BULLETIN

INTERNATIONAL CENTER FOR MATHEMATICS

June 2004

16

Contents

2004 Events

Thematic Term on Mathematics and the Environment

Coordinators

Juha H. Videman (Instituto Superior Técnico)

José Miguel Urbano (University of Coimbra)

Dates

May-July 2004

The **CIM Thematic Term** for 2004 is about Mathematics and the Environment. The topic could hardly be more timely. The knowledge about the impact of human activities on our planet's ecosystems is nowadays more vital than ever. Increasing human population to the detriment of others, cutting and burning vast areas of forest, polluting soil, air and water, are just few examples of how we humans have altered our environment. Within this Thematic Term we intend to address some of these issues from a mathematical and a physical modelling point of view.

The first event, School and Workshop on Dynamical Systems and Applications, was aimed at consolidating the research activities in Portugal in this area of mathematics fundamental for the understanding of evolution of ecological environments and monitoring of global changes. The Workshop on Forest Fires attempts to promote the communication among researchers with an interest on theoretical modelling of forest fires, in particular on fire front propagation. The third and fourth events, School on Atmospheric Sciences and Climate Dynamics and School and Workshop on Oceanography, Lakes and Rivers, are closely related and, hence, planned to be organized in two consecutive weeks. As their titles indicate, they address probably the most important natural processes for the world's ecosystem, and will touch on issues such as air quality, weather prediction, ocean waves and currents, estuarine dynamics, and avalanches, among others.

The programme of events is the following:

3-8 May: School and Workshop on Dynamical Systems and Applications

Organizers

José Ferreira Alves (Univ. Porto), Marcelo Viana (IMPA, Brazil).

For more information on this event, please visit the site

http://www.mat.uc.pt/∼tt2004/dynsystems

June 3 - 5: Workshop on Forest Fires

Organizers

Jorge André (Univ. Coimbra), José Miguel Urbano (Univ. Coimbra).

Aims

Along the past century, in many parts of the world, for human and natural causes, forest fires have become an increasing threat to ambient and man. At the broadest scale, forest fires interest researchers from very different areas, such as: forestry, ecology, geography, physics and chemistry, mechanical and chemical engineering, and applied mathematics. At a finer scale, forest fire physics can be considered mainly as a sub-area of fire science, itself a part of combustion science, but has also important intersections with forestry (fuels characterisation) and meteorology (interactions between the fire and the atmosphere, at various spatial and temporal scales). Within the different phenomena that have been studied, the quasi-steady propagation of surface forest fire fronts of low-to-medium intensity is the most developed research subject of forest fire physics, which justifies the emphasis of the workshop. Since the nineties, the two-sided challenge of constructing models describing the behaviour of the fire front that are, on the one hand, physically sound and general, and, on the other hand, potentially applicable on operational grounds, has originated the proposal of a diversity of modelling strategies, each one of them giving rise to some hard mathematical problems. Such strategies are in different stages of theoretical development and antagonize or complement each other in a larger or lesser extent, none of them self-imposing as clearly superior to the others. The choice of the lecturers precisely reflects the desire to encompass the most relevant strategies that have been proposed.

The main goals of the event are:

- to promote the communication (i.e., mutual knowledge, criticisms, possible future synergies respecting results and, above all, strategies of research) among researchers with a common interest and competence on theoretical modelling issues of forest fires, with an emphasis on fire front propagation;
- to introduce to the Portuguese mathematicians the open mathematical and physical research problems brought up by some representative theoretical modelling strategies that are being used to describe the behaviour of forest fire fronts.

The workshop will be held at the Departamento de Engenharia Mecânica da Universidade de Coimbra located in Pólo II.

Lectures

Numerical simulation of wild fires

Terry L. Clark (University of British Columbia, Canada)

What is missing from fire ecology?

Edward A. Johnson (University of Calgary, Canada)

Convection in forest fires

Jacques Simon (Université Blaise Pascal/CNRS, France)

Some developments in premixed combustion modeling

Gregory Sivashinsky (Tel-Aviv University, Israel)

On the modelling of forest fire propagation

Olivier Séro-Guillaume (CNRS, France)

For more information about the event, see

http://www.mat.uc.pt/∼tt2004/fire

July 12 - 16: School on Atmospheric Sciences and Climate Dynamics

Organizers

Didier Bresch (CNRS/Univ. Joseph-Fourier, France), José Miguel Urbano (Univ. Coimbra), Juha Videman (Instituto Superior Técnico, Lisbon)

Aims

The understanding of the fluid dynamics of the atmosphere and oceans and the development of techniques to simulate weather and climate are among the most important challenges for today's science. To make progress in this field and deepen our understanding of the complex processes that control the climate, the chemistry of the coupled atmosphere-ocean system, and the physics of the upper atmosphere, it is fundamental to intensify interdisciplinary collaborations amongst applied mathematicians and geophysicists.

The main goals of the event are:

- to promote the exchange of ideas among the distinct fields that share a common interest in Atmospheric Sciences, including fluid dynamics, physical oceanography, meteorology and applied mathematics;
- to provide students with a broad overview of this challenging topic.

The school will be held in Lisbon at the Complexo Interdisciplinar of the Instituto Superior Técnico.

Short Courses

Evidence for human influence on climate and implications for climate forecasting

Myles Allen (University of Oxford, UK)

Energy balance models in climate dynamics

Jesus Ildefonso Díaz (Universidad Complutense de Madrid, Spain)

Transport, stirring and mixing in atmospheric chemistry and dynamics

Peter Haynes (University of Cambridge, UK)

Modeling ocean mixing

Esteban G. Tabak (Courant Institute, NYU, USA)

For more information about the event, see

http://www.mat.uc.pt/∼tt2004/atmosphere

July 19-24: Summer School and Workshop on Oceanography, Lakes and Rivers

Organizers

Didier Bresch (CNRS/Univ. Joseph-Fourier, France), José Miguel Urbano (Univ. Coimbra), Juha Videman (Instituto Superior Técnico, Lisbon)

Aims

Mathematics has always played a fundamental role in the study of oceans and river flows, although these research fields are still perhaps more familiar to oceanographers, geophysicists and environmental engineers than to mathematicians. Nonlinear PDEs are crucial in describing ocean processes such as internal and surface waves, ocean tides and currents, turbulence, changes in salinity and temperature, just to mention a few.

The main goals of the event are:

- to promote the communication and interactions between the specialists working on different frontiers of Oceanography;
- to introduce to the Portuguese applied mathematicians, in particular to graduate and PhD students, the fundamentals, as well as some of the most relevant current problems, of Environmental and Geophysical Fluid Dynamics;
- to provide an opportunity for physical oceanographers and mathematicians to establish contacts and develop common research projects.

The event consists of a four-day summer school and a two-day workshop and will be held in Lisbon at the Complexo Interdisciplinar of the Instituto Superior Técnico.

Short Courses in the Summer School

Turbulent geophysical flows and transport in rotating fluids

Peter Constantin (University of Chicago, USA)

Hydrodynamics of rivers and estuaries

Benoît Cushman-Roisin (Dartmouth College, USA)

Rotating fluids and associated boundary layers

Emmanuel Grenier (ENS-Lyon, France)

Elements of geophysical fluid dynamics

Joseph Pedlosky (Woods Hole Oceanographic Institution, USA)

The Saint-Venant system for shallow water. Derivation from Navier-Stokes and numerical solution

Benoît Perthame (ENS-Paris, France)

Plenary Lectures at the Workshop

Stability of Ekman boundary layers and applications

Benoît Desjardins (École Polytechnique, France)

Avalanches: models and mathematical results

Reinhard Farwig (TU Darmstadt, Germany)

Mathematical and numerical analysis of the primitive equations in oceanography

Francisco Guillén-González (Universidad de Sevilha, Spain)

Adjustment of the global thermohaline circulation to local forcing anomalies

David Marshall (University of Reading, UK)

Bifurcations and pattern formation in Geophysical Fluid Dynamics

João Teixeira (UCAR/NRL, USA)

Turbulence, clouds and climate models

Shouhong Wang (Indiana University, USA)

For more information about the event, see

http://www.mat.uc.pt/∼tt2004/ocean

Other CIM events in 2004:

Workshop on Nonstandard Mathematics NSM2004

Universidade de Aveiro, 5-10 July, 2004

Organizers:

Francine Diener, Université de Nice, France

Imme van den Berg, University of Évora, Portugal

A. J. Franco de Oliveira, University of Évora, Portugal

João Paulo Teixeira, IST, Lisbon, Portugal

Keith D. Stroyan, University of Iowa, USA

Vítor Neves, University of Aveiro, Portugal

Aims

The conference will be held in honor of Abraham Robinson on the 30th anniversary of his death. The meeting is planned to be of interest to a broad mathematical public, especially mathematicians engaged in research in any area where Nonstandard Analysis has been found to be relevant, such as **Foundations, Analysis and Functional Analysis, Potential Theory, Control Theory, Stochastics, Differential Equations, Perturbation Theory, Economics, Quantum Physics**, amongst others.

