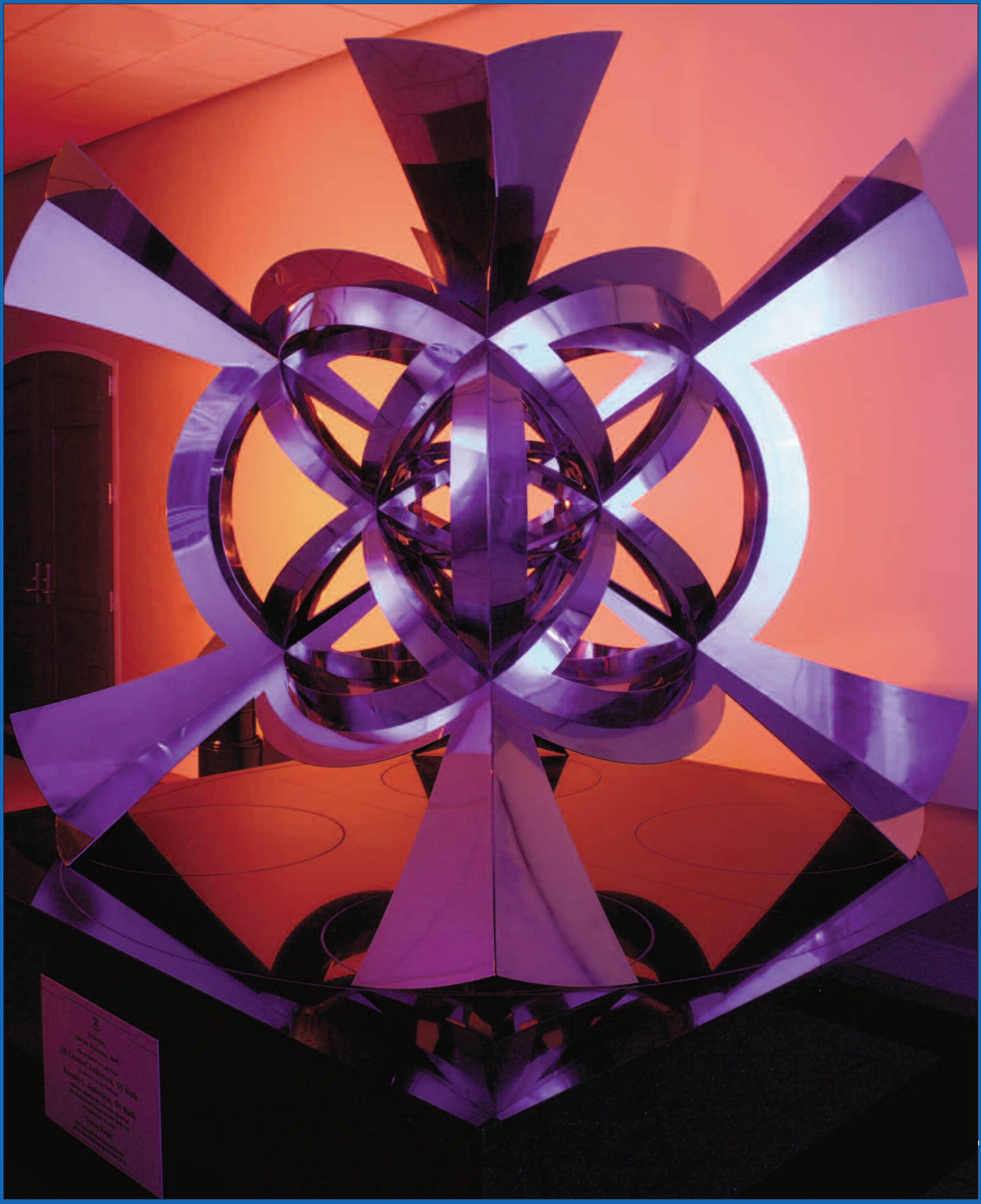
EBERLY COLLEGE OF SCIENCE

Department of Mathematics at Penn State

Faculty Profiles from *Science Journal*



The "Octacube " sculpture *in the first-floor atrium of McAllister Building represents the three-dimensional "shadow" of a four-dimensional solid object. Designed by Adrian Ocneanu, professor of mathematics, the sculpture measures about six feet in every direction and is mounted on a three-foot-high granite base.* *For more information about the Octacube sculpture, see page 9.*

