



OVERVIEW

A 13-PART, MULTIMEDIA, PROFESSIONAL-DEVELOPMENT COURSE IN MATHEMATICS
Produced by Oregon Public Broadcasting

“ ”

The most distinct and beautiful statement of any truth must take at last the mathematical form.

HENRY DAVID THOREAU

MATHEMATICS ILLUMINATED

is produced by Oregon Public Broadcasting.

© 2008 Annenberg Media

All rights reserved.

ISBN 1-57680-887-4

Funding for
Mathematics Illuminated
is provided by Annenberg Media.

Annenberg Media (formerly Annenberg/CPB) advances excellent teaching by funding and distributing multimedia educational resources (video, print, and Web based) to improve teaching methods and subject-matter expertise. Resources are distributed to schools and non-commercial community agencies, as well as colleges and universities, for workshops, institutes and course use. Annenberg Media makes its entire video collection available via broadband through www.learner.org. The Web site also houses interactive activities, online texts, downloadable guides, and resources coordinated with each video series.

To purchase video series and guides or learn more about other courses and workshops contact us by phone or email, or visit us on the Web.



1-800-LEARNER®

info@learner.org

www.learner.org

COURSE OVERVIEW

Mathematics Illuminated is a 13-part, integrated-media resource created for adult learners and high school teachers. The series covers the broad scope of human knowledge through the study of mathematics and its relevance in the world today. It reaches beyond formulas and computations to explore the math of patterns, symmetry, relationships, multiple dimensions, and more, all the while uncovering the secrets and hidden delights of the ever-evolving world of mathematics. Mathematics Illuminated unites the strengths of traditional and new media learning through the coordinated 13 half-hour videos, online texts, web interactive activities, and group activities.

Developed with an Advisory Board of high school teachers and leading scholars from across the United States, the course examines mathematics from a holistic perspective, offering an enthusiastic approach that will help learners understand the broad spectrum of disciplines that make up the field of mathematics. The information and activities will help all learners solidify unfamiliar and/or complex concepts by delving into the “why” and not just the “how” of approaching mathematical questions. Mathematics Illuminated explores many of the great historical figures in mathematics and the problems they confronted; it also introduces you to some of the fascinating people who are embracing and studying today’s emerging questions. Mathematics Illuminated provides an overview of how the content of the course connects and supports national and local standards in mathematics. Using these materials, teachers can simultaneously build content knowledge and explore and engage with new mathematical applications. For information on graduate credit, visit www.learner.org.

GOALS AND INTENDED AUDIENCE

Several goals have guided all aspects of the development of the Mathematics Illuminated course materials.

The goals of the project are to help teachers and those with an interest in math to:

- recognize the fundamental role of mathematics in all intellectual and artistic pursuits
- appreciate that mathematics can help us illuminate, define, and predict the world around us
- develop a better understanding of the nature of mathematics

The course approaches mathematics as a means to greater understanding, rather than as a successive set of skills to be mastered. The series is designed to awaken their senses to the power of math in their everyday lives, while enriching teachers' knowledge of the variety of inspiring subjects within the field of mathematics. The course integrates content throughout each medium (video, print, Web), in order to support different learning methods and styles.

The materials were specifically developed with two primary and one secondary audience in mind. In general, the materials were created to help interested, educated individuals, as well as high school teachers, develop a better understanding of the nature of mathematics. One primary target audience is educated adult learners who have either a non-mathematic undergraduate degree or an interest in mathematics (or both). The second primary target audience is in-service or pre-service high school mathematics teachers seeking a professional development experience focused on new, in-depth mathematical knowledge, as well as inspiration for viewing the world of math as an integrated whole.

The secondary audience for the series is non-teaching mathematicians who will use the materials informally for personal and professional development, or anyone interested in getting an overview of the mathematical landscape as it stands today.

HOW TOPICS WERE CHOSEN

The selected topics and themes covered in the course were carefully chosen under the guidance of the full Advisory Board to align with the project goals. The Board, comprised of high school math teachers, university professors, and professionals in the fields of education and professional development, chose topics spanning the depth and breadth of the field of mathematics, from humankind's earliest study of prime numbers to the cutting-edge mathematics used today to reveal the shape of the universe (see details below under "Unit Descriptions"). The Board's goal was to help the audience appreciate math's wonder, breadth, relevance, and usefulness. Together they chose topics that could be appreciated by a diverse collection of people with varied interests and talents.

Some of the topics explored in the course, such as game theory or chaos theory, may be new to some, yet review for others. Other topics are rooted in traditional mathematical concepts, such as prime numbers and geometry. However, all of the topics covered introduce a new way to approach learning and understanding as they lead learners on a journey to new discoveries, or “Aha!” moments, within the themes covered.

A rigorous test of the course was conducted by an independent evaluation company (more information below). Adult learners and math teachers evaluated a prototype of the video, text, and Web site materials. Results of the evaluation were taken into consideration, and the final course components were adjusted based on the results and recommendations of the evaluators.

