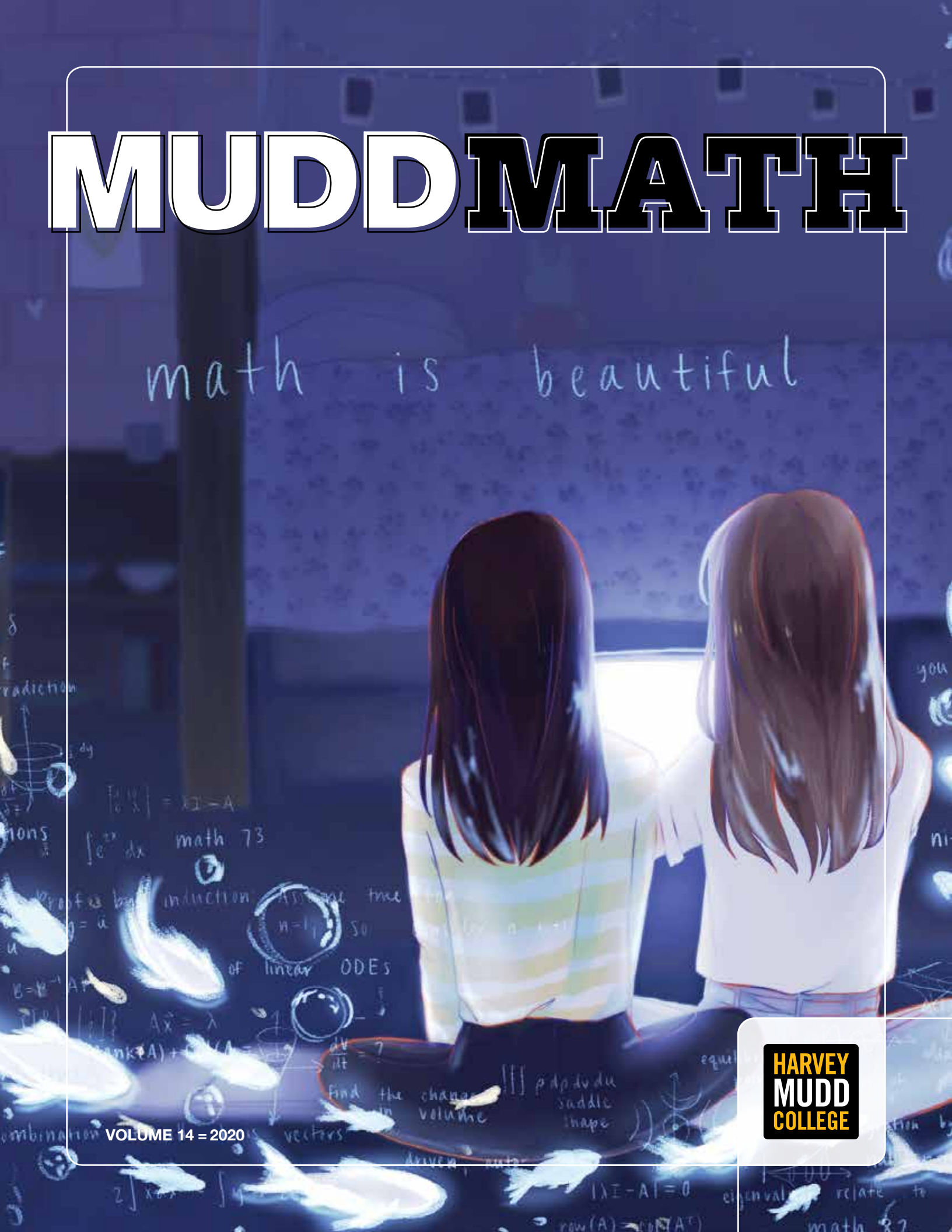
MUDDMATH



VOLUME 14 = 2020

HARVEY MUDD COLLEGE

Letter From the Chair

Dear Math Alumni, Families and Friends,

I write at a time when the COVID-19 pandemic has upended our world, our beloved campus is nearly empty, and we meet each other mostly over Zoom. Had I written this letter in February, I would have been downright jubilant about the incredible year our department was having. At the top of my excitement would be the fact that we hired three amazing new colleagues to join our department as assistant professors: Jamie Haddock (mathematical data science), Haydee Lindo (commutative algebra) and Heather Zinn-Brooks (nonlinear systems). One of these positions, at long last, is a growth position to enhance our course offerings and departmental vision for mathematical data science. The other two positions fill a vacancy left by Rachel Levy (who became deputy executive director of the Mathematical Association of America in 2018) and a pending vacancy due to Nick Pippenger's retirement at the end of the 2020-2021 academic year. We are thrilled to welcome these mathematicians to our department; we already love working with them and know that our students will feel the same.

For the 2020-2021 academic year, we also welcome current postdoc Jasper Weinburd and mathematical biologist Leif Zinn-Brooks to the teaching faculty as visiting professors. We thank visiting professors Jessalyn Bolkema and Yesim Demiroglu for their many contributions to our students and department last year and wish them all the best in their new positions at Cal State Dominguez Hills and Caltech, respectively. Finally, we were pleased to promote DruAnn Thomas to a full-time role in the department to support our Clinic and Thesis capstone programs.

It has been a significant year for department members to be recognized with national honors: Lisette de Pillis received the MAA's Southern California Teaching Award, Mohamed Omar was one of three mathematicians selected for the 2020 Inaugural Class of Karen EDGE Fellows, Francis Su was elected as a vice president for the American Mathematical Society, Talithia Williams received the Robert V. Hogg Award for Teaching Excellence and was selected as the MAA's Pólya Lecturer for 2020–2022 and Darryl Yong received the American Mathematical Society's Award for Impact on the Teaching and Learning of Mathematics. It is wonderful to see our colleagues being recognized for their teaching and scholarship through these richly deserved honors. Scholarly activity in the department remains high, with over 30 scholarly works accepted, published or submitted over the last year, many of which had student and/or alumni co-authors. Lastly, it was a notable year for student awards, with math majors Forest Kobayashi '20 and Savana Ammons '20 each receiving a National Science Foundation Graduate Fellowship offer and math major Aria Beaupre '21 receiving a Goldwater Scholarship.

It is both humbling and thrilling to work in a department with such amazing colleagues. As chair, my principal goal is to support our students, staff and faculty attain excellence in their teaching, learning and scholarship. Thanks to the generosity of several donors, including two gifts just last year to support research and community building, I am now fortunate to be able to say "yes!" to more of these requests, and for that I am very grateful. With such talented students and faculty we have many great ideas and activities to consider, and we appreciate your continued interest and support of our department.

