MATH IN THE VALLEY

Discovering the shape of data

WINTER 2020

Oregon State
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WINTER 2020

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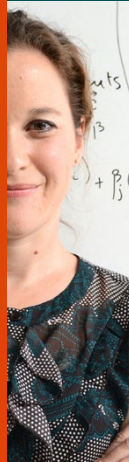College of Science

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On the cover —Topological data analysis studies patterns pertinent to the shape of the data, such as the pattern made by a flock of birds. See p. 8 to learn more.

From the head

BILL BOGLEY

Department Head

Dear mathematicians and friends of mathematicians!

Let me share a story. One of our first decisions when the pandemic struck was to cancel the spring 2020 Ph.D. qualifying exams while everyone adjusted to "remote operations." It was therefore doubly important for our graduate program that the fall 2020 exams, scheduled to begin September 8, should go ahead. In August, students, faculty and staff collaborated with campus liaisons to Benton County health officials to provide extreme low-density in-person exam venues to give our students the best chance to demonstrate their readiness for doctoral research. Remote alternatives accommodated individual safety concerns for students and proctors. Alas, September 8 was also the day when smoke from the terrible Oregon wildfires rolled into the Willamette Valley. Air Quality Indices went off the scale and the campus closed for the duration. By now accustomed to unprecedented disruption, we rescheduled and our faculty have now evaluated student work from those exams.

Meanwhile, the essential mission of the mathematics department is remarkably unchanged. University enrollment is up. When the pandemic struck in March, we tackled the immediate problem of delivering winter term final exams online without proctors. Over spring break, the faculty executed what I call the "OSU Miracle" by transforming the entire university curriculum to a remote format in less than ten days! It didn't all go perfectly, but the fact that the students are here again (or taking classes while remaining elsewhere!) means that OSU continues to deliver high educational value. I am extremely proud of our staff, faculty and graduate teaching assistants for their professionalism and dedication.

When we look back on these times, I hope that all will pale in comparison to the overdue social reckoning that is occurring in the wake of the killing of George Floyd and other Black Americans. The disabling impacts of systemic racism on our nation, our institutions and on each of us individually are unavoidably obvious. The Department of Mathematics will support the College of Science's commitment to diversity, equity, justice and inclusion by doing all we can to ensure that education and research in mathematics at OSU are truly for all people, especially including those who have not been fully included or supported before.

Please visit the department web page for future (or upcoming) event details and for news about the activities and accomplishments of our students, faculty and staff.

Wishing you health, safety and prosperity,

At the helm

ADVANCING MATHEMATICS THROUGH LEADERSHIP

Brady Bowen and Vrushali Bokil in France

Welcome new faculty and staff!

The year 2019-2020 was an extremely productive year in the hiring of new faculty and staff.

Nikki Sullivan has been a welcome addition to the mathematics department as our graduate coordinator, helping with submitting nominations for scholarships, fellowships and travel awards to both the College of Science and the Graduate School.

We welcomed six instructional faculty in fall 2019.

Johnner Barrett received his Ph.D. in mathematics from OSU in June 2014 (advisor Tevian Dray). Before coming to OSU, Barrett taught for four years at Willamette University where he was awarded the Mortarboard Professor of the Year in 2006. He strives for an atmosphere of free participation where everyone's approach is given attention without risk.

Michael Gilliam earned a Ph.D. from the University of Montana at Missoula in 2011. Gilliam spent seven years as an assistant professor of mathematics at The College of New Rochelle, NY. In 2017, he was one of 23 recipients of the Outstanding Educator Award from

Education Update from the New York City region. As an instructor, his current interests are college-prep transition programs and active learning practices.

Amanda Blaisdell earned her master's degree from OSU in 2019. She hopes to create equitable and active classrooms, and would like to develop curricula with a focus on equity. She especially likes to highlight mathematicians who are not white men, finding that many students, especially women and students of color, have never thought that someone who looks like them could be really great at math.

Raven Dean earned her master's degree in mathematics from OSU in 2016 with a thesis related to active learning and the ALEKS placement test in college algebra. She says, "I want my students to interact with me, other students and the mathematics. I want to create a mathematical village where people feel comfortable learning and teaching math."

Nikki Sullivan   Johnner Barrett   Amanda Blaisdell   Raven Dean

Patrick Donaghue   **Stephen Krughoff**   **Patrik Nabelek**   **Kristen Vroom**   **David Wing**   **Holly Swisher**

Patrick Donaghue earned his master's degree from OSU and his bachelor's degree in mathematics from Cleveland State University. His thesis focused on current topics in the non-uniqueness of solutions in fluid dynamics.

Stephen Krughoff earned his Ph.D. in mathematics from OSU in 2019 (advisor Ren Guo). As an instructor, he enjoys the challenge of providing active learning experiences and individualized attention to large class sections.

We are pleased to welcome into our community two postdoctoral scholars and two tenure-track assistant professors.

Patrik Nabelek started as a postdoctoral scholar in fall 2020. He received a B.S. in mathematics from OSU, and an M.S. and Ph.D. in applied mathematics from the University of Arizona. Nabelek's research is on completely integrable systems, from solitons to spinning things. He has most recently been an instructor in the mathematics department at OSU.

Kristen Vroom also started as a postdoctoral scholar in fall 2020. Vroom earned a Ph.D. in mathematics education from Portland State University. Her research focus is supporting undergraduates in engaging in authentic proof activity. Vroom received the Shepard Freshman Resource Center teaching award as an instructor at Portland State University.

Axel Saenz Rodriguez and **Swati Patel** will start as assistant professors in fall 2021.