The main part of the conference will consist of plenary talks and contributed talks. A *course in* ***Calculus with infinitesimals*** is foreseen as well as a *debate* ***Non Standard Mathematics, past, present and future of a new paradigm in Mathematics*** as part of a general assessment of the state of the field.

Main Lecturers

Imme van den Berg (Univ. of Évora, Portugal), Nigel Cutland (Univ. of Hull, England), Francine Diener (Univ. of Nice, France), Renling Jin (Coll. of Charleston, USA), H. Jerome Keisler, (Univ. of Wisconsin, Madison, USA), Peter Loeb (Univ. of Illinois, Urbana-Champaign, USA), Edward Nelson (Princeton Univ.), David Ross (Univ. of Hawaii, USA), Tewfik Sari (Univ. of Haute-Alsace, France), Keith Stroyan (Univ. of Iowa, USA), Manfred Wolff (Univ. of Tübingen, Germany).

For more information about this event, see

http://www.mat.ua.pt/eventos/nsmath2004/

Summer School on Mathematics in Biology and Medicine

20-24 September, 2004

Organizers:

Gabriela Gomes, IGC, Oeiras, Portugal

Jorge Carneiro, IGC, Oeiras, Portugal

Pedro Coutinho, IGC, Oeiras, Portugal

Isabel Gordo, IGC, Oeiras, Portugal

José Faro, IGC, Oeiras, Portugal

Francisco Dionísio, IGC, Oeiras, Portugal

For more information about this event, see

http://eao.igc.gulbenkian.pt/mbm2004/

Autumn School and International Conference on Stochastic Finance

20-30 September, 2004

Organizers:

Paulo Brito, ISEG, Lisbon, Portugal

Manuel L. Esquível, New University of Lisbon, Portugal

Maria do Rosário Grossinho, ISEG, Lisbon, Portugal

João Nicolau, ISEG, Lisbon, Portugal

Paulo Eduardo Oliveira, University of Coimbra, Portugal

For more information about this event, see

http://pascal.iseg.utl.pt/∼stochfin2004/

For updated information on these events, see http://www.cim.pt/cimE/eventos04.html.

CIM News

CIM Governing Bodies for 2004-2008

The CIM General Assembly, in a meeting held in Coimbra on May 29, elected the CIM Governing Bodies for the next four years:

Executive Board

Joaquim Júdice, Univ. Coimbra (President)

Ivette Gomes, Univ. Lisbon

Filomena Almeida, Univ. Porto

Domingos Cardoso, Univ. Aveiro

José Miguel Urbano, Univ. Coimbra

General Assembly

António Guedes de Oliveira, Univ. Porto, (Chair)

Fátima Martins, New Univ. Lisbon (Secretary)

António Ornelas, Univ. Évora (Secretary)

Auditing Board

Joana Soares, Univ. Minho (Chair)

Rafael Brigham, Univ. Algarve

Carlos Alves, Tech. Univ. Lisbon

CIM Events for 2005

The CIM Scientific Committee, in a meeting held in Coimbra on February 14, approved the CIM scientific program for 2005.

The **Thematic Term** for 2005 will be dedicated to Optimization. The Organizer-Coordinator is Luís Nunes Vicente (University of Coimbra, Portugal).

The list of events is the following:

Workshop on Optimization in Finance

5-8 July 2005

Organizers:

R. H. Tütüncü, Carnegie Mellon Univ., Pittsburgh, USA

L. N. Vicente, Univ. Coimbra, Portugal

Workshop on Optimization in Medicine

20-22 July 2005

Organizers:

P. M. Pardalos, Univ. Florida, Gainesville, USA

L. N. Vicente, Univ. Coimbra, Portugal

Workshop on PDE Constrained Optimization

26-29 July 2005

Organizers:

M. Heikenschloss, Rice Univ., Houston, USA

L. N. Vicente, Univ. Coimbra, Portugal

Summer School on Geometric and Algebraic Approaches for Integer Programming

22-24 June or 14-16 July 2005

Organizers:

M. Constantino, Univ. Lisbon, Portugal

L. N. Vicente, Univ. Coimbra, Portugal

Furthermore, the 2005 program will contain the following events:

International Conference on Semigroups and Languages

12-15 July 2005

Organizer:

Gracinda Gomes, Univ. Lisbon, Portugal

Workshop on Statistics in Genomics and Proteomics

6-8 October 2005

Organizer:

Antónia Turkman, Univ. Lisbon, Portugal

Research in Pairs at CIM

CIM has facilities for research work in pairs and welcomes applications for their use for limited periods.

These facilities are located at Complexo do Observatório Astronómico in Coimbra and include:

- office space, computing facilities, and some secretarial support;
- access to the library of the Department of Mathematics of the University of Coimbra (30 minutes away by bus);
- lodging: a two room flat.

At least one of the researchers should be affiliated with an associate of CIM, or a participant in a CIM event.

Applicants should fill in the electronic application form

http://www.cim.pt/cim.www/cim_app/application.htm

CIM on the WWW

Complete information about CIM and its activities can be found at the site

http://www.cim.pt

This is mirrored at

http://at.yorku.ca/cim.www/

Feature Article

The Portuguese and Mathematics

E. Marçal Grilo
Gulbenkian Foundation

1. If we wish to analyse any matter, global or special, about Education in Portugal, we must begin by describing realistically the features of the country in what concerns the skills and qualifications of its population.

   Portugal exhibits, at the start of the 21st century, a set of indicators that place it in a very unfavourable position in relation to the overwhelming majority of the 25 countries in the European Union. Actually, Portugal comes last in most indicators relating to population skills (in the 25-64 group) and it should be noticed that (i) around 68% of the Portuguese have been at most 6 years in school (which is even less than the mandatory 9 years prescribed in the 1986 Lei de Bases); (ii) only 9% possess a higher degree; and (iii) a very small number (around 11%) have completed the full 12 years at secondary school.

   If we add to these indicators the fact that around 80% of Portuguese businessmen have been at most 9 years in school, and that 50% of the Portuguese, when asked about their interest in learning new things, give the answer that they are not interested in learning anything else in their lives, we must conclude that the situation in Portugal concerning human resources is very weak and seriously constrains the development of the country;

2. To the situation just described we must still add, as a very negative indicator of the Portuguese situation, the results obtained by Portuguese students in tests designed to compare skill levels of school pupils in different countries.

   In recent reports assessing scientific and mathematical literacy (Program for International Student Assessment - GAVE - Education Ministry - December 2000) we can read the following statements, which cast an unfavourable light on the skills of our young people:

   (a) The performance of Portuguese students was inferior to the OECD average;

   (b) Many 15-year-olds are not able to handle simple symbolic representations, or relations between representations;

   (c) They also display poor reasoning skills, as shown by the arguments they use;

   (d) They generalize situations without checking their validity;

   (e) They use everyday information to base their answers on, without this information being relevant to the problem at hand; and

   (f) They base their answers on situations clearly excluded by the conditions stated.

3. It is in this setting that we must analyse the way the Portuguese relate to the school, to knowledge, and in particular to Mathematics, which has become an "Achilles' heel" and one of the main factors in the school failure of many Portuguese young people. (It should be said, however, that this "Achilles' heel" is not a Portuguese exclusive, since in many other countries Mathematics is also a subject disliked by many students. It is enough to recall the famous US report from the early 80s - A Nation at Risk - where Mathematics appears as one of the subjects in which US students had their worst performances and greatest difficulties when going into higher education);

4. Surely there are many explaining factors for the difficult relation Portuguese students have with Mathematics. Here I would like to be very straightforward and not pretend to be an expert in a very complex matter, which has already been the object of lots of research by people who have a scientific and academic authority I do not possess. That is why this article is a mere reflection on a subject, which worries many of those who, like me, have been following educational matters for a long time. This reflection is based on my own observation of several factors which influence the bad relation between the Portuguese and mathematical logic and rigour;

5. The first of these factors is the great lack of rigour and accuracy in the everyday behaviour of the Portuguese. Whether in being on time, in describing facts, or in following traffic rules, the Portuguese became accustomed to the banality of transgression and to systematically excusing those who do not fulfil their duties and obligations.