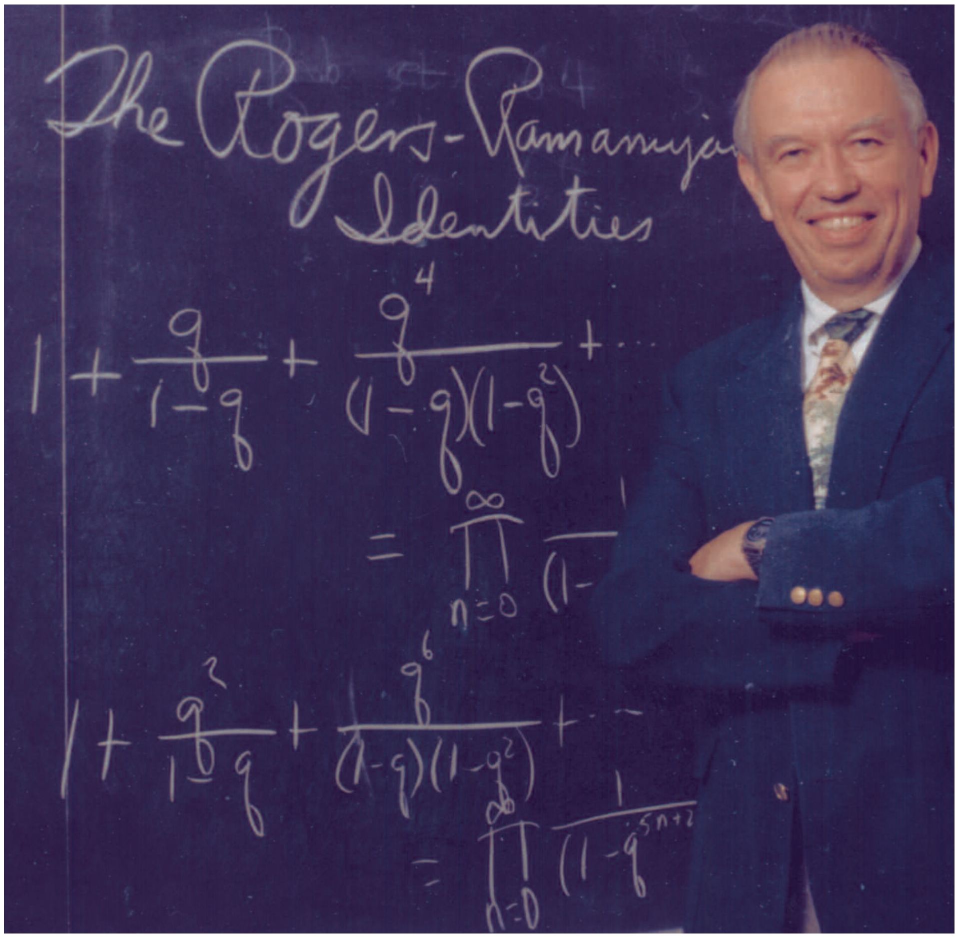
PENNSTATE

1855

FACES OF PENN STATE

George Andrews

Evan Pugh Professor of Mathematics



Would-be lawyer George Andrews discovered his love of mathematics in college, and that motivated him to become one of the world's foremost mathematicians, widely regarded as a researcher and as a teacher.

Years at Penn State: 37
Professional background: Penn State (1964-present, professor / associate professor / assistant professor)
Academic background: Doctoral degree in mathematics, University of Pennsylvania (1964); Master's degree in mathematics, Oregon State University (1960); Bachelor's degree in mathematics, Oregon State University (1960)

When George Andrews arrived at Penn State in 1964, he was one of the youngest members in the Department of Mathematics. Today, he's one of the veterans.

Thirty-seven years ago, the University's mainframe computer was located in the basement of Old Main with four refrigerator-size units providing half a megabyte of memory. Today, the laptop that Andrews carries exponentially dwarfs that computing capacity.

Still, as much as things have changed, they also have remained the same. Especially Andrews' enthusiasm.

"Mathematics has an elegance, a beauty, and an excitement of exploration that never gets old," Andrews says. "It's continually satisfying."

With advice from a high school guidance counselor—who told Andrews it was impossible to get a job in life that he would enjoy, so he should at least get a job in which he would do well—Andrews planned to combine his scientific skills with a pragmatic path and become a patent lawyer. Along the way, he discovered mathematics and, with the guidance of an inspiring teacher, his career path changed.

"Mathematics just came alive," Andrews says. "Before that, it had never occurred to me to become a mathematician."

He did not become just a mathematician, though. He became one of the best in world. His research includes number theory and partitions (writing a whole number as the sum of smaller numbers), and he has found applications and ongoing challenges on a regular basis.

In 1971, he was the first to use computers to search for partitions. In 1976, he discovered a lost manuscript of the Indian genius, Ramanujan. Andrews' efforts to prove the many unconfirmed assertions in that "lost notebook" led to his work in physics and, eventually, an honorary doctorate in physics from the University of Parma in Italy. More recently, his work provided part of the basis as other collaborators outlined a generalization of the Gollnitz Theorem—a problem that had nagged mathematicians for 30 years. Other collaborations have allowed him to lead in the development of software packages designed exclusively as research tools for mathematics.

"In the past decade or so, the amount of collaboration I've done has increased greatly," Andrews says. "My career started by following my own research interests and creating a body of work that had intrinsic merit as well as a potential for interacting with other areas. Recently that has lead to interesting work in other fields."

Andrews has served as head of the Department of Mathematics at Penn State on two different occasions, authored or coauthored five books, published hundreds of articles in peer-reviewed journals, and earned numerous awards and honors. His enthusiasm for mathematics never wanes.

"It's something like exploring a mountain range," he says. "As you become more familiar with it, you appreciate each new peak even more. Then you hope to describe what you find and present it so others can appreciate its meaning and value, too."

