process this amount of data. All the instrumentation, in short, was still too backward, including cameras.

Around 2005, high-resolution digital cameras came out on the market that could take repeat photos, 8 photos per second. We decided to take off. We put together a group, including two of my best students, Irene Giardina and Andrea Cavagna, but also, among others, some outsiders from the field of physics, two ornithologists, Claudio Carere and Enrico Alleva, as well as economist Marcello De Cecco. And of course Nicola Cabibbo. We asked the European Union for funds, and the funds came.

Starling flight was an experimental physics problem, and I had always been a theoretical physicist. But we soon discovered how important my skills and long experience in matching problems, statistical mechanics, and optimization were.

The technical problems were many and complex. Cameras that had to be perfectly aligned (we did this with a fishing line, Andrea used to fish in Pantelleria and was used to handling it), shoot in bursts, be synchronized with great precision. Then we had to follow the bird as it moved, and identify it with certainty on one photo and on the other.

Considering that the distance of the birds from each other was about one meter, the machines had to be placed 20 meters apart for good resolution.

Where could we have put them?

We tried with the ENI building in EUR, but the conditions were not there.

The Palazzo Massimo - home of the National Roman Museum - overlooking Termini Station was perfect. That was also perhaps the main gathering point for starlings in the evening, it had a terrace that seemed to be made especially for us, and eventually they even gave us a closet where we could leave some of the equipment, the less valuable stuff (the cameras we took with us), the professional tripods and things like that.

None of us had ever done such things before.

We found that 5 photos had to be taken per second with the accuracy of one millisecond. A total of two cameras 20 meters apart and a third back up to identify a bird when two overlapped in one of the main cameras. If you have one photo with 2500 birds and another with 2500 birds taken immediately after, which is the bird in the before photo and the after photo? Because you want to follow that one.

There were these "winter campaigns" where you had to go to the roof-terrace, assuming it didn't rain, stay there two hours, 40-50 days when all this could be done. Starlings come in November and leave in March. On the terrace the younger guys used to go there. I didn't.

Then we began to analyze the data, all this accumulated body of observations and information.

In a couple of years we got the first results. Unexpected ones. That the flock had a flattened shape, not a round one (actually a hunch of Cabibbo's), that the birds kept a distance from each other from 80 centimeters to 2 meters depending on the situation, most importantly that the birds adjusted their movement only on nearby mates and the information they received from them. What might have seemed like wonderful, fascinating, extraordinarily choreographed behavior, coordinated evolutions as if in a very complicated but also very harmonious dance that was the result of collective intelligence, was the product of individual rules: each bird only watched and oriented itself with others close to it without any idea of the structure of the group. What we read as an overall alignment is only the result of the alignment propagating from bird to bird. There is no choice of the flock-from changing direction to landing-that is not determined solely by the information that, very quickly, spreads from bird to bird and then shows us a collective, global figure.

Not only that. It turns out that each bird relates to a fixed number of neighbors, about seven, regardless of their distance. This contradicts naive physical models based more on distance than on the number of mates in flight and flock density. A predator attack changes the shape of the flock and its density. A flock widens and narrows to escape hawks.

When the work was fully under way I detached myself from it, there was no longer so much need for me and it was not my specific field of research. As I recounted, curiously and quite coincidentally, when I left in the group my son Leonardo came in and took over his field, that is, the whole IT part.

We had trouble publishing the first article on starlings. Neither Nature nor Science - journals with an axe to grind - wanted to know about it. Then we published it in the journal of the U.S. National Academy (of which I had been a member since 2005), PNAS, which in a hypothetical world ranking of the most accredited and prestigious journals comes right after Nature or Science.

The success was extraordinary. The article is cited in 2,000 scientific publications.

## 67. Math you don't know what you're talking about (good thing)

In the years between 1980 and 1990 a number of new ideas I had brought out. The work on spin glasses went on with new calculations, new computer simulations, new understandings and applications far and wide.

As all this work continued and deepened, I began to work on what could be called contiguous, and partly overlapping terrains-optimization, satisfiability, collective behaviors, disordered systems, matching, real glass, hard spheres... - all of which can ultimately be traced back to a new vision of "complexity." I involved mostly Marc Mézard, then Riccardo Zecchina, then gradually so many others.

To try to explain the problems I studied I want to start with Bertrand Russell.

Bertrand Russell said that mathematics is that science where you never know what you are talking about. It sounds like just a figure of speech; it really is, and that is its strength and extraordinary usefulness.



If  $2 + 2$  meant only 2 apples + 2 apples = 4 apples that would be the end of it. We would know how to count apples and stop.

But since  $2 + 2$  does not apply to something specific, somehow "you don't know what it is talking about," we can use this calculation for everything: 2 elephants + 2 elephants, 2 ashtrays + 2 ashtrays, 2 electrons + 2 electrons.

This abstraction ability of mathematics is fundamental. We often start with an ideal situation, schematize it in mathematical formulas, and then go on to study the formulas, forgetting about reality. For those who have to study formulas two completely different real situations are the same thing. As I recounted, but it still strikes even me, the Stochastic Resonance mechanism we had discovered for ice ages was applied such and such to the movement of the crayfish tail.

How to be able to divide a group of people into two tables taking into account the sympathy-antipathy relationship between them? Assuming symmetrical relationships, otherwise the solution becomes complicated. If James wants to be at the same table as Francis, but Francis does not want James, the problem is more complex. But if the likes and dislikes are symmetrical, the problem can be addressed.

In the simplest case the people in a room all know each other and their feelings are mutual (in the real world this is often not the case), and at this point an order comes: divide into two groups. It is obvious that everyone wants to be with the people they like and stay away from those they dislike, so an initial division takes place. But then, after a while, if people have time to think about it, they find out that some friends have gone to the other group, and there are disliked people in their own group, so someone picks up and moves. As a result of all these shifts, someone says, buth, all the people who are friends have changed groups, I'll change too, and so a whole series of shifts takes place until everyone is satisfied. Or maybe someone unhappy will eventually remain but they will still have found themselves in the best possible situation, and each understands that moving again would not improve their condition. It should be added that there are so many solutions that are almost optimal.

Transferred into formulas, this tale-or this example if you will-becomes the same problem as the simplest possible model of spin glass.

In the case of a cocktail party with a thousand people where each person has talked to only ten people, among those ten some will dislike some likeable but do not know each other, each will feel indifference toward most of the participants. This large imbalance between well-defined feelings (positive or negative) and indifference makes the calculations more complicated, but basically the method to be followed, with appropriate but sometimes laborious adjustments, is the same as in the previous case. A more complex model of spin glass.

When we have to cram a car with luggage the first time they don't all fit in, if we have a lot of them, then what happens is that eventually I move this one I remove that one I put this other one there ... by doing a little maneuvering you manage to fit everybody in.

If the next day one does not remember how he or she did it the day before, or another person comes along, that person will also probably be able to put them all in, but finding a completely different solution.

This example is reminiscent of spin glasses, but it is more complex than what we know how to study. In glasses, the shapes of molecules are not as varied as in luggage. The crux of the example is that the optimal solutions are sometimes very different from each other.

Imagine we are in the subway. The more people there are the more difficult it becomes to move, you have to move more people, each person who enters greatly reduces the space for movement. Molecules behave the same way. If they have space they move freely then as the temperature changes they end up trapped because trapped are the neighboring molecules. You can't hang from the ceiling freeing up space, the neighbor can't move because you trap him. Neither can the molecules.

Imagine that in the subway, people are clad in very rigid armor. Space is either there or it is not; people are impenetrable. Every person (every object, component, particle in physics) is blocked.

This is a case of hard spheres.

With a doctoral student of mine, Francesco Zamponi, we started studying them in 2005 and came to understand how to solve the problem. After a decade or so of work, we had grown to five working on it. And, surprise: the calculations had the same formalism and the equations were extremely similar to mine from 1979, obviously with extra elements, but that was the theory.

The amazing thing was that the numbers that the theory predicted were in very precise agreement with what was seen in reality. We had expected only qualitative agreement, that is, that we would only be able to understand some essential features of the phenomenon, since we had made decidedly brutal approximations in order to make the calculations. Instead it all came together. And we still haven't figured out why! We do have some suspicions, but we would have to do extremely complicated new calculations to verify their correctness.

Imagine a school with 30 teachers. You have to make the school schedule with everyone's needs in mind. Someone doesn't want Saturdays, someone else says no to the first two hours because they are

not smart enough and able to connect, someone doesn't want too many hours in a row.... The question is, can we meet all these demands? It is clear that with a small number of requests or even someone making none you can make it, but if everyone has fifteen requests you can't make it.

This is a satisfiability issue.

At this point instead of 30 teachers I assume that I have a million teachers, a billion teachers, and I wonder what is the proportion between demands and teachers for which the problem can be solved or cannot be solved. That is, a situation where you can fulfill all the demands and one where you cannot fulfill them all. But how many requests can be fulfilled? This is a problem we faced in a simpler case than this one.

I have to organize a conference, I have a list of so many possible speakers. I have to choose them. I make a round of consultations with colleagues. I ask each of them to make three wishes like Paul must speak, Peter no, William yes, and I guarantee that for each of them at least one wish will be fulfilled. This is called in jargon the 3-SAT problem (3 because I ask for 3 wishes). If the people I consult are few and the speakers are many, it is easy to find the solution; however, if I have consulted so many people, I am in a lot of trouble: there are no solutions.

Trying this in concrete cases, I find that if the ratio of the number of people consulted to the number of speakers is greater than a certain number (satisfiability threshold), I cannot satisfy at least one wish per person. The evidence told us that the number was between 4.2 and 4.3, but how to calculate it with a mathematical formula?

One day in 1999 I go to lunch with Riccardo Zecchina, and he tells me that he is struggling with satisfiability problems, that he finds them very interesting but also not addressable; he has studied them by applying techniques similar to mine but has not been able to move forward. To explain the situation to me he tells me about a simpler model of spin glasses that had characteristics in common and that I had studied with Marc Mézard ten years earlier without success. I, too, tell him that that particular problem cannot be dealt with. But as I explained all the steps to him one by one, I realized that they were all solvable instead, and I told him exactly what had to be calculated. I immediately wrote to Marc, the two of us solved the easier problem first, then attacked the hard problem. In the end it went well, we got to the result. It was 2001.

We calculated for a whole class of problems the satisfiability threshold about which the mathematicians had no idea. The result was that while the mathematicians claimed that the satisfiability threshold had to be between 2 and 7 we calculated it to be exactly 4.256. A decade later the mathematicians were able to prove at least part of these results.

Our solution aroused enormous interest among those who were working on satisfiability and optimization problems. It opened up a whole range of fields and was a huge success in statistical mechanics.

## 68. To infinity

All of this also serves me to tell a fundamental thing about theoretical physics, thus about my work of years and years (and not just my own).

In all of these cases, but it is a typical thing in statistical mechanics, the theories turn out to be exact when the dimension of space becomes infinite, or when you rely on approximations, or when you do computer simulations for example in 7 dimensions (the computer has no problem simulating spheres moving in a 7-dimensional space), which are of course all very different situations from what happens in the 3-dimensional reality in which we are immersed. Then of course you take the theory and compare it with what happens in the real world. It is not easy, yet this method has yielded very important results. Controlling this step well is one of the most difficult things. It doesn't always work, going from the predictions of the infinite-dimensional theory to the one where you take away the approximation is precisely difficult, what you can say is: let's see how well the infinite-dimensional predictions agree qualitatively and quantitatively with what happens in the real world. And then you also have to understand well why it happens the way it does.

You take a borderline case that you can understand all the way through and use it as a springboard for further discoveries.

We have learned this witty and effective method since Galileo.

Galileo went ahead by neglecting friction. In the real world, friction is fundamental. A world without friction is an absolute abstraction. But Galileo's is perhaps the only way forward in the knowledge of certain phenomena.