   Mathematics requires a frame of mind, which is precisely the opposite of this behaviour. Mathematics implies absolute accuracy and a mental structure in which each "piece" connects with those nearby, forming a coherent set in which any error or deviation means a deformation incompatible with the model.

   This lack of rigour is often followed by a certain resignation of the population with respect to its mathematical knowledge. It is very common to excuse a bad mathematical performance by a child with statements like "That's no surprise, we are all like that at home";

6. The second factor has to do with a typically Portuguese attitude, which sees a connection between "luck" and "success". To many Portuguese people, someone's success is almost always attributed to exogenous factors such as "luck" and "opportunity", or, even worse, special "recommendations" or "requests". The positive results attained in life by someone are often explained by others as mere "chance" or resulting from "tricks". Seldom are they explained because the person (or the team, or the company) developed a plan of action, in which lots of time and work were invested, with commitment, effort and sacrifice.

   Mathematics is not compatible with ease or luck. To be learnt, Mathematics requires great effort and continued dedication. It is not enough to understand the concepts, it is necessary to know how to apply them, which demands time, repetition and effort, even more so when dealing with more complex subjects, where several concepts, methods or formulas come together in a web whose "design" requires great individual concentration and ability.

   Here we must mention some "theories" which view memorization and exercise repetition as anti-pedagogical methods.

   In my opinion, based on my own experience (though a little remote already), the learning of Mathematics goes beyond the understanding of concepts, methods and relations. Mathematics is a subject in which some automatisms are required, and these are acquired following a course full of trials and errors, which make us, think, experiment and test concepts, formulas and rules.

   We should also mention that Mathematics, with its difficulty, was, and still is, considered a subject of certain failure for underprivileged students. This led some "schools of thought" to try and make it less demanding for students coming from poorer backgrounds.

   This is surely a wrong interpretation of the "underprivileged" concept, whose practical consequences are too apparent nowadays to be ignored.

   In this matter we cannot and should not introduce any positive or negative discriminations. Only quality and demanding teaching can include all young people who look to education as the best way to progress and seek personal and collective fulfilment;

7. A third factor is the teaching in the first school years. Without questioning the quality of so many 1st and 2nd cycle teachers, it seems to me that, in many cases and in many schools, teaching in these cycles does not aim at creating an interest in and the love of Mathematics, but rather at teaching all items in the curriculum. This does not have in mind that the great aims of Mathematics teaching are the development of reasoning and mathematical communication, as well as the training of the student in stating and solving problems, in using information technologies, in building mathematical models for reality, in understanding different modes of mathematical representation.

   Aims like these demand great commitment from the teachers, and above all they require that the teacher himself is deeply interested and devoted to the teaching and learning of Mathematics.

   In the case of Portugal, these conditions are not necessarily satisfied, as many 1st and 2nd cycle teachers have not had any mathematical training since 9th grade (in the 2nd cycle, the scientific training of Mathematics teachers has been very poor for quite some time. It's a bidisciplinary teaching group, involving Natural Sciences and Mathematics, so that many Mathematics teachers are trained in Biology or Geography, with little or no high-level mathematical training). On top of this, some of them may even have completed the 9th grade without a pass grade in Mathematics. Also, we cannot forget the harm done to the teaching of Mathematics by the hiring of 3rd cycle teachers from candidates with no degree in the subject. (The lack of Mathematics graduates led to the hiring of many 3rd cycle Mathematics teachers without a degree in Mathematics, while those with such a degree usually taught in secondary schools.) This means that the most serious problems in the teaching of Mathematics probably lie in the first school years, where teacher training is often the critical factor in the whole teaching process;

8. The fourth factor relates to the poor command of Portuguese language by many students. To learn Mathematics, above all to be able to state and solve problems, language skills are required which involve the ability to understand readings and to express thoughts.

   Language learning is therefore a factor closely related to the learning of Mathematics. A recent study concluded that a large part of the failure in Mathematics follows from the poor command of the Portuguese language by many students. Here we see the importance of reading which, as stated in the OECD study "Reading for Change", is a decisive factor for success in education, above even the social, economic and cultural background of students;

9. A fifth factor has to do with the way the School Project promotes the teaching of Mathematics, as well as the organization and the work developed by the Mathematics teachers in the School. This is a relevant factor, related to the School leadership, and the incentives, control and assessment brought about by that leadership throughout the year.

   The teachers' scientific knowledge is a decisive factor to improve the learning of Mathematics, but if the school as a whole does not choose Mathematics as a subject requiring special efforts (specially because in most cases it's a subject in which results are poor and interest is low) the abilities of the teachers will not matter much.

   Mathematics is today, to many students and many families, a subject in which failure seems to pass from the parents to the children, and the latter often fall victim to the mentality of those who, on finishing the 9th grade, proclaim "Mathematics Never Again";

10. As a sixth factor we mention school organization and functioning, which together with the way students and their families look at the school also play a role in the shocking failure in Mathematics by our students.

    It seems to me crucial to consolidate an autonomy model in public schools which brings about greater responsibility of the leadership and increases the accountability to which all educational institutions must be subject. Along with is, it is also very important, to improve the way schools work and therefore student success, to bring the parents into the schools and thus eliminate some of the barriers which, in many cases, still exist between families and school leaders;

11. As we said before, teacher training and selection for the first school cycles are among the factors explaining poor teaching and learning of Mathematics. We believe that a great effort is equally necessary to improve the teaching of Mathematics in the 3rd and secondary cycles. This effort involves the initial training of teachers, which takes place at the Universities, where the courses must involve a scientific component duly qualified and assessed. (The elimination of the accreditation institute created in 1997 is a very troubling sign, which may mean the loss of quality control of teacher training courses);

12. The change in the Mathematics curriculum is traditionally considered as a measure, which might change the situation of the teaching of the subject. In the last 20 years countless reforms and changes were carried out in the curriculum. I honestly think (others more qualified may disagree) that the curriculum alone will not radically change the success indicators in Mathematics, or the lack of interest displayed by many students towards the subject.

    As proof of this there is the fact that many schools, public and private, have managed to create an atmosphere where the teaching of Mathematics is promoted, with significant rises in the numbers of students who begin to like the subject.

    The role of the teacher, the organization of the school and the way the school leaders face "the Mathematics problem", are much more decisive than the simple change or extension of the Mathematics curriculum.

    It should be said, nevertheless, that there surely are some aspects related to the curriculum that may be factors of change and improvement in the teaching of Mathematics. The most relevant of these have to do with the way the subject matter is divided by the successive years and the quality of some school textbooks (contrary to the heavy, grey and colourless "official textbooks" of the past, some of the current Mathematics textbooks have childish texts and images, as a sort of comic books where rigour is lacking and concepts are not clear);

13. Portugal has excellent Mathematics teachers. From the 1st cycle to the University we find countless success cases in the teaching of Mathematics throughout the country. Between the teacher who is able to instil the "love for numbers" into the 6-, 7- or 8-year-old child, and the researchers and university professors who do research and help train hundreds of masters and PhD's, there exist hundreds of qualified teachers who constitute the only way through which it will be possible to

solve the critical problem of improving the teaching of Mathematics in Portuguese schools.

Nothing will be achieved, however, if our students and their families do not understand that studying implies work, effort, dedication and sacrifice, for which they must be prepared. Mathematics is a subject with a structuring character in the education of an individual.

Much of the future of our country will depend on the work done in the schools, complementing the education by parents and families. And in the school a good fundamental education, specially in Mathematics, is surely one of the decisive factors for the development of a country wishing to base its future on human resources, on knowledge and on technology.