Achieving excellence in research & teaching

Yevgeniy Kovchegov published a book, "Path Coupling and Aggregate Path Coupling" with Peter T. Otto in the SpringerBriefs in Probability and Mathematical Statistics series. SpringerBriefs present concise summaries of cutting-edge research and practical applications across a wide spectrum of fields, and are published under the auspices of the Bernoulli Society for Mathematical Statistics and Probability. The book describes and characterizes an extension to the classical path coupling method applied to statistical mechanical models, referred to as aggregate path coupling. It was supported in part by a National Science Foundation (NSF) award.

Filix Maisch was promoted to Senior Instructor II of Mathematics. Maisch earned his doctorate in mathematics from the University of California, Santa Cruz. He loves to teach others about the beauty and elegance of mathematics. Maisch has been an instructor in the mathematics department since fall 2010.

Several faculty received awards during the 25th annual departmental awards, held virtually via Zoom on June 12, 2020. Due to the COVID-19 pandemic, the annual Lonseth Lecture was postponed to a later date.

Mary Beisiegel was recognized by graduate students with the Graduate Faculty Award. The Mathematics Student Success Award went to **Michael Gilliam**, who was nominated and selected by undergraduates to recognize inspirational teaching in lower division mathematics courses. The Mathematics Majors Award for Teaching, recognizing inspirational teaching in upper division courses, went to **David Wing**.

Mathematicians participate in inclusive excellence

The Inclusive Excellence@OSU program offered its first year of the inclusive excellence professional development training to STEM faculty at OSU, Linn Benton Community College and Lane Community College. The program consists of a weeklong academy followed by two meetings per term. **Holly Swisher** and **Wendy Aaron** attended the academy and developed projects to implement and study in their classes. Swisher emphasized the diversity of people working in number theory and highlighted their work in one of her graduate courses. Aaron focused her efforts on her work with undergraduate learning assistants.

National and global leadership to enhance mathematics

Mathematics faculty regularly organize and participate in regional, national

Addy De Chenne **Mary Beisiegel** **Elise Lockwood** **Filix Maisch** **Wendy Aaron** **Michael Gilliam**

and international conferences. Here we present some highlights.

Moving Toward Action, a workshop focused on understanding sexual harassment in mathematics and creating welcoming and inclusive work environments, was co-organized by **Vrushali Bokil** in partnership with the Association for Women in Mathematics. The January 2020 workshop took place in conjunction with the 2020 Joint Mathematics Meetings in Denver, Colorado. Funding was provided by the NSF award, "Improving Culture and Climate in the Mathematical Sciences: Moving Toward Action." Over 40 participants were provided with actionable information around best practices in policy implementation as well as training in creating action plans to help their respective departments.

Cascade RAIN 2020, the seventh annual Cascade Regional Applied Interdisciplinary and Numerical (RAIN) Mathematics Meeting was held April 4, 2020. Due to the COVID-19-related closure of campus, the meeting was held online via Zoom, making it the "first RAIN meeting in the Cloud." Since the first meeting, which was held in Corvallis in 2014, Cascade RAIN has grown to be an annual event bringing together researchers from across the Pacific Northwest for rapid and informal communication of ongoing research. There were nearly 60 participants attending, with 15 talks. The local organizers for this year's meeting were **Nathan Gibson, Blessing Emerenini** and **Tuan Pham**.

NUMS 2020, the 12th annual Northwest Undergraduate Mathematics Symposium, took place on April 18, 2020. NUMS is a regional mathematics conference providing a venue for undergraduate students in the Pacific Northwest to present mathematical research and projects. Originally scheduled to occur in person at Seattle Pacific University, this became a completely virtual event hosted by OSU faculty member **Nathan Gibson**.

Gibson and **Malgorzata Peszynska** each organized sessions and gave talks at The Mathematics of Finite Elements and Applications Conference at Brunel University in England in June 2019. Peszynska and Bokil each gave invited talks at the International Congress on Industrial and Applied Mathematics in Spain in July 2019.

Research awards to accelerate innovations

Nathan Gibson and **Vrushali Bokil** were awarded $225K from NSF's Computational Mathematics program for the project "Computational and Multi-Scale Methods for Nonlinear Electromagnetic Models in Plasmas and Nanocomposites." This project will involve mathematical modeling, computational simulation and experimental data for accelerating the design of advanced electromagnetic nanocomposite materials as well as magnetohydrodynamic power generators.

Bokil received a $12K College of Science Research and Innovation Seed

award to use stochastic modeling techniques and optimal control theory to understand the spread and control of plant diseases caused by coinfecting viruses.

Mary Beisiegel was awarded funding from NSF for two projects. A first project entitled "Collaborative Research: Mathematics Graduate Teaching Assistant Professional Development Focused on Implementation of Evidence-based Teaching Practices," was awarded $2.1 million, with OSU's portion $855K, over five years. This project aims to prepare mathematics graduate teaching assistants to implement teaching practices designed to improve the success of students in undergraduate mathematics courses.

A second three-year project for $124K (OSU portion) was awarded for "Collaborative Research: Algebra Instruction at Community Colleges: Validating Measures of Quality Instruction." This STEM Learning and Learning Environments project seeks to advance understanding of algebra education at community colleges.

International collaboration by advisor-student teams

Elise Lockwood and Ph.D. student **Addy De Chenne** traveled to Oslo, Norway in September 2019. Lockwood worked as a Fulbright Scholar on a project called "Investigating the Role of Computing in Undergraduate Students' Learning

of Mathematical Concepts," in which she collaborated with colleagues Knut Mørken and Tor Ole Odden at the University of Oslo. Addy visited for several days and gave a seminar talk. Lockwood also visited universities in Tromsø and Trondheim, and gave a colloquium talk to the mathematics department at the Norwegian University of Science and Technology.