ASSUMPTION OF USER KNOWLEDGE

In the creation of the materials for this course, it was assumed that the audience would be diverse in its exposure to, and level of understanding of, mathematics and its role in the world. For this course, we focused on individual adult learners, and high school teachers, acknowledging the variety of experience in how these groups would engage with, and learn and/or teach the mathematical content. Teachers will have familiarity with some of the concepts covered in the series, and may also have a selection of state and/or local mathematic standards to adhere to, while others may either have a very specific interest in one content area, such as prime numbers, or topology, or a broad interest in mathematics as a source for understanding the world around us. Regardless of the level of motivation or experience, we assume that all are pressed for time and/or resources and will expect our materials to provide them with exciting, and meaningful content that they can access quickly and efficiently, that will help them have a better understanding of how mathematics affects our understanding of the world we live in.

COURSE COMPONENTS

Mathematics Illuminated is a multimedia course. Each of the 13 content units is comprised of a half-hour video program, an online textbook chapter, nine unique Web-based interactives, and group or individual hands-on learning activities. The Web site for the course provides access to all of the materials, as well as additional resources, including:

- video transcripts
- a course guide
- a bibliography
- a glossary of the main concepts covered within each unit
- a family tree of mathematical concepts from the course

Any component can be used independently, or they can all be used together. If used together, we recommend progressing through the materials unit by unit, viewing the video first, then reading the online text, and finally completing the hands-on activities. The Web interactives, and all other Web content are meant to support the learning experience.

VIDEO SERIES

The videos reach the broadest audience by providing poignant, thought-provoking entry points into the concepts explored in the series. There are three major components in each of the 13 half-hour videos. First, they provide the historical context of the mathematical concepts, bringing to life some of the great mathematicians of all time, along with their struggles and breakthroughs, through visually compelling historical re-enactments. Next, they provide a deeper understanding of the concepts through interviews with leading experts. These enlightening discussions are augmented with illustrative animations that reinforce and explain graphically the concepts that are being explored intellectually. Finally, they take you on a field trip to view real-world applications of the concepts and introduce you to people who are using the mathematical ideas and techniques every day in their own unique, relevant, and wonderful ways.

ONLINE TEXTBOOK

The online textbook chapters explore in greater detail the ideas and themes examined in the videos and Web interactives. Each of the 13 chapters is laid out with clear unit and sub-section objectives that go deeper into the content, while modeling the arc provided in the videos. Most units begin by explaining the historical context of the unit content, and then go on to explore the field of study and its relevance. Completing the experience are numerous high-quality explanatory diagrams and illustrative pictures that help to set the material in context and to explain the sometimes difficult or complex concepts in a visual manner.

WEB SITE AND INTERACTIVES

The Mathematics Illuminated Web site serves as the entry point to all of the text and video materials, while providing links to additional resources that support the course themes. The site includes Web-based learning interactives that enable the user to engage in deeper explorations of some of the more powerful, beautiful, and challenging concepts from the series.

The nine interactives are:

- Figurative Numbers (the shape of numbers)
- Shotgun Sequencing (combinatorics)
- Robots (topology and configuration space)
- The Hypercube (dimensions)
- Symmetry (rotation and reflections)
- Galton Box (The Law of Large Numbers and the Central Limit Theorem)
- Spatial Games (game theory)
- Networks (network connections)
- Metronome (synchronization)

For example, the Metronome interactive simulates the correlation of a metronome's ticking to a sine wave. The Robot interactive allows participants to experience hands-on learning of an abstract concept. For a description of all nine interactives, go to the Mathematics Illuminated Web site at www.learner.org. The Web site also contains a glossary, organized by unit, and The Math Family Tree, which maps all of the content from the series on a dynamic timeline. This timeline illustrates how early mathematicians and their breakthroughs (as far back as 25,000 B.C.E.) influenced those that came later.

Users with Web access can also view streaming video of the series and can download the textbook chapters at www.learner.org.

FACILITATOR'S AND PARTICIPANT GUIDES

A course guide for each unit strengthens teachers' understanding of the content through hands-on activities for individuals or group workshops. Activities include concept application, problem-based learning activities, and opportunities for analyzing data—all in an inquiry-based model. A framework for applying concepts to state and local standards is included. The activities seek to model best teaching practices by requiring the participant to be an active explorer rather than a passive recipient of information and are designed to be used between each of the video segments and to draw from content in the unit's video, and the text chapter.

Each of the Facilitator Guides include notes on how to facilitate the session, a list of materials needed, tips, and answers for prepping and leading the session.

UNIT DESCRIPTIONS

UNIT 1. THE PRIMES

The properties and patterns of prime numbers—whole numbers that are divisible only by themselves and one—have been a source of wonder across cultures for thousands of years, and the study of prime numbers is fundamental to mathematics. This unit explores our fascination with primes, culminating in the million-dollar puzzle of the Riemann Hypothesis, a possible description of the pattern behind the primes, and the use of the primes as the foundation of modern cryptography. Guests interviewed include Terence Tao, UCLA, and Ray Perlner, National Institute of Standards and Technology.

UNIT 2. COMBINATORICS COUNTS

Counting is an act of organization, a listing of a collection of things in an orderly fashion. Sometimes it's easy; for instance, when counting people in a room. However, listing all the possible seating arrangements of those people around a circular table is more challenging. This unit looks at combinatorics, the mathematics of counting, or arranging, complicated configurations. In an age in which the organization of bits and bytes of data is of paramount importance—as with the human genome—combinatorics is essential. Guests interviewed include Jenny Quinn, University of Washington, Tacoma, and Terry Gaasterland from Scripps Genome Center, University of California, San Diego.

UNIT 3. HOW BIG IS INFINITY?