14. Universities will play a decisive role in any strategy to improve the teaching of Mathematics.

    Teacher training, the deepening of knowledge, the attraction of young people of great potential and the creation of a "critical mass" of researchers (as is being done in many Mathematics Departments of Portuguese Universities) are surely the best way for the Universities to be a sustainable basis for the improvement of the teaching of Mathematics. The rest will follow.

Lisbon, 16 May 2004

DNA does the twist. And the writhe. A "News and Views" item in the May 13 2004 Nature picked up a preprint posted by Maria Barbi, Julien Mozziconacci and Jean-Marc Victor, all with the CNRS. "In the cells of higher eukaryotes, e.g. animals or plants, meters of DNA are packaged by means of proteins into a nucleus of a few micrometer diameter, providing an extreme level of compaction." As we know, the nuclear DNA contains a library with all the instructions for making and maintaining a cell. But how does one access an item in a library where all the text is on a single line miles long bunched up into a volume inches in diameter? We know there are enzymes (topoisomerases) that allow one strand of DNA to pass through another, so there is no topological obstruction to moving any particular segment of DNA to where it may be copied. But transcription can take place without topoisomerases. How? Barbi and collaborators studied the way that DNA is coiled. The first two levels of packing result in a chromatin fiber.

"In order to provide the transcription machinery with access to specific genomic regions, the corresponding [chromatin] loop has to be selectively decondensed, via a reversible unwinding process that elongates the fiber." The CNRS team analyzed the way the differential-geometric quantities "twist" and "writhe" vary in terms of the angles and discovered that there is a unique way to simultaneously vary the αs and the βs so that the fiber elongates isotopically: without changing the linking number of the DNA. The unfolding process is illustrated in the following picture, where it is compared with the non-isotopic stretchings that come from changing the αs and the βs separately.

Understanding the ununderstandable. There's an essay about the nature of mathematical understanding in the May 25 2004 New York Times Science section. Susan Kruglinski interviewed four prominent popularizers of mathematics to find out how much of "the inconceivable, undetectable, nonexistent and impossible" described by mathematics can possibly be explained to a general audience.

* Ian Stewart, asked if there exist mathematical concepts that cannot be explained to a general audience: "Oh, yes – possibly most of them."

* Keith Devlin, speaking of the Hodge Conjecture: "Those equations ... are beyond visualization."

* Brian Greene defends imperfect metaphors: "The equations that govern a violin string are pretty close to the equations that govern the strings we talk about in string theory. So although the notion of strings is metaphorical, it's pretty close." And adds: "I suspect that the overarching aim of every mathematical study can be described, even if you can't get to the guts."

In what sense do scientists, including mathematicians, understand their own work?

* John Casti: "Mathematics is an intellectual activity – at a linguistic level, you might say– whose output is very useful in the natural sciences."

This approach sidesteps the question of math's connection to reality, so understanding may well be besides the point. Brian Greene has the last word: "Our brains evolved so that we could survive out there in the jungle. Why in the world should a brain develop for the purpose of being at all good at grasping the true underlying nature of reality?"

More about Kepler's Problem. "In Math, Computers Don't Lie. Or Do They?" was the headline on Kenneth Chang's exhaustive treatment of the brouhaha surrounding the publication of Thomas Hales' 1998 computer-assisted proof of the Kepler sphere-packing conjecture (New York Times, April 6, 2004). [Synopsis: Robert MacPherson, Editor of the Annals of Mathematics where Hales' proof was submitted, assigned the checking to a large group of referees who spent several years at the task and gave up. Everything they examined was OK, but there was always more. The "Solomon-like" decision of the Annals editors: publish the "theoretical underpinnings," and leave the computer programs, and their output, to be published elsewhere.] Chang describes the problem ("In the Produce Aisle, a Math Puzzle") and some of its history, but his main focus is computers, as used in mathematical proof. He interviewed John Conway ("I don't like them, because you sort of don't feel you understand what's going on") and Larry Wos, who claims that the advantage of computers is their lack of preconceptions: "They can follow paths that are totally counterintuitive." He also did some research on the natural history of mathematical proof. "Even in traditional proofs, reviewers rarely check every step, instead focusing mostly on the major points. In the end, they either believe the proof or not." An exemplary piece of journalism about mathematics.

Math is hard! This isn't Barbie speaking, it's Keith Devlin, NPR's "The Math Guy," and he was delivering the keynote address to 15,000 members of the National Council of Teachers of Mathematics at their annual meeting last month in Philadelphia. His remarks were picked up and disseminated by Joann Loviglio of the Associated Press (April 21, 2004). She paraphrases Devlin: "Our brains aren't well equipped to grasp those kinds of advanced mathematics" (those kinds include adding fractions and calculus). What the brain does naturally is "counting, algebra, geometry and simple arithmetic." This "natural mathematics" is contrasted with the "formal mathematics" that many NCTM members are condemned to teach, stuff that "seems counter common sense to our brains." How did Devlin himself become a math professor at Stanford? "Devlin said it was not until he was a graduate student that he really understood what he was doing. 'I learned to play the game first ... to manipulate the symbols to get the right answer, and the understanding came later,' he said." Like Pascal's method for attaining faith through prayer. More of Loviglio's paraphrase: "Maybe formalized math should be taught in a manner similar to the immersion method used for teaching language, in which a teacher just starts speaking in a foreign tongue and students eventually start figuring out what's being said. But not all students learn language that way - and not all students will master formal mathematics." The AP feed was posted on the webpage of the State College, PA Centre Daily Times. A webcast of the entire opening session, including Devlin's address, is available on the NCTM's website.

Recent math history in the Chronicle. "Math with a Moral" is the title of Robert Osserman's contribution to "The Chronicle Review" in the April 23 2004 Chronicle of Higher Education. Osserman sets the intellectual stage for the Poincaré conjecture and leads us through the main steps in its resolution. This is large-scale and coarse-grained mathematical history for a general audience, but very skillfully done. Osserman leaps from shoulder to shoulder (Riemann, Poincaré, Thurston) in sketching the flow of ideas from geometry through topology and back to geometry. He has a nice metaphor for Thurston's geometrization conjecture: "William Thurston's great contribution was to see a way to systematize all those shapes – to provide a kind of periodic table with which to classify and organize all possibilities, as built up out of components based on the original positively and negatively shaped geometries of Riemann, together with a few other basic types." Then the more recent developments (Hamilton, Perelman) and the news that Perelman's published and accepted work has been shown, by Perelman himself, and by Toby Colding (NYU) and William Minicozzi (Johns Hopkins), to be already sufficient to settle the Poincaré conjecture. [According to my sources this may be premature: Perelman's second paper, necessary for this proof, has still not fully been digested. TP] Perelman's full proof of the geometrization conjecture is still under examination. The story has two morals: "When faced with a problem that seems intractable, the best strategy is sometimes to formulate what appears to be an even harder problem. By expanding one's horizons, one may find an unanticipated route that leads to the goal. Second, ... usually mathematics is a highly social activity, with collaboration between two or more individuals the rule rather than the exception. ... Even when an individual takes the last step in solving a problem, the solution invariably depends on elaborate groundwork laid by others ..."

Chaos in Nature. "they have developed a powerful new method to determine from experimental observation of a system whether it is chaotic, and, if it is, what the precise quantitative nature of that chaos is." Thomas Halsey (ExxonMobil Research) and Mogens Jensen (Niels Bohr Institute) are commenting on recent work of Sam Gratrix and John N. Elgin (Physical Review Letters 92 014101), in a "News and Views" piece in the March 11, 2004 Nature. Halsey and Jensen briefly review the methods currently available for determining if a set is or is not a strange attractor. The criterion is multifractality, but box-counting ("simply reconstruct its trajectory through phase space, cover that trajectory with boxes, measure the amount of time spent in each box, and then determine whether or not the multifractal structure you have computed is consistent with chaos") is unreliable. A safer method involves periodic trajectories. "Mathematicians know that the strange attractor can actually be constructed from the union of all periodic trajectories of a system, provided that trajectories of arbitrarily long periods are included ..." This method can be applied to an analytically given dynamical system, for example the Lorenz attractor: "Using an ingenious method to categorize these long trajectories, Gratrix and Elgin have reconstructed in great detail both the Lorenz attractor and its multifractal properties." For systems in nature, there is rarely time for finding enough trajectories to apply this method. But Grantz and Elgin have developed "a much simpler approach, based on recurrence times" and have shown, by applying it to the Lorenz attractor, that it matches the periodic-trajectory method, and should give reliable diagnoses of chaos. "Because calculations based on recurrence times should be relatively straightforward for experimentalists, and as we now have reason to believe that they will be more reliable than box-counting results, we can confidently await a new series of experimental demonstrations of the chaotic properties of a variety of natural systems." The title of the piece is "Hurricanes and butterflies."