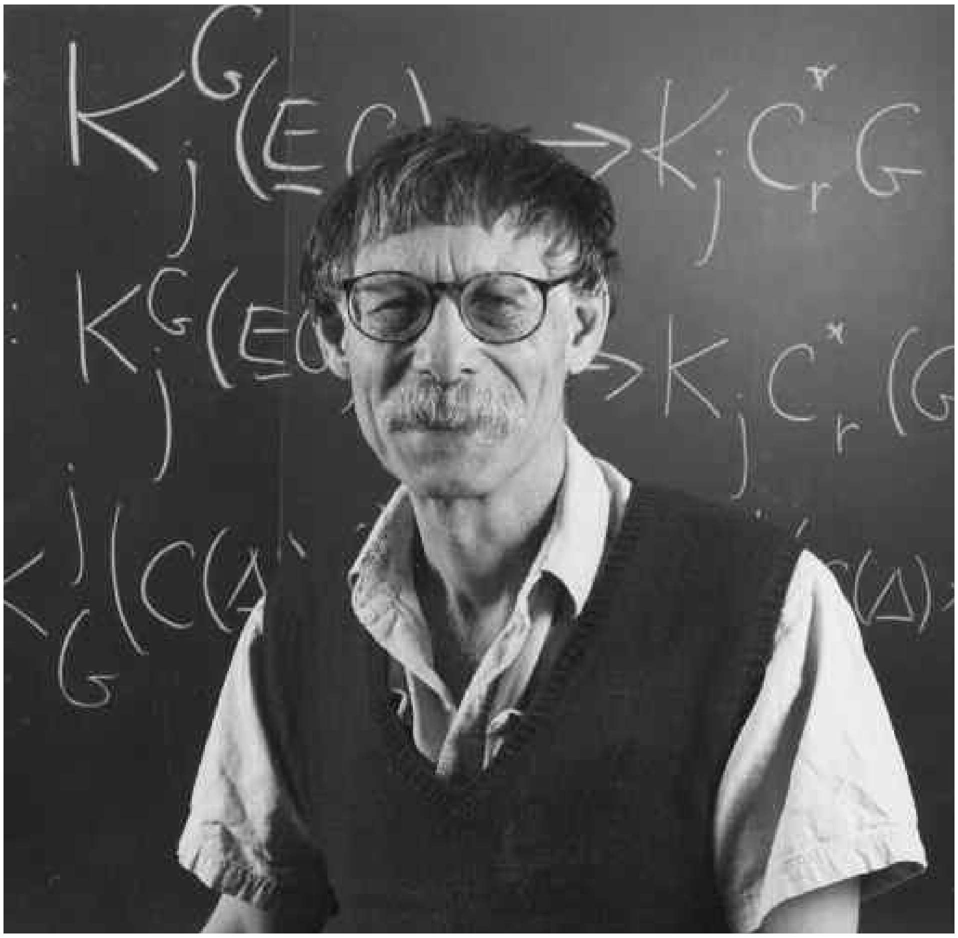
Steve Sampsell

FACES OF PENN STATE

Paul Baum

Evan Pugh Professor of Mathematics

Years at Penn State: 14.
Professional background: Penn State (1987-present, Evan Pugh professor / distinguished professor / professor); Brown University (1967-1987, professor / associate professor); Princeton University (1962-63 and 1965-68, visiting associate professor / assistant professor / instructor).
Academic background: Doctoral degree in mathematics, Princeton University (1963); Master's in mathematics, Princeton University (1961); Bachelor's in mathematics, Harvard College (1958).



Mathematician Paul Baum says an awful lot of people don't appreciate the fact that mathematics is a developing subject. Many people, he says, somehow think that mathematics is finished.

It's fitting that Paul Baum sometimes uses baseball metaphors to describe mathematicians, considering he grew up in New York City, home of Major League Baseball's fabled Yankees. But, at an age when most boys were enthralled with baseball, Baum was falling head over heels for mathematics.

"When I was in 10th grade at the Bronx High School of Science I had a teacher for plane geometry who was just absolutely marvelous," Baum recalled. "I liked the subject so much that from that moment on I said to myself, 'This is for me. This is what I want to do.' And I never really changed my mind."

Nor does mathematics ever stray far from his mind.

"I think about it consciously and subconsciously all the time. I'm never not thinking about it," Baum said. "I'll wake up in the morning sometimes and say to my wife, "I had a wonderful mathematical night.' "

Baum's lifelong pursuit of mathematical solutions has led him to concentrate on a new discipline—non-commutative geometry—a complex, advanced fusion of algebra and geometry.

It's a topic not easily explained to the uninitiated. But, Baum contended, mathematicians must endeavor to explain their oft-misunderstood profession.

"I think it is incumbent on mathematicians to try to give the world some idea of what it is we do. There are parts of the subject that you can explain."

Part of the explanation centers on popular misconceptions about mathematics.

"Many people seem to somehow think that mathematics is finished, that there's nothing more to say. Intelligent, well-educated people have said to me, '2+2=4, what more is there to say?,' " Baum said. "There's a huge amount that we do not understand, that is unsolved. It is extremely unlikely that we will reach a point where we can say mathematics is completed."

When he's not transfixed on some equation, Baum works out to keep both his body and mind fit. If not walking or jogging, he could be found on one of the exercise machines he owns. Baum said there's a basic unity between mind and body, and exercise sometimes provides a catalyst for inspiration.