Our beloved field of mathematics remains as important as ever for helping humanity model, analyze and respond to this global health crisis. When the Spring 2020 campus evacuation and transition to online learning occurred, many math faculty adjusted their courses, and in one case even created an entirely new course to introduce pandemic-related mathematics to help our students grapple with the barrage of information and data surrounding the novel coronavirus. Through social media and other outlets, we see many of our MuddMath alumni actively engaged in important scientific and community endeavors to help society respond to the pandemic. For this we thank you, and I extend my heartfelt wishes to you and yours for continued strength and fortitude as we care and support each other through these challenging times.

Jon Jacobsen
Kenneth and Diana Jonsson Professor
of Mathematics and Department Chair

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MuddMath is published by the Harvey Mudd College Department of Mathematics, 301 Platt Boulevard, Claremont, CA 91711.
math.hmc.edu

Jon Jacobsen and Francis Su, co-editors. Produced in cooperation with the Office of Communications and Marketing. Inquiries, suggestions, comments and updates are welcome and can be emailed to **jacobsen@g.hmc.edu**.

In 2006, the HMC Department of Mathematics received the very first Award for Exemplary Program by the American Mathematical Society.

Harvey Mudd College is a co-educational liberal arts college of engineering, science and mathematics that also places strong emphasis on humanities and the social sciences. The College's aim is to graduate engineers, scientists and mathematicians sensitive to the impact of their work on society.

About the Cover

Omega: A Love Letter to Mathematics

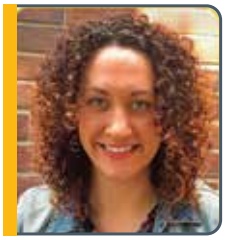
BY ZOOEY MEZNARICH '23

Math has been such an important part of my life. I grew up moving around the world, but math has been the constant that helped me to connect with those who are now my closest, most trusted friends. Core Math at HMC in particular represents how the Mudd Core really helped me make strong friendships, and that all started with the late nights I shared with my roommate. Even as we transitioned to a digital format and life's challenges arose, the wonder of discovery is what kept me engaged with those whom I love. To me, math is beautiful.

Submitted for Homework Omega, the last Core Math homework assignment, an open-ended creative project in which students summarize their Core Math experience.

New Faculty Q-and-A

We have several new faculty members we'd love for you to get to know, so we asked them five questions.

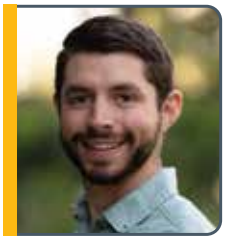


Jamie Haddock

Tenure-track assistant professor joining the department in July 2021

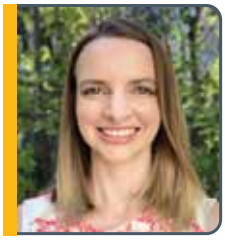
Haydee Lindo

Tenure-track assistant professor



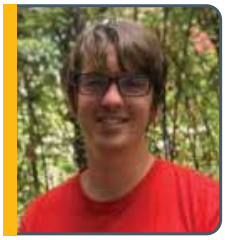
Jasper Weinburd

Postdoctoral scholar joining the teaching faculty this academic year



Heather Zinn-Brooks

Tenure-track assistant professor



Leif Zinn-Brooks

Visiting assistant professor

Briefly introduce yourself.

Jamie: I will be joining HMC after finishing the third year of a postdoctoral position at UCLA in computational and applied mathematics, but I am already enjoying becoming a Mudder! Broadly, my research is in the area of mathematical data science, which means I bring various mathematical tools to study problems dealing with (large and structured) data. Some of my recent research develops the relationship between popular topic modeling techniques and neural networks, leading to interpretable classification techniques that can be applied to data in which interpretability is key (e.g., medical data). I am additionally interested in curriculum and pedagogy development for data science, especially as it relates to the areas of algorithmic fairness and social justice. I am originally from northern Idaho, did my undergraduate degree at Gonzaga University in Washington, and have spent the last seven years in California (five years in Davis for my PhD and two years in the Los Angeles area).

Haydee: I'm from Jamaica, and before coming to Harvey Mudd, I was an assistant professor at Williams College. I'm a commutative algebraist, but I also have research interests in representation theory and homological algebra (and I'm always looking to learn more). I most enjoy the kinds of teaching where I can encourage students to be curious about math, to formulate then work on their own mathematical questions and thereby become mathematicians themselves. Outside of the normal class offerings, I'm hoping to bring more algebra to Harvey Mudd.

Jasper: I'm originally from upstate New York, but my last home was in Minneapolis, Minnesota, where I was a graduate student before coming to Mudd last fall. I research swarming and collective motion in locusts using mathematical modeling and dynamical systems. I'm excited to be teaching partial differential equations this fall and look forward to using the online format to implement a flipped-classroom model!

Heather: I was born in Hailey, Idaho, and I went to school in Salt Lake City, Utah. Before joining the faculty at Mudd, I was a CAM assistant professor at UCLA. My research is in nonlinear dynamics and complex systems. I study mathematical models in a variety of social and biological systems, including (but not limited to) opinion dynamics, intracellular transport, pattern formation and parasite spread. I love teaching math at all levels, but I especially enjoy teaching courses where the students and I can engage with current research as part of the course (e.g., dynamical systems, math modeling, networks).

Leif: I'm from Pasadena originally, and I've lived in the L.A. area most of my life. My last job was as assistant adjunct professor (postdoc) at UCLA. My research interests are in mathematical biology (more specifically, mathematically modeling cellular processes). I enjoy teaching mathematical modeling and differential equations.

What excites you most about Mudd?

Jamie: The most exciting aspect of Mudd is the community. When I visited, I was struck by how well-connected the faculty are both to other faculty as well as to students and how well everyone seemed to know one another. I'm so excited to be joining a department which values and fosters these relationships!

Haydee: So many people in the Mudd math department have found ways to be enduring positive forces in their classrooms, in their research fields and in the larger math community. I'm looking forward to learning from them and the wonderful Mudd students. I'm hoping to become a Mudder!

Jasper: During my first year at Mudd, I was consistently struck by the ability of students to connect mathematics to a broad range of disciplines.

Heather: What drew me to Mudd was the joyful and friendly community. I am especially excited about mentoring/collaborating on research projects with Mudd students.