Throughout the ages, the notion of infinity has been a source of mystery and paradox, a philosophical question to ponder. As a mathematical concept, infinity is at the heart of calculus, the notion of irrational numbers, even measurement. This unit explores how mathematics attempts to understand infinity, including the creative and intriguing work of Georg Cantor, who initiated the study of infinity as a number, and the role of infinity in standardized measurement. Guests interviewed include James Tanton, St. Mark's Institute of Mathematics, and Ivars Peterson, Mathematical Association of America.

UNIT 4. TOPOLOGY'S TWISTS AND TURNS

Topology, known as “rubber sheet math,” is a field of mathematics that concerns those properties of an object that remain the same even when the object is stretched and squashed. In this unit we investigate topology’s seminal relationship to network theory, the study of connectedness, and its critical function in understanding the shape of the universe in which we live. Guests interviewed include Greg Leibon, Dartmouth College, and Jeffrey Weeks, author of *The Shape of Space: How To Visualize Surfaces and Three-Dimensional Manifolds*.

UNIT 5. OTHER DIMENSIONS

The conventional notion of dimension consists of three degrees of freedom: length, width, and height, each of which is a quantity that can be measured independently of the others. Many mathematical objects, however, require more—potentially many more—than just three numbers to describe them. This unit explores different aspects of the concept of dimension, what it means to have higher dimensions, and how fractional or “fractal” dimensions may be better for measuring real-world objects such as ferns, mountains, and coastlines. Guests interviewed include Greg Leibon, Dartmouth College, and Karl Richter of LAIKA/house.

UNIT 6. THE BEAUTY OF SYMMETRY

In mathematics, symmetry has more than just a visual or geometric quality. Mathematicians comprehend symmetries as motions—motions whose interactions and overall structure give rise to an important mathematical concept called “group.” This unit explores Group Theory, the mathematical quantification of symmetry, which is key to understanding how to remove structure from (i.e., shuffle) a deck of cards or to fathom structure in a crystal. Guests interviewed include Rosa Orellana, Dartmouth College, and Mary McGrath, Structural Chemist at Gilead Sciences, Inc.

UNIT 7. MAKING SENSE OF RANDOMNESS

Probability is the mathematical study of randomness, or events in which the outcome is uncertain. This unit examines probability, tracing its evolution from a way to improve chances at the gaming table to modern applications of understanding traffic flow and financial markets. Guests interviewed include Greg Leibon, Dartmouth College, and Anthony Baerlocker, International Game Technology.

UNIT 8. GEOMETRIES BEYOND EUCLID

Our first exposure to geometry is usually the system proposed by Euclid, in which all triangles have 180 degrees. As it turns out, in curved space the sum of a triangle's angles can be more or less than 180 degrees. This unit explores these curved spaces, which are at once otherworldly and yet firmly of this world—and may hold the key to understanding the human brain. Guests interviewed include Daina Taimina, Cornell University, and Martin Styner and Brad Davis of the Computer Science, and Psychiatry Department's, University of North Carolina, Chapel Hill.

UNIT 9. GAME THEORY

Competition and cooperation can be studied mathematically, an idea that first arose in the analysis of games like chess and checkers, but soon showed its relevance to economics and geopolitical strategy. This unit shows how conflict and strategies can be thought about mathematically, and how doing so can reveal important insights into human and animal behaviors. Guests interviewed include David Krakauer, Santa Fe Institute, New Mexico, and Craig Packer, Dept. of Ecology, Evolution, and Behavior, University of Minnesota.

UNIT 10. HARMONIOUS MATH

All sound is the product of airwaves crashing against our eardrums. The mathematical technique for understanding this and other wave phenomena is called the Fourier analysis, which involves the disentangling of a complex wave into basic waves called sinusoids, or sine waves. In this unit we discover how the Fourier analysis is used in creating electronic music and how it actually underpins all digital technology. Guests interviewed include Elizabeth Stanhope, Mathematical Sciences, Lewis and Clark College, and David McCraaken, Jason Daniello, Aaron Grooms, and Cyril Lance of Moog Music, Inc.

UNIT 11. CONNECTING WITH NETWORKS

Connections can be physical, as with bridges, or immaterial, as with friendships. Both types of connections can be understood using the same mathematical framework called network theory, or graph theory, which is a way to abstract and quantify the notion of connectivity. This unit looks at how this branch of mathematics provides insights into extremely complicated networks such as ecosystems. Guests interviewed include Raissa D'Souza, University of California, Davis, and Neo Martinez, Rocky Mountain Biological Laboratory.

UNIT 12. IN SYNC

Systems of synchronization occur throughout the animate and inanimate world. The regular beating of the human heart, the swaying and near collapse of the Millennium Bridge, and the simultaneous flashing of gangs of fireflies in Southeast Asia—these varied phenomena all share the property of spontaneous synchronization. This unit shows how synchronization can be analyzed, studied, and modeled via the mathematics of differential equations, an outgrowth of calculus, and the application of these ideas toward understanding the workings of the heart. Guests interviewed include Steve Strogatz, Cornell University, and Glenn Fishman and Charles Peskin of the New York University Medical Center.