It's the type of inspiration his 10th-grade teacher provided. Some years later, the same teacher read an account of a Baum lecture in the Notices of the American Mathematical Society. The teacher later wrote him to inquire if Baum was one of his former pupils. Baum wrote back and said, "It was in your class that I first glimpsed the power and the beauty of mathematics."

And, true to his New York roots, that appreciation enabled Baum to embark on a big-league mathematical career.

"There are a small group of superstars who set the directions, who inspire us all and point us forward toward the new mathematics that is always coming to be," Baum said.

"It has been my good fortune to have written papers and worked with superstars."

Andy Elder

FACES OF PENN STATE

W. Dale Brownawell

Distinguished Professor of Mathematics

Years at Penn State: 35
Academic background: doctoral degree in mathematics, Cornell University (1970); bachelor's degree in German and mathematics, University of Kansas (1964)

Fredric Weber, Penn State

Dale Brownawell enjoys teaching and says, "Just going into a class that's interested is a lot of fun." The challenge, he says, is to provide utility while opening the door to beauty. He observes, "Tedious hours memorizing addition tables and such things in school do not provide a good basis for experiencing the fun and beauty of mathematics. Folks at many levels come to mathematics for its usefulness. But if they stay, they stay for its beauty."

Watching W. Dale Brownawell talk about mathematics is like watching an artist sketch out his next painting. Speaking calmly, he reveals the truth of it as his hand glides effortlessly between equations, drawings of X and Y axes, and diagrams of curves and planes.

Many artists would agree that Brownawell's description of developing a proof is the same for any creative process. "You can feel it happening but you really don't know what it is at first," says the unassuming Distinguished Professor of Mathematics. "You can see this is going somewhere, but it's like looking through a glass, darkly. So basically you've got some intuition when you're doing it that something is going on, and you kind of feel and grope your way, then you reach a point where you're pretty sure this is it, and you nail it down."

Brownawell leans back in his chair with the comfortable expression of accomplishment. "Then you've got to be able to explain it to somebody else. You strip away all the scaffolding that helped you get there, and you display in the end the finished painting."

The world-renowned mathematician, son of a farmer and Santa Fe Railway car inspector, studied both German and mathematics as an undergraduate. After a year in Germany, where he met his future wife, Eva, he returned to graduate work at Cornell University. Mathematics would become his future, or more accurately, German would not. "Eventually, I decided I didn't want to teach freshmen dative case for the rest of my life," he says, smiling. "Math, on the other hand, *is* fun," he continues gleefully.

Part of Brownawell's work focuses on transcendental numbers, investigating the hypothesis that there are no surprising relationships between constants that come from analysis. But he may be best known for his discovery regarding the Hilbert Nullstellensatz, which is one of the four fundamental theorems that connect algebra to geometry. His work rendered the theorem more surely applicable to robotics, image reconstruction, and more.

Though mathematicians are a comparatively solitary bunch according to Brownawell, he admits that finding like-minded colleagues was one of the more pleasant experiences of his career. "I can't explain the feeling when I went to my first international conference and other people were working on similar things and I didn't have to define all of these things," he says, nodding to a white board full of arrows, letters and numbers. "Instead of getting eyes glazed and muttering disingenuously, 'How interesting,' they would say, 'Hey, that's a great idea.' I didn't have to persuade them that there was something possibly interesting. And for me that was just amazingly energizing!"

At the end of the day, this veteran scholar and world traveler spends his off time inline skating, studying languages, and enjoying time with his wife. "If I get home early enough to have tea with Eva, that's a treat," he says.