Leif: I'm most excited to interact with and work with Mudd students.

What are some of your hobbies or interests outside of mathematics?

Jamie: I love to be outside—I like to backpack, bike and have just started rollerblading (slowly becoming less of a hazard on wheels). I also love playing and watching basketball and have been brewing beer for the past few years.

Haydee: I'm into travel and am getting into keeping indoor plants.

Jasper: Most of all, being in nature. I recently took a backpacking trip in the Eastern Sierras. I even got to try out my fly rod on some California golden trout, though I didn't catch much.

Heather: I'm someone who finds it very easy to become interested in things, so consequently I have a lot of interests/hobbies outside of math. Growing up in Idaho and Utah, I developed a love of the outdoors very early on. I like skiing, climbing, hiking, rafting and camping. I also enjoy playing flute and piano, baking, good food, trivia, listening to podcasts—the list goes on.

Leif: I love the outdoors—I enjoy golf, hiking, mountain biking, rock climbing, skiing and whitewater rafting. I also like video games and watching movies.

What would you be doing if you hadn't become a professor?

Jamie: Growing up, I told people I would be an astronaut/engineer/basketball coach—guess I was going to be busy! My older brothers are engineers, and I thought that seemed like the coolest job.

Haydee: I'd probably be involved in politics. I also have a B.A. in political science.

Jasper: Probably working in higher ed administration, student affairs or residential life. I was an RA in college and almost went on to grad school for that. Or, maybe I'd be a lawyer.

Heather: I would probably still be a teacher of some kind. I studied music in college, and for a while I definitely thought about pursuing music performance and teaching.

Leif: I think I'd really enjoy being a park ranger or an outdoor guide.

Random trivia about yourself?

Jamie: Former Utah Jazz point guard John Stockton is my second-cousin!

Haydee: I went to high school in India.

Jasper: One of my first jobs was at a summer camp for live-action role playing.

Heather: My ears are two different shapes because of an incident with a sliding door when I was little.

Leif: I've been to the Australian outback (twice) more times than I've been to Outback Steakhouse (once).

Community Events

In the 2019–2020 academic year, the department hosted several events to help build community in the department and program. One of these events was an informal Friday Pizza Seminar designed to accommodate busy Mudders by providing pizza for lunch during a math activity. Pizza Seminars included "An Introduction to Surface Tension (Or Why Raindrops are Spherical)" with Professor Andy Bernoff, "A Journey to Waring's Problem and Sum-Product Formulas" with Professor Yesim Demiroglu, "Errors, Eavesdroppers, and Entanglement: Coding Theory for a Quantum World" with Professor Jessalyn Bolkema, "Math Careers in Industry Chat" with Aaron Archer '98, and "Dots and Boxes with the Profs." These events provided fun informal ways to gather as a community around mathematical topics.

We also hosted several events related to puzzles. The Brainteaser Battle, hosted by Joey Thompson from Susquehanna Investment Group (SIG), was a huge success with over 100 students participating in the competition. The winning team of seniors—Evan Johnson, Joon Lee, Princewill Okoroafor and Sonia Sehra—solved all the puzzles and the hidden "meta-puzzle" earning the top prize. This was the first event SIG has hosted at HMC, and they were quite impressed with Mudders' approach to solving the puzzles. We look forward to future events with SIG.

Another great puzzle event was the Estimathon, hosted by Andy Niedermaier '04 from Jane Street Capital. This was an action-packed event with some interesting point-garnering strategies for teams to think about as they try to estimate 10 quantities in a time-limited setting. Sample quantities to estimate included the number of commas in *A Tale of Two Cities*, the number of Twitter followers for Megan Rapinoe, the length (in miles) of the shortest closed polygonal path that connects the 48 state capitals in the continental U.S., and the number of names in the end credits of *Avengers: Infinity War*.

The Math Social Fund, led by Shanni Lam '22, is a student club focused on fun social events for math enthusiasts. Events last year included the traditional semesterly Pancakes with the Profs (an evening session at the local favorite Norms) and a nature hike in Johnson's Pasture. MSF had planned a trip to Pioneertown that was delayed due to the campus evacuation.

Another fun community event was Rubik's Cube Magic Night hosted by Steven Brundage, a magician who specializes in Rubik's Cube magic. He has appeared on *America's Got Talent* and fooled Penn and Teller on their show. He had just finished a week performing at The Magic Castle and was willing to spend an extra day in town to perform at HMC. We notified students on Sunday, less than 24 hours before the event, and sure enough, we packed the Shanahan Auditorium where all could enjoy an amazing and interactive performance.

Brainteaser battle opening

Winning Team in action at Brainteaser battle

Pancakes with the Profs @ Norms

Brundage event

New Course Provides Closer Look at COVID-19

Students delve into COVID-19 data in real time in a new five-week spring semester course led by Weiqing Gu, McAlister Professor of Mathematics

COVID-19: Data Analytics/ Machine Learning is a project-based, online course that challenged a multidisciplinary group of 36 upper-level students to use materials collected from an international dataset to study the novel coronavirus. They employed big data analytics and machine learning techniques to process the data, identify its key features and infer, predict, integrate, classify and extract unique insights from the COVID-19 Open Research Dataset, a free resource. The dataset contains scholarly articles about SARS-CoV-2 and related viruses in the broader coronavirus group and is the most extensive collection of machine-readable coronavirus literature.

One of the primary goals of the course is to contribute to existing research and data analysis to help the science community understand data genetics, incubation and symptoms of the virus, as well as to fill gaps related to the novel coronavirus as scientists pursue knowledge around prevention, treatment and a vaccine. Gu developed the online course after hearing students were disappointed to lose in-person, on-campus research opportunities for the remainder of the spring semester due to the COVID-19 pandemic. In addition to specializing in differential geometry and topology, applied to big data analysis, computer-aided design and robotics, Gu also researches applications to math-biology. She has created mathematical models to illustrate treatment-resistant strains of HIV and has used numerical calculations to analyze the behavior of the mutated HIV strains and to examine the effects of various treatment regimens on those strains.

Based on her work modeling strains of HIV, Gu has been building a model of COVID-19 using geometric techniques to determine patterns in its structure that are unique to the virus. She and her students discussed this structure and studied its impact.

Students also investigated a connection between the virus and global warming and climate change, and discussed ways they think the virus might be controlled.

"I saw Prof. Gu's big data class as a good way to become familiar with the math side of machine learning," Josh Cordova '22 says. "Being focused on such a relevant topic made it even more appealing."