Vrushali Bokil and Ph.D. student **Brady Bowen** visited Rennes, France in August 2019 with funding from Bokil's project, "Mathematical epidemiology of viruses coinfecting plants: Modeling, Analysis and Optimal Control Strategies," provided by the French American Cultural Exchange Foundation's Thomas Jefferson Fund. Brady and Bokil visited co-investigator Frederic Hamlin at Agrocampus Ouest in Rennes for two weeks. While in Rennes, they also participated in and gave talks at the International Conference on Stochastic Models for Biology.

Problem-solving in the midst of a pandemic

The mathematics department's Teaching & Tech Team (T3), consisting of instructors **Wendy Aaron, Johnner Barrett, Michael Gilliam, Dan Rockwell** and associate professor **Mary Beisiegel**, was created to support faculty and graduate students as they transitioned to remote instruction during spring 2020 due to the COVID-19 pandemic. T3 began with an objective of creating guidelines and examples to provide the department with everything needed to operate smoothly in a remote setting. T3 developed instructional materials concerning the use of technology in mathematics courses.

Student success was specifically addressed by constructing a virtual Mathematics and Statistics Learning Center (MSLC). Drawing on the experiences of OSU physics instructor KC Walsh, T3 formulated a vision for tutoring remotely. T3 then enlisted graduate students and faculty to test its vision and thus, the virtual MSLC was born. Even better is the fact that Ecampus students have access, too. Thanks to the efforts of exceptional undergraduates, graduate students and faculty, the virtual Learning Center is a hive of activity and promises to continue indefinitely.

RETIREMENTS

A fond farewell to Ralph Showalter and David Finch

Ralph Showalter joined OSU in the fall of 2003 and served as department chair from 2004-2007. Previously he held the Blumberg Centennial Professorship in Mathematics at the University of Texas at Austin. He was also a visiting professor at Brown University, Virginia Tech, Purdue University and the University of Augsburg, Germany. Since receiving his Ph.D. in mathematics at the University of Illinois as an NSF Graduate Fellow in 1968, Ralph has authored and co-authored over 100 research journal articles and three research monographs, and supervised 20 Ph.D. dissertations. His research interests include singular or degenerate nonlinear evolution equations and partial differential equations, related variational inequalities and free-boundary problems. His current work is on the analysis of multi-scale models of coupled fluid-solid dynamics, flow in deformable porous media and hysteresis.

David Finch arrived at OSU in September 1977, just a few weeks after defending his Ph.D. at MIT. Finch's doctoral work was on applications of singularity theory in analysis, but once at OSU he became excited by the work presented by Kennan Smith and Don Solmon in their tomography seminar, and before long he joined the tomography research group. During his career, he held visiting positions at Tufts University, the Institute for Mathematics and its Applications, the Mathematical Sciences Research Institute, Flinders University of South Australia, and UMass Lowell. During his time as graduate chair, he was among the leaders of the move to join the Math Alliance to help build a diverse graduate student body.

Thinkers & Doers

Alumni win nation's top graduate research award

Two OSU mathematics alumni are among the 2,076 graduate students nationwide to receive the NSF Graduate Research Fellowship Program award. **Patrick Flynn** (B.S. Mathematics & Physics '18), a Ph.D. student in applied mathematics at Brown University and **Gregory Mirek Brandt** (B.S. Mathematics & Physics '18), a Ph.D. student in astrophysics at the University of California Santa Barbara, have won the five-year fellowship, which carries a $34,000 annual stipend for three years and partial tuition. Gregory won the prestigious Goldwater Scholarship as an undergraduate student. Patrick won several awards in the mathematics department for outstanding academic performance.

Serious mathematics springs from Conway's Game of Life

Princeton mathematician John Horton Conway, who died from COVID-19 in April, was our Lonseth speaker in 1992. Conway is famous as the inventor of the Game of Life, among many other things. An international community of Life experts continue to discover new phenomena within the game. Graduate student **Matthias Merzenich**, who lives with his family on a multi-generation tree farm near Brownsville, Oregon, is one of the best-known and most prolific experts in

Life in the world (See **conwaylife.com/wiki/Matthias_Merzenich**). Matthias, for example, discovered the "lobster" pattern, which illustrates a periodic configuration that was previously unknown. The "lobster" was voted Pattern of the Year in 2011, a prize shared with one other.

Matthias defended his Ph.D. in mathematics in June 2020 (advisor Bill Bogley). In his research, Matthias used his experience from the Game of Life to make new discoveries in group theory. Using sophisticated open-ended search algorithms, he was able to construct complex new combinatorial objects called spherical pictures. In his thesis, Matthias applies these constructions to solve a number of knotty problems in group theory that have been actively studied by many people since the early 1990s.

From energy fellowship to a job at Amazon

Megan Lynn Tucker, a double major in mathematics and writing, graduated in spring 2020. A valedictorian, Megan has maintained a very impressive GPA and was elected to the Phi Beta Kappa Honor Society. Megan will move to Seattle to work as a technical writer with Amazon Web Services — a subsidiary of Amazon providing on-demand cloud computing platforms to individuals, companies and governments.

Megan was awarded the Department of Energy's Mickey Leland Energy

Megan Lynn Tucker

Fellowship to work with an interdisciplinary team at the National Energy Technology Laboratory (NETL) in Albany, Oregon, during the summer of 2019. Megan's 10-week internship took her to NETL's Geospatial Analysis, Interpretation and Assessment Computational Facility to perform geospatial data analysis and statistics related to carbon storage modeling. She presented her research at a Department of Energy conference in Pittsburgh in August 2019.

Congratulations to our mathematical biology graduates!

