# News from New Zealand

BY

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After 21 years of uninterrupted presence (this column didn't appear in the October 2013 issue due to a clerical problem in the change of editors-in-chief) this is the last report from New Zealand.

I wish to warmly thank Professor G. Rozenberg for inviting me to contribute with a column of news to the Bulletin, the other Bulletin editors-in-chief I have worked with, the eminent scientists who have accepted to be interviewed, and, last but not least, the Bulletin readers.

This column includes the continuation of the interview with Professor G. Rozenberg. An edited-augmented-structured selection of interviews published in this column will appear in the book *The Human Face of Computing* to this year at Imperial College Press, London.

## 1 Scientific and Community News

The latest CDMTCS research reports are (`http://www.cs.auckland.ac.nz/staff-cgi-bin/mjd/secondcgi.pl`):

470. B. Khoussainov . A Quest For Algorithmically Random Infinite Structures, II

471. C.S. Calude, A. Coull and J.P. Lewis. Can We Solve the Pipeline Problem?

472. A. A. Abbott, L. Bienvenu and G. Senno. Non-uniformity in the Quantis Random Number Generator

473 C.S. Calude and M.J. Dinneen. Solving the Broadcast Time Problem Using a D-Wave Quantum Computer

474 C.S. Calude and G. Longo. Classical, Quantum and Biological Randomness as Relative Incomputability

475 T. Resnick. Sudoku at the Intersection of Classical and Quantum Computing

476 D. Thompson. Formalisation and Understanding. A Case Study in Isabelle

# 2 A Dialogue with Grzegorz Rozenberg about Natural Computing II

*Professor G. Rozenberg is a professor at the Leiden Institute of Advanced Computer Science of Leiden University, The Netherlands and adjoint professor at the Department of Computer Science, University of Colorado at Boulder, USA. He published over 500 papers, 6 books, and is a (co-)editor of more than 100 books on natural computing, formal language and automata theory, graph transformations, and concurrent systems. He founded a number of journals and book series in theoretical computer science and natural computing. He is often referred to as the guru of natural computing.*

*Professor Rozenberg is a Foreign Member of the Finnish Academy of Sciences and Letters, a member of Academia Europaea, and he is holder of Honorary Doctorates of the University of Turku, Finland, the Technical University of Berlin, Germany, the University of Bologna, Italy, and Åbo Akademi, Swedish University in Turku, Finland. He has received the Distinguished Achievements Award of the EATCS.*

*With the artist name Bolgani, he is a performing magician specialising in close-up illusions.*

**CC:** What is more important for research in natural computing: potential applications or understanding how “nature" computes? Does “nature" really compute?

**GR:** Advancing our understanding of the computation taking place in nature will often lead to (potential) advances in human-designed computing, simply because so often the way nature computes is superior to the way humans compute. In this sense, understanding how nature computes is “primary”. But there is a catch here. Our classical notion of computation is rooted in the quest for formalising

the way humans compute/calculate—it dates back (at least) to the work of Leibniz and it culminated in the first half of the 20th century with the research/results by Post, Church, and Turing. Quite often, this (beautiful) notion/idea of computation does not really apply to the computation going all around us in nature because it violates various "underlying axioms" of the way that nature works. I strongly believe that research in natural computing will eventually lead to a novel notion of computation, as a matter of fact to a new "science of computation" which will be developed by the interaction/co-operation of computer scientists, biologists, chemists, mathematicians, physicists, ... Indeed, the research in natural computing has already changed our understanding of what computing is about.

**CC:** Can you give examples of such differences in underlying axioms?

**GR:** An answer to such a question should be given by writing a series of papers but let me just mention one such difference, *persistence*.

In models of computation in computer science one assumes that if in a global state a local part of it is not "touched", then this local part will be preserved, i.e., it will be a local component of the successor global state. This does not hold in biology, e.g., when you model the living cell. An entity from a current state will be present in the successor state only if it is produced, hence sustained, by a reaction (or "thrown in" by the environment). This reflects a basic principle of bioenergetics: life must be sustained. Standard computer science models of computation would imply immortality!

**CC:** You founded two journals and a book series dedicated to natural computing. Tell us more about them.

**GR:** The journals are: "Natural Computing", originally published by Kluwer and then taken over by Springer, and "Theoretical Computer Science, Series C: Theory of Natural Computing " (TCSC) by Elsevier, and the book series is "Natural Computing " by Springer. "Natural Computing " is a journal of a very broad scope: it covers experimental, applied and theoretical aspects of natural computing. There you will find publications by biologists, chemists, nano-scientists, physicists, mathematicians, computer scientists, ...—it really reflects the genuinely interdisciplinary nature of natural computing. It is an ideal journal for publishing special issues of interdisciplinary conferences such as, e.g., "DNA Computing". The TCSC journal, on the other hand, aims at publishing theoretical papers that are in the style of the well established Theoretical Computer Science journal. The book series "Natural Computing " by Springer publishes both texts and monographs covering the whole spectrum of "natural computing" (theory, experiments, and applications). All three publications were very well received by the scientific community. They are doing very well and will certainly grow and flourish in the years to come.