Math for America at HMC

In 2018, mathematics professor Darryl Yong '96 and computer science professors Colleen Lewis, Zachary Dodds and Karen Gallagher (USC) launched their National Science Foundation-funded project, "Math for America Los Angeles: Elevating Mathematics and Computer Science Instruction through Teacher Leadership."

A collaborative effort between USC, Harvey Mudd College, school districts in the greater Los Angeles area and Math for America Los Angeles, the project includes funding for 34 master teaching fellows to create an improvement plan for their respective schools' mathematics and/or computer science instructional needs.

The fellows participate in summer computer science training, academic team teaching and monthly professional development meetings, one of which was held on campus in October 2019.

"For me, the highlight is in seeing how much teachers seem to be getting out of the work that they're doing with each other and with us," says Yong. "No matter how tired I am by the end of the week, I find that spending my Saturdays with these teachers is energizing and uplifting. I learn a lot of things from them about my own teaching. We challenge each other to be better teachers."

Michael E. Moody Lecture

Mathematics for Human Flourishing

Francis Edward Su, Benediktsson-Karwa Professor of Mathematics, presented the 17th Michael E. Moody Series Lecture on "Mathematics for Human Flourishing" Dec. 4. His book *Mathematics for Human Flourishing* was published by Yale University Press on Jan. 7, 2020.

Mudd Talks

The Harvey Mudd Office of Alumni & Parent Relations presented the virtual discussion series Mudd Talks. All presentations are available via the Harvey Mudd College YouTube channel. Several Mudd Talks featured mathematics alumni.

Epidemiology and COVID-19

Nadia Abuelezam '09 (mathematical biology) and chemistry and biology professor **Karl Haushalter**

Abuelezam, epidemiologist and assistant professor at the Boston College William F. Connell School of Nursing, and Haushalter discuss the coronavirus pandemic. They cover the latest research and information regarding the novel coronavirus.

"Defending Against Hackers"

Porter Adams '18 (CS and mathematics)

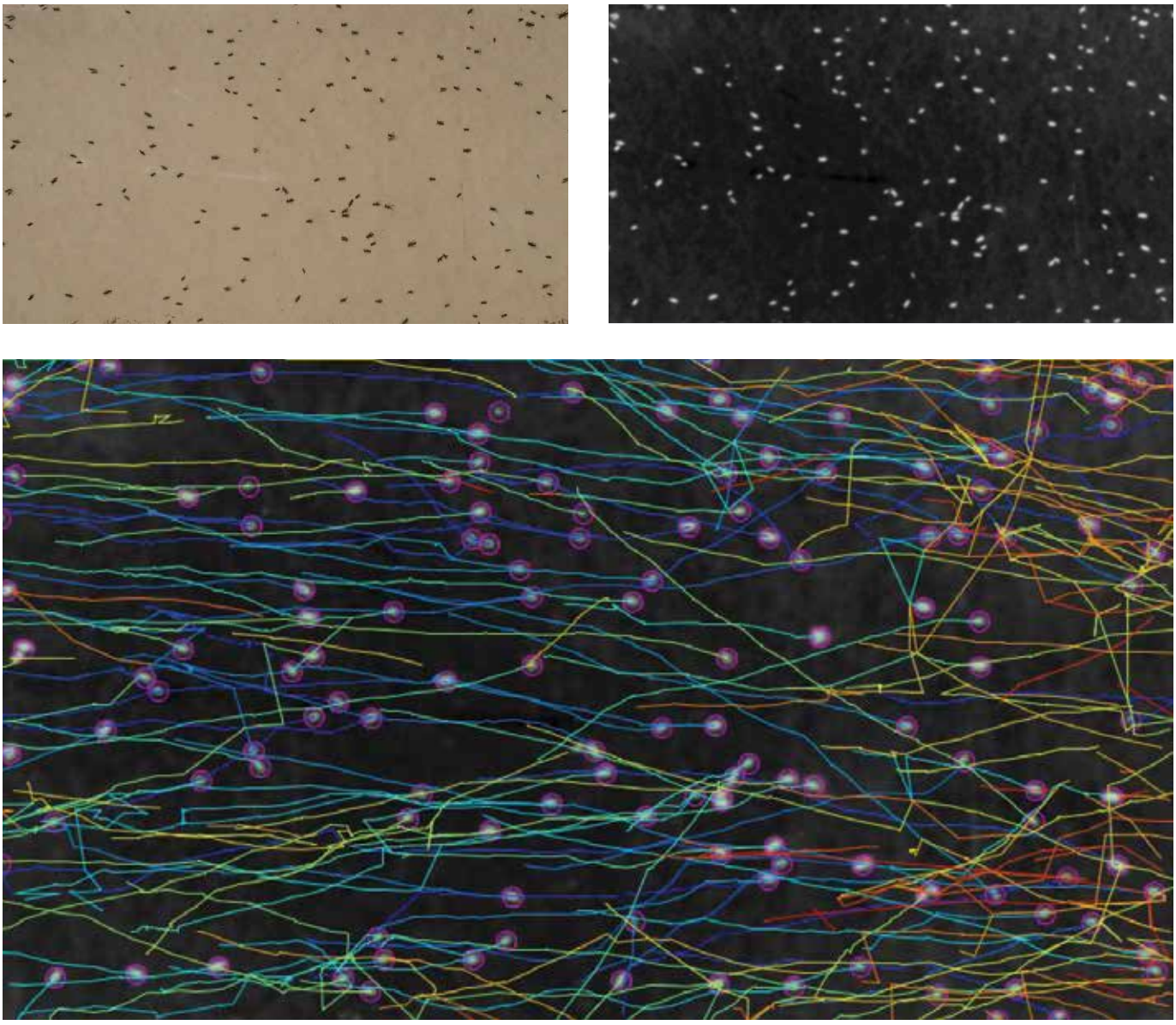
Adams discusses how to protect your information online. Defending your information can be difficult when you don't know how the offense operates. Learn how hackers attack so you can build a better defense. Adams is a software engineer focusing on cyber security for Blacktop Government Solutions in Washington, D.C.

"Building Wealth 2020"

Beverly J. Orth '74 (math)
and **Bruce Barton '86** (math)

Orth and Barton focus on actions and habits that can start individual wealth-building and financial wellness. They cover basics like savings, taxes, retirement funds, investing and credit.