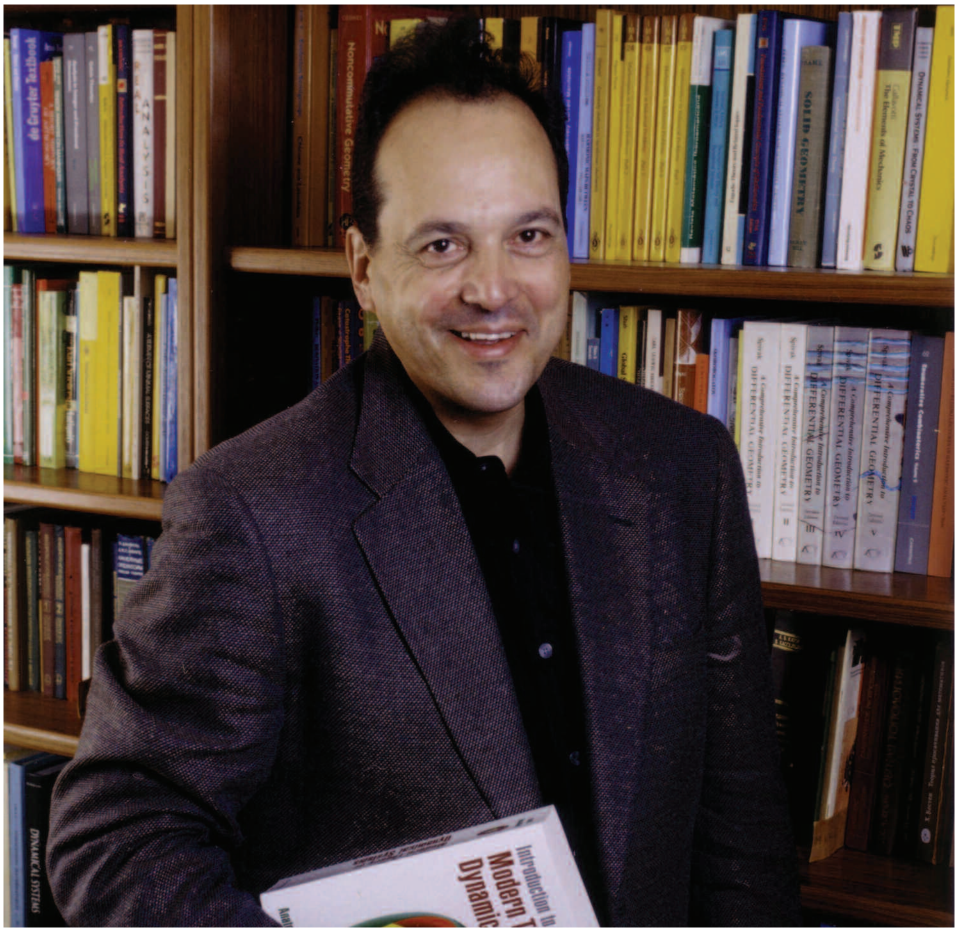
Suzan Erem

FACES OF PENN STATE

Anatole Katok

Raymond N. Shibley Professor of Mathematics

Years at Penn State: 11.
Professional background: Penn State (1990-present, professor); California Institute of Technology (1984-1990, professor); University of Maryland (1978-1984, professor); USSR Academy of Science Central Economics-Mathematics Institute (1968-1978, Senior Scientific Research Worker / Junior Scientific Research Worker).
Academic background: Candidate degree in mathematics, Moscow State University (1968); Diploma degree in mathematics, Moscow State University (1965).



Anatole Katok has played an integral role in two major University mathmatical programs, and he has been recognized for his graduate-level teaching and supervision of Ph.D. candidates.

Anatole Katok's career path began at a quirky intersection of unrealized potential and some not-so-subtle prodding. Reminiscing over old photos in his office, Katok pinpointed the moment he knew he was destined to become a mathmetician.

Katok was a 14-year-old Soviet high-school student when, he recalls with a smile, "I had one good teacher who forced me to enter a Mathematics Olympiad. I was fortunate to earn a high honor. It was then I knew I wanted to be a mathmetician."

That teacher's intervention awakened a dormant passion for mathematics, and led to Katok dedicating his professional life to parallel, but closely related, pursuits—research and teaching.

His propensity for solving highly complex mathematical problems has aided his contribution to developing the mathematical side of chaos theory and the theory of dynamical systems, which involves developing appropriate mathematical paradigms for explaining long-term behaviors such as weather prediction, or the movement of celestial objects.

Katok helps mentor future mathmeticians and researchers by enthusiastically advising doctoral candidates. He has been adviser to nine successful doctoral candidates, six who now hold academic appointments. He's currently advising more. Katok partially owes the success of his advisees to his own sixth sense for spotting the potential for success in others.

"It's an artform. No amount of standardized skill necessarily makes a good mathematician," Katok says. "It takes skill and creativity. It takes creativity put to use to discover new things. And it takes the ability to change an old question or come up with a new approach."

A University committee recognized Katok's dedication to his dual mission by earlier this year awarding him the Graduate Faculty Teaching Award, which honors tenured faculty who have excelled both in teaching at the graduate level and in supervising the thesis work of graduate students.

"I was delighted that someone outside the mathematics department recognized my emphasis on advising Ph.D. candidates and training future researchers," he said.

"It is the greatest joy for an adviser when suddenly something clicks and the student is transformed from a plain apprentice into a master of his or her subject."

Katok also played a key role in starting and developing the University's Mathematical Advanced Study Semesters, which assembles undergraduate math majors from all over the country for an intensive one-semester immersion that features specially designed courses, seminars, and research-oriented projects. Many of these students have gone on to excellent graduate schools. Katok says this program is unique in this country.

He is also one of three investigators on the University's Grants for Vertical Integration of Research and Education in the Mathematical Sciences (VIGRE). The five-year VIGRE program is an ambitious effort to make the Department of Mathematics a premier center for training the next generation of mathematical scientists. Now in its third year, Katok said VIGRE is already showing some desired results.

Andy Elder

FACES OF PENN STATE

Yakov Pesin

Distinguished Professor of Mathematics

Years at Penn State: 14
Professional background: Penn State (1990 to present, distinguished professor / professor); scientific researcher at research institutes in Moscow, USSR (1970-1984)
Academic background: Doctoral degree, Gorky State University, USSR (1979); Master's degree with honors and Bachelor's degree, Moscow State University, USSR (1970 and 1968)

Fred Weber, Penn State

"Life in the Soviet Union wasn't easy. I had a family. We spent a lot of meaningless time in long lines to buy something trivial. That makes you even more devoted to doing what makes huge sense to you. Come to work, do something, then go to Moscow University at night and do something incredibly interesting."