**CC:** You edited four influential handbooks. The last one is "Handbook of Nat-

ural Computing ” which is really huge; tell us more about it.

**GR:** It is indeed huge: 4 volumes, around 2100 pages, over 100 contributing authors, ... This was the editing project which, by far, took most of my time and energy. But I am happy with the result.

The goal of the Handbook is two-fold: (1) to provide an authoritative reference for a significant and representative part of the research in natural computing, and (2) to provide a convenient gateway to natural computing for motivated newcomers to this field.

Apparently, we have succeeded, as the handbook seems to be popular among both groups of readers; also, it has received very good reviews.

Sometimes one compares writing a book to writing a symphony and editing a book to directing an orchestra. I think that this is a nice and fitting comparison, except that there are two important differences between editing a book and directing an orchestra. Usually there is a rehearsal period (often intense) before an actual performance by an orchestra and mostly the individual players do follow very closely (to the best of their abilities) the instructions of the conductor. Unfortunately in book editing (especially with a large number of authors, like, e.g., in a handbook) there is essentially no rehearsal and close following of the instructions by the editor is very difficult to enforce.

**CC:** You are also a magician ...

**GR:** I am a performing magician, but I earn my living as a scientist. Both science and magic are beautiful and provide an exciting way of living. I feel very privileged that an interleaving of these two strands of creativity forms the double helix which determines my creative life.

Although science is very rational and magic is emotional, there are many similarities between them. Here are some similarities:
(1) First of all, both are based on creativity – the main source of success in both disciplines.
(2) An important lesson you learn from magic (either as a performer or as a spectator) is NOT to accept things on their face value (you just saw the King of Hearts in a deck of cards, but when you inspect the deck this card is not there!). Thus you need to question everything, which in fact is one of the key principles of an original research in science.
(3) Trying to achieve something astonishing/impossible is one of the key motives/incentives in both science and magic. In mathematics (theoretical computer science) we get a great satisfaction if we settle a conjecture (preferably an “old” conjecture), because in this way we achieve something that was difficult/impossible for other scientists. Perhaps, the satisfaction is even greater when we disprove a conjecture, as then we are even closer to something impossible (something believed to be not true). Similarly an important goal/essence of out-

standing magic is to get as close as possible (close by epsilon) to something totally impossible, something that contradicts the reality (as we know it). My (magician's) business card says "Be Astonished by The Impossible."

However, there is also a cultural difference between scientists and magicians concerning achieving something "impossible". In my long scientific career I witnessed too often situations where scientists (too quickly) declared: "This looks impossible, let's do something else." On the other hand, in my long life in magic I heard quite often a statement of this sort: "This looks impossible, let's work on it".

There are also other important differences – here is one of them. Magic is a performing art, and the performance is the essence of magic. In science the standing/quality of a scientist is determined by her/his peers (e.g., the quality/acceptance of your publications is determined by reviews done of your peers). In magic there are essentially two ways in which your quality is determined/judged.
(i) The first one, the primary one, is the judgement by spectators – you are a good/great magician if this is the judgement by your audience (of laymen).
(ii) Then there is a judgement by your peers, e.g., when you demonstrate/discuss magic in a magic club. The judgement of your peers may be very different, e.g., they may be fascinated by your mastery of a specific sleight-of-hand, while you may be a lousy performer. But . . . it is a performance that determines an emotional reaction of spectators – without it a lot of magic would be reduced to various kinds of puzzles!!!

As a matter of fact, the attitude of spectators is one of the problems facing magicians. Quite often, spectators (especially scientists or those who see a real magic performance for the first time) come to a show with the "puzzle attitude" – they sit there totally stressed, watching your every move, ready to catch you, to solve the puzzle. I always explain at the beginning of a show that this is a wrong attitude because illusions have no explanation and so there is nothing there to discover (to catch onto). In fact, if they would ever get a glimpse of "something", then this particular effect was not an illusion. When I explained this to Mike Rabin (after performing for him and his wife) he called this "The Rozenberg Principle": an event observed disappears! Thus, there is a direct link between magic and quantum mechanics! Apropos, I have a magic show focussed on explaining some of the principles behind various areas of natural computing – one of the card effects demonstrates some principles of quantum computing.