▶ Watch Mudd Talks at **bit.ly/2ZBy1fK**



Video tracking for a locust swarm. From top left: still frame from video of an Australian plague locust hopper band traversing the desert (courtesy of Prof. Jerome Buhl); a gaussian blurred inverse of the image where locusts appear as white spots; output of the video tracking software indicating locusts (pink circles) and their trajectories (colored lines).

Summer Research

Over summer 2020, professors Andy Bernoff and Jasper Weinburd advised Shanni Lam '22, Jacob Landsberg (Haverford) and Anna Kravtsova (Eastern Washington University) on the project "Swarming Locusts: Deducing Insect Interactions from Field Data." Summer research students were supported by the NSF Data Science REU as well as HMC's Summer Undergraduate Research Program.

Project description: This summer a devastating plague of locusts is ravaging the Horn of Africa and threatening food security in the region. Back in the U.S., students are analyzing the individual mechanisms that drive the formation of locust swarms. Working with video footage from collaborator Professor Jerome Buhl (University of Adelaide), students use computer-vision software (Trackmate) to extract the position of each locust as trajectory data over time. Statistical analysis of this time-series data set reveals how locusts align their direction with neighbors, how they avoid collisions, and how densely they pack together. Examining these mechanisms informs our understanding of the formation and persistence of swarms, supports agent-based modeling efforts and provides clues that may eventually lead to more effective methods for locust control.

Omar Named Karen EDGE Fellow

Mohamed Omar, associate professor of mathematics and holder of the Joseph B. Platt Chair in Effective Teaching, is a member of the EDGE Foundation's 2020 inaugural class of Karen EDGE Fellows.

The foundation selects mid-career mathematicians who are from underrepresented minority groups as fellows based on their research programs and their plans to use funding from the fellowship to enhance their programs through collaboration and travel.

Omar employs sophisticated mathematical techniques to study foundational questions at the interface of algebra, geometry and counting problems. Recently, he has been particularly interested in fundamental questions about shapes arising in neuroscience motivated by Nobel Prize-winning work.

His mathematical goal with the EDGE Fellowship is to contribute to the understanding of intersection patterns of convex sets—how oval-like shapes can overlap and what restrictions there are in the ways they can overlap.

"The fellowship will allow me to support research visitors to collaborate at Harvey Mudd and to travel to visit other collaborators," says Omar, a leading expert on creativity in mathematics and the recipient of the Mathematical Association of America's 2018 Henry L. Alder Award for Distinguished Teaching by a Beginning College Mathematics Faculty Member. "It also gives me a one-week visit per year to the Institute for Advanced Study, one of the world's foremost centers for theoretical research and intellectual inquiry."

AMS Teaching Award for Yong

For his many sustainable and replicable contributions to mathematics and mathematics education, the American Mathematical Society Committee on Education awarded Darryl Yong '96 the 2020 AMS Award for Impact on the Teaching and Learning of Mathematics.

Mathematics professor and Mathematics Clinic director, Yong is an accomplished mathematician who has written six books and several research papers that have appeared in top applied math and physics journals. He is also a prominent researcher in math education, with a scholarly focus on active and inquiry-based learning, inclusive pedagogy and training of high school math teachers.

"I am truly honored to receive this award and humbled to be included among the other award recipients," Yong says. "The efforts for which I'm being recognized are/were collaborative efforts made possible by supportive and wonderful colleagues across many institutions."

Since coming to Harvey Mudd in 2003, Yong has become an expert on inquiry-based learning methods. In 2007, Yong started a nonprofit professional development organization for math teachers called Math for America Los Angeles (MfA LA). This program has supported over 200 high school math and computer science teachers with multiyear fellowships for salary supplements, in addition to providing professional development opportunities and a supportive community.

Yong is regarded by his colleagues as a gifted teacher who will continue to have a profound influence on how students and teachers perceive mathematics.

"I am especially grateful to my colleagues at Harvey Mudd College for nominating me and supporting me in my work," says Yong. "I am grateful to Kenneth I and Mary Lou Gross and the AMS for their support of mathematics education at the pre-college and college levels."

Williams Receives MAA Award, Lectureship

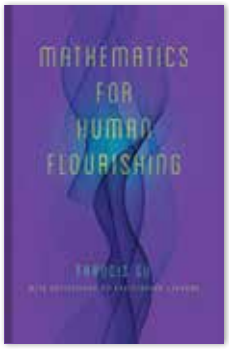
Harvey Mudd College mathematics professor Talithia Williams opened the decade with two honors: the Robert V. Hogg Award for Excellence in Teaching Introductory Statistics and a term as the Mathematical Association of America (MAA) Pólya Lecturer for 2020–2022.

The Special Interest Group on Statistics Education (SIGMAA) of the Mathematical Association of America selected Williams to receive the Hogg Award, which recognizes an individual who has been teaching introductory statistics at the college level for between three and 15 years and who has shown both excellence and growth in teaching during that time.

Williams says she's happy to be recognized for her work, which is intentionally public facing. "Often, faculty at other institutions may not see the value in this work because there's a disincentive for faculty to engage in the type of public visibility that I've engaged in in my career and to instead focus on more traditional metrics for tenure. I want to encourage STEM faculty to engage in the kind of public work I've been doing. It's important that we move the needle on issues that are affecting society today, such as global warming, and that we inspire the next generation to become STEM enthusiasts."

As the 2020–2022 Pólya lecturer, Williams will have a chance to share her experiences with other mathematicians around the country. The MAA established the George Pólya Lectureship with the goal of encouraging high-quality exposition embodied by George Pólya, an educator, author and prominent figure in mathematics. Williams, notably the first African American to receive the lectureship, will speak at three section meetings each academic year during her term.

Su Publishes Math Book for Wide Audience



Francis Su wants you to live life more fully, and one key, he says, is more math.

"The practice of mathematics cultivates virtues that help people flourish," says Su, Benediktsson-Karwa Professor of Mathematics. "These virtues serve you well no matter what profession you choose. And the movement towards virtue happens through basic human desires."

This is the premise of Su's new book, *Mathematics for Human Flourishing* (January, 2020), in which Su describes how mathematics meets basic human desires—such as play, beauty, freedom, justice and love—and cultivates virtues essential for human flourishing.

"The book is a broad explanation for the general public about what math is, who it's for, and why anyone should learn it," Su says. "There are better answers to the question 'why do math?' than 'because you'll need it later.' We don't tell people to learn basketball by having them shoot free throws over and over and then say, 'you'll play the game later.' So I make the argument that people are able to enjoy math when they see how it connects to their basic human desires. I discuss a dozen human desires in the book that math can, or should, meet."