Atiyah, Singer in The Boston Globe. "MIT professor wins major international math prize" was the heading on a March 30 2004 "White Coat Notes" item by Scott Allen in the Globe. The story is the award of the 2004 Abel Prize to Isadore Singer (MIT) and Michael Atiyah (now at Edinburgh) for their 40-year-old discovery of the Index Theorem. "The Atiyah-Singer index theorem calculates the number of solutions to complex formulas about nature based on the geometry of surrounding space, an idea that is difficult to explain but amazingly useful in both math and physics." The wide applicability of the index theorem in physics was referred to by the Norwegian Academy of Science and Letters in their citation, where, as quoted by Allen, they described the work as "instrumental in repairing a rift between the worlds of pure mathematics and theoretical particle physics." King Harald will present the prize on May 25.

Statistical Topology of Networks. "Superfamilies of Evolved and Designed Networks" appears in Science for March 5, 2004. The authors are a team of 8 scientists in various departments of the Weizmann Institute. The idea is to classify networks by the statistical properties of their local topology, in the case of oriented networks by the statistical significance of each of the 13 possible "direct connected triads". These correspond to the exactly thirteen ways (up to symmetries of the triangle) of placing forward (F), backward (B) and double-headed (D) arrows on the three edges of a triangle so that all three vertices are touched:

$$BF, FB, FF, FD, DF, DD, FBB, FFF,$$
$$DBF, DFB, DFF, DDF, DDD.$$

The statistical significance of a triad compares its frequency of appearance with the way it appears in an ensemble of randomized networks with the same degree sequence as the network under examination. (The degree sequence is the distribution of the variable "number of edges per node"). The authors number the triads from 1 to 13, as listed; the sequence of 13 statistical significances is the significance profile of the network. The authors examine a collection of networks arising in nature ("evolved") or artificially ("designed") and find four "superfamilies" of networks with very similar significance profiles. For example word-adjacency networks from various languages (English, French, Spanish, Japanese) all fall in the same superfamily. WWW Hyperlinks between pages on the Notre Dame website, and interpersonal social networks from a variety of contexts, fall in another one. Biological systems involving direct transcription interactions and those involving signal transduction interactions fall in two other, distinct superfamilies; the paper justifies this difference in biological terms.

Perelman in Nature. The January 29 2004 issue contains a piece by Emily Singer entitled "The reluctant celebrity," about Gregory Perelman and his attack on the Poincaré conjecture. Singer gives a sketch of the problem, including a correct intuitive picture of the 3-sphere. Unfortunately one might get the impression that Poincaré was not able to prove that the 3-sphere is simply connected, but let's not quibble. The roles of Thurston and Hamilton in beginning and continuing work on the Geometrization Conjecture are well described, as is Hamilton's Ricci flow program ("a systematic procedure that smooths an object's surface into a simpler ... shape by spreading its curvature") and the singularities that obstructed it ("Some parts of the surface may transform faster than others, resulting in a 'lumpy' shape"). There are nice quotes from mathematicians who knew Perelman before he embarked on his eight-year quest to iron out Hamilton's singularities. Jeff Cheeger: "He was already considered extremely brilliant; this was apparent in conversation and on the basis of his work." But the main focus of the article is the reluctance mentioned in the title. That Perelman does not want to bask in the limelight or accept one of the opulent offers dangled before him by american universities is apparently almost as unfathomable as the mental processes that led to his discoveries.

Love Model Equations. The AAAS annual meeting was in Seattle last month, and the February 13 Seattle Times reported on some of proceedings. A local team of psychologists and applied mathematicians presented no less than a "mathematical formula for marital bliss." Unfortunately this formula, derived by John Gottman, James Murray, Kristin Swanson and their collaborators, is not an algorithm for achieving bliss. Rather it is a mathematical model of a relationship, based on the analysis of how a couple interacts when arguing, that can predict "with 94 percent accuracy which marriages will last and which will end in divorce." The model is a set of "coupled" first-order ordinary differential equations. In LoveModelEquations-2.pdf (available from the online Seattle Times article) Swanson spells them out:

$$\frac{dx}{dt} = q_1\,(x_0 - x) + I_1(y),$$

$$\frac{dy}{dt} = q_y\,(y_0 - y) + I_1(x).$$

Here I_1 and I_2 are piecewise linear functions (two different positive slopes, changing at 0) which encode the couple's argument-interaction behavior. Geometrically speaking, the health of the relationship can be read off from the convexity of I_1 and I_2. Both close to straight lines gives a "validating style of interaction." Both are very convex downward in conflict-avoiding couples, very convex upward in volatile couples. We are not told the prognosis for a mixed marriage.

Aromatic Möbius strip. "Synthesis of a Möbius aromatic hydorcarbon" appeared as a letter to Nature, December 18, 2003. There is a "Hückel rule" that constrains the number of carbon atoms in cyclic hydrocarbon compounds: the number of carbon atoms in an uncharged ring (always even) must be of the form 4n + 2. The most familiar member of this family, benzene, has 6 carbons. The Kiel and Stuttgart-based authors (D. Ajami, O. Oeckler, A. Simon, R. Herges) of this article took up a prediction of E. Heilbronner (1964) that rings of 4n molecules could be stable if they had the topology of a Möbius strip. They found an ingenious method for synthesizing a stable, twisted "annulene" with 16 carbon atoms: surgery between an annulus-like 8-carbon aromatic molecule and a cylinder-like one (in this case, tetradehydrodianthracene).

"Malignant Maths" is the title of a piece in the January 22 2004 Economist. The subtitle is less threatening: "Mathematical models aid the understanding of cancer." The focus is on three works appearing in Discrete and Continuous Dynamical Systems–Series B which is devoting its February issue to the topic.

- Zvia Agur and her colleagues (Institute for Medical BioMathematics, Bene Ataroth, Israel) present a model for the workings of angiogenesis (the process by which a tumour creates its own blood vessels). Dr Agur set up a system of differential equations, where the variables are "the number of cells in a tumour, the concentration of the angiogenetic growth factors within it and the volume of the blood vessels." Analysis of this system led to "the discovery that there are circumstances in which a tumour oscillates in size, instead of growing steadily," with clear therapeutic implications.

- Denise Kirschner (University of Michigan) describes her investigations into the use of the immune system to fight tumor growth. A novel treatment, known as small interfering RNA (siRNA) therapy, might suppress the action of a molecule called "transforming growth factor beta" (TGF-beta), which large tumours use to elude the immune system. Dr. Kirchener also uses a differential equation model. Her variables are "the number of immune-system 'effector cells' (those that combat tumours), the number of tumour cells, the amount of interleukin-2 (a protein that enhances the body's ability to fight cancer), and an additional variable to account for the effects of TGF-beta. ... In the model, a daily dose of siRNA over the course of 11 successive days succeeded in counteracting the effects of TGF-beta, and so allowed the immune system to bring the tumour under control."

- Pep Charusanti and his colleagues (UCLA) investigated the action of Gleevec, a drug used against chronic myeloid leukaemia. Gleevec starves cancer cells by inhibiting their metabolism of ATP. The riddle was why Gleevec was ineffective in a "blast crisis," the terminal state of the disease. Charusanti's mathematical model "shows that cells in blast crisis expel the drug too quickly for it to be useful as an ATP-blocker," giving a direction to look for improvements in the therapy.

The article ends by quoting Richard Feynman: "mathematics is a deep way of describing nature, and any attempt to express nature in philosophical principles, or in seat-of-the-pants mechanical feelings, is not an efficient way."

Bayesian filters for spam. "Bayesian" may be the new geek buzz-word. Here we have Andrew Cantor in his USA Today Cyberspeak column (December 26, 2003) telling us how "The Reverend Thomas Bayes was an 18th century English mathematician who came up with a theorem for determining the probability of an event based on existing knowledge." And how "In August 2002, Paul Graham wrote an article called 'A Plan for Spam'. He suggested using Bayes's techniques to identify the probability of a message being spam. Unlike other spam filters, this would be based on the content of messages you already knew were spam." Cantor mentions some commercial products devised to convert this 18th-century notion into 21st-century cash. Article available online.