There is a sentence by Evangelista Torricelli that is beautiful: I make the assumption that motion is frictionless and that objects move with constant velocity horizontally and acceleration vertically. "If then the balls of lead, of iron, of stone do not observe that supposed proportion, its detrimental, we will say that we do not speak of them."

The mathematician and philosopher Alfred North Whitehead, who lived at the turn of the nineteenth century, said that science cuts the jacket of nature, separates the various pieces of a nature that is instead made seamless. In fact, science cuts the jacket apart as a method, not as an interpretation. Then whether the universe "itself" is made of one piece, or well sewn together, who knows.

## 69. The toolbox

The British call it the tool box. For me it is a fundamental concept - I should say a method. I have dealt with so many different problems and fields. Why was I able to do this, apart from curiosity and commitment? Because as one works, does research, studies a problem, one develops and increases skills. It adds tools to one's technical and scientific and theoretical background, it adds tools to one's toolbox that one can then carry with him all the time because those tools will prove useful in dozens and dozens of even very different cases. Equations that turn out to be surprisingly useful in so many far-flung areas, models that apply in different situations, physical-mathematical mechanisms (often without any control on your part), but also skills, experience, knowledge in the broadest sense. Ability to deal with a problem.

Noam Chomsky laid the foundation for modern linguistics by defining certain grammars mathematically in the 1950s. After a decade or so, computer scientists realized that his theories were also very useful for checking the grammatical correctness of computer languages.

## 70. No sandwiches at the polling station

With varying intensity and somewhat intermittently I have also done active politics, or rather party-politics, because active politics in the sociocultural sense I think I do even now, in fact more now than before.

The most distant memory is when, in Trastevere, in the 1981 local elections - a year before I entered Tor Vergata - I was a list representative at the polling station for Democrazia Proletaria (I was voting DP but didn't have a card), arguing with comrades from the PCI but most of all envying them because back then there was still a strong and widespread

organization and to them the party made sandwiches arrive at lunchtime, while we in the little parties stayed dry.

In the 1989 municipal elections, the last ones with the PCI symbol, I was a candidate as a left-wing independent. Among the candidates for mayor of the capital was Enrico Garaci, a Christian Democrat, rector of Tor Vergata, and to counterbalance him they had put me. But I was not among those supported by the party so the votes, if I wanted them, I had to look for them on my own.

I remember being on stage once next to Achille Occhetto, then a block assembly and one at the university that was quite well attended.

I campaigned with Giovanna Marini, we had prepared election cards together. Surprisingly I managed to get two thousand preferences. Which cost a friend of mine who had bet with another friend that I would not get to a thousand, dinner.

In 2005, friends connected to Romano Prodi asked me to write an essay on the university in Arel, Enrico Letta's magazine.

In 2006, Fabio Mussi, minister of University and Research, sought me out. A couple of things I had suggested to him he even implemented. There was sympathy between us.

In 2007, at the DS congress, I publicly support Mussi's motion, with an article in Unity. Then as you know Mussi left, Democratic Left was born, and always Mussi phoned me to ask me to become a permanent invited member of the leadership. Since I had agreed, it also seemed reasonable to me to take the membership.

I remember the mauling of the 2008 policies. My list, La Sinistra l'Arcobaleno-which had every reason to think it would take at least 8 percent-had taken 3 percent, failing to even cross the threshold. The leader was Bertinotti and the list was the sum of Rifondazione Comunista, Party of Italian Communists, Federation of Greens and Democratic Left. The right wing of Berlusconi plus Lega took almost 47 percent, Veltroni's PD ten points less.

I remember Altan's cartoon, "Could it have been worse?" "No."

Indeed.

And there was thinking about the following year's Europeans.

The Association for the Left was born, which later became Left Ecology Freedom. I join and at that time I make perhaps the best political speech of my entire career. I was always in some leading body, intervening, writing articles.

I am at the speakers' table at the press conference presenting the Association for the Left, in Rome, Feb. 18, 2009.

Less than five minutes in which I bring out all my convinced passion, almost without taking a breath.

My being here before you might seem an unusual, incongruous, totally improbable fact. How come a scientist is speaking at the press presentation of a new Association that wants to promote the establishment of a new political entity? It is no accident, though. We are determined to move in a different perspective from traditional politics. Politics used to be a passion but it has become a profession and has driven away more and more those who used to do it for passion.

There has been in the past an increasing separation between the political class and those who do politics in alternative ways, in movements and volunteerism. We want to put an end to this separation, which is detrimental to the left. We want to establish a new political subject that is different from others in form and manner, a political subject that can proudly claim its own diversity. But why am I here? Why do I want to participate in this adventure? I firmly believe that in the world, and particularly in Italy, there is a need to have a strong left that can correct the distortions of capitalism. The world needs the gaze of those who do not consider capitalism a natural fact. Capitalism is not the end of history; it is only a transitory phase in the development of human society. The current economic crisis is also the direct consequence of the weakening of the left, of a faithless capitalism that has developed its worst sides. We have terrible challenges before us: oil depletion, global warming. Humanity must come to terms with the finiteness of the planet's resources and face its transition from exponential development to sustainable growth. It is a pious illusion to think that only the power of the invisible hand of the market will suffice to do this.

But this need for the left, for a left of change, will not be realized unless there is a political subject that is up to these challenges, that is capable of bringing together all men and women of good will, that is capable of gathering the trust of Italians, of arousing their enthusiasm. This new political subject must become the common home of all those who want to concretely change this country and design a new future. We must take up again the great flags of freedom, equality and solidarity. Freedom that is participation, citizen participation in the management of public services, citizen participation in the choices made by politics. We must move from a state that controls the citizen to a citizen who controls, judges and evaluates the state.

We want the freedom of citizens to carry out, according to their possibilities and their own choice, their preferred activity. We want equality of opportunity, an equality that can only be achieved through

factual solidarity. The state must make sure that every Italian boy has the same opportunity to receive an education, even a high level one if he has the ability. It used to be that everything was easier, the left had a dream and it was enough to follow it, we must learn again to dream collectively and work to realize our dreams, without forgetting our everyday problems. That is why we appeal to all men and women who care about the future of Italy beyond current political affiliations and invite them to join us in building a left that changes Italy, a left that is a new party in which everyone counts. A huge task lies before us, one that requires imagination and participation to accomplish but if we are united anything is possible. A better world is possible. We must project Italy into the future and the young people will be with us because the future belongs to them.

At the first congress in Florence in October 2010 there was--simplifying-- a more ecologist side and a more Marxist-socialist side. On the table were two documents with respect to which it was difficult to find a mediation. They entrusted them to me and I am the one to write the final document that will be approved at the congress. I go into the national assembly.

The last act of my political career is a motion that we present in four - opposed to Nichi Vendola's - that loses more or less 200 to 10. We are already in 2012. The majority wanted to stand in the general election together with Bersani (PD) and Riccardo Nencini (PSI), as then happened. I disagreed with that. I wanted unification work to be developed first among the political formations to the left of the PD.

I stopped caring about party-politics. Not because losing to Vendola had prejudiced who knows what glorious political future. The truth was that I had grown tired of it. The feeling was one of having gone round and round in circles - albeit with commitment and conviction - and of great agitation that had not led to concrete results.

Thus, I neither sought to participate in the next congress nor to be part of the new national assembly.

And in any case, it's not like I went running and hiding in a closet. Many relationships remained open, some even very much alive.

And a part of politics has continued to seek me out, if only as a "technician," consultant, call me what you will.

In 1997, Luigi Berlinguer, Minister of Education, University and Scientific and Technological Research, called me to serve on a select committee of seven to eight people. It was supposed to be almost a full-time job instead we were meeting twice a year. The delegated decrees were approved a few days before the fall of the Prodi government, but the key thing - as always - would be the implementing decrees, to which, moreover, we had deputed, precisely, some of the thorniest unresolved issues. With the fall of Prodi all our work or almost all our work went up in smoke; Berlinguer's



successor, Ortensio Zecchino, did not have the same ideas. But perhaps the problem had also been to concentrate Public Education, University and Research on one person. A real folly. Berlinguer had no undersecretaries who enjoyed his trust (and vice versa) to whom he could delegate anything important. And he did not get everywhere, and when he delegated, his advisers boycotted him.

Today, after the Nobel Prize, I accepted the invitation of the mayor of Rome Roberto Gualtieri to chair the Scientific Technical Committee in charge of drawing up the project of the City of Science, in the former barracks in Via Guido Reni, Flaminio.

## 71. Farewell to arms

In the end, I realized that there were not a few civil, social, political battles in a broad but profound sense in which I engaged, sometimes even in the role of outrider.

Back in Italy from Paris, I have been concerned (and worried) about nuclear power, about the (un)safety of power plants. Long before Chernobyl, then, and also the Fukushima disaster, and the referendums of 1987 and 2011.

I must say that at that time I still had no certainties, but many doubts did. I remember thinking it was more reasonable to move toward energy conservation, for example.

I am promoting a collection of signatures to ask the Italian Physical Society to organize a conference on the safety of nuclear power plants. I pull up a few hundred, not a few on such a topic in the late 1970s and with the communication and information tools of the time.

At a conference of the Physics Society in Bologna I file a motion. The presidency, by a really mean trick and later admitted in confidence, challenges it in a false light and it is resoundingly rejected.

I remember a call 20 years ago, in 2002, together with Legambiente for "science allied with the environment against fundamentalism."

I quote a few passages from them because they are very topical--I myself recently reposted them--really precursory, which is no consolation, to be honest, if after 20 years we are still standing there.

With this appeal, we appeal to institutions, businesses, the scientific community, the environmental world, and the entire public to become fully aware of the inseparable link between the progress of science, of a free and responsible science, and the goal of countering environmental degradation that threatens ecological balances, affects the lives of people today, and mortgages the fate of future generations. Although ecological movements have also been influenced by utopian positions, environmentalism, however, is a political thought with a strong scientific bias.

[...] For all this, we rebel against attempts to pit the reasons of science against those of environmental defense. We oppose the fundamentalism of those in the environmental world who express anti-scientific positions and see scientists as enemies. This attitude appeals to irrational and ancestral fears: the fear of "intrusion" into our bodies and minds and loss of identity. At the same time we oppose the instrumental or uninformed campaigns of those who describe environmentalism as a culture that is the enemy of science, of progress, going so far as to deny the scientific evidence of global problems such as the rise of the greenhouse effect and its anthropogenic origins, or of environmental hazards such as energy production through nuclear fission.

Signatories included such prestigious names as Rita Levi Montalcini, Enrico Alleva, Luigi Boitani, Enzo Boschi, Marcello Cini, and Umberto Galimberti.

A more distant memory. It is the early 1980s. NATO decides to install in Comiso, Sicily, the new Cruise missiles, which in fact arrive in 1983. A great mobilization begins, I remember in particular the demonstration on October 25, 1985 on the occasion of the visit of U.S. President Ronald Reagan to Italy.

I get very busy in my natural habitat. This time the Italian physics world agrees, a petition is signed by two thousand people. Amaldi - who on nuclear power plants was against my positions - on opposition to missiles was in favor. We asked President Pertini to be received, and he received us at the Quirinale, listened to us, even went so far as to tell us that he agreed with us but could not intervene.

Among the most active was Francesco Calogero, a very good mathematical physicist, son of the philosopher Guido Calogero, who had been part of the Roman Resistance group and married Ugo La Malfa's daughter. I remember him because Francesco Calogero from 1989 to 1997 served as secretary of the international Pugwash Movement (named after the small Canadian town where it had sprung up), which originated from the manifesto with which in 1955 Bertrand Russell, Albert Einstein, Józef Rotblat and a dozen Nobel laureates in physics urged scientists around the world to denounce the dangers of atomic warfare and promote nuclear

disarmament. When Pugwash received the Nobel Peace Prize in 1995, it was Francesco Calogero who went to Stockholm to collect it. Very important had been the efforts of mathematical physicist Paolo Cotta-Ramusino, also a future secretary general of Pugwash since 2002.