Castro Named to McAlister Professorship

Alfonso Castro has been named McAlister Professor of Mathematics. Established in 2018 by longtime supporters Robert and Barbara McAlister to recognize and support the work of an outstanding faculty member within the Department of Mathematics, the appointment includes an annual discretionary fund to support travel, research or teaching.

Endowed faculty chairs are among the highest recognition accorded to a faculty member. An endowed chair honors and recognizes the distinction of outstanding faculty while providing invaluable support for salary, research, teaching or service activities.

A member of the College's mathematics faculty since 2003, Castro specializes in applied mathematics, differential equations and nonlinear functional analysis. His research areas include partial differential equations (including semilinear equations with discrete spectrum), variational methods, inverse-function theorems and water waves (solitons).

In 2012, Castro was awarded a Simons Foundation Collaboration Grant for Mathematicians to support his research project, "Solvability of semilinear equations with discrete spectrum," which involves equations fundamental to every area of science.

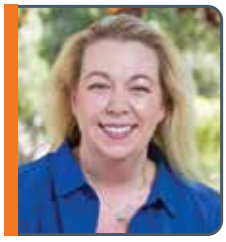
Castro is the co-founder and managing editor of the Electronic Journal of Differential Equations, a pioneering journal in paperless publication that publishes in excess of 150 research papers per year, accessible free of charge via the Internet.

Castro has served in several positions for the American Mathematical Association, including chair of the Human Rights Committee of the AMA.

Art Benjamin served as Mathematician in Residence for the Budapest Semesters in Mathematics Summer Program in 2019. During the pandemic, he has focused on exercising and doing research in backgammon. Perhaps as a result, he won first prize in two backgammon tournaments on the American Backgammon Tour Online.

Andrew Bernoff's research on locusts took him to Australia last fall to visit a locust biologist at the University of Adelaide. He just finished a stint as chair of the SIAM Dynamical Systems activity group and helped run their annual conference last May in Snowbird Utah with over a thousand attendees.

Alfonso Castro presented a series of lectures at the III Jornada Internacional De Ecuaciones Diferenciales y Aplicaciones, Universidad de San Marcos in Lima (Peru), in October of 2019. He also published papers with cooperators Nsoki Mavinga (Swarthmore College), Rosa Pardo (Universidad Complutense de Madrid, Spain), Ivan Ventura (Cal Poly Pomona), Jorge Cossio, Sigifredo Herron and Carlos Velez (Universidad Nacional sede Medellin, Colombia).

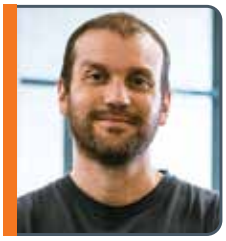


Lisette de Pillis was awarded the 2019 MAA Southern California-Nevada Section Award for Distinguished College or University Teaching of Mathematics, given to instructors recognized as extraordinarily successful and whose teaching effectiveness has had an influence beyond their own institutions. She also co-authored with Steven J. Leon the online textbook Linear Algebra with Applications, published by Pearson. The text was used for the first time in our 2020 spring introductory linear algebra core course and was made available to all students for free.

Weiqing Gu created a course this spring, COVID-19: Data Analytics/Machine Learning, that challenged a multidisciplinary group of upper-level students to use materials collected from an international dataset to study the novel coronavirus. They employed big-data analytics and machine-learning techniques to process the data from the COVID-19 Open Research Dataset, a free resource. Read about the course on page 5.

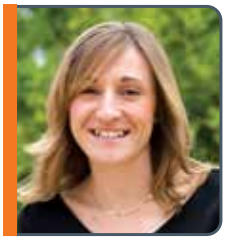
Jamie Haddock will officially join the department in July 2021 but is already enjoying becoming a Mudder. Some of her recent research develops the relationship between popular topic modeling techniques and neural networks, leading to interpretable classification techniques that can be applied to data in which interpretability is key (e.g., medical data). In recent times, she has begun rollerblading and enjoys it, despite remaining a hazard on wheels. Read more about Haddock on page 2.

Jon Jacobsen enjoyed his first year as department chair. Highlights include helping the search process (chaired by Francis Su) that led to the hiring of three new colleagues, co-teaching the new first-semester math core course and fundraising to support student and faculty research and community building. He co-authored "Radial Solutions to Elliptic Equations" with Alfonso Castro and wrote an article "Teaching from the Unknown," which explores connections between teaching and acting that will appear in the Journal of Humanistic Mathematics in 2021.



Dagan Karp was elected chair of the Southern California-Nevada Section of the MAA and continues to serve as chair of the Diversity Committee of the Park City Mathematics Institute. His projects include studying moduli spaces via tropical geometry with students and anti-racist post-secondary mathematics education in the time of pandemic.

Haydee Lindo joined the math department in July. She spent the summer thinking about teaching as part of the Brown cohort of MAA Project NeXT and learning about free resolutions during a workshop at ICERM. Because of the pandemic, Lindo now remembers to water her plants; they have flourished. Read more about Lindo on page 2.



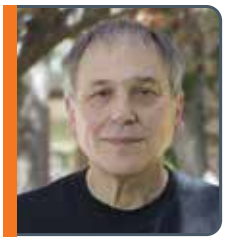
Susan Martonosi completed four years of service on the INFORMS board as VP for Membership and Professional Recognition. This year, she had great fun co-authoring with Alice Paul '12 a chapter on operations research in the forthcoming book, Data Science for Mathematicians. One of her sabbatical goals for the 2020–2021 academic year was to spend more time with her kids: Mission accomplished!

Mohamed Omar spent his sabbatical revamping his YouTube channel and working on various research projects. He gave an invited address at MAA Mathfest and the Joint Math Meetings and was appointed the Joseph B. Platt Chair in Effective Teaching. The pandemic has allowed him to move his local pub trivia passion to online trivia with friends across the country.

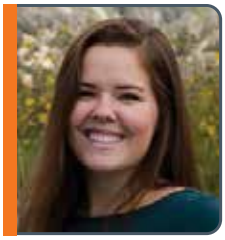
Jocelyn Olds-McSpadden traveled with her husband to Australia and France in 2019 and is coping with quarantine life by looking after her feisty 82-year-old mother and three rescue cats, Violet, Abby and Rocky-the-cat-who-eats-things-he-shouldn't. One math sweater, three blouses, many scarves and some yarn have all suffered career-ending noshings thus far. This has brought on a new quarantine habit; putting her clothes away.