Michael Kupperman graduated in spring 2020 with honors degrees in mathematics and biochemistry and minors in chemistry and history. Michael was also an Accelerated Master's Platform student in mathematics and completed his honors thesis in math in his junior year. He has joined the Ph.D. program at the University of Washington in the Department of Applied Mathematics. **Aoﬁe Burke** graduated fall 2019, and started as Amazon Area Manager in Salem, Oregon, in January 2020. **Rachel Sousa** has joined the Ph.D. program in Mathematical, Computational and Systems Biology at the University of California, Irvine, with full funding. Sousa, who also holds a minor in computer science, was a research assistant in the OSU chemical engineering lab of Cory Simon.

Announcing the Ramanujan-Hardy Fellowship in Pure and Applied Math

Late last year anonymous donors made a gift to create the first graduate fellowship in the mathematics department that provides full funding to a student. The Ramanujan-Hardy Fellowship in Pure and Applied Mathematics at OSU was established to help recruit and retain post-baccalaureate and graduate students from communities that are historically underrepresented in higher education, while also providing support for faculty research mentorship.

The goals of the fellowship align closely with those of organizations such as the National Alliance for Doctoral Studies in the Mathematical Sciences (aka Math Alliance) and the National Association of Mathematicians (**nam.math.org**), promoting excellence in mathematics while attracting new students from communities that may not otherwise consider careers in mathematics.

"As we considered ways in which we could 'give back,' we seized on the support of highly motivated students from underrepresented groups who seek to pursue a Ph.D. in mathematics as a way to support diversity and to enrich the mathematical research community. Coupling the financial assistance with the value added by a research active
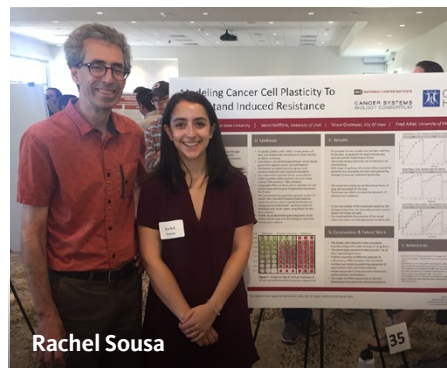

Rachel Sousa

faculty mentor seemed a natural pairing with OSU resources that we hope will be captured by the fellowship title," the donors said.

"Perhaps in these challenging times it is noteworthy that the First World War began on July 28, 1914, three and a half months after Ramanujan arrived in England. In spite of the overwhelming impact that ensued, G.H. Hardy was steadfast in his continued support of Ramanujan's efforts to complete his Ph.D. thesis at Cambridge University. We regret the very real hardships on students and faculty presented in 2020, but we hold great hope that our efforts will prove helpful," the donors added.

Kathryn Price

The inaugural recipient of the Ramanujan-Hardy Fellowship is **Kathryn Price**, a 2020 graduate of University of Alaska Southeast (UAS) in Juneau, Alaska. Kathryn entered UAS in 2017 as a major in Alaska Native Languages and Studies. She switched to mathematics almost immediately after enrolling in her first college level mathematics course that fall, while maintaining continuing interest in promoting the study of Sm'algyax, the language of the Tsimshian people indigenous to Southeast Alaska and coastal British Columbia. Kathryn received the Ron Seater Award as the outstanding mathematics major at UAS in 2018. She is also a drummer in the Yees.Ku.Oo multicultural dance group.

Is a donut the same as a coffee cup? To get an answer in the affirmative, ask a topologist. Specifically ask Professor Christine Escher, whose supporting role for students and faculty interested in topological data analysis (TDA) is leading the mathematics department at Oregon State University into new frontiers of research in an area collectively called data science.

Topology is the study of those properties of objects that are not affected by continuous deformations. For example, properties such as stretching, bending and twisting, but not tearing. TDA is an emerging area in applied mathematics that combines elements of applied topology and computational geometry to analyze large data sets. It has been very successful in discovering structures and patterns in many large, complex and possibly noisy data sets by designing algorithms that exploit geometric and domain specific information about the "shape" of data. One of the key messages in TDA is that data has shape and that shape matters. For example, all positions of a robotic arm with two pivots can be thought of as points lying on the two-dimensional torus, i.e., the surface of a donut. A second example comes from a network of cell towers; how does one know if there is a gap in coverage? Studying the graph associated with the network and its geometric properties, so-called topological invariants, using algebraic topology (specifically homology theory), can detect such features.

Training the quantitative workforce

With demands for quantitative data scientists projected to grow fast, the science and art of mining and distilling useful information from vast datasets has never been in greater demand. The value of studying data and providing new and innovative tools to study data is fairly clear: total internet traffic currently averages 88 terabits per second and is projected to grow 26% annually (Source: CISCO). The College of Science at Oregon State has, as part of its vision, a collaborative enterprise to thrive in

Christine Escher

Underst
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a data-rich world. This is a chance for mathematics at OSU to get into an exciting hybrid field that has the potential to bridge with several other areas, such as biology, including human health, tele-communications and geographic information systems, among others. Jobs in data science are projected to grow 11% every year until 2026, faster than most other jobs (Bureau of Labor Statistics). Research growth and hires in TDA will train students and bring such jobs to Oregon.

Creating a data science ecosystem

Escher, whose research is in algebraic topology and differential geometry, is currently running a seminar on TDA with active engagement from mathematics faculty, graduate students and undergraduate students, as well as faculty and graduate students from computer science and engineering. Escher has reached out to experts in TDA both locally and nationally. One of the leading experts, Gunnar Carlsson of Stanford University (co-founder of the company Ayasdi), was scheduled to give the department's annual Lonseth Lecture during the spring term of 2020 (now postponed due to the COVID-19 pandemic). Escher also has been in regular discussions with Bala Krishnamoorthy (VP of AI & Optimization at Cognetry Labs, Inc.)

of Washington State University as well as Chad Giusti of the University of Delaware.