UNIT 13. THE CONCEPTS OF CHAOS

The flapping of a butterfly's wings over Bermuda causes a rainstorm in Texas. Two sticks start side by side on the surface of a brook, only to follow divergent paths downstream. Both are examples of the phenomenon of chaos, characterized by a widely sensitive dependence of the future on slight changes in a system's initial conditions. This unit explores the mathematics of chaos, which involves the discovery of structure in what initially appears to be random, and the imposition of limits on predictability. Guests interviewed include Steve Strogatz, Cornell University, and Martin Lo, Jet Propulsion Laboratory, California Institute of Technology.

EDUCATION PARTNERS

Mathematics Illuminated was developed through a collaboration of the following education partners, led by Oregon Public Broadcasting (www.opb.org)

ASSOCIATION FOR WOMEN IN MATHEMATICS (WWW.AWM-MATH.ORG)

The purpose of the Association for Women in Mathematics is to encourage women and girls to study and to have active careers in the mathematical sciences, and to promote equal opportunity and the equal treatment of women and girls in the mathematical sciences.

THE MATHEMATICAL ASSOCIATION OF AMERICA (WWW.MAA.ORG)

The Mathematical Association of America is the largest professional society that focuses on mathematics accessible at the undergraduate level. Our members include university, college, and high school teachers; graduate and undergraduate students; pure and applied mathematicians; computer scientists; statisticians; and many others in academia, government, business, and industry.

ADVISORY BOARD**Dan Rockmore—Lead Content Advisor and Program Host**

Dan Rockmore is the John G. Kemeny Parents Professor of Mathematics and Professor of Computer Science at Dartmouth College and a member of the External Faculty of the Santa Fe Institute, where he also directs the Complex Systems Summer School. He is well known for his work in computational harmonic analysis, and in 1995 he was the recipient of a White House Presidential Faculty Fellowship in recognition of his teaching and research. He has published many technical papers, and his work has been supported by the National Science Foundation, National Institutes of Health, and the Department of Defense. He is also known for his exposition of mathematics. He has co-produced two documentaries on mathematics, has written and performed radio essays for NPR, and is the author of *Stalking the Riemann Hypothesis*, which was longlisted for the 2006 Aventis Science Writing Prize. His ability to communicate mathematics effectively to a broad audience has been recognized through his appointments as a Sigma Xi Distinguished Lecturer and as a Visiting Lecturer for the Society of Industrial and Applied Mathematics. Dr. Rockmore served as Lead Content Advisor for the series and is also the series host.

Lisa Adajian—Teacher Professional Development Consultant

Dr. Lisa Adajian has more than 26 years of experience teaching in a variety of educational settings at the elementary, secondary, and university levels, and in schools with predominantly minority and limited-English-speaking populations. For the past 13 years, she has worked with pre-service and in-service schoolteachers at the elementary and secondary level, teaching math content and methods courses and conducting workshops to improve teachers' capacity to teach mathematics. She is currently teaching mathematics and science at James Madison High School in Portland, Oregon. Dr. Adajian served as Professional Development Advisor for the project.

ADVISORS**William P. Berlinghoff—Steering Advisor**

William P. Berlinghoff earned his B.S. from Holy Cross, M.A. from Boston College, and Ph.D. from Wesleyan University, where he specialized in abelian group theory. Dr. Berlinghoff, who recently retired from college teaching after more than 40 years, has been a faculty member at the College of Saint Rose, a professor at Southern Connecticut State University, and most recently a visiting

professor at Colby College in Maine. He is author or co-author of five college texts—Math through the Ages: A Gentle History for Teachers and Others (winner of the 2007 Beckenbach Book Prize from the Mathematical Association of America); A Mathematics Sampler: Topics for the Liberal Arts; The Mathematics of the Elementary Grades; A Mathematical Panorama; and Mathematics, the Art of Reason. He is also a Senior Writer of the MATH Connections program, an NSF-supported, standards-based core curriculum for high school students. Dr. Berlinghoff served as a Steering Advisor for the project.

KC Cole—Steering Advisor

A long-time science writer and columnist for the Los Angeles Times, KC Cole is the author of *The Universe and the Teacup: The Mathematics of Truth and Beauty*, as well as four other popular books on science. She has written about science for *The New York Times*, *The New Yorker*, *The Smithsonian*, *Discover*, *Newsweek*, *The Washington Post*, *Esquire*, and many other publications. She currently teaches at the Annenberg School of Journalism at USC, and runs a series of conversations about art and science at Santa Monica Art Studios. Ms. Cole served as a Steering Advisor for the project.

David Eisenbud—Steering Advisor

Dr. Eisenbud is currently the Director of the Mathematical Sciences Research Institute at Berkeley, one of the most prestigious mathematics research centers in the country. He is also the outgoing president of the American Mathematical Society with integral connections at the AMS, and has a record of advocacy in the field of mathematics, including congressional testimony. Dr. Eisenbud served as a Steering Advisor for the project.

Jacquelyn A. Buxton Flowers—Teacher Advisor

Jacquelyn Flowers has been teaching high school for 11 years. She is currently teaching algebra and geometry at Oneonta High School in Oneonta, Alabama. She has also taught at McAdory and Pinson Valley High Schools, both of which are located in Alabama. Ms. Flowers has taught keyboarding, computer applications, Algebra, Honors Algebra, Geometry, Honors Geometry, Algebra II, and Honors Algebra II. She is an adjunct professor at Jefferson State Community College where she teaches two nights a week. Ms. Flowers is a member of the National Council of Teachers of Mathematics and has been named to *Who's Who Among American High School Teachers*. Ms. Flowers advised on Unit 5, Dimension, and Unit 9, Game Theory.