For several years now, many news items in a variety of media (newspapers, scientific journals, social media) suggest that magic is just misdirection. I get often links to such news items from my friend Moshe Vardi (and he expects my comments). For example, some prestigious neuroscience journals publish studies which demonstrate how misdirection by a good magician (and some very good

magicians are involved in these studies) can fool our brains and what it implies for the understanding of the functioning of the brain. Although some of these studies are interesting, a big flaw (in my opinion) is that the involved neuroscientists become convinced that they have become magicians (through conducting these experiments), and hence express opinions as if they were magicians, while the involved magicians become convinced that they have become neuroscientists (through their participation in these experiments) and hence express opinions as if they were neuroscientists. As a result, the studies/conclusions presented are often superficial. I wrote several times to Moshe that some beautiful magic effects indeed rely on misdirection, but on the other hand some beautiful magic effects have nothing to do with misdirection. You may be a top magician without ever employing misdirection – "magic by misdirection" is just a part of magic, in the same way as graph theory or calculus are parts of mathematics.

Living in two worlds, science and magic, is also enriching from the social point of view. Through my life in magic I got embedded in a wonderful community of people (which is very different from the academic community). The notion of quality (of magic performance) is central here and it is also easy to interact with other magicians. Once you have something interesting/amazing to show, a whole stream of interactions follows: you get comments, your spectators (magicians) show you their creations, ... naturally very close contacts are established and they often lead to collaborations and friendships.

**CC:** How did your family react to your "magic"?

**GR:** When my son Daniel was a teenager, he was not really impressed by the fact that I was a university professor. But the fact that I was a magician was a different story. Once, when I got back home from my office and entered our house I found Daniel and his friend Ferdie in the hall. After Daniel introduced me to Ferdie I proceeded to the kitchen to have a glass of water. While drinking water I heard Ferdie asking Daniel "What is your father's profession?" to which Daniel replied "He is a university professor" and then a few seconds later Daniel added "But he is not stupid, he is a very good magician"! Also, my grandson Mundo is now very proud that his grandpa is a wizard.

Coincidence, predestination, ... are important concepts in magic. Thus I wonder (magic, unlike mathematics, does not have to be rational) whether being a magician was my predestination. First of all, the maiden name of my mother was Zauberman (which translates into "magician") – I did not notice this connection until I was already in my thirties. Then, my wife's name is Maja and during a trip to India we were told that in Hindu Maja means "illusion". It is certainly great for a magician to be married to an illusion – this makes my magician friends pretty jealous!!!

**CC:** How do you see computer science after working in the field for about 50

years?

**GR:** The visibility and importance of computer science grew very impressively during this period. The main reason is the spectacular progress in Information and Communication Technology (ICT) which is very much driven by progress in computer science. This is a blessing but also a curse for computer science, because computer science is often perceived, by the public as well as by scientists from other areas of science, as a technological discipline, a collection of practical skills. Perhaps the most frequent perception of a computer scientist is that of a skilful programmer, an educated hacker. I remember that a long time ago at my university in Leiden, some physicists were not supporting a formation of a computer science department because "our people are also good programmers".

However there is so much more to computer science than ICT. The only reasonable definition of computer science is that this is THE science of information processing. If you consider a typical computer science department and observe the specialities of its faculty members, you will get a list of this sort: computer graphics, data bases, human-computer interactions, natural language processing, computer architecture, programming languages, theory of computation, compiler construction, bioinformatics, concurrent systems, ... The only common denominator for all these research areas is that they are concerned with various aspects of information processing. As a matter of fact the term "Informatics" used in Europe is much better than "Computer Science" which suggests that computer science is just focussed on one specific device/instrument, viz., computer.

Thus informatics is the science of information processing and it is concerned with information processing in computers and elsewhere, e.g., in nature. Therefore informatics is a fundamental science for other scientific disciplines. This historical evolution of computer science into becoming also a fundamental science of information processing was strengthened by developments of some other scientific disciplines, especially in the second half of the 20th century, which adopted "Information" and "Information Processing" as their central notions and thinking habits. Biology and physics are prime examples of such development – in both areas informatics provides not only instruments but also a way of thinking.

This is not just the opinion of a computer scientist, but also the conviction of top biologists and physicists. For example:

- Richard Dawkins, a famous evolutionary biologist, says "If you want to understand life, don't think about vibrant throbbing gels and oozes, think about information technology".

- Sydney Brenner, one of the best known living biologists, Nobel Prize winner, says "Biology is essentially (very low energy) physics with computation".

- John Wheeler, eminent physicist, stated that while some time ago he thought that everything is particles, now he thinks that everything is information.