The missiles at Comiso as I said were installed, we had no illusions, but we felt it was important to raise awareness.

To be honest, personally in the 1980s I was not at all comfortable that an atomic bomb would not go off.

One of the sensitive targets in Italy was Monte Cavo in the Castelli Romani. Every now and then I would look at it-I had learned to recognize it-and say to myself, okay, they haven't launched anything yet.

On the end of life, I spoke together with Paolo Flores d'Arcais. By the way, although Paolo did not know that Daniella was my wife, he knew Daniella's brother Guido, who was very close friends with Paolo's brother, Maurizio Flores d'Arcais, a writer who died very young.

I am interested in the issue of denatality. I recently fought against the biodynamic agriculture scam. I intervened for Giulio Regeni, who by the way was a university researcher, and signed a letter circulated especially in the United States (I am a member of the U.S. Academy of Sciences) on the crucial role of public opinion.

I am also a member of the international organization Committee of Concerned Scientists, which is active in protecting human rights and scientific freedom.

In recent months, but before the Russian invasion of Ukraine, with about fifty other scientists, almost all Nobel laureates, I signed a document to say no to military spending and to call for a new international treaty to reduce spending on both conventional and nuclear weapons. The slogan is: "More funds for humanity's emergencies, less to weapons."

We all remembered the 1968 Nuclear Nonproliferation Treaty, which committed countries that did not possess nuclear weapons not to make them, and those that did to open bona fide negotiations to divest from them.

It had been a success of world politics but also of science, which had clamored for the treaty. In more than half a century, the nuclear weapons available on the planet have been reduced tenfold, thus obviously reducing the risk of atomic warfare as well. It is clear, however - in these months more than ever - that this is not enough. So I join those who are clamoring for a further reduction to achieve a total ban as soon as possible.

## 72. The future of the country

In 2016 we are beginning to have many of us come out publicly to claim adequate public funds for research.

A dense exchange of e-mails began, about a hundred of them, leading to the idea of launching a petition in Nature, addressed to the European Union, which was asked to urge national governments not only to fund research but also to keep their commitments. It said among other things:

We call for the European Union to push governments to keep research funding above the subsistence level. This will ensure that scientists all over Europe can compete for Horizon 2020 research funding, not just those in the UK, Germany and Scandinavia. Some member states are not holding up their end of the bargain. Italy, for example, is seriously neglecting its research base. To avoid a distorted development of research among EU countries, national policies must be consistent and ensure a balanced use of resources.

The prestigious journal published the petition on February 4, 2016, signed by Giovanni Ciccotti, Duccio Fanelli, Vincenzo Fiorentini, Stefano Ruffo, among others. I sign it not only as an adherent but as the corresponding author, the author who handles the correspondence, somehow the coordinator of the initiative.

At this point I am even more personally committed. I launch a petition on Change.org, addressed to the Italian government, with the title "Let's Save Research." The text reads, among other things:

Europe is currently asking governments to respect limits on the budget, but it should just as strongly demand from national governments a minimum threshold for R&D funding, as called for by the Lisbon European Council (2000) and the Barcelona European Council (2002), which set it at 3 percent of GDP by 2010. The Italian government has made this commitment not only to Europe but also to Italian citizens and has an obligation to fulfill it. We demand that the next government implement as a matter of urgency a multi-year plan to raise R&D spending from the current 1 percent up to 3 percent of GDP, and that it abide by it in the future by reaching, albeit with a great delay, the Barcelona target.

I use Facebook a lot and organize a conference in Rome. Almost full-time work for a month. And this time we get to 170,000 signatures and a video made by Piero Angela. A very nice thing also happens. I had met the great Altan at the Nonino Prize. I ask him if, as a token of support, he would give

me one of his very valuable cartoons. And he, very kindly, sends it to me. There are two gentlemen in lab coats, one standing and one sitting at a desk in front of a microscope. The joke is, "How is the research going?" "Everything is found except money."

Already in the document for Legambiente there was, after all, great attention to these issues.

We wrote:

In our country, science has never enjoyed the prestige and attention that would be due to it, and the demand for research on which funding depends (from governments but also from business and public opinion) is extremely low: this is why scientists and technologists, in a perennial struggle for survival, often tend to take refuge behind bulwarks made of absolute certainties, behind an axiomatic and determinist vision of science. However, these reactions end up reinforcing in public opinion that image of scientists as sorcerer's apprentices, which is precisely one of the causes of the fragility of the scientific research system in Italy. We believe that it is necessary to overcome this opposition, and to revive a strong dialogue between the scientific community and the environmental world. A strong public and private investment in research and the development of technologies derived from it is needed. The need for a stronger investment in research is all the stronger in Italy, where the share of GDP devoted to these uses is much lower than the average in industrialized countries.

I also went back over it in 2005 just at Nonino.

Italy ranks last in Europe for per capita spending on research and development. Countries like Finland, which make a forward-looking policy, invest about three times more than Italy: as a result of this policy in Northern European countries there is a migration of tens of thousands of highly skilled people from countries like ours, where schools still work well (but I don't know for how long), but research is poorly funded, and even those who finish their studies brilliantly cannot find interesting work.

The most serious damage caused by the lack of research funding is not so much the difficulty in buying new equipment (for a few years we can make do with older equipment, we can get European funding). The real disaster is the near impossibility of giving permanent positions to our young people before they reach the age of 35 or 40 (in other countries the situation is completely different: in France researchers are usually hired before the age of 32). Bright, trained young people are not an easily renewable resource: we cannot tell them "for five years go do other things and then we'll talk about it." They may be doing other things, but after five years they have either gone to more welcoming countries or have no intention of returning to research.

Responsibilities unfortunately are not only governmental; sometimes university professors use their position only as a springboard to gain more prestige in society or to increase their power and favor their students regardless of their abilities. This is a widespread malpractice in many circles, which unfortunately tends to worsen, fostered by bad legislation, when it should be combated with great determination.

The result is not only a detriment to our culture and the country's ability to develop, but also an injustice in the organization of society. After all, the basis of a truly democratic system lies in everyone being equally enabled to engage with all the various opportunities the country is able to offer its citizens. In academic and research careers this is not the case: there are clear generational jumps and there are generations that have practically not been allowed to participate (thoughts go back to the early 1980s, but also to these last few years of ours). This insanely infringes on the right that all young people should have, regardless of their fortuitous date of birth, to realize their aspirations if these are commensurable with their abilities: young talents born in certain years have had their access to research closed off even though they were very capable of making important contributions. An invaluable asset to the country's culture has been lost.

### 73. Steps forward

About 20 years ago my doctor says to me, if you don't start doing some physical activity, moving around, exercising, you're going to go into premature aging.

This stark statement had impressed me greatly and I immediately took it seriously.

Skiing and swimming were things confined to vacations. I must admit that the idea of exercising in Rome had never even crossed my mind.

I started to walk. For example, from home to the university, which is four kilometers.

The first few times I had to stop, rest, repeat to myself "but when it ends when I get there," then slowly I noticed that the fatigue diminished (the miracles of training), that I had put on a more regular but also faster pace.

I'm relatively close to Villa Ada, I can walk five to six kilometers at a fairly fast pace; then you sweat, of course, after 30-45 minutes of walking

fast it's impossible not to sweat, but when you get used to it you like it, and now I couldn't stop.

I also started going to the gym, but for a few years I stopped, the gym under my house had closed, then Covid came along. But it was an important experience because even then I experienced all the fatigue of the beginnings, of something new and very far from me, gymnastics to the rhythm of music, going right, left, lifting a leg, especially going in time, a very tiring thing, I was doing everything at half the speed of the others, and not being used to singing I didn't hear the musical tempos, I was watching the neighbors, adjusting to them. Gradually I started moving in time, I started group dances. I liked that new relationship with the body.

With perseverance, persistence, things improved there as well.

I had the feeling of not only being able to slow down the aging process, but to make it go backwards, regress. I was able to do things that I couldn't do before. After all, the idea of old age is that you don't learn new things anymore, consequently learning something new even with the body was something I really enjoyed.

#### 74. Dancing dancing dancing

From rhythmic gymnastics to actual dance, the step-that's the right word-was, however casual, a short one.

I was doing group dances at the gym when I discovered on the Nomentana, six kilometers from home, Greek folk dances and it was love at first sight. It was 2004. I attended classes and internships just about everywhere in Rome, I didn't think there were so many. Greek folk dances, when you get to know them better, have an incredible variety: of steps, of sounds, of instruments. Daniella likes certain Greek music very little, the dances interest her but she gets tired of them.

In this way I brought together very strong interests that had always been strong in me, and very far removed from physics: the love of choreography, history and popular culture, Greece-as a place of beauty and cultural background, especially the Greek islands-, not least then dance as a pleasure in itself, pleasure of meeting in a different way than usual people, and letting go, expressing unseen sides of oneself overcoming shyness and inhibitions. From the social point of view it is a very nice thing, you form communities where everyone is fond of each other, you get to know each other slowly.

All of this was and is really exciting.

I realized that I was absolutely bad at dance, but I struggled for a decade or so to learn how to get in time and eventually I think I got by.

Greek dances have the advantage that they are group dances, you hold hands, mostly they are circle dances, the others do what the first one does, you feel with your hands where they are dragging you, you see the others what they are doing, how they are moving...

I had started dancing in the gym and then outside as well, but it was more partner dances, salsa essentially, with some bachata, one year tango but the teachers were boring and had failed to create a good group. To prepare for the salsa and bachata essays I would do as many as three hours of class in a row, and one year I had memorized almost a quarter-hour of choreography, which I would go over in bed as I fell asleep. Sometimes I would go back to dancing even after dinner.

For a couple of years I also practiced lindy hop, an African-American swing dance that originated in Harlem, a predecessor to rock, but even there the teachers were not good enough.

Daniella has tried several times to follow me to these dances but has given up because she can't stand the spins. She comes to see me at the essays, though.

I look on Facebook at all these Greek dances, I realize I had learned them pretty well, and I come across an ad inviting to a "university forró" class. I think it's something for undergraduates, it's in San Lorenzo so attached to Sapienza, I go and find out that university forró was a type of dance that was called just that, but it had nothing to do with the university. I take this one-year course and I find out about forró, I find out I like it, I find out there are many kinds, that it came from the Northeast of Brazil, then it had moved to the South, modifying itself of course.

I also give up lindy hop and throw myself on the forró which - strangely for me - I like even though it is a couple's dance that from the point of view of rhythm is much more difficult, the first few times I was a little ashamed, the one I danced with would do a two three, a two three, trying to get me to go in time.

Teacher Francesca Maiolino was great.

Couple dances at first are very anxiety-provoking, you hope you don't make a fool of yourself: going out of time, not understanding the cue the person leading the dance gives you, having to catch up. Then you relax, although some concentration is always needed. The further you go the more you have a repertoire you do with your eyes closed, that is, your eyes don't have to close so you don't bump into your neighbor, but in



short you learn, you have fun. In Greek dances you hold hands in a circle and it's all about absolute tranquility compared to partner dances.

I had started going to the gym for health. As chance would have it, the free exercise teacher was the same one who taught group dances. It was done. A new passion had been born.

## 75. Crete mon amour

Music can be more or less good, it can be liked or disliked, but it has its own absolutely special, unique charm. All ethnic music has a special charm in it and the more you know and listen to it the more you like it - I think of Cuban music, for example - but Greek music is very rich, there are so many regions and each region has its own music. In fact, a lot of dances are practiced in one town, if you go to the neighboring town you find a dance maybe similar but different.