Fernando Q. Gouvêa—Steering Advisor

Fernando Q. Gouvêa is Carter Professor of Mathematics at Colby College. Dr. Gouvêa, who was born in São Paulo, Brazil, went to Harvard University for his Ph.D. He then taught at the Universidade de São Paulo and at Queen's University before moving to Colby. He is the author of *p-adic Numbers: An Introduction* and the co-author, with William P. Berlinghoff, of *Math through the Ages: A Gentle History for Teachers and Others*. In addition to his scholarship and teaching, Gouvêa is the editor of *MAA FOCUS*, the news magazine of the Mathematical Association of America, and of *MAA Reviews*, the MAA's online book review service. His scholarly interests are in the history of mathematics and in number theory. In addition to his interest in mathematics, he is interested in Christian theology, New Testament studies, modern science fiction, literature, politics, and wine. He is the proud owner of a graying scraggly beard. Dr. Gouvêa served as a Steering Advisor for the project.

Mark Jaffee—Teacher Advisor

Mark Jaffee has been a high school mathematics teacher for 41 years, most recently at Admiral King High School in Lorain, Ohio. Previously, he taught at Oberlin High School in Oberlin, Ohio, for 34 years. He has been active in the Ohio Council of Teachers of Mathematics (OCTM) in which he served as District Director and is currently the Constitution chairperson. He has made presentations at OCTM, NCTM, and Teachers Teaching with Technology (T3) local, state, national, and international conferences, has served as equipment chairperson at several of the conferences and is an editorial referee for the *Ohio Journal of School Mathematics*. In 2005 he was selected for the Outstanding Mathematics Teacher Award (Grades 7-12) for the North East Ohio District of Ohio and in 2007 received the Buck Martin Award from OCTM for Outstanding Teaching in the State of Ohio. Mr. Jaffee advised on Unit 3, *How Big is Infinity*, and Unit 12, *In Sync*.

David C. Krakauer—Content Advisor

David Krakauer is currently a Professor at the Santa Fe Institute in New Mexico. He has degrees in biology and in computer science and mathematics from the University of London, and a Ph.D. in evolutionary theory from the University of Oxford. He remained in Oxford as a Wellcome Research fellow and lecturer at Pembroke College. In 1999 he moved to the Institute for Advanced Study in Princeton as a long-term member, and was external Professor of evolutionary theory at Princeton University. In 2002 he moved to the Santa Fe Institute. Dr. Krakauer's work is concerned largely with the evolutionary

history of information-processing mechanisms in biology, with an emphasis on information transmission, signaling dynamics and their role in promoting novel, higher-level structures, such as social systems and language. He is the author of over 70 scientific publications; co-editor of a new book on transitions between non-living and living matter, which will be published by MIT press in 2008; and author of numerous popular expositions on evolutionary science. Dr. Krakauer serves as an editor on several journals including the Journal of Theoretical Biology, Theory in the Biosciences, and Biology Direct. Dr. Krakauer advised on Unit 9, Game Theory.

Greg Leibon—Content Advisor

Greg Leibon is a mathematician with more than a decade of research and teaching experience in probability, geometry, topology, and statistics. Sharing mathematical knowledge has always been one of Dr. Leibon's passions, and for years he taught the Chance course at Dartmouth College, allowing him to share the pleasure and beauty of statistics and probability with a less mathematically prepared audience. Dr. Leibon was thrilled to have the opportunity to advise on Mathematics Illuminated, especially Unit 5, Other Dimensions, where he finally got his opportunity to share the beauty of low dimensional topology and geometry (his long-time research loves!) with a wider audience. Currently, Dr. Leibon is a mathematics researcher at Dartmouth College as well as the Chief Mathematician at Memento, Inc, where he designs fraud detection tools using techniques from pattern recognition, geometry, and machine learning. Dr. Leibon advised on Unit 7, Making Sense of Randomness; Unit 4, Topology's Twists and Turns; Unit 5, Other Dimensions; and Unit 8, Geometries Beyond Euclid.

Barry Mazur—Steering Advisor

Barry Mazur, a renowned scholar from Harvard and member of the National Academy of Sciences, possesses a "very literary sensibility," and is "one of the deepest mathematicians of our time." When reminded that Sir Michael Atiyah once said "Algebra is a pact one makes with the devil!" Barry responded, "I rather think that algebra is the song that the angels sing!" Dr. Mazur served as a Steering Advisor for the project.

Wells Morison—Teacher Advisor

Wells (Buz) Morison holds the Arthur Day Welch Chair for Advanced Mathematics at Kimball Union Academy in Meriden, New Hampshire. He has been working with students as a teacher, coach, and administrator at both the high school and college level for over 20 years. During that time he has taught

mathematics, physics, biology, and law; served as Site Director for The Johns Hopkins Center for Talented Youth; served as Director of the Gould Academy Summer School; and was Assistant Headmaster at Kimball Union Academy. He coaches the cross-country running and Nordic ski teams. He recently completed a sabbatical year of study and research at Dartmouth College at the Center for Cognitive and Educational Neuroscience, specializing in the mathematical brain. He holds an M.S. in Physics from Rensselaer Polytechnical Institute and a J.D. from the University of Colorado School of Law. Dr. Morison advised on Unit 6, The Beauty of Symmetry, and Unit 10, Harmonious Math.