Since informatics is THE science of information processing it has a strong interdisciplinary character. As a matter of fact, I remember that in 1971 or 1972 when I was in the department of computer science at the State University of New York at Buffalo a delegation from NSF was visiting there. Tony Ralston, our department chair, asked me (probably as a representative of the "European school") to present my vision of computer science to this delegation. I said then that I envision computer science departments of the future to be divided into groups dealing with the "core computer science", language processing (linguistics), artificial intelligence, biology, physics, ... In particular I was arguing for biology where information processing is so apparent and so challenging to understand. Tony told me later that he heard from the delegation that they did not share my vision and in particular they thought that the relationship between biology and computer science is not as strong/intrinsic as I suggested (in their opinion it was rather superficial). I am glad to conclude that now, over 40 years later, everyone involved must conclude that they were awfully wrong. As a matter of fact it is apparent today that the interdisciplinarity of informatics is one of the main forces driving the tremendous progress of our disciplines.

It is fashionable nowadays to discuss grand challenges of informatics. I am myself convinced that one of the grandest grand challenges of informatics is to understand the world around us in terms of information processing. Each time progress is made in achieving this goal, both the world around us and informatics benefits. Natural computing is a natural avenue of research for achieving such a progress!

**CC:** Please reminiscence about your youth in Poland.

**GR:** I grew up in communist Poland, so my youth was dramatically different from the youth of my son in The Netherlands. It was not the best place to grow up, but on the other hand (seen from the perspective of time) in this way I got a deeper understanding of some important issues in life, deeper than that of my friends in my "new world". I strongly believe that deep matters in life can be understood only by experiencing them. As a matter of fact, I am often irritated by the attitude of many intellectuals who make statements of the sort "I understand what it means to live through a terrible war (or to live in a totalitarian system), because I read many books about it".

I received my education in Warsaw, Poland. As everywhere else in the world, the quality of teachers in my schools determined my "initial" taste/liking for many subjects. Thus, I had an awful teacher of chemistry and so I did not like chemistry at all, while today I think that chemistry is relevant, fascinating, and simply beautiful. On the other hand, I had a brilliant teacher of mathematics, his name was

Taytelbaum. He became my idol, and so I had already fallen in love with mathematics at school already. Coming back to the issue of coincidences in magic, Eddy Taytelbaum, one of the nestors of magic in The Netherlands, became my idol and friend quite soon after I got embedded into Dutch magic (to understand this coincidence one has to realize that Taytelbaum is a very uncommon name in Poland and it is a very uncommon name in The Netherlands).

I chose to study electronics at Warsaw University of Technology, as then electronics was then a very modern direction of study, known for its high level of quality (entry exams were very competitive), and, most importantly, in this way I could combine my love for mathematics and physics with my curiosity about technology. It turned out to be a very good choice for me – I found many classes interesting and challenging, and, very importantly for my later life as a researcher (I am theoretician), I got an understanding/feeling of and a respect for engineering.

For my master thesis (for the master degree in computer science) I chose "Theory of algorithms". At that time in Poland this was a combination of Markov algorithms and Turing machines. My interest in the theory of algorithms was instigated through my study of logic circuits design, where a transitive closure of references led me to basic papers on automata theory.

As a matter of fact I got so fascinated by automata theory that, while I was still a student, I approached one of the assistant professors, Pawel Kerntopf (who became a very good friend of mine), and with his help organised a seminar on automata theory. This seminar involved both graduate students and faculty. It turned out to be very successful in many respects. When I recently gave a series of lectures in Warsaw, I was told by colleagues from my Alma Mater that at least 15 participants of my seminar became later professors in Poland and abroad!

While working on my master thesis I met Andrzej Ehrenfeucht from the Mathematical Institute of the Polish Academy of Sciences. Meeting Andrzej changed my life in many ways. He became my source of wisdom on the theory of algorithms (my formal advisor from the department of electronics knew very little about this area). Moreover, it "clicked" between us and very quickly we became friends and later brothers by choice (we consider ourselves brothers). It is because of Andrzej that my love for the technology of information processing changed into love for the theory of information processing. We just celebrated 50 years of scientific cooperation – during this period we wrote hundreds of joint papers and spent thousands of hours talking to each other about scientific and many other matters.

Andrzej is a true renaissance man, deeply knowledgeable about so many areas: mathematics, linguistics, geology, physics, biology, spiders, dinosaurs, fossils, history and teaching of mathematics, ... Often, when I ask Andrzej a question I not only get an answer, I get a whole tutorial. Since 1971 I travel (on average twice a year) to Boulder, Colorado, where I am an adjoint professor in the department

of computer science of the University of Colorado. The main reason for me to travel there is to be with Andrzej. One of the many nice things related to our friendship/brotherhood is that Andrzej loves my magic – nobody else has seen as many of my magic shows, moreover he is the best spectator I ever had.