While dancing Greek dances, while going to my beloved Greek islands, I was also studying my beloved history, and origins, and meaning, and traditions.

I went four times to do seminars in Greece, not in physics but in dance, week-long stays, two a little bit rosewater but two tough ones: seven hours of class a day, with breaks of course, then after dinner we kept dancing. Daniella always accompanied me, some dancing too, some studying plants.

The first time was in 2007. A full immersion on the island of Ikaria (which preserves the myth of Icarus, as the name implies), an island in the northeastern Aegean, next to Turkey. Lessons in English, about fifty different dances (Ikaria, Samos, Crete, Asia Minor), there were Americans Israelis Italians Germans.

One day we went to lunch at a seaside restaurant then started dancing in circles, went out dancing in the street, then back in. It was like a Fellini movie.

Ikaria's dance with the most beautiful text says that "life passes quickly and one must take advantage of every moment."

On the island of Delos-which is an archaeological zone and has no hotels, you can't stay the night, you arrive by boat in the morning and leave at 1 p.m.-once with Daniella we were able to stay over instead. There was a big bar-restaurant that had a few rooms reserved for

archaeologists. Even when there were no archaeologists she had to leave the rooms free for a possible arrival. One day, I just swooped into that bar and asked if there was a room. There was, by then no one could arrive anymore for that day (except by swimming) and so we could have the island to ourselves in the afternoon-very exciting to have these outstanding archaeological ruins that one is used to seeing with so many people all to ourselves-it was like being in another place than in the morning, only a couple of small boats could be seen...the next morning we returned by boat.

Delos was the island where it was forbidden to be born and die so as not to be contaminated. When one was sick one was quickly taken off the island to die elsewhere.

The people of Crete have a pride all their own, which comes from the incredible amount of revolt against the Turks. And the dances revive exactly that. The typical dance of Crete is a warlike dance, the Pentozalis, "five steps," which would take its name from the fifth attempt (or step) to free the island from Ottoman rule. The story told is that the leaders of the revolution would go to the various fairs and folk festivals bringing the dance and at the same time making arrangements for the revolution.

It must be said that this is yes popular music, but composed by people who sometimes have good musical knowledge.

In Kavro Doro, South Evia, people dance to music that has a crescendo in the ending that gets faster and faster and higher and lasts two minutes. If you're not a good musician, you don't compose something like that.

## 76. Complexity

I repeat. My most important scientific contribution I am convinced was inventing new mathematical tools to describe rules and equilibria within disordered systems, and this is what gave great impetus to the study of complex systems.

Of course, it took me a while to realize how connected the solution of spin glasses was to the issue of complexity. And many years and much effort were needed by mathematicians to prove that what I had done was correct. (This is how science proceeds: insights that are laboriously and slowly verified. When you look at the end result, there is no trace left of the effort it took to get there.)

My results have become a model and a theorem. The unpredictable behavior of a spin glass became the paradigm par excellence for all complex systems. The solution I found turned out to be the analysis tool on which much of complex systems theory rests.

What then is a complex system? Physical phenomena. But also biological ones. Or economic. Or social. Almost everything we observe is a complex system, including ourselves. Our brains. Our nervous system. Earth's ecosystem. From the behavior of atoms to the world, to life, to society, all can be defined and understood as complex systems, composed of many elements each of which has different purposes and whose interactions produce ever new equilibria.

I must reaffirm that complex does not mean complicated. An airplane will be complicated, but certainly not complex, because its operation is based on simple laws and a few orders of magnitude. A glass of water is a simple system because its state is determined only by temperature and pressure. A glass, on the other hand, is a "disordered system" because the atoms from which it is made can be in a huge number of different configurations.

I recently wrote that my favorite definition of a complex system today is this: "A system about which we can talk at length. In other words, the more we can say about the behavior of a system, the richer the language to be used, the more varied its description, the greater the complexity of the system." Put another way, "A complex system is characterized by the fact that it can exist in many macroscopic states, all of which are relevant, and that it can move quickly from one state to another. This is precisely why it is impossible to predict exactly the macroscopic behavior of these systems. We have to resort to statistical mechanics, which allows us to obtain probabilistic predictions, giving up the possibility of computing every single state of the system." In statistical mechanics of complex systems, the probability of having certain collective behaviors is calculated and the relationships between them are determined.

The other important element is that in a complex system small changes, small perturbations have large effects, make it go from one state to a completely different state, which is typical of so-called "chaotic" behavior.

Finally, nothing like the physics of complexity has made us realize the importance of "cross-fertilization of research fields, even those seemingly far apart."

And so my, our "toolbox" has been greatly enriched: mechanisms, modeling, different looks from the past have been added to mathematical techniques.

In the end what expanded greatly, and along unexpected paths, was not only the level of specific knowledge, but our overall (complex) view of reality.

## 77. Tyranny

Complexity is a messy situation in which there is no global order. But global order would be repetitive therefore uninteresting. For a structure to call itself complex, therefore to be able to change over time, to adapt to the outside world continuously by having an enormous wealth of possible states -- life itself is like that -- a certain amount of disorder is needed.

Clutter and complexity go hand in hand, complexity hates order and at the same time clutter is what allows the system to get to order.

If complexity is simplified to the point that the system no longer has modifiable equilibria-that is, if we lose complexity tout court-the consequences are dire.

Tumor in the cell of a living being.

A disease in the nervous systems.

And dictatorship in society.

My Hungarian friend Imre Kondor reminds us that denying, rejecting, losing complexity is very dangerous, and the nineteenth-century historian Jacob Burckhardt states bluntly that "the denial of complexity is the essence of tyranny."

## 78. The damage of the encyclopedia

I am a hypochondriac.

From reading the UTET encyclopedia as a child, I was mostly left with the dread of having bowel cancer. When I was living in Paris a whole series of belly pains had convinced me that I was in danger of dying soon.

Worrying excessively about one's health does not help one live happily, and if as a kid the UTET encyclopedia was enough to make me anxious, now the Internet is an incalculable multiplier. Google in this is like the bugiardino multiplied by a thousand, it tells you that if you have a headache it may be a bump or a tumor and in between a thousand other gradations, but it doesn't even tell you what percentage headache indicates that you may have a tumor. It makes you smile but then you keep sticking to Google, there's nothing for us hypochondriacs to do.

On the other hand, the idea that through laziness or irresponsibility I have overlooked an important symptom that could cause an illness to be detected in time disturbs me, and this can fuel hypochondria. Where the line between anxiety and underestimation lies, I have yet to find anyone who has been able to explain it to me. I can't be so stupid that then it's late and the doctor tells me why he didn't inform me about this symptom earlier.

The paradox of hypochondriacs is that when they find out they have a moderately serious illness they feel relieved. Finally a certainty. Finally something that can be faced and overcome.

Once, however, I was really sick and risked my life. Around the age of 50, I had to have prostate surgery. I plotted until I couldn't take it anymore. Successful operation. Five weeks later, in the middle of August, in Anzio, at three o'clock in the morning a hemorrhage starts that is quite frightening to see, it looked like the whole house was smeared with blood. I go to the hospital in Anzio, they resolve. But in Rome after a week a second hemorrhage. Back to the hospital again. Back home and again hemorrhage. Six liters of blood transfusion. They stop her again this time but don't understand the cause. And the speech you never want to hear from a doctor: "I'm 53 years old, I've performed 15,000 surgeries, a case like this I've never seen."

Then it finally dawned on me that I was losing arterial not venous blood, that a small artery had been injured: two more liters of transfusion, hemoglobin at its lowest, my hands completely white that regained color as I received blood.

I then also looked at the scientific literature and it really seems that mine was a unique case. That an aneurysm had formed in the internal artery was totally unexpected. I became the protagonist of a medical-scientific article.

It took me a long time to recover. When I returned home for good, our domestic worker started crying, convinced that I was dying and they had sent me home because there was nothing left to do.

I had to leave for Morocco. I thought if it happened to me there-or even in Rome but at night not in the hospital where a nurse was monitoring me every hour-it would not end well.

It is the syndrome masterfully and ironically described in the opening of Jerome K. Jerome's *Three Men in a Boat* (to say nothing of the dog).

It is strange, but it never occurs to me to read an advertisement for patented specialties without feeling drawn to the conclusion that I am suffering from the peculiar disease-in its most virulent form-that forms the subject of the advertisement. At any rate, the diagnosis always seems to correspond exactly to all my particular feelings.

I remember going to the British Museum one day to read about the treatment of a little ailment of which I had some slight attack - I think it was hay fever. I got the book, and read all I had to read; and then, in a moment of oblivion, I idly turned the pages and began to study indolently diseases in general. I can no longer remember the first disease I plunged into - I know it was a fearsome, devastating scourge - and before I had glanced at one half of the list of "premonitory symptoms," I was already well and truly convinced that I was suffering from it.

I stood for a while chilled with horror; and then, in the heedlessness of despair, I turned the other pages. I came to typhoid - read about its symptoms - found I had it (I must have had it for months without knowing it) - wondered what else I had; encountered the St. Vitus dance - found, as I expected, that I had that too, - began to take an interest in my case, and resolved to go all the way, began alphabetically - read about malaria and learned that I had it and that the acute phase would begin in about a fortnight. I consoled myself by finding that I had albuminuria only in an attenuated form, and that therefore, as far as I was concerned, I could still live for years and years. I had cholera with serious complications; and it seems that with diphtheria I had been born with it. I laboriously and conscientiously went through all the letters of the alphabet, and I could conclude that the only disease I did not have was washerwoman's knee.

At this at first I felt a little offended; it seemed to imply a kind of contempt. Why didn't I have the washerwoman's knee? Why this outrageous distinction? After a while, however, less exclusive feelings prevailed. I thought I had all the diseases known in pharmacology, and I became less selfish, and resolved to do without the washerwoman's knee.

Even the dog of the title makes me smile because twice I have been bitten by a dog, with a fairly long series of annoyances. When I lived in Paris I was attacked by an urbanized dog, I was counting one by one all forty days of the risk period of having contracted rabies.

And again this year, the day after my visit with the Prime Minister to Gran Sasso, while I was with Daniella in Rocca Priora another dog

unexpectedly jumped on my leg and bit me. This time the risk seemed zero, but I wanted to do everything scrupulously, the reports, the dog checks, everything.

A friend of mine always says, "They tell you not to worry, you're a hypochondriac anyway. But even hypochondriacs get sick and die."

## 79. Mysteries of science fiction

There is the family. The dance. There are still, in my life, books, literature, music, film. And the old never-discontinued passion for history.

After reading the brick that is the history of World War II written by Churchill, around the age of 30 I had read Ferdinand Gregorovius's ponderous History of the City of Rome in the Middle Ages, full of unknown episodes that had greatly impressed me. Then the history of China, the history of the Soviet Union.

But fundamental for me have always been the classics in the strict sense, the Iliad, the Odyssey. I had also tried Orlando furioso, but halfway through I had gotten stuck, tried again, got stuck again. Too many characters, too intricate a story, perhaps also blamed on my bare text, no notes.

During school I had memorized Eliot's The Waste Land.

By Hemingway I have read a great deal.

And Proust.

And South American literature: García Márquez, the Great Sertão by Brazilian writer João Guimarães Rosa, Drum Rollers for Rancas by Manuel Scorza. These are "discoveries" from the 1980s-1990s, some derived from Daniella.

I was very affected by the dramatic death a few months ago of Paul Auster's son Daniel in Brooklyn. I really like Auster's writing, who lived in the same area of New York where I had also lived, but before I arrived and after I left. Funny that he was there until 1970, I arrived in 1972-1973, he returned in 1974. His novel Moon Palace takes its title from a Chinese restaurant-now closed-that used to be on Broadway and where I used to go to eat every Friday. I clearly don't like it because of that, but the sharing of places, of settings adds to the fascination.