Annah Ndiritu—Teacher Advisor

Annah Ndiritu is a mathematics teacher at Hiram Johnson High School in Sacramento, California. She was also a teacher in Kenya before she moved to the United States. Ms. Ndiritu has a Master's degree in Curriculum and Instruction. Eventually, she plans to move back to Africa, where most of her family lives, and continue her mathematics teaching. Ms. Ndiritu advised on Unit 1, The Primes, and Unit 8, Geometries Beyond Euclid.

Robert Osserman—Steering Advisor

Robert Osserman is Special Projects Director at the Mathematical Sciences Research Institute in Berkeley, California, where he served earlier as Deputy Director. He is also Professor Emeritus at Stanford University, where he was Mellon Professor of Interdisciplinary Studies and received several citations for outstanding teaching. His awards include a Guggenheim Fellowship in England and a Fulbright Lectureship in Paris, and he is a Fellow of AAAS. He is the author of many research and expository papers, as well as several books, including *Poetry of the Universe: a Mathematical Exploration of the Cosmos*, which has been translated into over a dozen languages. He has served as a consultant and appeared on several PBS programs, including the series *Life by the Numbers* and the program *Naked to the Bone*, which is devoted to the mathematics and science of medical imaging. In addition, Dr. Osserman has often been heard on NPR. In recent years he has organized and participated in a wide variety of public events, including *Mathematics in Arcadia* with Tom Stoppard, *Funny Numbers* with Steve Martin, *From Einstein to Koyaanisqatsi* with Philip Glass, and the upcoming *M*A*T*H* with Alan Alda. A number of these have been made available on videotapes or DVDs. Dr. Osserman served as a Steering Advisor for the project.

Jenny Quinn—Content Advisor

Jennifer J. Quinn, aka, “Dr. Quinn, Mathematics Woman,” is Professor of Interdisciplinary Arts and Sciences at the University of Washington, Tacoma, and co-editor of the Math Association of America’s (MAA) journal, *Math Horizons*, for “math enthusiasts of all kinds.” Recently, she served as Executive Director of the Association for Women in Mathematics. Her book, *Proofs that Really Count: The Art of Combinatorial Proof*, co-authored with Arthur Benjamin and published by the MAA, was awarded the 2006 Beckenbach Prize as a distinguished, innovative book. In 2007, she received the MAA Deborah and Franklin Tepper Haimo Award for Distinguished College or University Teaching of Mathematics. The award recognizes extraordinarily successful teachers who have been shown to have had influence beyond their own institutions. Dr. Quinn advised on Unit 2, Combinatorics Counts, and Unit 11, Connecting with Networks.

Susan Schwartz Wildstrom—Teacher Advisor

Susan Schwartz Wildstrom is a classroom teacher of mathematics at Walt Whitman High School in Bethesda, Maryland, where she currently teaches precalculus, calculus, and multivariable calculus courses. She also coaches the math team. She is particularly proud of her “reading and writing in mathematics” assignment in which every student reads mathematical selections for pleasure. She has a speakers series in which she brings professional mathematicians into her classroom to show students that mathematics is much more than difficult calculus problems. Outside of the classroom, Ms. Schwartz Wildstrom is involved in professional development as a learner, presenter, and developer. She is currently on the MathCounts Question Writing Committee, the AP Calculus Realignment Commission, and the NAEP Mathematics Standing Committee. In addition, she serves on the board of governors of the Mathematical Association of America and The Art of Problem Solving Foundation. Ms. Schwartz Wildstrom advised on Unit 2, Combinatorics Counts; Unit 4, Topology’s Twists and Turns; Unit 7, Making Sense of Randomness; and Unit 11, Connecting with Networks.

Steven Strogatz—Content Advisor

Steven Strogatz is the Jacob Gould Schurman Professor of Applied Mathematics at Cornell University. He has received numerous awards for his research, teaching, and public service, including a Presidential Young Investigator Award from the National Science Foundation (1990); MIT’s highest teaching prize, the E. M. Baker Award for Excellence in Undergraduate Teaching (1991); the Tau

Beta Pi Teaching Award (2006), from Cornell's College of Engineering; and the Communications Award from the Joint Policy Board for Mathematics (2007), a lifetime achievement award for the communication of mathematics to the general public. His books include *Nonlinear Dynamics and Chaos* (Perseus, 1994), which is the most widely used textbook on chaos theory, both nationally and worldwide, and *Sync: The Emerging Science of Spontaneous Order* (Hyperion 2003), which is aimed at non-scientists and was chosen as a Best Book of 2003 by *Discover* magazine. Dr. Strogatz advised on Unit 12, *In Sync*, and Unit 13, *The Concepts of Chaos*.

James Tanton—Content Advisor

James Tanton received his Ph.D. in mathematics from Princeton University in 1994 and has worked at all levels of mathematics education, as well as continuing to actively practice research. Dr. Tanton believes that mathematics really is accessible to all, and he is committed to sharing the joy and beauty of the subject with a wide audience. In 2004 he founded the St. Mark's Institute of Mathematics, an adjunct organization to St. Mark's School in Southborough, Massachusetts. The Institute's goal is to promote mathematics. Dr. Tanton works with students of all ages and with mathematics educators of all levels to help create a rich and lively mathematics culture within school and college departments. He is the author of two books—with more in the works—and writes frequently for expository mathematics journals and magazines. He has also helped high-school-age scholars publish their own mathematics articles. He is the recipient of several awards for teaching excellence, as well as awards for his expository writing. Dr. Tanton advised on Unit 1, *The Primes*, and Unit 3, *How Big is Infinity*.