Andrzej is very much interested in the history of mathematics and in the didactics of mathematics. He collaborates in research in these areas with Pat Bagget, his life partner – she is a professor of mathematics at New Mexico State University in Las Cruces. They are a very nice couple and it is always a pleasure when we three get together.

Telling political jokes in Poland was important for intellectual survival. This was the only way that one could beat the system into pieces. I have created many political jokes, which was pretty dangerous. As a matter of fact when I would tell a friend (whom I could trust) that I have a new joke, then he/she would first ask me "How good is this new joke?" and my typical answer would be "about 5 years" (referring to a punishment, the number of years in prison, in case that I would be "caught" when telling this joke). On my recent lecturing trip to Warsaw, when I met with a group of my colleagues and friends from my years in Poland, I was reminded about my creativity in inventing new jokes, and also reminded how dangerous it was. It was quite interesting for me to learn that some of my jokes are still in circulation today!

**CC:** Please tell us an "about 5 years" joke.

**GR:** Here is one. A huge factory was built in a communist country. It was going to serve as a symbol of the superiority of the communist system, thus many visitors came to see it. Important visitors were given a tour of the factory by the mayor of the city. On one of such tours when the visitors arrived at the entrance gate the mayor proudly announced: "This is the biggest factory in the world employing 50,000 workers. It could be built only in a communist country." However, because of the noise of a truck passing by, one visitor didn't hear the first part of the sentence, so he asked: "How many people work in this factory?" The mayor answers: "Oh, you mean *working* here. Perhaps two or three."

This joke describes in a compact way one of the big disasters of the communist system: the destruction of work ethics. For many years after I left Poland I was planning to write a book "The Essence of Communism" which would consist of a set of jokes illuminating various features of the system. Unfortunately, because of chronic shortage of time, this project never materialised.

**CC:** You started your academic career at the Institute of Mathematics of Polish Academy of Sciences which was one of the world-famous mathematical research institutes ...

**GR:** Even before I completed my master thesis, I was offered a position at the Institute of Mathematics of Polish Academy of Science (Polish acronym: IM-

PAN) in the group of mathematical logic headed by Andrzej Mostowski. I was also offered a position in the Electronics Department, but I made a choice for IM-PAN because I wanted to pursue research in theory – this was among the best choices I ever made! The senior members of the mathematical logic group were Mostowski, Grzegorczyk, Pawlak and Ehrenfeucht. Mostowski was a very "special" man: very kind with very good manners (a real gentleman) and genuinely friendly. He was very positive during my interview for the position in his group. He had only one small "objection", viz., that I was very young. I still remember when, looking through administrative documents, he said "I see that you will be the youngest member of our group" and then he added "but this problem will resolve itself with time". I recalled this statement many times later in my life as I saw myself to be first the youngest professor, then a well-established member of a department, then a senior professor, and then Professor Emeritus! The kindness of Mostowski manifested itself also in the fact that he always had time when I asked for a consultation in matters of logic. I had less contacts with Grzegorczyk, but I had numerous discussions with him concerning computability theory, especially about his hierarchy of recursive functions. Grzegorczyk wrote a very good book on mathematical logic (in Polish) and I benefited a lot from discussing with him in depth various topics from this book.

I spent a lot of time with Zdzisław Pawlak – we also became very good family friends. He was a wonderful person and a great scientist. He had a very good understanding of the applied aspects of computer science and an extraordinary talent for forming elegant, simple models capturing the essence of applications.

For a man of unusual talents he was very modest. He had a great sense of humour and loved good jokes – his laugh was very contagious. He was one of the few people whom I trusted with my new political jokes. Kayaking and walking were his two favourite physical activities. He had a great talent for writing rhymes and in the later phase of his life he was painting – he was a good painter. His scientific talents are best illustrated by the framework of rough sets which he invented in his sixties. It is an area of research which is very impressive by both its theory and applications, and it is immensely popular all over the world.

He was a delightful friend and I remember that I got very emotional when he told me that I was his best friend.