Maybe it was the world-class opera, concert hall, and ballet Yakov Pesin grew up with in his hometown of Moscow. Maybe it was the beauty of the subway stations, where Soviet-supported artists created superb mosaics. But somehow, Yakov Pesin, Distinguished Professor of Mathematics, came to the United States with an intense love of the beauty of mathematics.

"Math is the art of science," Pesin said. "It can be explained without long boring formulas or arguments no one seems to understand. The history of math is full of many intriguing detective stories, and if kids were taught these stories they would love it like they love Arthur Conan Doyle or Agatha Christie or anyone else."

Growing up in the Soviet Union, Pesin also developed persistence in the face of a government that would not use his mathematical talents to their fullest, but instead relegated him to an "unbelievably stupid job" programming in code at an obscure institute in Moscow. "So I did math after work," Pesin said, smiling. Math, he said, was a safe haven for hundreds of talented intellectuals who preferred not to have their work used for ideological purposes.

This was Pesin's life for almost twenty years, until he was able to emigrate to the United States as a visiting professor at the University of Chicago for a semester. "I had little idea about how the system works in the U.S.," Pesin said. "Unemployment was an abstraction, something from Mars." Thankfully, it wasn't long before offers for permanent positions came pouring in and Pesin decided to make Penn State his home.

He describes his work as the underlying "pure" mathematics that supports research in chaotic dynamics, a combination of the mathematical theory of mechanics—stating that the physical world can be predicted with the correct equations—and the classical theory of "randomness," or naturally occurring chaos. His work supports the theory that both can exist simultaneously, as it does in computer programs that generate random numbers, for example, or that model the weather. "We think we can predict weather because we can compute the behavior of every single element, but it turns out we can't always predict it even a day before," he said.

As Pesin discusses examples of entertaining, yet challenging, mathematical problems for young people, there's an echo of political wisdom in his words, that world leaders could have used years ago, when nuclear annihilation was just one button away. "When we put our mind in a very narrow place we impose this condition on ourselves," he said. "Math tries to teach you to get rid of these extra constraints, to see things much broader, and once you can do that, you can understand the beauty of mathematics. Give kids some examples of this type, and they start to like mathematics. At the very least they will stop hating it," he said, chuckling. "I dream about that."

Suzan Erem

Bressan is Named Holder of the Eberly Family Chair in Mathematics

Alberto Bressan

Alberto Bressan, professor of mathematics at Penn State, has been named Holder of the Eberly Family Chair in Mathematics for his excellence in research. The chair is one of the highest honors awarded to Eberly College of Science faculty members. As part of this appointment, Bressan will receive research funds from an endowment given to Penn State by the Eberly Family Trust. In 1986, the Eberly Family Trust gave $10 million to establish a chair in each department in the Eberly College of Science, to create endowments for biotechnology, and to provide funding for the Hobby-Eberly Telescope. At that time, the gift was among the largest donations made to the campaign to raise private support for Penn State.

Bressan's research interests fall within the broad area of nonlinear analysis, which includes such topics as nonlinear partial differential equations, optimization problems, the mathematical theory of control, and differential games. He is highly regarded for his work in the field of hyperbolic conservation laws, where he has established fundamental properties of solutions and the convergence of vanishing viscosity approximations.

Bressan has written two books. The first one, titled "Hyperbolic Systems of Conservation Laws: The One-Dimensional Cauchy Problem," was published by Oxford University Press in 2000. The second one, titled Introduction to the Mathematical Theory of Control, was co-authored by Benedetto Piccoli and appeared in 2007 within the book series of the American Institute of Mathematical Sciences. Bressan also has authored more than 120 scientific papers. He currently serves on editorial boards for 17 international journals, including Archive for Rational Mechanics and Analysis, Discrete and Continuous Dynamical Systems, Journal of Differential Equations, and SIAM's Journal on Mathematical Analysis.

Prior to joining the Penn State faculty in November of 2003, Bressan was a professor at the International School for Advanced Studies (SISSA) in Trieste, Italy from 1991 to 2003 and an associate professor at the University of Colorado in Boulder from 1986 to 1990. He received his bachelor's degree in mathematics from the University of Padova in Italy in 1978 and his doctoral degree in mathematics from the University of Colorado in Boulder in 1982. In 2006, Bressan received the Antonio Feltrinelli Prize in Mathematics, Mechanics, and Applications from the Accademia dei Lincei in Rome. This prize is among the highest awards reserved for Italian citizens for achievements in the arts, music, literature, history, philosophy, medicine, and physical and mathematical sciences.

Du Named Willaman Professor

Qiang Du

Qiang Du, professor of mathematics, has been named Willaman Professor of Mathematics in the Eberly College of Science. The Willaman Professorships were established in 1999 by Verne M. Willaman, a 1951 graduate of Penn State. The professorships provide a supplemental source of support for outstanding faculty members to provide them with the resources necessary to further their research, teaching, writing, and public service.

Du studies applied mathematics and scientific computation. He is developing innovative computational algorithms to solve a broad spectrum of scientific and engineering problems ranging from understanding the dynamics of quantized vortices—a problem in modern fluid mechanics—the evolution of microstructures, the deformation of biomimetic membranes, to model reductions and data mining. He uses numerical simulations based on mathematical modeling to complement physical experiments and analytic investigations.