Escher's work in the area has broadened graduate education in the department, giving our students exposure to new ways of understanding complex datasets and an opportunity to work at the frontiers of mathematics, data science and engineering.

In collaboration with Giusti, Escher will co-advise graduate student **Chung-Ping Lai** who is writing an expository master's paper in TDA on the topic of discrete Morse theory and persistent homology, and will continue with his Ph.D. in TDA. **Danial Wentland** completed his master's thesis in TDA during spring 2020, entitled "Instability of Mapper Type Algorithms," and **Branwen Purdy** finished her master's in TDA in May 2018, with a thesis on "Topological Data Analysis and Sensor Coverage Problems." Finally, **Zheting Dong** completed his Ph.D. in 2019 in differential geometry but regularly participated in the TDA seminar. He is now employed as a researcher at Huawei in Hong Kong where he works with a team of mathematicians and engineers on topological and geometric tools in data analysis such as manifold learning.

During winter 2020 term several graduate students attended the "Data Science and Image Analysis Conference of the Pacific Northwest," in Pullman, WA. Three of our students gave talks at the conference.

The TDA seminar will continue throughout the 2020-2021 academic year to continue to help faculty and students learn about this fascinating subject, bring in outside speakers and build connections with other units on campus.

Elaine Swanson in Nepal

Delivering impact

STUDENTS MAKE THEIR MARK IN MATHEMATICS

Undergraduate research spans machine learning and mathematical biology

Two mathematics majors were awarded funding from the Office of Undergraduate Education through its Undergraduate Research, Scholarship and the Arts (URSA) Engage program, and one other was awarded a Summer Undergraduate Research Experience (SURE) award, which pays a stipend of $5000 for 11 weeks of full-time research. Math faculty advised students from other majors on funded projects as well.

Edward Kingston is a mathematics major with a statistics option minoring in music, statistics and actuarial science. Working with mathematics instructor Hoe Woon Kim, Edward studied the Navier-Stokes equations

during winter 2020 term. Since November 2019, **King Hin Chan** has worked with Patrick Donnelly from OSU-Cascades on using machine learning methods to predict the valence and arousal values for music excerpts.

Saki Nakai received a SURE award to support her summer research on mathematical modeling of psychological disorders, with a particular focus on bipolar disorder. Saki is an Honors scholar double major in mathematics (with an option in mathematical biology) and psychology and minoring in French and music performance. Saki was advised by Vrushali Bokil on her research.

Math faculty **Hoe Woon Kim** and **Tuan Pham** mentored students from other majors. **Alan Schultz**, a physics

major advised by Kim, studied the linearized Navier Stokes' equations on the unit sphere for his SURE fellowship. SURE scholar **Hunter Nelson**, a physics major and math minor, worked with Pham, on the blow-up of reaction diffusion equations.

Going places with summer research

The 2019 OSU Research Experiences for Undergraduates (REU) Program in Mathematics and Theoretical Computer Science directed by **Holly Swisher**, trained 10 students from a variety of institutions across the country, including OSU's own **Justin Bloom**. There were four research groups, led by OSU faculty members **Blessing Emerenini** (mathematical biology), **Clay Petsche** (arithmetic dynamics),

Swisher (partitions and modular forms) and Mike Rosulek in computer science (secure computation). Two of the REU students from the 2019 cohort have won NSF Graduate Fellowships. The 2020 REU program ran virtually with faculty mentors Petsche, Emerenini and **Juan Restrepo**.

OSU math students also participated in external research opportunities. In winter 2020, undergraduate student **Kendra Beers** completed a research internship at Galois, Inc. in Portland. Kendra worked on two government-funded mathematical modeling projects. Kendra also joined in on the huge DARPA (Defense Advanced Research Projects Agency) effort to collect as many models for COVID-19 as possible.

Post-baccalaureate student **Elaine Swanson** attended the CIMPA Summer School in Mathematical Biology in Kathmandu, Nepal and the Second International Conference on Applications of Mathematics to Nonlinear Sciences in Pokhara, Nepal, in June 2019. Elaine

completed a poster presentation with an international student team on modeling competition between honeybees and their impact on Nepalese flora biodiversity.

In summer 2020, **Josie O'Harrow**, a computer science and mathematics dual major with a minor in physics, participated in the selective Distributed Research Experiences for Undergraduates program, doing graph theory research remotely with Theresa Migler from Cal Poly, San Luis Obispo.

Welcoming a new graduate cohort

The department welcomed a new graduate cohort in 2019-2020. Our incoming class represents six states: Minnesota, Florida, Alabama, Kentucky, California and Washington, and includes four international students and one exchange student from France. **Emily Hoard** received a Provost Scholarship, and **Diane McMillan** received a Ford Foundation Scholarship. Two Accelerated Master's

Platform students now are officially in the graduate program: **Jeremy Lilly** and **Noah Langlie**.

Research talks and summer experiences enrich graduate training

Three mathematics graduate students received Graduate School Travel Awards to support their conference travel.

Alireza Hosseinkhan

Dallas Foster presented his research at the 2019 American Geophysical Union's Fall Meeting. Working in collaboration with scientists at Los Alamos National Laboratory in New Mexico, Dallas's research aims to improve the predictability of sea surface temperature anomalies — an important climate indicator that is used to measure climate change as well as stochastic climate cycles like El Niño and La Niña.

Alireza Hosseinkhan attended the 2020 Society for Industrial and Applied Mathematics (SIAM) Conference on Analysis of Partial Differential Equations in La Quinta, California, and presented a poster, "Biot-Pressure System with Unilateral Displacement Constraints."

Lisa Bigler attended the (virtual) SIAM Conference on Mathematics of Planet Earth, August 3-14, 2020, in Garden Grove, California. Bigler, the vice president of the SIAM student chapter at OSU gave a virtual talk at the conference.