And I also very much loved Black Dogs by Ian McEwan.

And Mo Yan, awarded together with me at the Nonino in 2005.

If I indulge in memories, feelings, and impressions, one of the books I have enjoyed the most is the autobiographical account Diary of a Monkey Man by Robert Maurice Sapolsky, a neurobiology researcher who spent two months a year doing field research studying baboons. He would pitch his tent in Kenya next to a tribe of baboons-whom he called by biblical names: Rebecca, Samuel, Emanuel, Saul-and study them, and study how they changed over the years.

I had read it as a boy and retained a mythical memory of it. I rediscovered it a few years ago: William Somerset Maugham. My father had these books from the 1930s, Maugham had started as a writer of brilliant comedies, then moved on to novels and short stories. The ones I find very good, masterpieces, are the short stories. I remember a collection of a hundred or so, moderately priced, in English, only a few of which were also discontinuously translated into Italian. Stories of a compelling comedian and others that revealed a disenchanted, "cynical" eye on people. Among the novels I had enjoyed The Moon and Sixpence, the fictionalized biography of Paul Gauguin, the painter's life revisited by the author who interfaces it with that of the novel's protagonist.

And then science fiction, always. During the pandemic I re-read almost all of Asimov. Who writes novels that are yes science fiction but that can be approached from the detective genre: there is a problem, the protagonist has to solve it, there are very long discussions about how and eventually the solution is found.

I have also read many detective stories by the Greek writer Petros Markaris, who brought to life the character of Athens homicide squad commissioner Kostas Charitos, a very homely fellow with a wife who makes him the foods he likes. These books show an interesting cross-section of Greek society, which is very close to my heart: immigration, Albanians, the debacle of the crisis. For example, the author lashes out at the Polytechnic students who fought against the colonels and treats them as men who, for a one-day act of courage, have had their jobs all their lives. An author for me difficult to categorize, certainly he is against the mainstream left establishment but he has a leftist attitude for example on the issue of immigration.

Just as I really like Inspector Chen, who came out of the pen of Shanghai writer Qiu Xiaolong, who is strongly anti-regime, branded as an enemy of the government after Tiananmen Square and forced to stay in the United States to avoid repression.

And then I am of those who work well with music in the background, certainly not the kind for which you need to focus on lyrics. When I was in



science, I used to study by listening to Boncompagni and Arbore's Yellow Flag on the radio. I have very eclectic tastes. I like classical music, but also 1960s American folk music: Joan Baez, Bob Dylan, Simon & Garfunkel.

I went a lot to Folkstudio, here in Rome, when it was in Trastevere, sometimes with Lucetta, and also to Filmstudio. Daniella went for a while to Giovanna Marini's Testaccio choir school then she stopped, she was too far from home.

I have a great passion for the music of Giovanna Marini-who, after the election experience, I met many times, including at the Nonino Prize-and for Paolo Pietrangeli and Ivan Della Mea.

For many years we went to the movies a lot, Daniella and I, then a little less, for various causes, one also the possibility of watching movies at home on dvd or streaming. Dvds we have a huge amount, it will take us years to dispose of it.

This is not the place for my complete bibliography and filmography, but I must say that a Polanski film that had greatly disturbed me was The Tenant of the Third Floor. And, in the Italy of opposing heroes and myths-Coppi and Bartali for instance-I loved Troisi more than Benigni. I like Benigni, but Troisi was unmatched.

## 80. Quotes

There are several sites on which you can check how many times a scientific paper of yours has been cited and by whom it has been cited. This is not megalomania or self-aggrandizing vanity. It is also an important working tool.

The number of times an article is cited gives you an idea of the scientific impact of what you thought and discovered, and what your work has produced, perhaps in fields very different from what you had been working on and starting from.

Of course these are, although important, only indications. Acquire some more information. To say something very simple: if you influence a scientist, he quotes you, then those who continue his work, originally originated by you, it is normal that they quote him and not you.

But in this way you, starting from the article he quoted to you, can follow what was done next, what came out of it, what progress was made.

If you deal with a topic that few people are interested in, citations will obviously be few beyond the qualitative value of what you have done. It remains a very useful thing though if you keep in mind that quality and quantity have some degree of overlap. And it gives you an idea of how an issue has evolved over time.

I occasionally take a look at Google Scholar.

The article on the Altarelli-Parisi equation is the most cited, exceeding 11,000 times. For years the average has been one citation a day. I think it is also because it is used for a good part of the experiments that are done at CERN.

The people with whom I have collaborated throughout my life number almost four hundred.

And I have come to almost a thousand contributions, including articles and conference papers.

## 81. Mentor

I cannot say that I do not feel deeply and gratefully the affection of the students towards me (I always have in my eyes the banners, the smiles, the parties after the Nobel), but with equal honesty I have to say that giving courses, teaching about fifty students by giving a monologue, I never really enjoyed it, even though I was doing it with absolute seriousness, preparing handouts and some university texts in English that are still used today in several universities around the world. On the other hand, I was delighted on the rare occasions when I could teach small groups, as a dialogue was created, which was also very instructive for me.

I also loved following undergraduates in their dissertations.

Most of the theses in physics were research papers that generally lasted a year and in small part became publishable, perhaps with some additional work.

I always aimed to give theses whose final result was publishable (then I did not always succeed).

The problem of the advisor's choice of thesis is very delicate, you have to identify something that you see will allow the student to make significant progress (and to understand this you have to have half an idea yourself of how the story is going to turn out), and figure out where, for

each of them, to place the bar: it must not be a compilative work but really new, a real research work, and at the same time it must be doable, doable for their level of preparation and also in an acceptable time, you cannot keep a student who has to graduate busy ten years on a problem. You have to follow them, help them, but at the same time give them space, let them grow.

In the end, if they had worked very well, the thesis would be published, either under their name alone or jointly, because in any case it came to an acceptable scientific level.

In doctoral dissertations even more so. Ph.D. theses are much more challenging, they are often true collaborations, the Ph.D. student is coming to or is already included in a research group, and the thesis rather than the end of a school-university journey is the beginning of a job.

Important for a researcher, for a scientist are the people he or she trains, who share the same interests, more so a style of work, and who will then carry on a common line of thinking to the point of teaching you new things. The teacher helps the student and the student helps the teacher. It is the idea of "school" in the oldest and most beautiful sense of the word. And Roman Physics was a very good example of that. It was for me when I arrived as a mere student, it was for many of my students who later became collaborators, colleagues, friends.

In the end, without rhetoric, you have to know physics well, but ... also people.

Then people know you well, and they often remember things that you had forgotten (perhaps not accidentally). I forgot it, but one of my closest students and friends, Enzo Marinari, he remembers it all too well and continues to tell about it. Once we were returning together from Frascati, it was night and raining and I was driving, and the glass was constantly fogging up. Instead of cleaning it I would use it to write formulas on it with my finger. Enzo is terrified even now. With some reason, I suppose.

The journal Nature has established in several countries a mentoring award reserved for faculty who have been singled out for their particular prowess at "mentoring." Five mentees-who have themselves achieved success (in my case Enzo Marinari, Roberto Benzi, Guido Martinelli, Federico Ricci-Tersenghi and Francesco Zamponi)-report you and explain why you have been a "mentor" to them.

I was particularly happy when on November 25, 2013, President of the Republic Giorgio Napolitano presented me and, ex aequo, Vincenzo Balzani, a very great chemist from Bologna - also, like Cabibbo, an unjustly missed Nobel and by a hair's breadth - with the Nature Award for Mentoring in Science, "for outstanding 'mentorship' activity over the course of his career."

## 82. What magic science

Should science be popularized? Teach it? If so, how? To whom? When? Where?

I know one thing for sure. That, on this point, I am in danger of preaching well and razzing badly. I know another thing, with equal certainty, and I take it from my friend Marco d'Eramo's beautiful book *The Helicopter Shaman*: there is a pseudo-disclosure that is used to propagandize one's own research and that takes on the overwrought tones of advertising.

But in general, the word "dissemination" is not the best word one can use. It suggests that someone has good news and that he or she disseminates it. Science is not that. Then "dissemination," "communication" would be preferable terms.

The problem is that sometimes science is presented precisely in a magical way, and at this point it becomes pseudo-magic, and if science becomes pseudo-magic we cannot then be surprised if people prefer real magic.

Communicating science in an accurate and non-pseudo-magical way - in this a master was Stephen Hawking, despite his illness and all the progressive problems he had in communicating through machines - is an extremely important task.

And I would add that one should stay very far away from the desire to amaze. That is not what can catch on, on the contrary.

It would be important to explain not the single problem, the single theory, the single result or concept but to tell about the scientific method, to make people understand how scientists arrived at their conclusions and how consensus is formed around a certain theory or solution or understanding of the world. There is a continuous interchange, now made faster by the Net, among scientists all over the planet: one publishes a paper, the paper is discussed, challenged, verified, corrected, and so on until it is understood, all at once, that everything works, that - at the moment - that is just the way things are.

Unfortunately, in the general and widespread discontent, everything that is seen as power arouses distrust. Science pays for all this even though it is the opposite of an established power, because there is no who

commands and who must obey, as I just said, there is a slow, complex debate that often lasts for years.

Max Planck said that new ideas become established not because opponents are convinced but because the carriers of previous ideas die. I am not so pessimistic. But it is true that for very new ideas to become established and find widespread acceptance takes time. Sometimes a very long time.

Of course, there is the not simple problem of translating from a technical and increasingly specialized language to a language understandable, if not to everyone, to as many people as possible. While it is true that there is a "spirit of the age" that links art, science, literature, philosophy, there remains a great unresolved difference between these different activities of the human spirit. While the beauty of art, music, and literature tends to reach everyone's heart, the sciences remind me of Chinese artistic calligraphies: the ability to understand their beauty and elegance remains the privilege of the few who have spent long years studying them.

Little or a lot is lost in translation, but it is not by giving up at the outset that one can expect to solve the problem.

All of this is fundamental to (return to) trusting science. And (returning to) trusting science is fundamental.

### 83. The spirit of the time

One thing that is never remembered, and that schools guiltily do not use in their curricula, preferring to teach "subjects," is that there is something important that we might call "zeitgeist."

Quantum mechanics was also born out of a great desire to do something new, something that had never been seen before, to experience new emotions and new looks inside and outside of ourselves.

But when quantum mechanics is born, in the early twentieth century, it is not only physics, or it is not only physics and mathematics that experience this exhilarating desire for the new. Simultaneously moving in the similar direction of breaking established patterns are music, which discovers, for example, dodecaphony; art, with abstractionism; literature, with futurism; psychoanalysis, with Freud and Jung. And so on.

It is difficult, indeed impossible, to read these things as completely autonomous, separate, enclosed only within themselves.

It is even more impossible to understand-without these connections-how the typical curiosity of human beings, their desire for progress, drives history, and ultimately each individual and each specific life, forward.

#### 84. What is it for?

It is the question of questions, right after or right before the question about distrust in science. All right, I have faith, but then tell me what it's for. Tell me what's the use of all these things you study, these abstruse theories you formulate, these incomprehensible equations you write.

I always answer the same way. That the primary purpose of the scientist-and his strongest motivation-is curiosity. But not a pastime, or gossipy curiosity. The "practicality" of science lies first and foremost in understanding and thus being able to control nature.

After that, many technological breakthroughs that have profoundly changed our society (just think of the invention of the transistor, which is the basis of modern electronics) are the result of initially disinterested theoretical studies and were first achieved purely theoretically and only later realized concretely.

It remains true that direct practical applications are often not seen, or not seen right away, or seen-but it is not as paradoxical as it might seem-in fields far removed from those from which one had started in theoretical, mathematical, physical study.

Science today has a unity, and everything that is understood in one field can then be used in another field. And it is difficult to separate what is useful from what is not - eventually it will be understood that everything has been useful - and what research will have applications and what will not.