Du currently is on the editorial boards of leading computational mathematics journals, such as the Society for Industrial and Applied Mathematics (SIAM) *Journal of Numerical Analysis*. He also is on the editorial boards of interdisciplinary journals, including *Applied Mathematics Research eXpress*, *Discrete and Continuous Dynamic Systems*, *Journal of Information and Computational Science* and the *Chinese Journal of Computational Physics*. From 2000 to 2006, he also served on the editorial boards of the *Journal of Computational Mathematics* and *Communications in Pure and Applied Analysis*. He has served on as a reviewer for several private research foundations and for government agencies, including the U.S. National Science Foundation, the Austrian Science Foundation, the Portugal Science Foundation, the Chinese Ministry of Science and Technology, the Hong Kong Research Grant Council, and the Israel Science Foundation. In 1999, he was appointed chief scientist for the largest state-funded basic-research project on scientific computing in China.

Du's scientific contributions have been recognized with a Feng Kang prize in scientific computing in 2005, a Liberal Arts and Sciences Award for Outreach and Extension at Iowa State University in 2000 and a Frame Faculty Teaching Award at Michigan State University in 1992.

Prior to joining the Penn State faculty in 2001, he was an associate professor and professor at Iowa State University from 1997 to 2001, and was an associate professor and professor at Hong Kong University of Science and Technology from 1996 to 2001. He was a visiting associate professor at Carnegie Mellon University in 1993, and an assistant professor and associate professor at Michigan State University from 1990 to 1996. From 1988 to 1990, he was the L.E. Dickson Instructor at the University of Chicago. He was a research assistant in 1988 and participated in faculty research in 1989 at Los Alamos National Laboratory. Currently, he holds a courtesy appointment in the Department of Materials Science and Engineering at Penn State.

Du earned a bachelor's degree in mathematics at the University of Science and Technology of China in 1983. He earned a master's degree in applied mathematics and a doctoral degree in mathematics at Carnegie Mellon University in 1986 and 1988, respectively.

(*Originally published in the Spring 2007 issue of Science Journal*)

Higson Named Evan Pugh Professor

Nigel Higson

Nigel Higson, distinguished professor of mathematics, has been named Evan Pugh professor, the highest distinction that Penn State can bestow upon a faculty member.

Named after Penn State's first president, this award is given to faculty members whose research publications and creative work or both are of the highest quality over a period of time; are acknowledged national and international leaders in their fields as documented by pioneering research or creative accomplishments; are recipients of prestigious awards; and demonstrate excellent teaching skills with undergraduate and graduate students.

Higson is a specialist in noncommutative geometry, particularly the operator-algebra theory, a subject that has roots in the mathematical foundations of quantum theory and in Fourier analysis and that has powerful consequences in the fields of topology and geometry. His recent work focuses on the Baum-Connes conjecture, a broad program that connects operator-algebra theory to problems in other areas of mathematics. Along with Paul Baum, Evan Pugh professor of mathematics at Penn State, and Alain Connes, their colleague in Paris, Higson is responsible for the current form of the Baum-Connes conjecture.

Higson has received much recognition for his research, including a Sloan Foundation Fellowship in 1992, the Andre Aisenstadt Prize of the Center for Mathematical Research in Montreal in 1995, the Israel Halperin Prize of the Canadian Operator Symposium in 1995, and the Coxeter James Prize of the Canadian Mathematical Society in 1996. In addition, he was among the first group to be honored as Fellows of the Clay Mathematics Institute in 1999 and he was elected a Fellow of the Academy of Sciences of the Royal Society of Canada in 2000.

His bachelor's, master's and doctoral degrees all came from Dalhousie University in Halifax, Nova Scotia. From 1986 to 1990, Higson was an assistant professor at the University of Pennsylvania. He joined the Penn State faculty as an assistant professor in 1989 and was promoted to associate professor in 1990 and to professor in 1994. He was named distinguished professor of mathematics in 2000.

(Originally published in the Fall 2006 issue of Science Journal)

Xu Named Distinguished Professor of Mathematics

Jinchao Xu

Jinchao Xu, professor of mathematics, has been named Distinguished Professor of Mathematics at Penn State. This title is presented in recognition of his exceptional record of teaching, research, and service to the University community. The honor is designated by the Office of the President of Penn State based on the recommendations of colleagues and the Dean.

Xu studies numerical methods for partial differential equations, especially fast iterative methods for solving large-scale algebraic systems that arise from the numerical approximation of mathematical models in science and engineering. One major research interest is the theoretical analysis, algorithmic development, and practical application of multigrid methods. These methods combine classical iterative techniques with multiscale structures obtained from a given application to yield a class of optimally efficient methods that are far superior to the classic iterative techniques alone.