REU 2019 at OSU

Other students received external funding to support their travel to conferences and summer schools.

Worapan Homsomboon, Slade Sanderson and **Mesa Walker** were participants at the Riemann Surfaces and Their Moduli Spaces conference held at the University of Utah in Salt Lake City, February 7-9, 2020 with financial support provided by NSF.

Arthur Mills, a second-year graduate student, received funding to attend the Graduate Student Topology and Geometry Conference in April 2020 at Indiana University in Bloomington, Indiana. This conference was unfortunately canceled due to COVID-19.

Graduate students **Naren Vohra, Martijn Oostrom**, and **Hannah Barta** were all selected to attend the NSF-funded Graduate Summer School programs at the Mathematical Sciences Research Institute in Berkeley, California, during summer 2020. Naren and Martijn enrolled

Choah Shin

in a program on "Random Graphs" which has been postponed due to the COVID-19 pandemic. Hannah enrolled in "Introduction to Water Waves," and was able to participate online via Zoom and Slack.

2019 New Graduate Students

Choah Shin was accepted to present a poster (with travel support) at the Gordon Research Conference and Seminar in Galveston, Texas, in February 2020. She also gave an invited presentation at an American Physical Society conference in Seattle in November 2019.

A large group of mathematics graduate students including **Chung-Ping Lai, Arthur Mills, Danial Wentland, Wei Xi Boo, Nachuan Zhang, Zachary Gregg** and **Johannes Krotz** attended the "Data Science and Image Analysis Conference of the Pacific Northwest" in Pullman, Washington, in February and March 2020. Chung-Ping, Arthur and Danial gave talks and all were awarded travel funding.

Wasamon Jantai attended the Houston Summer School on Dynamical Systems in summer 2019 with funding from NSF.

Allison Arnold-Roksandich gave a talk at the conference "Analytic and Combinatorial Number Theory: The Legacy of Ramanujan," at the

University of Illinois at Urbana-Champaign in June 2019, with travel funding from NSF, the National Security Agency and the University of Illinois Department of Mathematics.

Several mathematics graduate students received funding to perform research in summer internships at national labs.

Choah Shin was a 2019 summer research intern funded by the NSF Mathematical Sciences Graduate Internship Program at the National Renewable Energy Laboratory, Golden, Colorado.

Greg Detweiler completed a summer internship at NASA Ames Research Center in Mountain View, California in 2019 with funding from Stinger Ghaffarian Technologies.

Lisa Bigler completed a summer internship at Lawrence Berkeley National Laboratory, Computational Research Division in 2019.

Evan Rajbhandari was supported by an Oak Ridge Institute of Science and

Education fellowship to complete a summer internship at National Energy Technology Laboratory in Albany, Oregon in 2019. Due to the successful collaboration, Evan was additionally awarded a 24-month fellowship starting summer 2020.

Sebastián Naranjo Alvarez was supported by Department of Energy funding for a summer internship at Los Alamos National Laboratory during summer 2020.

Oregon State faculty and students showed strong presence in numbers and in quality of research presentations in thematic sessions and posters at the Second Biennial Meeting of SIAM Pacific Northwest Section held at Seattle University in October 2019.

The conference was attended by current and former OSU mathematics students and faculty: **Naren Vohra, Nachuan Zhang, Sooie-Hoe Loke, Tuan Pham, JJ Zeng, Ralph Showalter, Choah Shin, Yi Zhang, Lisa Bigler, Malgo Peszynska, Patrik Nabelek, Evan Rajbhandari, Dallas Foster, Blaec Bejarano, Radu Dascaliuc, Alireza Hosseinkhan, Robert Higdon, Thomas Humphries, Adel Faridani** and **Enrique Thomann**.

Sebastián Naranjo Alvarez
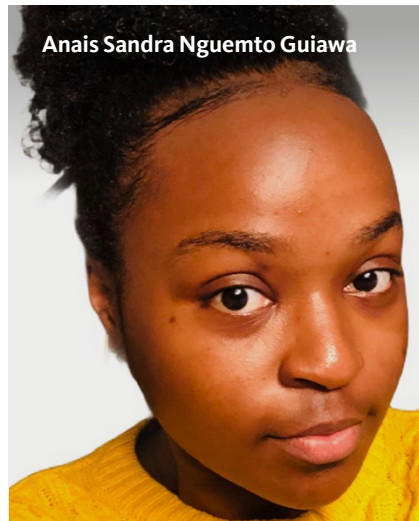
Anais Sandra Nguemto Guiawa

Achieving academic and teaching excellence

Anais Sandra Nguemto Guiawa was awarded the Graduate Student Award for Excellence in Qualifying Exams. Anais is originally from Cameroon and earned a B.S. in Mathematics and Computer Sciences from the University of Buea in Cameroon in 2014. After obtaining a Master of Science degree in applied mathematics from Columbia University, New York, in 2016, Anais worked as a financial analyst at BMW headquarters in Woodcliff Lake, New Jersey. Anais is currently a third year Ph.D. candidate in the mathematics department, pursuing a minor in statistics and a research focus on using machine learning on data assimilation problems.

Sarah Hagen published "Active Learning and the Transformation of a Graduate Student Instructor" in the American Mathematical Society blog "On Teaching and Learning Mathematics" (See **blogs.ams. org/ matheducation**). The article is about her own transformation from a lecturer to a facilitator of active student learning in the classroom and her insights about it, in the context of teaching the OSU math boot camp for incoming graduate students. Sarah joined Western Oregon University as a visiting assistant professor in fall 2020.