#### 85. All Children of Mary (Montessori)

But the most important talk for me is about education, schools, young people. And here we should not talk about popularization. The important

thing in schools is not so much the popularization of science as the teaching of science.

Maria Montessori used to say that the child is naturally a scientist, he has to discover so many things, that by putting his finger on the fire he gets burned, to mention just one of a thousand empirical laws that will make him increasingly aware of the world that exists outside him and the "regularities" that govern it.

Montessori thought -- rightly so -- that if one can make this science explicit in the child in a natural way, by having the child have practical experiences with his hands, within his reach, the child already learns the rudiments of the scientific method. So the role of the school is very important, but the methods and programs I see seem old and inadequate. Lectures, exercises aimed directly at a pre-established solution are not up to the challenges of the present. I would think of teaching that is more laboratory-based and that succeeds in inducing curiosity about the world, ready then to provide the methodological tools to satisfy curiosity.

We are moving toward a situation where we will be increasingly dominated by technology. Science has a key role to play in building sustainable development and in having knowledgeable and responsible citizens.

To the boys - who, moreover, often question me - I repeat that only knowledge and culture allow them to understand and thus to live as free men. And then to "have fun," as my teacher Nicola Cabibbo used to say, which means trying to do the things we like.

Called that easy: and who would ever say no? But doing the things we enjoy does not exclude great commitment and effort, and the first effort is to understand-which is sometimes far from easy-what our aptitudes, talents, and abilities are. Making the most of one's abilities. And to try to realize one's dreams, to believe in them, not to be afraid of them.

In order to realize your dreams, you first have to know them, and know your aptitudes, and that is not at all a given. The first thing to do for me is just that, and it's not new: know yourself, try to understand what you like, what comes best to you, what fulfills you. Of course, there are things you don't know how to do at first, and then you learn them. What is more difficult is not to acquire the ability to learn but to understand what your potential is, which being just potential is not explicit.

A famous English mathematician of the early twentieth century-Godfrey Harold Hardy (I had read his Apology of a Mathematician as a boy)-argued that the fundamental thing, the most important thing one must do is precisely to make the best use of one's aptitudes. And it gave him pleasure that the mathematics, the things he did had no application. He was doing number theory. Today, number theory has a lot of applications.

As George Bernard Shaw said, "The wise man adapts to the world, the mad man tries to change the world to adapt it to himself. So all change comes from mad men."

## 86. Maturity

I was, once again, surprised, and very pleased to have found myself in one of the tracks for the June 22, 2022 high school graduation essays.

Happy above all--among the thousands of things the ministry could fish out of me, my history, my writings--about the choice made, the crucial node for me of climate change, in itself and in relation to the responsibilities of politics and the importance of science.

The outline comes from my speech given in the House on October 8, 2021, before the President of the Republic and U.S. House Speaker Nancy Pelosi, on the eve of the U.N. conference in Glasgow on climate, precisely. I had had to prepare that text in a hurry, they were hectic days just three days after the Nobel Prize, as you can imagine, but it was the fruit of long reflections and theses that were and are very close to my heart. That they were included among the topics of the baccalaureate makes me a little hopeful that that heartfelt plea, not just mine, was heard and can be taken up more and more and also quickly.

I think the consequences of climate change drawn by scientists, which are already very heavy, may be much heavier, and the predictions may even turn out to be optimistic.

Then there is the issue of measuring well-being. Today we assess the health of our economy through gross domestic product. But it is not a good measure. Robert Kennedy already said that GDP measures everything except what makes life worth living.

The issue of climate change is also closely linked to those of sustainability and social justice. And to the predictive capacity of science, but ultimately to the responsibilities of policy.

It's like driving in the night; I've said that over and over again, too. Science provides data, illuminates the road like the headlights of a car--aware that even headlight light has a limited range--but politics is behind the wheel, and must try to spot even the dangers that lurk outside the range of the headlights or that may pop up suddenly.



What we have seen so far does not bode well. We are already seriously behind schedule, and there does not seem to be an awareness of what we are up against. But this forces all responsible people to work even harder. Taking refuge in depression certainly does not make things better. We say we cannot afford it. We need, once again, the optimism of the will when the pessimism of reason cannot be ignored.

## 87. The duty to know

There is more than just our curiosity to know, to know. We came down from the trees for something and not just to chat at the bar.

To understand what is around us also means not to suffer it passively. Or rather, not only. Maybe we suffer it just the same, but at least we understand it.

I think it is only fitting that there are people who try to understand and explain how things are.

I think society has a duty to make curiosity-driven science possible.

Certainly we live, we humans, in a very unique condition: a small part of the universe trying to understand what the universe looks like.

Steven Weinberg, who died in July 2021 and won the 1979 Nobel Prize in Physics, wrote, "The effort to understand the universe is among the very few things that raise human life above the level of a farce, giving it some of the dignity of a tragedy."

Everyone has completely different talents and has a duty to put them to use. One is happier, he is better off in the world if he does things he likes. Then there is no hierarchy, whether one is a good lawyer or a good plumber is not important.

However, it is important for society to provide the necessary means for those who want to devote themselves to learning more about nature.

## 88. My cat hates Schrödinger

Einstein could not accept the emerging quantum physics, to which he was certainly no stranger. He was not so stupid as to say that quantum mechanics did not work, but he argued that there had to be a different, more thorough description in which reality was deterministic-as in classical physics-and not probabilistic, which is the epoch-making breakthrough of quantum mechanics. What disturbs many people even today is that quantum mechanics only allows one to calculate not what happens but the probability of it happening. Rebelling against this, Einstein blurts out in the famous line "God does not play dice," to which Niels Bohr, in turn stymied, replies, "Stop telling God what to do with his dice."

Gerard 't Hooft - Nobel Laureate in Physics in 1999 - returns to talk about hidden variables. The fact that experiments are no longer repeatable (what is repeatable is probability), that every time you measure a "system," the result is different, that there are a thousand possible equilibrium states, for 't Hooft and others indicates not that this is how things work but that quantum mechanics is still inadequate, that there must perforce be a hidden "reality" (a word that is very difficult to define and use) and that a more fundamental theory can and should be found that can predict with certainty the outcome of a measurement.

It must be said that this is where science touches to the highest degree (if not actually overlaps with it) a debate that would once have been only philosophical, for example, the issue of free will. The meaning of what exists, the very meaning of the verb "to exist."

And I understand that there is a Facebook page called "My Cat Hates Schrödinger," because the very famous example of the cat in a box that can be dead and alive at the same time and that only the observer brings into one state or the opposite state fits within this debate.

Parallel universes bifurcating, the fact that someone claims that the universe contains all possible stories, both those in which the cat is alive and those in which the cat is dead, and someone is in one story, someone else in the opposite story, all of this seems very imaginative to me.

89. To be and not to be

The verb "to exist."

Something exists.

Until Kant the meaning of "exist" was clear. This exists this does not exist, this has happened this has not happened. Even with Newton it is still somewhat so, but he takes it a step further, or implies a question that philosophers had not yet grasped: are the forces that Newton uses objects that exist or are they convenient for calculation? Kant - I say this at the level of school memories - poses the problem of the thing-in-itself, which is undescrivable, which is unknowable, in the sense that we know its attributes as they result to our mind but we do not know whether there is a reality behind it and how it is.

Kant stands on a ridge, on a transition. Although he does not make it explicit, already in Kant there is the theme of unknowability.

All of this becomes even more important, and if you will, complicated, when electricity, magnetic fields, come into play, and I am talking about classical, nineteenth-century electricity.

One can make a theory of electricity in two different ways: 1) one says that two charges attract with a force inversely proportional to the square of the distance and proportional to the product of the charges; 2) another says that an electric charge produces an electric field and the electric field produces a certain force.

Is this electric field there or not? Does it exist in space or not?

You go in a direction where you have different descriptions of the same physical system: in one there is an electric field, in another there is not. If you ask yourself what exists, if you want to use the word "exist," you start having problems.

And even the word "reality" evaporates, becomes slippery, equivocal, problematic. What is reality? The same question that - not surprisingly - is being asked today by philosophers, Gianni Vattimo above all, who advocate an anti-absolutist idea of "truth" and problematic about "reality."

Even more serious, all this, when quantum mechanics comes along, with formulations in which waves exist, others in which particles exist, formulations in which you describe waves and others in which you describe particles.

In Newtonian mechanics, there was no problem of interpretation: there is a space within which particles move that have coordinates. That space was three-dimensional, we move in a three-dimensional space, and this conception of space is absolutely natural for us. Just as the medieval philosopher could say, "There is that which is observed by God," but to make this statement he had to place something outside the universe.

The word "exist" we keep using but, if we look inside, it vanishes.

90. But why all this?

A scientist, as a scientist, cannot and should not deal with God, so he should not and cannot deal with "sense."

The universe is 13 billion years old, I am just over 70, the universe has millions of times our lifetimes. You can say that we control these quantities mathematically, but not emotionally. It is impossible. We think of-and see, in part-the galaxies that contain from hundreds of millions of stars to a hundred trillion stars. How do we keep all this within us? I think we can and should work as scientists trying to understand how what is around us works regardless of whether it makes sense or not.

The laws of gravity tell what happens if an object falls, regardless of whether it is valuable or not, whether it breaks or not, whether one dropped it on purpose or not. A doctor studying a disease tries to make an exact diagnosis regardless of whether the sufferer is likeable or dislikeable, his friend or not. One must somehow "sterilize" the idea and problem of sense.

Scientific inquiry arose by separating itself from philosophy and purposely does not consider the question of meaning that each of us asks and resolves in our own way. Meaning leads to a scale of values outside what is scientific, observable, quantifiable. We are dancing and dancing. We did not ask to be here and we will give ourselves meaning, values, connected also to the survival of the human species.

One can be overwhelmed by these spatial and temporal quantities (but we know that space and time are no longer so clearly separated).

When one is overwhelmed one tries to change the subject.

I am reminded of the Galactic Hitchhiker series of books, there is a theme that comes back often, many say that if a person really realizes the irrelevance of his or her position in the universe he or she will go crazy.

We are a speck in a galaxy that is a speck among so many other galaxies in a universe that we don't even know how big it is. And so. boh.

Can we get to the origins of this?

Very complicated.

We may be coming to understand the Big Bang, but from here to know whether and what was there before the Big Bang...

To date, the laws of physics are empirical, telling us the "how" not the "why." We know the various properties of the electron but these properties have no intrinsic necessity. Gravity is there and I describe it by Newton's or Einstein's law, but why there is gravity I do not know. We talk about a contingent fact, not a necessary one.

The universe we see has three dimensions, but why it does not have four or two who knows. And to really understand the universe, the Beginning, we would have to answer these questions, these whys, not just, down the centuries and with great effort, describe it more and more precisely.

I am not convinced by the answer of those who say: many universes are possible but in very many universes life cannot arise, probably in a one-dimensional universe life would not be possible and since we are alive we must be in a universe that has the characteristics we know. It's called the anthropic principle and I don't like this argument, I find it a last resort. Sure, if gravity were too weak the atmosphere would go away and we couldn't live, if gravity were too strong the apples falling on our heads would kill us. But that's a fake answer, a way around the real, radical problem. With the anthropic principle we would not have made any progress. The anthropic principle, rather than an answer, is confirmation of the difficulty and fallibility of the theory, of the problematicities in moving forward in this direction.

The same goes for the very fashionable theme of time. One could not say "before" because there was no time. But that is too easy, so it is the dog biting its own tail.

If one could develop a theory in which the various laws were necessary, not contingent, the origin of the universe might be clearer. Today one cannot derive all the laws of physics from a simple unifying principle. If one could get an understanding of the laws of physics as necessary and not contingent it would be different.