IMPAN was an "exclusive" institute as so many famous mathematicians worked there. Kuratowski was the director when I worked there. Among other famous mathematicians there were Sierpinski, Łoś, and Sikorski. I had quite frequent contacts with Łoś, but especially with Robert Bartoszynski who worked with Łoś. Robert was a real virtuoso of, and so my main consultant on, probability theory. Because of my interest in linguistics, I also talked a lot with Robert's wife who was a linguist. I remember following some seminars by Sierpinski – he was quite old then, always taken care of by the famous, then young, number

theorist Andrzej Schintzel. Because IMPAN was so well-known worldwide, we had a lot of visitors and this gave me a chance to meet a lot of famous scientists. For example, I met Solomon Marcus when he was visiting Pawlak. I spent a lot of time with him talking about science and many other matters, he also met my parents and my wife. I must have been among the first researchers he introduced to contextual grammars, a topic which I picked up again much later when I worked with Gheorghe Păun (a student of Marcus) on it. Marcus invited me to Bucharest to work together, and I still remember a very nice visit there. Anyhow, I became an admirer of Marcus and remain so still today. We meet from time to time at various events, and I cherish these meetings.

My relationship to Marcus continued also in a different way when during my later years in science, I became a collaborator, mentor, and friend of many Romanian scientists educated/influenced by him. This group includes Lila Kari, Gheorghe Păun, yourself, and Elena, Alexandru Mateescu, and Ion Petre. I was always impressed by the mathematical and human qualities of disciples of Marcus.

My first big new research topic at IMPAN was category theory – I got interested in both pure category theory and its potential to express and investigate computations. Concerning the former, I worked on axioms for the category of relations and this work brought me in contact with Samuel Eilenberg. I was very flattered by his interest in my work. We also remained in contact after I left Poland. He visited me in Utrecht and stayed in our apartment. His main passion outside mathematics was collecting certain types of figurines from Indonesia. Because of the long history of Dutch-Indonesian relationship, The Netherlands was a real gold mine for these figurines. So I visited a lot of "strange places" with him in Utrecht and Amsterdam.

At the beginning of my commuting to Boulder I met Stan Ulam, another famous Polish mathematician. Also, together with Aristid Lindenmayer, we invited Ulam to attend a symposium we organised in The Netherlands (on information processing in biology). Thus I had many conversations with Ulam and was fascinated by him. Mostowski, Eilenberg, and Ulam were typical representatives of the famous old school of Polish mathematics. There was something common (in my perception) to all three of them: they were brilliant, erudite, well-mannered, and had a very good sense of humour (I was certainly telling jokes to all three of them).

I was very much influenced by the paper "Finite automata and their decision problems" by M. Rabin and D. Scott – it was certainly one of the most important papers I read. I started right away working on various problems inspired by it. In particular, I started to develop a theory of multitape automata, this was going very well and I hoped it would become my PhD thesis. Then one day Mostowski brought a manuscript (I think that this was an official report from Harvard, perhaps a PhD thesis) by Arnold Rosenberg on multitape automata, and asked me to look

it up in connection with my own research. I observed that more than half of my results (with many of them already presented at our internal seminar) were covered by Arnold. I even remember making a joke that if Arnold's surname would be also written with "z" (hence "Rozenberg") then ALL my results would be already covered by him! Mostowski explained then to me (he was always very kind and supportive) that in mathematics if you get "good" results and discover later that these results were already proved by good scientists, then you get in this way the best possible confirmation that your research is on a good path. I decided then to switch to research on certain type of regular languages and got my PhD for this work.

This and a number of other events made me realise how isolated we were in Poland (nobody really cared about "us"!), even though through personal connections of Mostowski and others we were in a privileged position. I remember making a resolution then that if I ever got out of Poland, I would "do a lot for the scientific community" as opposed to "doing a lot only for myself". This resolution got strongly implemented when I left Poland. I have devoted a huge amount of my professional time to service for the academic community – this includes my work for EATCS, my work for organising conferences, my work for founding new journals and book series, ... Clearly, my list of publications would be much longer if I would not spend so much time in the service of the scientific community. But, I always remembered my resolution from Poland and really get a lot of satisfaction from serving the community and seeing many positive effects of this service.

To summarise, I was really lucky and privileged to work at IMPAN. It was a real oasis of tranquility: while there, the surrounding reality of the totalitarian political system was nonexistent. The only thing that counted was science, there were no political activities. Clearly, the situation must have been very different for people running the Institute, as they had to deal with the outside world.

**CC:** Why do you like so much Hieronymus Bosch paintings?

**GR:** I was always interested in paintings, and during my youth in Poland I was "possessed" by impressionism. I read everything that was accessible to me there about impressionism, looked up all possible albums with reproductions, even had in my room reproductions of van Gogh and Monet hanging on the walls. When I settled in The Netherlands, it was a sheer delight to visit museums here and see real paintings by impressionists as well as to go to Paris to see even more there.

However, one day, just by chance, I bought a book with many reproductions about Bosch, and right away I fell in love with Bosch (and impressionists were moved to the back burner). This love for Bosch only intensified with time.