She also enjoys vegan cooking and baking, yoga and revamping men's dress shirts to be less manly.

Michael Orrison was a guest instructor at the 2019 Canada/USA Mathcamp and a plenary speaker at the 2019 Fall Meeting of the Indiana Section of the MAA. He continues to enjoy thinking about various applications of harmonic analysis on finite groups, and he is looking forward to eventually getting back on the field as a youth soccer coach and referee.

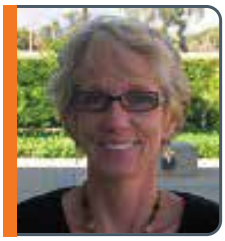


Nick Pippenger wrote a chapter for a forthcoming book from the ACM on the work of Steve Cook. He's had to use FaceTime to meet his second grandchild, Zara Klawe (born May 24), and to continue to see his first, Zain Klawe.



Molly Reeves successfully settled into her second year in the math department and helped assist faculty with migrating their courses online. She moved to a new residence and now has the pleasure of working remotely with her two cat coworkers, Griffin and Murphy.

Francis Su's book *Mathematics for Human Flourishing* was released in early 2020, before the world went mad, and his text *Topology Through Inquiry* (co-authored with Michael Starbird) and *Great Courses* video series Mastering Linear Algebra also recently appeared. He has been adjusting to pandemic teaching, and as of July, pandemic parenting (new baby Nathanael).



DruAnn Thomas has now fully joined the math department as the capstone coordinator, working with the thesis and Clinic students along with addressing various department needs. Her household grew as the family rescued a chocolate lab, Benson; and her adult son, Jordan, and his dog, Steve, moved from Wisconsin into the Thomas home.

Jasper Weinburd spent his first year at Mudd mentoring student research into swarming models for locusts. This summer, he and Professor Bernoff continued the investigation with Shanni Lam '22 tracking movements of individuals in video data (see page 7) and Yoni Maltsman '22 applying game theory to examine foraging efficiency. A highlight of his first year in California has been frequent hikes with his wife and dog in the San Gabriel Mountains. Read more about Weinburd on page 2.

Talithia Williams just completed a documentary with PBS, narrating for NOVA's new film, *Secrets in our Genes*. She's currently developing and hosting *From Zero to Infinity*, a mathematics documentary scheduled to air in summer 2021. She, like many parents of school-aged children, has spent the past few months engulfed in the epic adventures of pandemic homeschooling, often overheard saying, "Please don't interrupt Mommy while she's teaching" and "You still have to put on clothes."

This year, **Darryl Yong** received the 2020 Award for Impact on the Teaching and Learning of Mathematics from the American Mathematical Society (see page 8). He just completed a term as interim associate dean for faculty development and diversity and his first year as Clinic director for the mathematics department. He's enjoying his new pandemic hobby of gardening.

Heather Zinn Brooks joined the math department as an assistant professor in July. This past year, she's been working on various projects on opinion dynamics and networks and has been learning a lot as a 2019 MAA Project NeXT Fellow. She recently authored and illustrated an article for kids about math modeling and COVID titled "Disease Detectives: Using Mathematics to Forecast the Spread of Infectious Disease." She, like many others, learned how to bake bread during the pandemic. Read more about Heather on page 3.

Leif Zinn Brooks joined the math department as a visiting assistant professor in July. He has multiple ongoing research projects from his time as a postdoc at UCLA, which include a project with his postdoc mentor on modeling circadian rhythms in multinucleate fungal cells and a project with an undergraduate student on modeling behavior of ball-rolling dung beetles. He enjoys outdoor recreation, including golf, rock climbing, skiing, hiking and mountain biking. Read more about Leif on page 3.

Aria Beaupre ’21 Named a Goldwater Scholar

Aria Beaupre ’21, a Harvey Mudd College mathematics major known for making math joyful, accessible and inspiring on campus and beyond, is the recipient of a Barry Goldwater Scholarship, the most prestigious national award for undergraduate STEM researchers. The award for undergraduate U.S. sophomores and juniors covers the cost of tuition, fees, books, and room and board up to $7,500 per year.

Beaupre has taken advantage of the College’s many research opportunities. During her first year, she worked with Rachel Levy, former HMC professor of mathematics, on mathematics education research focused on integrating mathematical modeling into elementary school mathematics curriculum. Beaupre worked with Michael Orrison, professor of mathematics, on voting theory research—the mathematics behind elections. They worked on creating new voting procedures and analyzing their properties and relationships to other voting procedures. During summer 2019, Beaupre participated in a Research Experience for Undergraduates (REU) with David Milan, associate professor of mathematics at the University of Texas at Tyler. They studied semigroups and worked on a general characterization for the inverse hull of a Markov subshift.

Last year, the Department of Mathematics selected Beaupre to receive the Alvin White Prize, which is given to those who have contributed to the humanistic side of the mathematics community, both on campus and beyond.

Beaupre is a math tutor in the College’s Academic Excellence Program and a grader and tutor for Abstract Algebra.

“This scholarship was achieved with the help of so many people,” says Beaupre, who plans to attend graduate school for theoretical mathematics. Her goal is to become a mathematics professor. “I am very grateful to my research advisors and the professors here at Mudd, for giving me countless opportunities to learn and grow as a mathematician. I am also grateful to all the teachers in the Eatonville School District who ignited my love for academics.”

Ammons is NSF Graduate Research Fellowship Recipient

Savana Ammons was granted a National Science Foundation Graduate Research Fellowship.

Ammons plans to attend graduate school at University of Illinois at Urbana-Champaign. She intends to continue her studies in analysis, topology or geometry, or a combination of these topics. This academic year she has been working on her senior thesis, "A Discrete Analogue to the Poincaré–Hopf Theorem," exploring the notion of continuous vector fields over graphs and establishing an index theory for these fields with Francis Su, Benediktsson-Karwa Professor of Mathematics.

Emily Hwang '20 (chemistry) also won a fellowship and five seniors and four Harvey Mudd alumni were awarded honorable mentions, a significant academic achievement. The NSF Graduate Research Fellowship Program recognizes and supports outstanding graduate students in NSF-supported science, technology, engineering and mathematics disciplines who are pursuing research-based master's and doctoral degrees at accredited United States institutions. Program participants are expected to become experts who contribute significantly to research, education and innovation in the STEM fields.

Students Participate in Putnam Competition

Harvey Mudd College improved upon last year's team placement and maintained its position as the top-scoring undergraduate institution in the William Lowell Putnam Mathematical Competition, the preeminent undergraduate mathematics competition.