An Interview with Ian N. Stewart

You started out as a group theorist in the early 70's, then worked on successively in Catastrophe Theory, Bifurcation Theory, Dynamical Systems and Chaos, and now are turning towards Mathematical Biology. It's a rather remarkable trajectory. How did it come about?

It all seemed very natural at the time. As an undergraduate, I generally preferred 'pure' mathematics to 'applied', and I particularly liked the crisp logic of algebra. I was at Cambridge, and took courses from Philip Hall, one of the world's leading group-theorists. So I decided that my PhD ought to be in group theory. In fact, it was in a closely related area, Lie algebras, because my supervisor Brian Hartley was interested in a possible connection between Lie algebras and abstract groups.

Then, in 1970, Christopher Zeeman gave the first lecture course ever on Catastrophe Theory. I went to it, and really liked it. The underlying mathematics is very algebraic. But in addition there were applications, such as optical caustics. So I started to move into more applied areas. It was then natural to spread out into singularity theory and bifurcation theory. In 1983-4 I spent a year at Houston working with Marty Golubitsky, and that had a major effect on my choice of research area. Continuing the move into dynamical systems made a lot of sense... I just followed where the maths itself pointed. The recent interest in mathematical biology mostly came about because there are nice applications of dynamics with symmetry to biology.

One point which impresses me particularly in your career as a research mathematician is that you always seem to be in a field where the exciting action is going on — riding the crest of the wave — and you leave a permanent imprint. Would you like to comment?

I don't set out to follow fashion. There are lots of fashionable areas that I've never wanted to work in! I think it's just that the kinds of things that appeal to me are the kinds of things that appeal to lots of other people. The wave kind of forms itself, and I get swept along with it. In addition, I really like to work in NEW areas, where you don't need a lot of background to do useful research.

You were a group theorist in the days of the Appel-Haken proof of the classification of simple groups in 1976. Can you give us a first-hand account of the reactions of the mathematical community to the first computer-assisted proof in history?

The main reaction, oddly enough, was disappointment. "Oh, it's THAT sort of theorem, is it?" One that needs massive calculations that don't yield much insight. Most of us didn't worry much about the use of the computer — it was the philosophers who thought that changed the nature of proof. Our feeling was that it just changed the technique a bit.

Ian N. Stewart

Turning to Catastrophe Theory, there was after the classification theorem of René Thom and the groundbreaking work of Christopher Zeeman the idea, in some circles, that there it was at last, a mathematical theory for everything. Of course no mathematics can live up to these expectations. Do you think Catastrophe Theory was a victim of its own success?

I think that the popularization of the subject got mixed up with the technical aspects, and people got confused. No one seriously claimed it as a theory of everything. People did point out that it had very broad applications (which was and still is true). Then priority issues muddied the waters even more. The quality of criticism was very poor — lots of noise but very little genuine content, and a lot of confusion. In those days, mentions of maths in the media were rare, and academics didn't really understand how such things went. The subject was inherently interesting, the media picked up on that — it wasn't "hype", deliberate attempts to exaggerate. You can't hype maths, people don't take any notice.

As a first-hand actor in the explosive development of Dynamical Systems in the past 30 years, how do you see its role either with respect to the rest of Mathematics as well as with respect to the other sciences?

It occupies a very central position in the link between abstract maths and applied science. The world is non-linear, but until dynamical systems got going (thanks to Steve Smale and various others) virtually all applied maths was linear. People were tackling 20th century problems with 18th century methods. Now we have chaos, fractals, cellular automata... and powerful computers that make it possible to do the calculations for real systems. A few mathematicians still complain that chaos and fractals have never achieved anything useful... if they bothered to read NATURE and SCIENCE they'd realise how untenable that position really is.

Some mathematicians think (and say) that the future of mathematics is in Biology. What is your own view?

I think that one of the most exciting prospects for the next century is the interaction of maths with REAL, hard-core biology. The kinds of question that biology raises will need some very new ways of thinking, they will stimulate genuinely novel maths. Knowing an animal's DNA sequence is all very well, but that doesn't tell you very much about the animal unless you understand the processes that DNA controls. Well, more like a conductor controls an orchestra, which is to say, not very directly. DNA "orchestrates". I'm very encouraged by recent work of people like Enrico Coen and Hans Meinhardt, who are forging strong links between the general maths of pattern formation and the crucial role of genes.

You are connected with the Clay Institute, which has instituted biggest-ever awards in Mathematics — the "Millenium problems", sometimes called "Million-dollar problems". Which one do you feel will be the first to crack? The last? And for how long will they stand?

The obvious answer is the Poincaré Conjecture, which may well have cracked already, thanks to Grisha Perelman. I am inclined to think that the P=NP? problem may be the last to go. Timescale: could be a hundred years. The existence problem for solutions of the Navier-Stokes equations could be just as hard (and I suspect the answer is "no").

Do you agree with those who say that the Riemann Hypothesis will stand for another century? And what is the current feeling about G. Perelman's recent work which, it is said, may have solved Thurston's geometrization programme, carrying Poincaré's conjecture along the way?

You could have said much the same about Fermat's Last Theorem, 20 years ago. I have a sneaking feeling that the Riemann Hypothesis won't last another 20 years. There is a growing belief that Perelman's ideas may indeed have proved the geometrization conjecture, which trivially proves the Poincaré Conjecture. Several prominent mathematicians have been saying as much in print, especially in the Notices of the AMS. Certainly everyone thinks that he has made major progress.

You have had lots of Portuguese Ph.D. students. In fact, over here we half-jokingly call it "Ian's Portugal connection", and some of us organized a conference in 2000 in your and Marty Golubitsky's honour. How did this "Portugal connection" develop?

Isabel Labouriau. She came to Warwick from Brazil and wanted to do a PhD in mathematical biology. I was almost the only person on the staff at that time, and I agreed to act as supervisor. She was working through a paper by Rinzel and Miller - numerics of Hopf bifurcation in the Hodgkin-Huxley nerve impulse equations. Then Marty G visited and talked about his recent work with Bill Langford on degenerate Hopf bifurcation, and the Rinzel-Miller results looked just like one of their pictures. So Isabel got the task of finding out why.

Then she moved to Porto, and after a few years started sending her students over to Warwick. It kind of grew from that. I am now supervising mathematical "great grand-daughters" with Isabel as the first daughter.

How many Portuguese students have you had? And how do you feel they compare scientifically with the universe of British postgraduate students?

It's 6, not counting Isabel. Plus a couple of Brazilians, which I tend to think of as honorary Portuguese. In total, about one third of my PhD students. They are entirely the equals of the British ones (and I've been fortunate to have some extremely good students). And it's very encouraging that Portugal produces so many top-quality women mathematicians.

What do you feel was the most exhilarating moment in your career as a research mathematician? Can you describe it to us? And the funniest one (not necessarily involving yourself)?

Most exhilarating — I think it was when a chance remark in a book review led to a long-term collaboration on animal locomotion. I was reviewing a book about connections between biology and engineering, and there was a paper on patterns in animal movement. They reminded me of symmetric Hopf bifurcation patterns, and I said something like "does anyone want to fund an electronic cat?". Next day, Jim Collins phoned from Oxford, and said: "I can't fund an electronic cat, but I know people who can." And that began a major collaboration and turned my attention more towards biology.

The other exhilarating experience was the year in Houston with Marty Golubitsky, 1983-4. We've been good friends and close collaborators ever since. It's fantastic to have someone who understands the maths in the same way, but can complement your own ideas.

Funniest? Around 1990 I went to a conference at Abisko in Lapland, next to a huge frozen lake, solid enough to run a car over, and my wife and I were persuaded to go cross-country skiing. We'd never done any skiing before, so when the Swedish organizers took us 10 km away from the Research Station and left us to ski home, we decided to ski on the lake. There was one Lapp fisherman, fishing for his dinner through a hole in the ice. We spent the morning practising skiing on the lake ice, falling over when we hit infinitesimal bumps. By lunch time there were about a dozen Lapp fishermen, all staring at us as if we were stark staring mad. In retrospect, this was hilarious.

