

Introduction

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A little more than eight years ago I planned a series of “best writing” on mathematics with the sense that a sizable and important literature does not receive the notice, the consideration, and the exposure it deserves. Several years of thinking on such a project (for a while I did not find a publisher interested in my proposal) only strengthened my belief that the best of the nontechnical writings on mathematics have the potential to enhance the public reception of mathematics and to enrich the interdisciplinary and intradisciplinary dialogues so vital to the emergence of new ideas.

The prevailing view holds that the human activity we conventionally call “mathematics” is mostly beyond fruitful debate or personal interpretation because of the uncontested (and presumably uncontested) matters of fact pertaining to its nature. According to this view, mathematics speaks for itself, through its cryptic symbols and the efficacy of its applications.

At close inspection, the picture is more complicated. Mathematics has been the subject of numerous disputes, controversies, and crises—and has weathered them remarkably well, growing from the resolution of the conundrums that tested its strength. By doing so, mathematics has become a highly complex intellectual endeavor, thriving at the ever-shifting intersection of multiple polarities that can be used to describe its characteristics. Consequently, most people who are engaged with mathematics (and many people disengaged from it) do it on a more personal level than they are ready to admit. Writing is an effective way of informing others on such individualized positioning vis-à-vis mathematics. A growing number of authors—professionals and amateurs—are taking on such a task. Every week new books on mathematics are published, in a dazzling blossoming of the genre hard to imagine even

a decade ago (I mention a great number of these titles later in this introduction). This recent flourishing confirms that, just as mathematics offers unlimited possibilities for asking new questions, formulating new problems, opening new theoretical vistas, and rethinking old concepts, narrating our individualized perspectives on it is equally potent in expressivity and in impact.

By editing this annual series, I stand for the wide dissemination of insightful writings that touch on any aspect related to mathematics. I aim to diminish the gap between mathematics professionals and the general public and to give exposure to a substantial literature that is not currently used systematically in scholarly settings. Along the way, I hope to weaken or even to undermine some of the barriers that stand between mathematics and its pedagogy, history, and philosophy, thus alleviating the strains of hyperspecialization and offering opportunities for connection and collaboration among people involved with different aspects of mathematics. If, by presenting in each volume a snapshot of contemporary thinking on mathematics, we succeed in building a useful historical reference, in offering an informed source of further inquiry, and in encouraging even more exceptional writing on mathematics, so much the better.

Overview of the Volume

In the first article of our selection, Mario Livio ponders the old question of what makes mathematics effective in describing many features of the physical universe and proposes that its power lies in the peculiar blending between the human ingenuity in inventing flexible and adaptable mathematical tools and the uncanny regularities of the universe.

Timothy Gowers brings the perspective of a leading research mathematician to another old question, that concerning features of discovery and elements of invention in mathematics; he discusses some of the psychological aspects of this debate and illustrates it with a wealth of examples.

In a succession of short pieces, Peter Rowlett and his colleagues at the British Society for the History of Mathematics present the unexpected applications, ricocheting over centuries, of notions and results long believed to have no use beyond theoretical mathematics.

Brian Hayes puzzles over the proportion between the volume of a sphere and that of the cube circumscribed to it, in various

dimensions—and offers cogent explanations for the surprising findings that this proportion reaches a maximum in five dimensions and it decreases rapidly to insignificant values as the number of dimensions increases.

Terence Tao tackles a few conundrums concerning the distribution of prime numbers, noting that the distribution displays elements of order *and* of chaos, thus challenging simplistic attempts to elucidate its patterns.

John C. Baez and John Huerta tell the story of the tenacious William R. Hamilton in search of a better number system—and how his invention of the quaternions led John Graves and Arthur Cayley (independently) to thinking up the octonions, which play a vital role in the theory of strings.

David Swart and Bruce Torrence discuss several ways of projecting a sphere on a plane, the qualitative trade-offs involved in them, the basic mathematics underlying such correspondence, and their applications to panoramic photography.

Drawing on their experience as mathematicians and choreographers, sarah-marie belcastro and Karl Schaffer explore the interplay of dancing and such mathematical ideas as symmetry, group structure, topological links, graphs, and (suggestions of) infinity.

A musician and mathematician, Rob Schneiderman, offers a critical viewpoint on the literature that explores the hidden and the overt connections between music and mathematics, pleading for a deepening of the discourse on their interaction.

Robert J. Lang describes a mathematical condition ensuring that an origami paper folding unfolds into a flat piece of paper.