If one had a complete theory of physics one could perhaps answer these questions. The so-called Unified Theory should be this. A theory that can describe everything. Or the Everything. It could open glimpses into the mystery.

String theory looks like this, a theory that can potentially describe everything. But from a technical point of view it is a very difficult theory that is not well understood what it predicts, new mathematical advances are being made all the time, new things are being understood in a systematic way, but the goal always remains far away.

It's like swimming--it really happened to me once--and you see a rock in front, you see it small, you swim, you don't know how far away it is, you keep swimming, you get closer, but at the same time you have the impression that it's always about the same distance, after you've swum a while you don't know exactly how far away it is, it may be that if you swim a little more the rock starts to get bigger and you're about to get there or it may take days and days.

String theory is kind of reminiscent of this swimmer. You go ahead, you make progress, but still you can't really get close, understand the fundamental things. String theory is unable to make a prediction as to why space should be three dimensions and not four or two.

If already the things that should be the simplest turn out to be so difficult instead, let alone the rest.

## 91. Uncertainty

It may sound like a paradox, but uncertainty is fundamental in the exact sciences. The very pursuit of the exactitude of analyses and measurements requires knowing their limits with equal exactitude. Uncertainty and certainty are two sides of the same coin. When I make a measurement, a theoretical calculation, most of the time I need is not to get the result but to understand the margins of error.

On the other hand, it would be enough to consider that if a prediction given for certain then does not come true all the credibility of science ends, and with it the trust we should place in science.

Even the word "probability" becomes a complicated thing.

Bruno De Finetti, beginning in the 1920s in opposition to the so-called "frequentist" school, had developed a "subjectivist" conception of probability, with which I agree.

The frequentist point of view says: if you toss a coin in the air, the probability of it coming heads or tails is 50 percent. Then maybe you flip it three times and it always comes heads. But that does not falsify the statement about fifty-fifty. Then you toss it a million times and it comes about fifty-fifty. A billion times and the percentage gets even more refined. The more you increase the number of throws the closer the percentage of heads and tails must get. So the probability is objectively defined by what happens when the number of throws becomes extremely large.

For the subjectivist point of view that heads and tails have the same probability means that to the best of our knowledge there is no preference about betting on heads or tails. From the conceptual point of view this changes a great deal; this is subjective, precisely. Probability quantifies what we know about a phenomenon.

I had given a lecture at the Lincei in which I talked a lot about probability. Immediately afterwards a lady I didn't know approached me and said, you talk a lot about probability, I want to know if you are in favor of the frequentist or subjectivist school. I say absolutely subjectivist. She says I'm glad. And she introduces herself to me as De Finetti's daughter. She used to go around checking who agreed with her father.

## 92. Who was

There is a tendency to attribute to Copernicus and Galileo the discovery of the heliocentric system, which had already been discovered by Aristarchus of Samos in the 2nd century before Christ.

I am very struck by the story of Nicholas of Oresme, a philosopher, theologian, astronomer, bishop of Lisieux but above all tutor to the son of the king of France, so not exactly the last of the last. It is he - and this is the 14th century, a hundred years before Copernicus, two hundred before Galileo and Giordano Bruno - who begins to examine the possibility that the Earth revolves around the Sun and not vice versa and says that it is a logical thing, compatible with everything, even with the Holy Scriptures (which will be the point dolens a few centuries later). He argues-as Galileo would later do-that you can only see relative motion, and not absolute motion, if you are on a moving ship or carriage, in short, if you are inside an enclosed environment you cannot know which direction you are moving.

On the famous biblical example of Joshua ("stop Sun") always brought up in this diatribe, Nicholas of Oresme says very clearly that the Bible is not a treatise on astronomy, that one should not look for astronomical truths in the Bible. Joshua had to make himself understood and if he had said "stop Earth" to those who were fighting he would have been told "what the hell are you talking about, the Earth is already stopped." Nicholas of Oresme gives a blow to the circle and a blow to the barrel: with Joshua God did a miracle and the miracle is yes a vulnus with respect to the laws of nature, the laws of nature are the most perfect that can be imagined and God in doing this miracle tries to interfere as little as possible in these laws. The most perfect laws of nature are those that regulate the motion of the planets," says Nicholas of Oresme, "so God did

not interfere in the motion of the Earth and the Sun, which is most perfect, but he tries to make the smallest possible intervention compatible with his ends. The end was for the Jews to win the battle, and God gave them two extra hours of light there, in that precise place, but the Earth and the Sun did not move them. Then he concludes his treatise with a very strange thing: You see, I have shown you that it is most possible and even most logical that the Earth revolves around the Sun, however I remain convinced to the contrary, in any case the important thing is to show you that things that seem absurd seen with reason can be true. All the more reason for the faithful to believe the truths of faith even if they seem absurd.

I had met someone who had made a remarkable impression on me, the Dutch Dominican Father Van Diemen, who taught at the Angelicum, the university of the Dominicans. One day we went to see him, Marco d'Eramo and I, and we got into a discussion about miracles. If a miracle is a divine intervention that does something contrary to the laws of the universe, then one might say, but couldn't God have done them better in the first place? This whole discussion is a very old story. The Dominican had given an answer that impressed me but certainly not convinced from the standpoint of logic: a miracle is an event compatible with the laws of nature in which the believer sees God's intervention. Oh yes, but at this point one can retort: if it is compatible with the laws of nature what kind of miracle is it?

One hundred years after Nicholas of Oresme and one hundred before Galileo comes Copernicus, and he too is measured by the matter of Joshua. Copernicus was Catholic and fiercely attacked by Protestants. But why? Again, the scandal was not that the Earth revolved around the Sun. What Luther reproached the Catholic church for was being soft on Copernicus because holding together Joshua stopping the Sun and the laws of nature involved interpreting the Bible, interpreting the Bible according to Luther needed a church and that was what he could not accept. To get rid of the idea of the need for a teaching church to establish the right interpretation and to be able to give every believer direct access to the Bible needed a totally literal reading of the sacred texts, a Sun that goes around the Earth and can be stopped by a divine miracle.

Keep in mind that with the advent of printing it had become possible to own a Bible at home.

It is Giordano Bruno-a century later, a contemporary of Galileo, who was born sixteen years later, and of Kepler, only seven years younger than Galileo-who really relativizes the position of man. It is no accident that he ended up burned and Galileo did not.

Giordano Bruno with the affair of the plurality of worlds, worlds inhabited by other sentient beings, from the point of view of reducing human



ambitions is the one who scored the winning goal, who gave the biggest blow.

But Giordano Bruno, who was burned alive in Campo de' Fiori, especially abroad many have forgotten him and remember Galileo who became instrumental in the victory of the Copernican system. Not only that. Perhaps Galileo's most important astronomical observation, from this point of view, is that celestial objects are similar in nature to terrestrial objects, because there was the idea that they were instead substances of a different nature. By showing that there were mountains on the Moon, that the celestial bodies were not perfectly round, that there were other satellites circling around, slowly a completely different idea was imposed, and with the discovery of Jupiter's satellites it was natural to think that the Earth could also have a satellite like the Moon. And at that point the story ends or rather begins.

Many centuries later would come two more strong blows to our big little egos: Darwin, who sets us straight with respect to "where we come from," and Freud, who warns us that the motives for our actions are always as noble as we tell ourselves.

### 93. Having brains

Someone asked me how it is possible for the brain to think itself. And also that it is able to formulate concepts and ideas that it not only cannot understand but cannot even imagine, contain: Nothingness, Infinity, Eternity. How something that by definition is finite can conceive of infinities. From where even ideas of magnitudes - spatiotemporal - that we cannot imagine can come.

My impression is that it is somehow the effect of language. Once you create a language, that language has its own rules, and the rules of the language allow you to do things that you didn't expect and didn't suspect, that weren't within what you already knew when you formulated it. Language has its own autonomy, there are examples of artificial languages (computers) that only after years revealed what they could do, not at the time their structures were created.

Let's take mathematical language.

One divided by zero is how much? Of course it doesn't make any whole number. You can either say the question doesn't make sense or come up with a new number: infinity. At this point you have infinity. Mathematical language has "created," conceived infinity.

Once you have built this formal system you discover that there are questions inside that have no solution, so you extend it, one divided by zero makes infinity, language pushes you to make extensions that are beyond your imagination.

It is language that allows us to think about absolutely inconceivable things, make extrapolations, invent new concepts. It is always language that produces extension and abstraction.

Not all communication is language.

Humans, and even animals, communicated even before language. But it is the birth of language that is the real "leap."

I have never raised monkeys in my home, but I am told that the intellectual abilities of anthropomorphic monkeys up to 2 years of age are comparable to those of children up to 2 years of age, but then they stop there, while in humans a process of incredible leaps begins, connected precisely to the structure of language. Language is not only a way to communicate but also allows for the transmission of a symbolic representation of thought.

Once you have the language of math you can write one divided by zero equals infinity, but what if you don't have the language of math? Then what is this infinity? An extension that you start reasoning about and out come the discussions about infinity in power, in act, the paradoxes of infinity. You conceptualize this infinity as something without end, however what you can really think of is only a finite number of numbers. In the midst of all this lies - if you will also as a paradox - language.

Neuroanthropologist Terrence Deacon has addressed this issue by showing how the human brain and language evolved simultaneously, influencing each other, and how our species is unique in handling symbols. But it is increasingly certain - neuroscience confirms this for us - that the issue of language is decisive when we want to deal with concepts that seem and somehow are unimaginable.

There is a science fiction novel by Samuel Ray Delany, *Babel-17*, that I had read in New York and loved it so much that I then read and reread it several times in both Italian and English. It talks about the relationship between thought and language, how language can influence what you think. During an interstellar war, Rydra Wong, commander of a spaceship, realizes that the enemy is using as a weapon a language that unconsciously makes traitors. The author imagines an artificial language called precisely *Babel-17* that influences not only thought but perception. This whole theme of language plays a major role in the novel and it is beautiful. (I must honestly say that I later bought two-three other books by Delany but they slipped too far into fantasy.)

This is not all there is to it.

Science is successful in the sense that it works, but the philosophical question is: Is it reasonable for science to be successful? We observe the success of science, but we may wonder how reasonable it is for science to be successful.

Physics, the "armed arm" of mathematics. What reasonableness is there in the fact that the laws I devised to see how apples fall must be valid in a universe at enormous scales?

It was Gianni Jona who further pointed out to me the unreasonable success of language. Why does this conceptualization that we do and then put into language allow us to understand the world and move forward? Mathematics is a language, but the success of mathematics is part of the success of language.

Then it can be turned around: why does the world have to be comprehensible to the brain? Perhaps it is the brain that has evolved to make the world comprehensible, and that is already more reasonable.

Think also about dreams, their mysterious complexity.

By association I am reminded of Philip Dick's *But Do Androids Dream of Electric Sheep?* from which the very famous *Blade Runner* was later based. A science fiction novel, but metaphysical and anticipatory of many of these issues that we now group under the macro-category of bioethics.

94. Flying, oh oh

I don't think I am an android, and I certainly don't dream of electric sheep.

But I have recurring nightmares. Not frequent but recurring.

One is to be in a house, hit the light switches and the light doesn't come on.

This dream could also in some way be a dreamlike reinterpretation of a real episode.

Around the age of 10 - I remember it well, we lived in the house on Spontini Street, I slept in a room by myself in a rollaway bed that became

my desk during the day - one night I suddenly woke up and everything was dark. Strange because my mother - who I suspect was, she was, afraid of the dark, though of course she never told me - kept in every bedroom what today would be called night lights, back then they were just little candles like the ones you might find in front of Madonnas. I wake up and see nothing. We had shutters at home, some light always filtered in, at night even just the light from the street lamps. Not this time. I convince myself that I have gone completely blind.