Besides an outstanding mathematician, you are a brilliant and foremost popularizer of Mathematics. Good popularization is very difficult and requires a lot of hard work. Why do you think it important enough to dedicate a significant amount of your time and effort to it?

Well, nowadays I get paid pretty well for it, so that's a bonus. But I didn't to begin with, for years, and it never bothered me. I've always enjoyed writing, I like to write about things I understand, and it just seemed a natural thing to do.

Some hard-line mathematicians regard popularization, at best, as a meaningless waste of valuable time which could and should be put into serious things like research, implying in particular that popularization of science is not a serious activity. What is your comment?

I was never greatly bothered whether anyone else approved of it or not. It was a kind of hobby. I thought it was worth doing. Nowadays, most scientists have realised that it's important to engage with the public. I've had a lot of support from colleagues, and very little criticism. It helps, though, that I still do a full research job. My popularization activities don't damage my research.

What would your answer be if you were told by another mathematician, as I have, that "popularization is worth nothing"?

Ignorant rubbish.

How many popularization books (if you can still track them) have you authored? In which languages are they translated? What is the best one, in your opinion, and does it coincide with the best-selling?

I've written about 70-80 different books, of which about 25-30 are popularizations. Between them they've been translated into at least 19 languages — Portuguese, Spanish, French, German, Italian, Dutch, Japanese, Chinese, Swedish, Norwegian, Danish, Indonesian, Russian, Romanian, Polish, Korean, Persian, Hungarian, Estonian, Greek, Croatian, Chekoslovakian...

Best one? I think they're all good! In some ways my favourite is Fearful Symmetry (written with Marty). Plus Flatterland, a modern sequel to Edwin Abbott's Flatland—but you either love that book or hate it. The best-selling ones are The Science of Discworld I and II, written with my friend Jack Cohen and Britain's best-selling fantasy writer Terry Pratchett. They both spent weeks in the Sunday Times top 10 bestseller list for nonfiction. Mostly thanks to Terry. The best-selling mathematical one is Does God Play Dice?

With which non-mathematical journals have you collaborated? And which has been the most pleasurable collaboration for you?

Oh, lord... which one's HAVEN'T I written for? I've written for Scientific American, New Scientist, Pour La Science, Times Literary Supplement, Analog science fiction magazine, The Guardian, The Scientist, Prometeo, The Economist, The Times, Daily Telegraph, The New York Review of Books, London Review of Books, Discover , Brand Strategy , The Lancet, Prospect , El Pais, Newton...

The most fun was probably with Pour La Science – Phillippe Boulanger, the editor, asked me to write a monthly mathematical games column, a successor to Martin Gardner's column in Scientific American. Eventually I ended up writing it for Scientific American too.

You even have time for other lives. I remember, when I was your student, that you were proud of having received a prize for a Science Fiction book (if I'm not mistaken, you had been nominated "Earth's ambassador to the other galaxies"). And you write for example about "The science of Discworld", of Terry Pratchett. Are there no limits to your imagination?

I'm just interested in lots of things. And I write fast. Jack Cohen and I wrote a science fiction novel Wheelers a few years ago. A sequel, Heaven, will be published in May. We've already planned a third book in that series.

How do you manage to do all this? I am assuming that your days have 24 hours, but please correct me if I'm wrong (as you have done in the past).

(a) I write fast. (b) My position at Warwick University is now half-time research and half-time Public Understanding of Science. So I save time by not having lots of courses to teach.

Thank you very much for your most valuable time!

Interview by Jorge Buescu - Department of Mathematics, IST, Lisbon

Ian Stewart was born in 1945, educated at Cambridge (BA and MA in Mathematics) and Warwick (PhD). He was awarded an honorary DSc by the University of Westminster in 1998, and an honorary DSc by the University of Louvain in 2000, and an honorary DSc by the University of Kingston in 2003. He is Professor of Mathematics at Warwick University and Director of the Mathematics Awareness Centre (MAC@W). He has held visiting positions in Germany, New Zealand, and the USA, and is a regular research visitor at the University of Houston, the Institute of Mathematics and Its Applications in Minneapolis, and the Santa Fe Institute. He is an adjunct professor at Houston.

Among the general public he is best known for his popular science writing on mathematical themes. In 1995 he was awarded the Royal Society's Michael Faraday Medal for furthering the public understanding of science. His book *Nature's Numbers* was shortlisted for the 1996 Rhone-Poulenc Prize for Science Books. He delivered the 1997 Royal Institution Christmas Lectures on BBC television and repeated them for NHK in Japan in 1998. He is winner of the 1999 Communications Award of the Joint Policy Board for Mathematics, and he was awarded the 2000 Gold Medal of the UK's Institute for Mathematics and Its Applications. His joint book *The Science of Discworld* was nominated for a Hugo award at the 2000 World science fiction convention. Jointly with M. Golubitsky he won the 2001 Balaguer Prize for a mathematical monograph based on the author's own research, awarded by the Institut d'Estudis Catalans, Barcelona. He was elected a Fellow of the Royal Society in 2001, and won the Public Understanding of Science and Technology Award of the American Association for the Advancement of Science in 2002.

Francisco Gomes Teixeira

Francisco Gomes Teixeira was born at São Cosmado, a small village near Armamar, in the North of Portugal, near the river Douro, on the 28th January 1851.

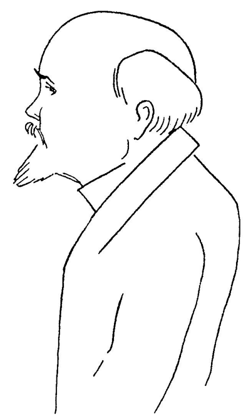
He went to school at his native village and to the *Liceu* in Lamego. After a period of uncertainty regarding his future, during which he hesitated between Theology and Mathematics, he entered the University of Coimbra, the only one in Portugal at the time, and completed his degree in Mathematics in 1885 with the highest classification. He was still a student when he published *Desenvolvimento das funções em fracções contínuas.* He sent this work to Daniel Augusto da Silva (1814-1878), a Navy officer, author of some important work on Number Theory and on Mechanics, Professor at the *Escola Naval* in Lisbon and by then the most respected Portuguese mathematician. Da Silva acknowledged the reception of this work with words of high praise, encouragement and support. It was the beginning of a friendship that only finished with Da Silva's death.

In 1875 Gomes Teixeira presented a thesis *A integração das equações às derivadas parciais de 2ª ordem*, with which he obtained his doctor degree again with the highest classification. The following year he obtained a professorship with the work *Sobre o emprego de eixos coordenados oblíquos em Mecânica analítica.* In 1878 he also became a member of the *Academia Real das Ciências de Lisboa.*

In 1877, Teixeira received a letter from his friend Daniel da Silva, in which he complains about a recently published paper by Darboux about some work on Mechanics by Möbius and Miding. According to Da Silva, he had already obtained the results of Darboux himself twenty five years before, in a paper published in Portuguese in the *Memórias da Academia das Ciências de Lisboa.* Da Silva writes:

> *My memoir, which has many more things than those obtained by Möbius (...) lays down ignored for almost twenty six years in the libraries of almost all the Academies of the world. The reward of writing in Portuguese!*

This letter must have made a strong impression in the mind of the young mathematician, making him realise the isolation of the Portuguese scientific community. He soon began to fight this isolation: he wrote the main original results of his thesis in French and sent them to the *Mémoires de la Société de Sciences Physiques et Naturelles de Bordeaux* (where the paper was published in 1878); this kind of initiative was very unusual in the Portuguese scientific community of the time.



Francisco Gomes Teixeira (a drawing by his student Eleutério Fernandes)

This was just the first of a long series of papers he published in important mathematical periodicals, both national and foreign. To keep the examples to a minimum, he collaborated with Liouville's and Crelle's Journals and he was the first Portuguese to publish in *Acta Mathematica.* His interest in educational questions led him to publish also with *L'Enseignement Mathématique*, for example. He became a member of the scientific committee of this journal.