He is an enigmatic painter in many ways, and therefore a difficult painter for art historians to analyse. Hence, e.g., we know very little about his life, we don't

even know when he was born except for some reasoning which leads to "around 1450" – his funeral took place on August 9, 1516. This on its own is quite an obstacle in analysing his art. Furthermore, no more than 25 of his paintings survived and we are not even sure whether all of them are authentic. He signed only a few of these paintings and none of them is dated.

But what we know for sure is that he was a genius, who went his own way, and was much ahead of his time – much of his creation is of timeless beauty. For me he is a personification of vision and creativity. My admiration for him is very well expressed by Jose de Siguenza (1544–1606) who was a historian, monk, and prior of the monastery of El Escorial (a Spanish royal site close to Madrid). El Escorial was home to many Bosch paintings collected by Phillip II of Spain. Jose de Siguenza wrote that he was amazed that "a single mind could imagine so many things".

The best known of Bosch's paintings is "The Garden of Earthly Delights" in Museo del Prado in Madrid. Many art historians list it as one of the most remarkable paintings ever. For me Prado is the best museum in the world, as they have (in one room!) 5–6 paintings of Bosch (recall that no more than 25 paintings of Bosch exist today). Madrid is my favourite art city as they also have Bosch paintings in Palacio Real and close by in El Escorial. Then on top of it Madrid is famous for its school of card magic!!!

Bosch drawings are less known than his paintings, but his drawings are also extraordinary. Again, no more than 40 of his drawings survived. He almost exclusively used only the pen in his drawings. My favourite drawing by Bosch is "The Wood Has Ears, the Field Eyes", which depicts a larger tree in front of a grove of smaller trees, all set up in a meadow. The drawing shows a number of open eyes embedded in a meadow and two large ears embedded between trees of the grove. There is a later Netherlandish woodcut from 1546 (30 years after Bosch's death), possibly based on Bosch's drawing, which illustrates the same theme, where the inscription says "The field has eyes, the wood has ears, I will see, be silent, and listen." This demonstrates the timeliness of Bosch's art – think about today's concern about privacy in the time of all the electronic media, surveillance cameras, etc. Even more interestingly, at the top of this drawing there is an inscription in Latin which says "For poor is the mind that always uses the ideas of others and invents none of its own". Most probably it was the "official motto" of his workshop, but it surely should be the motto for each researcher!

The larger central tree in this drawing has an owl sitting in a natural hollow opening in it. At this time period in this geographic location (Brabant) owls were a symbol of wickedness and evil spirits. Thus the owl in the center of the drawing was contributing to the intended theme of the drawing.

As a matter of fact, owls appear a lot in paintings of Bosch and also in his drawings. For example, another drawing of Bosch which I like a lot is "Owl's Nest

on a Branch". Also, owls are quite central in "The Garden of Earthly Delights". Bosch was certainly fascinated by owls!

Since I am also fascinated by owls, this makes Bosch art even more dear to me. My interest in owls originated in science, more precisely in my collaboration with Juhani Karhumäki. I was his mentor when we worked on his Ph.D. thesis with Arto Salomaa (by today Juhani is one of the world leaders in combinatorics on words). On one of his working visits to my home in The Netherlands, he brought many pictures of young (baby) owls in their nests. Juhani is also an ornithologist and spends a lot of time during the summers (mostly in June) banding young birds high in their tree nests (sometimes 30–40 meters high!!!). He is also an excellent photographer, so his pictures of young owls were really beautiful.

I fell in love, first with the pictures of owls, and then with owls in general. Started to read a lot about real owls but also about the images and the symbolism of owls in various cultures all over the world. By today I have a collection of over 2000 owls of all sorts: real stuffed owls, ceramic owls, glass owls, metal owls, silver owls, incrustrated owls, ...

A painting by Bosch which is well-known to many magicians is "The Conjurer". It is a beautiful painting depicting a magician performing (most probably at a market).

I need now to make a digression into the history of magic. Unfortunately the history of magic is not so glorious, as magic was often used as an instrument of control and as a skill for cleaning people out of their possessions/money. As examples of the former, one can point out that pharaohs in Egypt had magicians in their entourage who were performing all kinds of tricks which would prove that pharaohs did possess inhuman powers given to them by gods. As examples of the latter, one can point out magicians robbing people out of money at markets by playing "very fair" cups and balls or 3 card monte guessing games. Thus cheating became closely associated with magicians. Magic became a performing art only in the 19th century (with a lot of credit for this transformation given to the famous French magician Robert Houdin). Today magic flourishes as a performing art and is often referred to as the queen of performing arts.