LONSETH AWARDS, 2020

Joel Davis Award for Excellence in Mathematics
Rachel Sousa
Elijah Winkleman
Botond Gabor Eross Math Memorial Scholarship
Diego Bergareche Solana
Tanner Fromcke
Josie O'Harrow
Edward H. Stockwell Award
Benjamin Bauml
A.J. Rise
Evan Tufte
Mattia Carbonaro
Actuarial Science Award
James J. Hansen
Alexander Putnam
Gary L. Musser Award
Katherine Leah Thomsen
WIC Culture of Writing Award
Richard Puro
Oregon Lottery Graduate Scholarship
Choah Shin
William Lowell Putnam Mathematics Competition
Kevin Sunderland
William Dettmer
Jackson Wiley
William F. Burger Graduate Teaching Award
Bruno Barbosa
Graduate Student Excellence Award
Dallas Foster
Choah Shin
Graduate Student Outstanding Performance in Coursework Award
Danial Wentland
Wasamon Jantai
Evan Rajbhandari
Alireza Hosseinkhan
Graduate Student Award for Excellence in Qualifying Exams
Anais Sandra Nguemto Guiawa
Graduate Student Achievement Award
Sarah Erickson
Sebastián Naranjo Alvarez

Alumna's COVID-19 modeling aids public health initiatives

Carrie Manore

The ongoing COVID-19 pandemic has placed mathematical models in the spotlight as they have become central to public health interventions, planning, resource allocation and forecasts. OSU mathematics alumni have made important contributions to COVID-19 modeling and research at both national and regional levels.

Alumna **Carrie Manore** (Ph.D. '11), a mathematical epidemiologist in the Information Systems and Modeling Group at Los Alamos National Laboratory (LANL) since 2013, is currently working with the LANL COVID-19 modeling team. Her work focuses on modeling mosquito-borne diseases such as Zika, chikungunya, dengue and West Nile virus. The LANL COVID-19 forecast is part of the modeling that the New Mexico Department of Health officials have been using since April to tackle COVID-19.

The Los Alamos COVID-19 model is also among the forecasts the Centers for Disease Control and Prevention (CDC) has used throughout the pandemic to create health guidelines. It is a part of the CDC's ensemble forecasts to understand the impact of the virus. An ensemble forecast combines models from multiple teams and organizations into one aggregate forecast to get a reliable estimate of total COVID-19 infections and deaths over the next four weeks.

A compilation of LANL and other New Mexico-based models of the SARS-CoV-2 virus's transmission patterns have proven to be successful in helping New Mexico contain the spread of COVID-19. In an article in September, Scientific American reported that, "New Mexico's models and its system for collecting and tracking data allow its policy makers to make forward-looking, evidence-based decisions." The scientific expertise and contagion forecasts of LANL epidemiologists like Manore have played an important

role in shaping the state's fight against the coronavirus. Manore's work has received mention in New Mexico media, as well as the New York Times.

Mapping epidemics from Zika to COVID-19

Manore was modeling the spread of infectious diseases like Zika and West Nile virus at the beginning of 2020 when news about the novel coronavirus in China got the team's attention. Manore's modeling team started working on the COVID-19 outbreak in late January and their efforts intensified in mid-March when the infection started surging globally and within the U.S. Her work on forecasting models is primarily based on data, predicting what will happen given current trends of positive cases and deaths. The national and global COVID-19 models by the team are made publicly available every Monday and Thursday to project case counts for every state in the U.S. as well as every country that has more than 100 cases.

As a mathematical epidemiologist, Manore helps ensure the model accurately captures the transmission dynamics of COVID-19 to forecast the national and global spread of the disease. Manore and her team have adapted a probabilistic artificial intelligence computer model for COVID-19 developed by a Los Alamos statistician, which garnered national recognition when it won the CDC's flu forecasting challenge in 2019, beating 23 other teams.

"We needed to revise and adapt this model for COVID-19 forecasting because we have 20 years of flu data but only a few months of data for COVID-19," said Manore. The Los Alamos model offers distinct advantages and stands out among other models because "it is truly data driven," Manore observed. "Quite a few of the other models have a lot of assumptions about how people may behave and their possible decisions. Our model is just really driven by the data on cases and deaths. In particular, that gives more accurate short-term forecasts than some of the other models."

In response to the reopening of businesses as well as many schools, Manore's team has also moved forward simultaneously with other models and simulations that account for asymptomatic people, changes in people's behavior and the consequences of relaxing restrictions.

Manore got her start in disease modeling in the mathematics department at OSU, which she joined in 2006 after studying mathematics at Whitworth University and Eastern Washington University. At OSU, she was an NSF IGERT (Integrative Graduate Education and Research Traineeship Program) Fellow in Ecosystem Informatics and worked at the intersection of mathematics, biology, geosciences and computer science. Manore was advised by Vrushali Bokil and completed her dissertation on population dynamics and epidemiology.

"I got a really strong background in math at OSU, which not only helped me acquire mathematical skills, but also a way of thinking," Manore said. "The IGERT program was truly interdisciplinary as it involved working collaboratively with academics from different disciplines, and I found that extremely useful in my training as a mathematical epidemiologist. It prepared me to work on real problems in the world like I am doing now."

SUPPORTING COMMUNITY HEALTH

Peter Banwarth (M.S. '12, Advisor: Tom Dick) is an epidemiologist and public health data scientist with the Benton County Health Department in Oregon. He has developed models to guide county health policies on testing as well as safety and health measures for employees and the public to minimize infections and deaths in Corvallis and nearby areas. To keep the public informed about COVID-19 models and public health initiatives, Banwarth has presented his work with Oregon health departments for audiences at OSU and the Corvallis City Council. Banwarth's modeling suggests that the restrictions Benton County implemented during the shutdown phase have been successful in reducing the spread of the virus. Prior to joining the mathematics graduate program at OSU, Banwarth received an undergraduate degree in economics and a master's degree in statistics from Stanford University.