His main areas of work were Partial Differential Equations, Function Theory (namely series expansions), Geometry (properties of curves) and History of Mathematics. But he was not only interested in being known by the international mathematical community: he also intended that the Portuguese mathematical community became a part of that international community. Having this in mind and also the desire of popularisation and diffusion of science, he founded in 1877 the *Jornal das Sciências Mathemáticas e Astronómicas*, the first Portuguese journal devoted solely to mathematics. Important mathematicians such as Hermite and Bellavitis collaborated with their articles. Gomes Teixeira also visited several foreign Universities during his career, having personally contacted several European mathematicians (namely in Italy, France and Germany). Referring to this effort of internationalisation of science, he writes much later in a paper about Daniel da Silva:

> *Nothing can cause more damage to the scientific knowledge of a nation than its isolation from the science of the other nations. There was an almost complete isolation in Portugal during most of the XIX century and the main reason was the fact that our language was unknown in foreign scientific circles. Our journals were almost unknown outside the country and our scientists did not use the most widespread journals of foreign countries to present the results of their research. (...) the Annaes da Academia Polytechica do Porto, a journal to which I have tried to give an international character in order to fight the dangerous isolation of Portuguese science. (F. Gomes Teixeira, Panegíricos e Conferências, p. 160, 165)*

Around this time Gomes Teixeira made a short incursion into politics. He was ellected to Parliament by the *Partido Regenerador* in 1879 but, clearly, this was not his calling and he left the capital in 1884. In a interview much later to a Lisbon newspaper, he said:

> *I am and always have been deeply ignorant about politics. Look, I have been a member of Parliament at the time of Fontes! And I did not like it. As a parliamentarian, the best I have done at that time, when there was a splendid opera company in Lisbon, was to listen to magnific singing at S. Carlos. (Diário de Notícias de Lisboa, 7th March 1927)*

In 1883 Gomes Teixeira asked to be transferred to Oporto, a requirement which was heartedly supported by the Politechnical Academy of that city. He entered it in 1884, having been assigned the fourth chair (*Descriptive Geometry*). The following year he moved to the second chair (*Differential and Integral Calculus*; *Calculus of Differences and of Variations*). The lessons he gave in this course were at the origin of one of the most important of his works, *Curso de Análise Infinitesimal*, which has known four different editions beginning in 1887. This treatise is divided into two volumes, with the subtitles *Cálculo Diferencial* and *Cálculo Integral*. The former was reviewed in 1904 by James Pierpont, professor at Yale, in the following terms:

> *While perusing the present book it was a constant source of regret to me that Portuguese is not better known in our country. Otherwise this admirable work on the calculus would enjoy widespread popularity among us. Its author, the distinguished director of the Academia Polytechnica at Porto, has been uniformly successful in the difficult task of selecting from the immense material available. The manner of presentation leaves nothing to be desired. The style is lucid and elegant, and the whole work bears in a refreshing manner the imprint of an original mind. In many places the author has incorporated parts of his own prolific and valuable writing on the subject. In regard to rigor, it seems to us that Professor Teixeira has very happily chosen the golden mean. The excessive rigor of a Weierstrassian has been wisely avoided; at the same time the author has given this matter due attention. An occasional slip will doubtless be corrected in later editions. Altogether the work has so favorably impressed us that we should prefer to see it translated into English rather than any other work on the subject we know of. It is a deplorable confession that the English language does not to day possess a work on the calculus of this class. (Bulletin of the American Mathematical Society 5, 1898 1899, p. 483-484)*

James Pierpont goes on with a detailed analysis of the contents of Gomes Teixeira's treatise.

In 1897, the *Real Academia de Ciencias Exactas, Fisicas y Naturales de Madrid* proposed a prize for an ordered catalogue of curves. The prize was awarded to Gomes Teixeira, with *Tratado de las Curbas Especiales Notables, tanto planas como alabeadas*, and to Gino Loria, with *Las Curvas Planas Particulares Algébricas y Transcendentes. Teoria y História*. A third work presented to the prize was *Catálogo General de Curvas*, by the architect Joaquín Vargas Y Aguirre. Henri Brocard presented *Vocabulaire des Courbes Géométriques et Notes Bibliographiques*, which, being written in French, was not admitted for the prize (although the Madrid Academy nominated Brocard as a foreign correspondant on account of this work). That work of Gomes Teixeira was translated into French, substantially augmented and published under the title T*raité des Courbes Spéciales Remarquables, Planes et Gauches*, in 1908, 1909 and 1915 (as was Loria's into German in 1910 under the title *Spezielle Algebraische und Transzendente Ebene Kurven. Theorie und Geschichte*). Teixeira´s *Traité* became a well known reference book on curves, still quoted on works on the subject, and had two reprints: one by Chelsea Publishing Co., New York, 1971 and the other by Éditions Jacques Gabay, Paris, 1995.

From 1904 to 1915, Gomes Teixeira's *Obras Completas* were published in seven volumes by the Portuguese government. The first two volumes contain articles on Analysis, such as partial differential equations, series developments of various kinds of functions, and on Geometry (properties of curves). His *Curso de Análise Infinitesimal* occupies volumes III (differential calculus) and VI (integral calculus), whereas the *Traité des Courbes Spéciales Remarquables, Planes et Gauches* is to be found in volumes IV, V and VII. The latter, dated 1915, contains a supplement on famous but elementary geometrical problems which cannot be solved with straightedge and compass.

The regular publication of the *Jornal das Sciências Mathemáticas e Astronómicas* was not affected by Gomes Teixeira's transfer to Oporto, until 1905. In this year, the journal was replaced by the *Annaes Scientíficos da Academia Politécnica do Porto.*

The University of Oporto was founded in 1911, and the Politechnical Academy was converted into the Faculty of Sciences. The faculty was divided into sections, the first one of which was called *Ciências Matemáticas* and was further subdivided into two groups. Gomes Teixeira belonged to the first group (Analysis and Geometry) until 1925, when he asked to be transferred to the second one (Mechanics and Astronomy).

As the leading scientific personality of Oporto in his day, Gomes Teixeira was elected Rector of the University on the 16th June 1911, with many more votes than any other candidate. He kept this office until 1917 and in the following year he was made Honorary Rector. A further proof of his great prestige was given in 1921, when, in spite of having attained the age of seventy, he was reappointed as a Professor of the Faculty of Sciences of Oporto. He retired in 1929, when he reached the age limit.

His international reputation was manifest, since he received two honorary doctorates, from the Universities of Madrid in 1922 and Toulouse in 1923.

A short word should also be said about the correspondence of Gomes Teixeira, kept in the archive of the University of Coimbra. This is an interesting field of historical study, for he exchanged letters with some of the most important mathematicians of his time. It suffices to say that he corresponded with Levi Civita, Peano, Mittag Leffler and Hermite.

From 1895 onwards Gomes Teixeira turned his attention to history. As he himself puts it:

> *When, the years passing, my mind became incapable of long and deep meditations, I decided to devote all my attention to the History of Portuguese Mathematics, holding lectures to expose some subjects that interested me the most. (Panegíricos e Conferências, prefácio)*

Several of his papers, as well as the last editions of the *Curso de Análise* and especially the *Traité des Courbes Spéciales Remarquables, Planes et Gauches* reveal his growing interest on this subject. In 1917 the *Traité des Courbes* received the Binoux prize for the history of science from the French Academy of Science. Gomes Teixeira's *História das Matemáticas* em Portugal was only published posthumously in 1934.

In the last eight years of his life Gomes Teixeira also wrote five other books, which are neither of a mathematical nor of a strictly historical nature: *Panegíricos e Conferências* (1925), *Santuários de Montanha. Impressões de Viagem (1926)*, *Apoteose de S. Francisco de Assis - sua vida e obra* (1928), *Uma Santa e uma Sábia* (1930) and *Santo António de Lisboa, história, tradição e lenda* (1931).

Gomes Teixeira died in Oporto on the 8th February 1933. By then a new generation of mathematicians was active, namely Aureliano Mira Fernandes (1884-1958), José Vicente Gonçalves (1896-1985) and Ruy Luis Gomes (1905-1984). Although Gomes Teixeira did not leave a "school" and none of these mathematicians had been a student of his, they greatly admired the old master and received his influence. All of them published (especially Mira Fernandes and Ruy Luis Gomes) in foreign journals and maintained contacts with foreign mathematicians (namely with Levi-Civita, a friend of Gomes Teixeira's) and their papers, even when written in Portuguese, were quoted by the international mathematical community. The isolation about which Daniel da Silva sadly complained in 1877 no longer existed. Certainly Francisco Gomes Teixeira played a major role in breaking that isolation.

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