Dorothy Wallace—Content Advisor

Dorothy Wallace, a mathematician at Dartmouth College, helped create several interdisciplinary courses through the Math Across the Curriculum project supported by the National Science Foundation. She is the co-editor of *Numeracy!*, the ejournal of the National Numeracy Network; recently co-authored *The Bell that Rings Light* (World Scientific Press), with a colleague in chemistry; and produced a 7-part video series (available on CD), *That's Calculus*, featuring performance artist Josh Kornbuth. Dr. Wallace advised on Unit 6, *The Beauty of Symmetry*, and Unit 10, *Harmonious Math*.

WRITERS**TEXT WRITER**

MacGregor Campbell—Online Text, Facilitator and Participant Guide Writer
MacGregor Campbell is a teacher and writer based in Portland, Oregon. After obtaining a B.S. in Physics from Duke University, he went on to teach middle school math in the Los Angeles inner-city as part of Teach for America. He has written curricula for the Compton Unified School District and for UCSD in La Jolla, California. Mr. Campbell wrote all thirteen online textbook chapters, facilitator guides, and participant guides for the series.

VIDEO SCRIPTWRITERS**Kristian Berg—Scriptwriter**

Kristian Berg is an experienced writer and producer of documentaries and non-fiction series television, specializing in history, science, and children's programming. Mr. Berg served as a series writer for American Passages: A Literary Survey, a sixteen-part series for Oregon Public Broadcasting and Annenberg Media. He has written and produced for PBS series, including History Detectives, Newton's Apple, ZOOM! and DragonflyTV. His historical documentaries include The Dakota Conflict (PBS), Dakota Exile (PBS), The Scottsboro Boys (Court TV), and The Capture and Trial of Adolf Eichmann (Court TV). Kristian lives in Saint Paul, Minnesota, and is produced a story on the Minneapolis I-35 bridge collapse for the PBS science series NOVA scienceNOW. Mr. Berg wrote the scripts for Unit 8, Geometries Beyond Euclid, and Unit 9, Game Theory.

Jacquelyn Blain—Scriptwriter

Jacquelyn Blain is a Writer's Guild of America screenwriter with over 40 hours of produced network television and both a feature film and short film in pre-production. She has worked with the UCLA Extension Writer's Program, is on the faculty of the Art Institute of Portland (OR), and does script consulting work through her firm Yellow Lab Ltd. Her students' films have been accepted by and won awards at numerous film festivals, including the New York Film Festival, the San Francisco Film Festival, the Longbaugh Festival, and the Salem Film Festival. Ms. Blain wrote the scripts for Unit 2, Combinatorics Counts; Unit 4, Topology's Twists and Turns; and Unit 6, The Beauty of Symmetry. She also worked with Red Door Films and with Oregon Public Broadcasting producing this video series.

Melissa Gerr—Scriptwriter

Melissa Gerr is a writer, producer, and still photographer focusing on documentary and knowledge-based products. She wrote and produced for the Annenberg series *Rediscovering Biology* and *America's History in the Making Volume II*. She has produced and directed Spanish, French, and Italian products for McGraw-Hill Publishing Company, as well as programming for PBS in Minnesota and Oregon. She is currently a Senior Producer for Health Sciences media at Laureate Education, Inc., based in Baltimore, Maryland. Working with the advisors on *Mathematics Illuminated* provided her with a new respect for math, a profound admiration for mathematicians, and the unforeseen outcome of expanding her own universe. Ms. Gerr wrote the scripts for Unit 3, *How Big is Infinity*; Unit 7, *Making Sense of Randomness*; and Unit 12, *In Sync*.

Richard Marcus—Scriptwriter

Richard Marcus is an award-winning writer of TV, film, and educational software. He has written for some of the best TV shows ever produced, including *Sesame Street*, *The Tonight Show with Johnny Carson*, and *Dinosaurs*. His educational software has been awarded the Parents' Choice Award, ITA - Gold Medal, and Time Magazine's "Top 100 educational gifts for kids." He has also created attractions for the Seoul Olympics Korean Folklore Pavilion, and for Disneyland and Universal Studios Theme Parks. He is the author of a textbook on Edgar Allen Poe and has had his poetry published in *The New York Times*, *Berkeley Poets Magazine*, and other publications. His short story, *Chosen*, was published in the last Alan King anthology, *Matzoh Balls for Breakfast and Other Memories of Growing Up Jewish*, published by Simon and Schuster. In 2005 he won "Best Screenplay" and "Best Comedy" for his film *Checking Out* starring Peter Falk. Mr. Marcus wrote the scripts, along with David Poulshock, for Unit 1, *The Primes*, and Unit 13, *The Concepts of Chaos*.

Eric Slade—Scriptwriter

Eric Slade is an independent writer/director in Portland, Oregon. He has recently worked as a producer of the National Primetime PBS series *History Detectives*. He worked as a producer on the Annenberg/OPB series *Rediscovering Biology* and as series producer/director on *Bridging World History*. His independent documentary *Hope along the Wind* had its PBS premier in June of 2002, and his works have been screened at dozens of national and international film festivals, at which he has won seven "best documentary" awards. He is also a professional magician and an amateur cartoonist. Mr. Slade wrote the script for Unit 5, *Other Dimensions*.