Xu has published more than 100 scientific papers about his research and, according to the Institute for Scientific Information's (ISI's) Highly Cited Authors in Mathematics, is among the most highly cited mathematicians in the world. He has been invited to present a plenary lecture at the 6th International Congress for Industrial and Applied Mathematics (ICIAM) held in Zurich in July 2007. The ICIAM, held every 4 years, is the largest international conference for industrial and applied mathematics. He serves on editorial boards for many major journals in computational mathematics, including the Journal of Computational Mathematics, Mathematics of Computation, Mathematical Modeling and Numerical Analysis, Mathematical Models and Methods in Applied Sciences, the Journal of Computational Methods in Applied Sciences and Engineering, Advances in Computational Mathematics, Journal of Computational Physics in China, the International Journal of Numerical Analysis and Modeling, and the Journal of Selected Articles from Chinese Universities: Mathematics. He is also a co-editor of many conference proceedings and research monographs.

In 1995, Xu's research accomplishments were recognized with the first Feng Kang Prize for Scientific Computing from the Chinese Academy of Sciences and an Outstanding Achievement Award from the Xiangtan University in China. He received a Schlumberger Foundation Award in 1993 and the Natural Science Award from the National Academy of Science in China in 1989. He received the Liu Memorial Award at Cornell in 1988. In honor of his achievements in computational-mathematics research and teaching, he received the Humboldt Award for Senior U.S. Scientists in 2005. He also received a Research Award for National Outstanding Youth (Class B) in 2006 in China.

Xu earned his bachelor's degree at Xiangtan University in 1982 and his master's degree at Peking University in 1984, both in China. He earned his doctoral degree at Cornell University in 1989. He joined Penn State in 1989 as assistant professor of mathematics. He was promoted to associate professor in 1991 and to professor in 1995. He has been Changjiang Professor in Peking University since 1999 and Furong Professor in Xiangtan University since 2003. He is the director of the Center for Computational Mathematics and Applications at Penn State and of the Institute for Computational and Applied Mathematics at Xiangtan University in China. He is a member of the American Mathematical Society and the Society for Industrial and Applied Mathematics.

(Originally published in the Spring 2008 issue of Science Journal)

On the Cover:

Artistic works traditionally carry significance beyond their physical beauty, but a new sculpture in the McAllister Building headquarters of the Penn State Department of Mathematics may carry that tradition to its limits. The stainless-steel work, a striking object of visual art, also is a mental portal to the fourth dimension, a teaching tool, a memorial to a graduate of the math department, and a reminder of the terrorist attacks of 11 September 2001. The sculpture, which measures about six feet in every direction, is mounted on a base that brings its center approximately to eye level.

The sculpture, designed by Adrian Ocneanu, professor of mathematics, presents a three-dimensional "shadow" of a four-dimensional object. One aspect of Ocneanu's research on quantum-field theory based on symmetry is modeling regular solids, both mathematically and physically. In the three-dimensional world, there are five regular solids—tetrahedron, cube, octahedron, dodecahedron, and icosahedron—whose faces are composed of triangles, squares, or pentagons. In four dimensions, there are six regular solids, which can be built based on the symmetries of the three-dimensional solids.

Unfortunately, humans cannot process information in four dimensions directly because we don't see the universe that way. Although mathematicians can work with a fourth dimension abstractly by adding a fourth coordinate to the three that we use to describe a point in space, a fourth spatial dimension is difficult to visualize. For that, we need physical models. "Four-dimensional models are useful for thinking about and finding new relationships and phenomena," says Ocneanu. "The process is actually quite simple—think in one dimension less." To explain this concept, he points to a map. While the Earth is a three-dimensional object, its surface can be represented on a flat two-dimensional map.

Ocneanu's radial stereography process presents a new way of projecting four-dimensional solid into a space perceptible to the human observer, analogous to mapping a globe of the Earth onto a flat surface. The technique can be used to make a two-dimensional projection of a cube by first mapping the cube radially onto the surface of a globe. Ocneanu explains, "The edges of the cube become circles on the map, just like straight highways are slightly curved on maps of the Earth. Its angles, however, remain true, so the map retains the key aspects of the symmetry of the original cube, unlike a photograph of a cube."

When the same technique is applied to project a four-dimensional solid into three dimensions, the inner part of the projection has smaller, undistorted faces, while the outer part extends toward infinity. Linear edges of the solid become circles in the projection. However, the projection is conformal, which means that the angles between faces and the way that the faces meet at corners are uniform throughout the projection. The retention of these key characteristics makes the sculpture a powerful teaching tool in addition to a powerful aesthetic object.

The sculpture was funded by Jill Grashof Anderson, a 1965 graduate of the mathematics department. It is dedicated to the memory of her husband, Kermit Anderson—also a 1965 mathematics graduate—who was killed in the World Trade Center terrorist attack. She also has sponsored a scholarship in his memory. "I hope that the sculpture will encourage viewers to ponder and appreciate the wonderful world of mathematics," says Anderson. "I also hope that all who view the sculpture will begin to grasp the sobering fact that everyone is vulnerable to something terrible happening to them and that we all must learn to live one day at a time, making the very best of what has been given to us. It would be great if everyone who views the Octacube walks away with the feeling that being kind to others is a good way to live."

Steve Miller

Science Journal is published by the Penn State Eberly College of Science.
520 Thomas Building, University Park, PA 16802-2112, phone: (814) 863-8453, www.science.psu.edu/journal,
e-mail: science@psu.edu