In the second of two texts in this volume, Timothy Gowers argues that high-school level mathematical thinking of calculus notions is not as different as most professionals assume from the thought process common to similar notions of analysis taught in university courses, at a higher level of rigor and abstraction.

Brent Davis argues that successful teaching of mathematics relies more on tacit, unconscious skills that support the learner's full engagement with mathematics, than on the formal training currently available in preparatory programs for teachers.

Erica Flapan tells us, with disarming candor, about her charming adventures in search of the best methods for teaching mathematics—and

concludes that, despite various degrees of success, she remains an agnostic in this matter.

Bonnie Gold argues that everyone teaching mathematics does it according to certain philosophical assumptions about the nature of mathematics—whether the assumptions are explicit or remain implicit.

Susanna S. Epp examines several uses of the concept of “variable” in mathematics and opines that, from an educational standpoint, the best is to treat variables as placeholders for numerals.

David Mumford and Sol Garfunkel plead for a broad reform of the U.S. system of mathematics education, more attuned to the practical uses of mathematics for the citizenry and less concerned with the high-stakes focus on testing currently undertaken in the United States.

Jeremy Gray surveys recent trends in the study of the history of mathematics as compared to research on the history of science and examines the possibility that the two might be somehow integrated in the future.

Charlotte Simmons writes about Augustus De Morgan as a mentor of other mathematicians, an aspect less known than the research contributions of the great logician.

Giuseppe Bruno, Andrea Genovese, and Gennaro Improta review several formulations of various routing problems, with wide applications to matters of mathematical optimization.

Special curves were at the forefront of mathematical research about three centuries ago, and one of them, the cycloid, attracted the attention (and the rivalry) of the most famous mathematicians of the time—as Gerald L. Alexanderson shows in his piece on the Bernoulli family.

Fernando Gouvêa examines Georg Cantor’s correspondence, to trace the original meaning of Cantor’s famous remark “I see it, but I don’t believe it!” and to refute the ulterior, psychological interpretations that other people have given to this quip.

Ian Hacking explains that the enduring fascination and the powerful influence of mathematics on so many Western philosophers lie in the experiences engendered on them by learning and doing mathematics.

Richard Elwes delves into the subtleties of mathematical infinity and ventures some speculations on the future clarification of the problems it poses.

Finally, Mark Colyvan illustrates the basic mathematics involved in the games of choice we encounter in life, whenever we face processes that require successive alternative decisions.

Other Notable Writings

As in previous years, I selected the texts in this volume from a much larger group of articles. At the end of the book is a list of other remarkable pieces that I considered but did not include for reasons of space or related to copyright. In this section of the introduction, I mention a string of books on mathematics that came to my attention over the past year.

It is fit to start the survey of recent nontechnical books on mathematics by mentioning a remarkable reference work that fills a gap in the literature about mathematics, the *Encyclopedia of Mathematics and Society*, edited in three massive volumes by Sarah J. Greenwald and Jill E. Thomley.

A few new books inform pertinently on mathematicians' lives, careers, and experiences. The *Academic Genealogy of Mathematicians* by Sooyoung Chang is impressive; Donald J. Albers and Gerald L. Alexanderson follow up on previous volumes of interviews with *Fascinating Mathematical People*; and Amir D. Aczel presents a highly readable collection of biographies of famous mathematicians in *A Strange Wilderness*. Other historical biographies touch on more than immediate life details, by examining the broader influence of their subjects: *Remembering Sofya Kovalevskaya* by Michèle Audin, *Abraham De Moivre* by David Bellhouse, *Turbulent Times in Mathematics* by Elaine McKinnon Riehm and Frances Hoffman (on J. C. Fields), *The Man of Numbers* by Keith Devlin (on Fibonacci), *Giuseppe Peano between Mathematics and Logic* edited by Fulvia Skof, and *Stefan Banach*, a collection edited by Emilia Jakimowicz and Adam Miranowicz.

Several highly accessible books of popular mathematics introduce the reader to a potpourri of basic and advanced mathematical notions or to encounters with mathematics in daily life. They include Peter M. Higgins's *Numbers*, James D. Stein's *Cosmic Numbers*, Marcus Du Sautoy's *The Number Mysteries*, Ian Stewart's *The Mathematics of Life*, David Berlinski's *One, Two, Three*, and Tony Crilly's *Mathematics*. Slightly more technical and focused on particular topics are William J. Cook's *In Pursuit of the Traveling Salesman*, Alfred S. Posamentier and Ingmar Lehmann's *The Glorious Golden Ratio*, and *Probability Tales* by Charles M. Grinstead and collaborators. An elegant book in an unusual format is Nicolas Bouleau's *Risk and Meaning*. And an accessible path to higher geometry is in *Geometry Revealed* by Marcel Berger.