Going back to "The Conjurer" painting, it depicts a magician at one side of a table, with cups there and a small ball kept "professionally" in his right hand, clearly performing the famous cheating game of "cups and balls". A small group of spectators stands at the other side of the table with one of them "central" in this composition. This central spectator bends over the table watching the magician and is totally flabbergasted by the performance, so much so that a green frog jumps out of his gaping mouth (there was a proverb in Brabant at this time saying that you may be so flabbergasted that a frog will jump out of your mouth). While this spectator is so lost in the performance, a thief (perhaps a confederate of the magician) is cleaning him out of money kept in a leather pouch.

This beautiful painting shows Bosch as a keen observer of everyday life, while it also reminds magicians about the not so glorious history of magic.

I would like to add a comment about my love of visual arts. It begun in Poland when I was a teenager, and it was purely "theoretical" in the sense that nobody in my family had any talent for painting. This situation changed dramatically when my son Daniel was born – it was clear already since he was about three years old that drawing and painting were his vocation. Indeed, he became a very well known visual artist – creations of DADARA (his artist name) are amazing. Since neither me nor my wife Maja had any talent for drawing/painting, in my lectures on molecular biology I was giving Daniel as an example of a "beautiful mutation" – his talent came from "nowhere". It turned out that I was wrong: just a few years ago we discovered that Maja has a real talent for painting. In fact Daniel says now that his artistic genes come from her. Thus, when my love for paintings begun in Poland I had just (cheap) *reproductions* of van Gogh and Monet hanging on the walls of my room. Now our home is full of *original* beautiful paintings by DADARA and Maja!

**CC:** You really love books. Which of them have influenced most your professional life?

**GR:** I have loved books all my life. My wife said once that I spend my money on books and playing cards! However I remember that when I was a teenager in Poland, there were non-monetary ways to get access to good books. Many good books from before the World War II were not available in bookstores because they were "ideologically wrong". The way to get access to these books was through ... rewriting. One could borrow such an unavailable book (or a hand rewritten copy of it) for a certain period of time, and during this time one would rewrite (a part of) this book. The borrowed book had to be returned, but one would have a handwritten copy that could be read several times. Such a copy could be also exchanged for a handwritten copy of another book. Rewriting a book by hand was very time consuming, so one had to be a real book lover to engage in this way of collecting books.

During my study years and also during my work at IMPAN I profited a lot from the lawless pirating behaviour of the Soviet Union. They were translating scientific books published in the West on a massive scale, without respect for copyrights. Moreover, all Russian books were very cheap in Poland. In this way I read many excellent science books published in the West – without the lawless behaviour of Soviet Union I would not have had access to most of these books!

One of the blessings of working at IMPAN was their mathematics library – certainly the best source of mathematical books and journals in Poland.

Also, the library of the Institute of Foundations of Informatics of Polish Academy of Sciences (Polish acronym: IPIPAN) in Warsaw had a very good li-

brary, especially of computer science and electrical engineering books. This was my library when I was a student. I would sit there whole days, as many of the books there (especially British and American books) could not be moved out of the library. I became a good friend with the young librarian (her name was Lidia Miernicka) and at some point we were doing something illegal (which could have bad consequences for her): when she was closing the library in the evening I was allowed by her to take with me (secretly) a couple of books which had to be back on the shelves when she was opening the library in the morning. This meant that I was studying the books all night and waiting for her to open the library to (secretly) return the books. I was extremely indebted to her. When many, many years later Poland became a noncommunist country and I learned that she was the main librarian of IPIPAN I began to buy books for her library as a way of saying "thank you" for what she did for me when I was a student. When I was lecturing at IPIPAN some time ago, I was shown a wall of shelves filled in with "Rozenberg books" – to see this was very satisfying and emotional for me.

I should also mention that I have a really impressive collection of books on Hieronymus Bosch, perhaps one of the best private collections in The Netherlands. Indeed a lot of money and collecting effort went into establishing this collection, but it is very useful for my studies of Bosch.

As for the books that influenced my professional life, this would be a long list which would require a long time to construct (also because of my bad memory). But on a short call, and somehow ad hoc I would list the following books: "Network Analysis" by Van Valkenburg, "Set Theory" by Kuratowski and Mostowski, "Abelian Categories" by Freyd, "Elements of Mathematical Logic" by Rosenbloom, "Automata Studies" edited by Shannon and McCarthy, "Computability and Unsolvability" by Davis, "Algebraic Structure Theory of Sequential Machines", by Hartmanis and Stearns, "Mathematical Theory of Context-Free Languages" by Ginsburg, "Formal Languages" by Salomaa, "The Language of Life" by Beadle and Beadle, "Dealing with Genes" by Berg and Singer, "Recombination DNA" by Watson, Tooze and Kurtz, "Bioenergetics" by Lehninger, and several books by Peter Atkins on chemistry and thermodynamics.

**CC:** Many thanks.