**SITE AND SERIES
CREDITS****Steve Wright—Scriptwriter**

Steve Wright is an accomplished writer based in Austin, Texas. He writes scripts for both short-form and long-form projects including documentaries, news magazine programs, multipart instructional videos, marketing and promotional pieces, and other projects for television, businesses, universities, associations, and others. He is a former television news reporter for CBS and NBC affiliates, and he received the Associated Press's top honor for the best documentary in the state of Texas. He has written scripts narrated by top talent in the broadcast industry including Bill Moyers of PBS. Mr. Wright has written scripts for numerous Annenberg/OPB projects on American history and world history. Mr. Wright wrote the scripts for Unit 10, Harmonious Math, and Unit 11, Connecting with Networks.

Oregon Public Broadcasting

Oregon Public Broadcasting (OPB) is an award-winning producer of educational content with expertise in both traditional and new media approaches to formal education, community outreach, and television production.

OPB has produced many series for Annenberg Media, including *American Passages: A Literary Survey*, a multimedia series for college students; *Artifacts & Fiction: Workshop in American Literature*, a professional-development workshop series for teachers on interdisciplinary approaches to American literature; *Rediscovering Biology: Molecular to Global Perspectives*, a series to help in-service teachers update their content knowledge in the life sciences; and *Bridging World History*, a professional-development course for high school teachers and students.

OPB produces Web sites, teachers' guides, and other curriculum materials to accompany textbooks and PBS broadcast series. Working in close concert with national academic experts and advisory boards, OPB's staff has produced curriculum materials in the humanities and sciences for a variety of grade levels and teacher professional development.

Red Door Films

Red Door Films is a Portland, Oregon-based production company, originally founded in 1989 as David Poulshock Productions, Inc. Mr. Poulshock is an award-winning producer, writer, and director of the *WEE SING* children's series. Red Door Films has produced numerous commercials, infomercials, and corporate films for clients, ranging from Goodwill Industries and the

Oregon Lottery to Hewlett-Packard and View-Master 3-D. Mr. Poulshock served as chairman of the 2005 Willamette Writers Conference, is a member of the Board of Directors of the Northwest Academy, and is on the adjunct faculty of the Art Institute of Portland.

ADi

Founded in 1996, ADi excels in visual communication with a focus on 3-D and visual effects for business and business marketing, consumer advertising, direct response television, education, and entertainment. Clients range from Fortune 500 high-tech firms to independent film producers. The Portland-based company is recognized for its skill in rendering digital prototypes for pre-production marketing efforts. Recent accolades include two Telly Awards, a Northwest ADDY Award, and a Summit Marketing Effectiveness Award.

HUB Collective, Ltd.

HUB is a full-service design firm specializing in identity, print, event, and environmental graphic design. HUB designs visual communication that is intelligent, elegant, and compelling. They believe design, like all language, arises from a human need to craft coherence out of chaos, to be heard, and, ultimately understood. Clients include Chartreuse Portland | New York, Cranium, Pacific Northwest College of Art, Portland Development Commission, Nike, and Umpqua Bank.

RMC Research Corporation

RMC Research Corporation was organized in December 1970 as a private, technical consulting firm specializing in research, evaluation, training, and technical assistance for educational and human service agencies at the federal, state, and local levels. Clients have included several federal agencies and departments, including the United States Departments of Education, Justice, Labor, and Health and Human Services; the Center for Mental Health Services; the Center for Substance Abuse Prevention; the Center for Substance Abuse Treatment; the Centers for Disease Control and Prevention; and the Corporation for Public Broadcasting. Offices are located in New Hampshire, Colorado, Virginia, Florida, and Oregon. RMC Research Corporation performed the formative evaluation for the series.

Tweak Interactive

Founded in 1999, Tweak Interactive is a marketing design and usability services firm. Their professional team is composed of designers, developers, writers, and usability experts, all trained and experienced in the practice of user-centered design. Tweak has served such notable companies as Unicru, Tripwire, Hollywood Entertainment, Blue Cross/Blue Shield, InfoSpace, Wells Fargo, United Healthcare, and Serena Software. Tweak conducted the usability study for the interactive tools on the Mathematics Illuminated Web site.

OREGON PUBLIC BROADCASTING PRODUCTION TEAM

Executive Vice President National Productions: David Davis

Series Producer: Sam Ward

Production Manager: Catherine Stimac

Project Manager: Doug Brazil

Field Producer: Hillary Brown

Video Producers: Sean Hutchinson and Stewart Boyles

Web Developer: Heather Young

Researcher: Traci Fantz

Web Assistant: Chris Gates

Associate Producer: Beth Lipson

Production Assistance: Laurance Johnson

Video/Online Editors: Tom Babich, Pamela Chipman, Cathie Clifford, Jerry Pratt, Wendy Morgan, and Patrick Weisenhempfle

Director of Engineering, IT: Dave Fulton

Production Services: Howard Beckerman, Bill Dubey, Milt Ritter, and Gary Schiedel

Graphic Design: Gini Chin

Original Theme Music: Nathan Larson

Lead Copy Editor: Tom Bensman, The Leslie Group, Inc.

Additional Copy Editor: Monica L. Caplan, The Leslie Group, Inc.

Production Interns: Sarah Fox, Catherine Kurz, and Holly Werner