The number of interdisciplinary and applicative books that build connections between mathematics and other domains continues to grow fast. On mathematics and music, we recently have *A Geometry of Music* by Dmitri Tymoczko and *The Science of String Instruments*, edited by Thomas D. Rossing. Some remarkable books on mathematics and architecture are now available, including *The Function of Form* by Farshid Moussavi (marvelously illustrated); *Advances in Architectural Geometry 2010*, edited by Cristiano Ceccato and his collaborators; *The New Mathematics of Architecture* by Jane and Mark Burry; the 30th anniversary reissue of *The Dynamics of Architectural Form* by Rudolf Arnheim; and *Matter in the Floating World*, a book of interviews by Blaine Brownell.

Among the books on mathematics and other sciences are Martin B. Reed's *Core Maths for the Biosciences*; *BioMath in the Schools*, edited by Margaret B. Cozzens and Fred S. Roberts; *Chaos: The Science of Predictable Random Motion* by Richard Kautz (a historical overview); *Some Mathematical Models from Population Genetics* by Alison Etheridge; and *Mathematics Meets Physics*, a collection of historical pieces (in English and German) edited by Karl-Heinz Schlote and Martina Schneider.

Everyone expects some books on mathematics and social sciences; indeed, this time we have *Mathematics of Social Choice* by Christoph Börgers, *Bond Math* by Donald J. Smith, *An Elementary Introduction to Mathematical Finance* by Sheldon M. Ross, and *E. E. Slutsky as Economist and Mathematician* by Vincent Barnett. A highly original view on mathematics, philosophy, and financial markets is *The Blank Swan* by Elie Ayache. And an important collection of papers concerning statistical judgment in the real world is David A. Freedman's *Statistical Models and Causal Inference*.

More surprising reaches of mathematics can be found in *Magical Mathematics* by Persi Diaconis and Ron Graham, *Math for the Professional Kitchen* (with many worksheets for your convenience) by Laura Dreesen, Michael Nothnagel, and Susan Wysocki, *The Hidden Mathematics of Sport* by Rob Eastaway and John Haigh, *Face Geometry and Appearance Modeling* by Zicheng Liu and Zhengyou Zhang, *How to Fold It* by Joseph O'Rourke, and *Mathematics for the Environment* by Martin E. Walter. Sudoku comes of (mathematical) age in *Taking Sudoku Seriously* by Jason Rosenhouse and Laura Taalman. More technical books, but still interdisciplinary and accessible, are *Viewpoints: Mathematical Perspective and Fractal Geometry in Art* by Marc Frantz and Annalisa Crannell and *Infinity: New Research Frontiers*, edited by Michael Heller and W. Hugh Woodin.

Many new books have been published recently in mathematics education, too many to mention them all. Several titles that caught my attention are Tony Brown's *Mathematics Education and Subjectivity*, Hung-Hsi Wu's unlikely voluminous *Understanding Numbers in Elementary School Mathematics*, Judith E. Jacobs' *A Winning Formula for Mathematics Instruction*, as well as *Upper Elementary Math Lessons* by Anna O. Graeber and her collaborators, *The Shape of Algebra in the Mirrors of Mathematics* by Gabriel Katz and Vladimir Nodelman, and *Geometry: A Guide for Teachers* by Judith and Paul Sally. Keith Devlin offers an original view of the connections between computer games and mathematics learning in *Mathematics Education for a New Era*. Among the many volumes at the National Council of Teachers of Mathematics, notable is the 73rd NCTM Yearbook, *Motivation and Disposition*, edited by Daniel J. Brahier and William R. Speer; *Motivation Matters and Interest Counts* by James Middleton and Amanda Jansen; and *Disrupting Tradition* by William Tate and colleagues. NCTM also publishes many books to support the professional development of mathematics teachers. A good volume for preschool teachers is *Math from Three to Seven* by Alexander Zvonkin. With an international perspective are *Russian Mathematics Education*, edited by Alexander Karp and Bruce R. Vogeli; *International Perspectives on Gender and Mathematics Education*, edited by Helen J. Forgasz and her colleagues; and *Teacher Education Matters* by William H. Schmidt and his colleagues. *Mathematics Teaching and Learning Strategies in PISA*, published by the Organisation for Economic Co-operation and Development, contains a wealth of statistics on global mathematics education.