Out there

DIVERSITY, OUTREACH, NEWS AND EVENTS

Calculus, the Musical hosted by the OSU Math Club

Mathematics faculty and graduate and undergraduate students are involved in extensive outreach and efforts to promote diversity and inclusion. We highlight some of our significant activities in 2019-20.

College of Science Inclusive Excellence Award

Vrushali Bokil with Dean Roy Haggerty

Vrushali Bokil received the inaugural Inclusive Excellence Award at the College of Science Fall Awards Ceremony on November 21, 2019. Bokil has participated extensively in the Oregon State ADVANCE program, which seeks to create an equitable and socially just academic climate in the University. She was an ADVANCE Faculty Fellow in 2018. Bokil was recognized for "meeting head-on the challenges of putting words into actions to advance Equity, Justice and Inclusion at OSU." This includes Bokil's ADVANCE Seminar action plan to embed a systems of oppression perspective in a graduate math seminar and organizing a workshop for faculty from all College of Science departments to assist them with equity, diversity and inclusion in their own units.

Creative access to math through Calculus, the Musical

On January 24, 2020, the OSU Math Club hosted Calculus, the Musical. The musical tells the story of Ada, a modern math student who joins forces with Sir Isaac Newton to learn more about the history and development of calculus. Musical parodies that span genres illuminated concepts of limits, integration and differentiation. Over two hundred people attended the night of comedy, music and math, making the ambitious project a great success. The Math Club's production of Calculus, The Musical was recognized at OSU as the "Large Scale Event of the Year."

Building a diverse and inclusive community in the mathematical sciences

The Math Alliance is a national organization whose goal is for every underrepresented or underserved American student with talent and ambition to have the opportunity to earn a doctoral degree in the mathematical sciences through mentorship by a mathematics faculty member.

After being a mentor for several years, Professor Emerita **Mary Flahive** was asked in January 2019 to be one of eight faculty members who evaluated students for the Facilitated Graduate Applications Process (F-GAP) and then matched successful students with mentors. Since January 2020, Flahive has chaired the committee of ten evaluators, now called the Doctoral Faculty Council, and administers F-GAP with Phil Kutzko, the founder of the Math Alliance. Professors **Vrushali Bokil, Tom Dick, Adel Faridani, Malgorzata Peszynska** and Emeritus Professor **Ed Waymire** served as F-GAP mentors in 2019-2020. Waymire also helps with fundraising.

Improving the first-year student transition experience

In fall 2018, OSU launched a voluntary mentoring program called Beaver Connect to increase retention and graduation rates overall and reduce the opportunity gap for underrepresented minorities, first-generation and Pell-eligible students. The program focused on improving the student transition experience. In 2019-2020, mathematics faculty participating in the program included **Enrique Thomann, Dan Rockwell, Filix Maisch, Wendy Aaron, Tom Dick** and **Tom Schmidt**. Each faculty member was paired with one to three first-year students and one peer mentor, meeting about five times every term.

Addressing Systemic Oppression

Last December, President **Branwen Schaub** and Vice-President **Sarah Hagen** of the OSU student chapter of the Association for Women in Mathematics (AWM) went to the Coffee Creek Correctional Facility to conduct a workshop on mathematics and astronomy. Everyone was astounded to learn that it's possible to calculate the diameter and distance to the moon with nothing except a little geometry and knowledge of how solar eclipses work!

At the end of the school year, in response to the murder of George Floyd and protests around the U.S. calling for action against systemic racism,

Branwen
Schaub

AWM members came together and donated to the National Association of Mathematics (NAM). They also helped support the mathematics department in buying an institutional membership to NAM, whose two-fold mission is promoting excellence in the mathematical sciences and promoting the mathematical development of all underrepresented minorities.

Promoting mathematics to young minds

The AWM student chapter and Math Club participated in several OSU outreach events in which they enjoyed teaching kids about Mobius Bands, playing on infinite size Tic-Tac-Toe boards, and introducing them to mathematical analysis through the game "The Sword of Knowledge."

Discovery Days is a two-day event featured in spring and fall at Oregon State where elementary school students come to learn about science and engineering. Discovering the Scientist Within is an event hosted by OSU designed to introduce girls in middle school to the STEM (science, technology, engineering and mathematics) fields by providing a program of hands-on activities paired with women scientist role models.

Family Science and Engineering Nights occur at local elementary schools and provide another opportunity for clubs and student organizers to give back to their community. At a typical event, hundreds of young students and their families crowd their school's gym to make gel beads and slime, test rockets, ride a Segway and solve mathematical coloring puzzles. The Math Club volunteered at over twenty schools this year before the pandemic paused activities. Over 4,000 K-12 students got to participate in the math activities alone!

Math Club attends annual Women in Science Mixer

Rachel Sousa, Grace Strid and Michael Gilliam

On November 14, 2019, Math Club members **Rachel Sousa, Grace Strid** and club co-advisor and mathematics instructor **Michael Gilliam** attended the 6th Annual Women in Science Portland Mixer, held at the Oregon Museum of Science and Industry. With a mix of professionals and graduate students in science and medicine, the event was a great way to network with women in STEM. Both Rachel and Grace received valuable information about applying to graduate schools.

Celebrating International Women in Mathematics Day

On May 11, 2020, the AWM student chapter hosted a colloquium for the mathematics department, in honor of International Women in Mathematics Day and the birthday of Maryam Mirzakhani, who became the first woman mathematician to win a Fields Medal in 2014. OSU math professor **David Pengelley** gave a Zoom talk on nineteenth-century French mathematician Sophie Germain and her grand plan to prove Fermat's Last Theorem. David also revealed a surprising connection between Sophie Germain, Maryam Mirzakhani and International Women's Day! The link to enjoy his colloquium talk can be found at **tinyurl.com/sophiegermainosu**.

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