But, who knows why, I don't call, I don't scream, I don't cry, I don't even get up. I stay on the bed, paralyzed by fear but also by the incongruous question, "what do I tell Mom now? That I can't see?" It was beyond imagination. Fortunately, at some point a car passes on the street and the glare of the headlights is projected on the ceiling. I realized that the power had gone out, not only in our house but in the whole neighborhood. Fear passed, but today I tell myself that a person who wakes up in the dark as the first thing he thinks is that the power has gone out, not that he has suddenly gone blind.

The other recurring nightmare is that I am going down the stairs to the first floor but the stairs never end, I go down I go down and the steps are still there, going down, to who knows what depths, while the entrance to the first floor never arrives. I wake up and more than fear of an actual nightmare I feel a sensation as if of embarrassment, of discomfort.

Once, many years ago, I must have been about 30 years old, I dreamed that I had become president of the United States. As I'm giving the inaugural address a boring physicist-one I really knew, in waking life, and who was really boring when he was lecturing-was constantly interrupting me with physics questions. I would say, "no come on, we'll talk about it later," but he kept interrupting me.

But I also have beautiful, crazy, imaginative dreams that if it goes well you remember them the next morning then forget them completely.

Instead, a beautiful and recurring dream that I remember well is that of flying.

Flying.

Sometimes out in the open, over houses, over rooftops, so about 30 meters away not in the deep, distant sky, other times -- concentrating -- I can rise in the room to the ceiling, a levitation rather than a flight, or lift my feet and remain suspended in the air. Sometimes it's all so sharp that in the dream I tell myself it's not a dream, it can't be a dream, I'm really flying. Then I wake up.

It sounds like that Fabrizio De André song, in the Good News, Mary's Dream:

We really flew over the houses,  
Beyond the gates, the gardens, the roads,  
Then we slid through flowery valleys  
Where the olive tree is embraced by the vine.  
We descended there, where the day is lost  
Looking for himself hidden among the greenery.

## 95. Things I'd like to understand

I have often given the example of being able to divide a group of people into two tables by taking into account the sympathy-antipathy relationship between them.

But it really gets much more complicated-and this is what has not yet been solved, which I am studying and would like to understand-if you add to these elements one that was not there in earlier versions of the problem: space. We're still at the spin glasses, of course, at gradually increasing complexity.

Let's imagine that these people are sitting in the movie theater and talking to those next to them and have knowledge only of the small group of people next to them. Then, without moving from their seats, they have to raise a paddle to cast a vote, yes or no, trying to make like nice neighbors and the opposite of dislikeable neighbors. This, from the theoretical point of view, is a problem that to control it in earnest is extremely complicated because precisely an element makes its appearance that was not there before, the space, the cinema space.

When the actors in the game all know each other with everyone at this stage the space is not there. When we have people sitting in a hall, in a movie theater, in a theater, you have to introduce a space into the problem, in this case two-dimensional space, because you are talking to the neighbors on the right and left not above or below, we don't assume that someone will jump up to the peanut gallery or open a trapdoor and find spectators in the under-stage.

When you try to schematize this mathematically, when this two-dimensional space comes into play, when you have to take into account

not only the interactions between people but also how they are distributed in space, the problem becomes much more difficult.

Together with Italian and Spanish friends for a few years now, I have been analyzing such situations with numerical experiments. We have not yet found a clean theoretical understanding. There remain things we have not understood.

Let's also say you've found the optimal situation, the best situation for everyone, and after you've found it two who were friends and were standing next to each other get into a big fight, so one of them you have to move him somewhere else. But if you move him, cascading, you have to move others from where they were before. If the changes stop at four to five, you don't have to redo the whole audience, but questions remain open: how long can you go on, what spatial shape should you have, a group of how many people? In short, you add an extra theoretical dimension that complicates things infinitely, and there are a number of technical difficulties that make the study extremely complicated.

Friends and colleagues as early as the early 1990s had been analyzing possible algebraic calculations. But after preliminaries they had estimated that a million algebraic terms would be needed. A million is too many, and in the 1990s you certainly couldn't do it.

96. See inside

I can invent a new piece of math that has never been seen before and that even to me may seem crazy then turns out to work instead. I can build entirely new physical theories that push our understanding of the world a little further. But that is not enough for me, in fact maybe not even the most important thing.

Insight, the British say. "Seeing into," deep understanding. Suppose we write an extremely complex expression and after fifty pages we find that it comes zero. This is no accident. Either whoever had prepared the exercise had constructed it specifically so that it would give zero as a result or it is there, it must be there, you have to find a shorter way to get to zero.

Why did it come zero? There must be a reason why it is zero. The question is not just doing the calculation exactly, but understanding the deep reason why. Current computers are capable of doing algebraic (not just numerical) calculations-let's put a computer to work one year and find the result. But at that point we still have no insight, we still know nothing about why the result is that and only that. And we want to understand it

instead. And also understand whether the same result can be obtained in a simpler way.

It is not enough for the result to come, I want to understand why.

## 97. Quite

A friend asked me point blank if I am happy. It's not a question one hears asked often.

I answered him: enough.

I would tend to say just that, enough. I'm getting by. It's just that "happy" seems excessive to me. I prefer "content." I would say overall I'm happy.

He was a little insistent; it seemed to be more his problem.

That the term "happiness" is a bit much do you think of yourself or everyone? he asked. I mean, do you think and would you personally like to be happier? Do you think a person in general could feel happier than you do today?

These are not the kind of questions I generally ask myself. These feelings are very subjective. I know that I have been very lucky in life. I am aware that happiness is like the air you breathe, and you realize that you were happy only when you miss it.

I certainly don't complain about not being happy enough, that's not what I meant.

But there are times when more than happy I feel content. Happy with the way things are going for me but mostly at peace, knowing that I did everything I needed to do, that I managed to do the things that were needed.

## 98. After

I notice time passing by small mutations, for example I who used to work often in the evening now realize that this is becoming more and more tiring.

Of old age what I fear most is that I will no longer be able to do the things I like or that there will be no more things I like to do.

You adapt to do different things, discover more, give something up.

Skiing from the morning at eight o'clock until the evening when they close the lifts, as I loved it when I was young, is certainly not something I could do now at age 74 (apart from the herniated disc that made me stop altogether, and with the screws still in my leg that I broke in my 20s).

I did learn to dance, though, and that happened quite a bit later in the years, and I've continued to this day, to Covid, at least.

I hope I have not lost too much in these two and a half years. Last year, at the height of the pandemic, one of the four Greek dance groups in Rome organized an online meeting. Of course, it was not like live, in something as physical as dance. You can't keep your balance while holding hands with your neighbor. It was better than nothing, though.

Of course, the idea of death is very frightening to me; I try to exorcise it by not thinking about it. I am also afraid of the death of loved ones. I try not to think about it, but I am very careful to avoid occasions that I can foresee, I am cautious by character and I do not like to take risks, even though I know that this does not shelter me from misfortune.

I have a definite memory of the first time I really became aware of death. Around the age of 15, I suddenly woke up at night and thought that sooner or later, but for sure, one day I would die.

It was neither a good awakening nor a good thought.

## 99. Owls and larks

I was born on August 4, 1948. It was Wednesday, a leap year.

For fans of this sort of thing, Obama, Louis Armstrong, Artusi, Shelley were born on August 4.

1948 is the year of the Marshall Plan, the assassination attempt on Togliatti, Gino Bartali winning his second Tour de France and the London



Olympics. And it ends - think about it - the rationing of milk and meat that was still in effect. All this within a month before I was born.

A funnier thing is that August 4 is World Owl Day. But I am a lark, not an owl.

When it comes to biological rhythms related to sleep, people fall into two categories: early risers and night owls. The former consists of people who like to wake up early in the morning and feel more productive in the early hours of the day, and the latter of those who prefer to delay waking up and are more active from the afternoon onward.

Early risers are called larks, night owls.

I am a lark, not an owl.

Daniella is an owl.

I tend to wake up early in the morning, unlike Daniella.

I also took classes at the university at eight o'clock without any problems.

But no moralism. Good and Evil have nothing to do with it. Neither do the Best and the Worst.

There is a wonderful little story about Wolfgang Pauli. He had been asked if he could take classes at eight o'clock in the morning. He had replied, "But I can't stay up that late."

100. Asteroid take me away

And now there is an asteroid named after me. It had been christened 1994 CW and is now called (15803) PARISI, and the name was approved by the International Astronomical Union (IAU), through the Working Group for Minor Body Nomenclature, upon the proposal of the Farra di Isonzo Astronomical Cultural Circle. It is a 6-kilometer-diameter asteroid of the so-called "main belt."

That I would win the Nobel maybe I could imagine it, or dream it, but that an asteroid would one day bear my name, no. It is something that excites and moves me.

Although it is not called B-612, I like to think that it is the same asteroid on which the Little Prince lives, the one to which he returned, to take care of his rose, after his brief passage over our planet.

We may discover not only that there is life in the universe, but love. Who knows. That love which the Little Prince did not know and which he learned only on Earth, thanks to the patient teaching of a Socratic fox, and also to that, perhaps even more powerful because it is wordless, of an aviator left alone in the middle of the desert, in tears, waiting (in vain) for his return.

## Credits

For the Heraclitus quote in the exergue we followed Gabriele Giannantoni, *The Presocratics. Testimonies and Fragments*, Laterza, 1969.

The song Van Loon by Francesco Guccini is part of the album *Signora Bovary* (1987).

The song *Viale del Re* by Nino Manfredi is the A-side of a 1991 45 rpm.

Marcello Cini's remembrance was published in the October 24, 2012 manifesto.

The phrase by Ignazio Silone is found in *Uscita di sicurezza*, Vallecchi, 1965.

The book is *Fiabe italiane raccolte dalla tradizione popolare durante gli ultimi cento anni e trascritte in lingua dai vari dialetti da Italo Calvino*, first edition Einaudi 1956 in the series "I millenni".

The quote from Evangelista Torricelli is taken from: *Evangelista Torricelli to Michelangelo Ricci* [in Rome]. Florence, February 10, 1646, in *Works of Galileo's Disciples, Carteggio 1642-1648*, edited by P. Galluzzi and M. Torrini, Giunti-Barbera 1975, Vol. I, pp. 275-277.

The speech at the press conference presenting the Association for the Left on Feb. 18, 2009 is unedited.

[Legambiente's full 2002 document is formally unpublished, in the sense that it was disseminated via press release and in the form of a simple flyer].

The speech at the Nonino Prize is unpublished.

Three Men in a Boat (Not to Mention the Dog), by Jerome K. Jerome, first English edition 1889, Rizzoli 1978.

Fabrizio De André's song (Il sogno di Maria) is from the album La buona novella (1970).

The definition of complexity given here is taken from an article by Giorgio Parisi in INFN's semiannual journal *Asymmetries*, issue 32, April 2022.

What does a theoretical physicist who first arrives at fundamental discoveries to the point of winning a Nobel Prize do in life? He thinks, reasons with other physicists and calculates. Many crucial insights throughout existence, the result of myriad calculations and hypotheses, sometimes exact and sometimes wrong, which, in a moment or over the course of years, unravel a part of the mystery that surrounds us with often unthought of and unpredictable consequences. Giorgio Parisi has followed his passion for numbers from an early age, a talent nurtured by great teachers at university and grown in constant confrontation with the international scientific community.

Alongside an extraordinary professional career, in this autobiography Parisi recounts his private life behind the spotlight, the parable of a child who loved mathematics and managed to become a great scientist. The origins of his family, the uncertainty about his studies throughout high school, the loneliness until college, the close association not only with scientists but also with writers such as Luce d'Eramo and Ignazio Silone. And the love of his life, Daniella, his relationship with his children and grandchildren, his passion for music and politics. All the way to the mystery of consciousness, fear and acceptance of our limitations, as a man and as a scientist, but also trust in what makes us truly human: the diversity that surprises us, the dreams that inspire us, the love that warms us