An excellent volume at the intersection of brain research, psychology, and education, with several contributions focused on learning mathematics, is *The Adolescent Brain*, edited by Valerie F. Reyna and her collaborators.

Besides the historical biographies mentioned above, several other contributions to the history of mathematics are worth enumerating. Among thematic histories are Ranjan Roy's *Sources in the Development of Mathematics*, a massive and exhaustive account of the growth of the theory of series and products; *Early Days in Complex Dynamics* by Daniel S. Alexander and collaborators; *The Origin of the Logic of Symbolic Mathematics* by Burt C. Hopkins; *Lobachevski Illuminated* by Seth Braver; *Mathematics in Victorian Britain*, edited by Raymond Flood and collaborators; *Journey through Mathematics* by Enrique A. González-Velasco; and

Histories of Computing by Michael Sean Mahoney. Two remarkable books that weave the history of mathematics and European arts are *Between Raphael and Galileo* by Alexander Marr and *The Passionate Triangle* by Rebecca Zorach.

Several historical editions are newly available, for instance, Lobachevsky's *Pangeometry*, translated and edited by Athanase Papadopoulos; *80 Years of Zentralblatt MATH*, edited by Olaf Teschke and collaborators; and Albert Lautman's *Mathematics, Ideas, and the Physical Real*. Other historical works are *The Theory That Would Not Die* by Sharon Bertsch McGrayne, *From Cardano's Great Art to Lagrange's Reflections* by Jacqueline Stedall, *Chasing Shadows* by Clemency Montelle, and *World in the Balance* by Robert P. Crease.

In philosophy of mathematics, a few books concern personalities: *After Gödel* by Richard Tieszen; *Kurt Gödel and the Foundations of Mathematics*, edited by Matthias Baaz et al.; *Spinoza's Geometry of Power* by Valtteri Viljanen; *Bolzano's Theoretical Philosophy* by Sandra Lapointe; and *New Essays on Peirce's Mathematical Philosophy*, edited by Matthew E. Moore. Other recent volumes on the philosophy of mathematics and its history are Paolo Mancosu's *The Adventure of Reason*, Paul M. Livingston's *The Politics of Logic*, Gordon Belot's *Geometric Possibility*, and *Fundamental Uncertainty*, edited by Silva Marzetti Dall'Aste Brandolini and Roberto Scazzieri.

Mathematics meets literature in William Goldbloom Bloch's *The Unimaginable Mathematics of Borges' Library of Babel* and, in a different way, in *All Cry Chaos* by Leonard Rosen (where the murder of a mathematician is pursued by a detective called Henri Poincaré). Hans Magnus Enzensberger, the German writer who authored the very successful book *The Number Devil*, has recently published the tiny booklet *Fatal Numbers*.

For other titles the reader is invited to check the introduction to the previous volumes of *The Best Writing on Mathematics*.

As usual, at the end of the introduction I mention several interesting websites. A remarkable bibliographic source is the online list of references on Benford's Law organized by Arno Berger, Theodore Hill, and Erika Rogers (<http://www.benfordonline.net/>). Other good topic-oriented websites are the MacTutor History of Mathematics archive from the University of St. Andrews in Scotland (<http://www-history.mcs.st-and.ac.uk/>), Mathematicians of the African Diaspora (MAD) (<http://www.math.buffalo.edu/mad/>), the Famous Curves index (<http://www>

-history.mcs.st-and.ac.uk/Curves/Curves.html), the National Curve Bank (<http://curvebank.calstatela.edu/index/index.htm>), and Free Mathematics Books (<http://www.e-booksdirectory.com/mathematics.php>). An intriguing site dedicated to the work of Alexandre Grothendieck, one of the most intriguing mathematicians alive, is the Grothendieck Circle (<http://www.grothendieckcircle.org/>). An excellent website for mathematical applications in science and engineering is Equalis (<http://www.equalis.com/>). Among websites with potential for finding materials for mathematical activities are the one on origami belonging to Robert Lang, a contributor to this volume (<http://www.langorigami.com/index.php4>); many other Internet sources for the light side of mathematics can be found conveniently on the personal page maintained by Greg Frederickson of Purdue University (<http://www.cs.purdue.edu/homes/gnf/hotlist.html>).

I hope you, the reader, find the same value and excitement in reading the texts in this volume as I found while searching, reading, and selecting them. For comments on this book and to suggest materials for consideration in preparing future volumes, I encourage you to send correspondence to me: Mircea Pitici, P.O. Box 4671, Ithaca, NY 14852.

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