Twenty-five HMC students spent the better part of Saturday, Dec. 1, 2018, taking a challenging six-hour exam, which requires a unique blend of cleverness and problem-solving skills. The median score for the competition, in which 4,623 students from the U.S. and Canada participated, was two out of a possible 120. The median score for Harvey Mudd students was 10.

In team competition, veteran Putnam competitors Adam Busis '19, Shyan Akmal '19 and Xuming (Evan) Liang '20 placed an impressive sixth out of 568 institutions, and Harvey Mudd was the top scoring undergraduate institution. Last year's team of Busis, Akmal and Jordan Haack '19 placed ninth.

In the individual category, Busis ranked 87 in the nation, and received an honorable mention. Three other Harvey Mudd students, Akmal, Liang and Mengyi Shan '21, scored in the top 200.

"We are proud of all the students who sacrificed their time, talent and energies to represent Harvey Mudd in this year's Putnam competition," says Mohamed Omar, professor of mathematics and Putnam Seminar co-coach (along with Professor of Mathematics Nicholas Pippenger). "These students who enjoy problem-solving represent a cross-section of majors at the College."

25 HMC PARTICIPANTS OUT OF 4,623

6TH OUT OF 568 PARTICIPATING INSTITUTIONS

MEDIAN SCORE FOR MUDD STUDENTS

10 OUT OF 120

6-HOUR EXAM
12 PROBLEMS
10 POINTS EACH

CRA Recognizes Student Researchers

The Computing Research Association (CRA) announced its 2020 Outstanding Undergraduate Researcher Awards in December, and two Harvey Mudd College students were commended. Ivy Liu '20 was selected as a finalist, and Daniel Bashir '20 earned an honorable mention. Sponsored this year by Mitsubishi Electric Research Labs, the prestigious program recognizes undergraduates at North American colleges and universities who demonstrate outstanding potential in an area of computing research.

FINALIST

Ivy Liu '20

A joint mathematical and computational biology major, Liu is interested in developing and applying computational methods to facilitate biomedical research. "Integrating computer science with biology has allowed me to see the beauty of theoretical computer science as well as the applications of tools first-hand," she says.

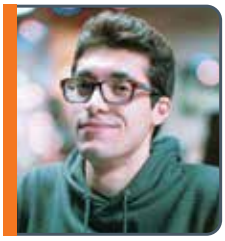
Liu's research experience includes working with biology professor Catherine McFadden to test the feasibility of using a particular gene to differentiate species within the coral genus Sinularia; working with computer science professors Ran Libeskind-Hadas and Yi-Chieh (Jessica) Wu to improve a dynamic programming algorithm for phylogenetic tree reconciliation; and using deep learning to predict DNA sequences related to the remodeling of epigenetic marks driven by a carcinogen with Dr. Cristian Coarfa and Dr. Cheryl Walker at Baylor College of Medicine.

Last summer, Liu worked with Dr. Pavel Sumazin at Baylor College of Medicine to develop computational models to infer cell-type-specific expression from bulk tumor expression profiles. This year, Liu is conducting senior thesis research with biology professor Eliot Bush, developing methods to study the evolutionary history of microbes.

"Through these experiences, I have found a love for computational biology, and I look forward to continuing research on fundamental problems as well as developing tools that will aid biomedical research in the long run," she says.

HONORABLE MENTION

Daniel Bashir '20



"The main purpose of my team's research is to develop a quantitative framework for overfitting and underfitting in machine learning," says Bashir. "Both of these pitfalls are major issues for anyone interested in using machine learning for practical purposes."

Bashir says his research, conducted with other members of computer science professor George Montañez's AMISTAD Lab at HMC, seeks to answer the question, "given a particular learning algorithm and a particular dataset, by how much will my algorithm overfit or underfit the data?" Having a specific, quantifiable answer to this question for any learning algorithm and set of data would allow a researcher to understand whether or not a particular algorithm is appropriate for a specific task.

"I became interested in this research while I was taking a class from Prof. George in machine learning, information theory and search," says Bashir, a joint computer science and mathematics major. "I got a chance to think about machine learning from an information-theoretic perspective and see the useful and fascinating parallels between the two fields. This perspective is not only interesting theoretically, but also has practical use. There's a fair amount of general advice on how to identify whether learning algorithms are overfitting or underfitting and how to fix those problems, but I think that a more quantified framework for answering these questions has the potential to help practitioners iterate on solutions to different problems using machine learning in a more principled way."

HMC Teams Place in Programming Contest Top 20

Harvey Mudd College fielded three teams at the 2019 Southern California Regional of the International Collegiate Programming Contest (ICPC) and all placed in the top 20.

Team List Incomprehension was the College's highest scoring team at fifth place (the third consecutive year an HMC team has placed fifth); this was quite a move up from their 30th-place finish last year. It also earned them an invitation to the North American Invitational Programming Contest in March 2020. Team RIP Jacky placed 11th and Team HMC 656 placed 13th out of the 98 teams competing.

Each team of three students sharing one computer attempts to solve as many of the 11 complex, real-world programming problems posed within five hours as possible. Team List Incomprehension solved seven problems in just over 19 hours of total time-since-contest-start; the winning Caltech team solved nine in 16:32:10.

Programming problems included creating a compact Morse-like code, devising a program to assist builders to bound the number and dimensions of stairs, and removing walls to enable escape from a maze. The contest fosters creativity, teamwork and innovation in building algorithms and programs and enables students to test their ability to perform under pressure. Coached by ACM team advisor and computer science professor Zach Dodds, Harvey Mudd team members are

Team List Incomprehension
Cole Kurashige '20, Princewill Okoroafor '20, Kye Shi '21

Team RIP Jacky
Evan Johnson '20, Radon Rosborough '20, Owen Gillespie '20

Team HMC 656
Mathus Leungpathomaram '23,
Joe Santichaivekin '21, Jarred Allen '22

Music Informatics Research Accepted to International Workshop

Research on machine learning and music is a burgeoning interdisciplinary field that encompasses data-driven approaches to the production, analysis and retrieval of music. Joint major in computer science and mathematics Mazda Moayeri '20 knew very little about music informatics and deep learning, but that didn't stop him from taking on this challenging new area. The result? He is co-author of a paper that was accepted to the 12th International Workshop on Machine Learning and Music held in conjunction with the European Conference on Machine Learning and Principles and Practice of Knowledge Discovery in Databases in Würzburg, Germany Sept. 16.

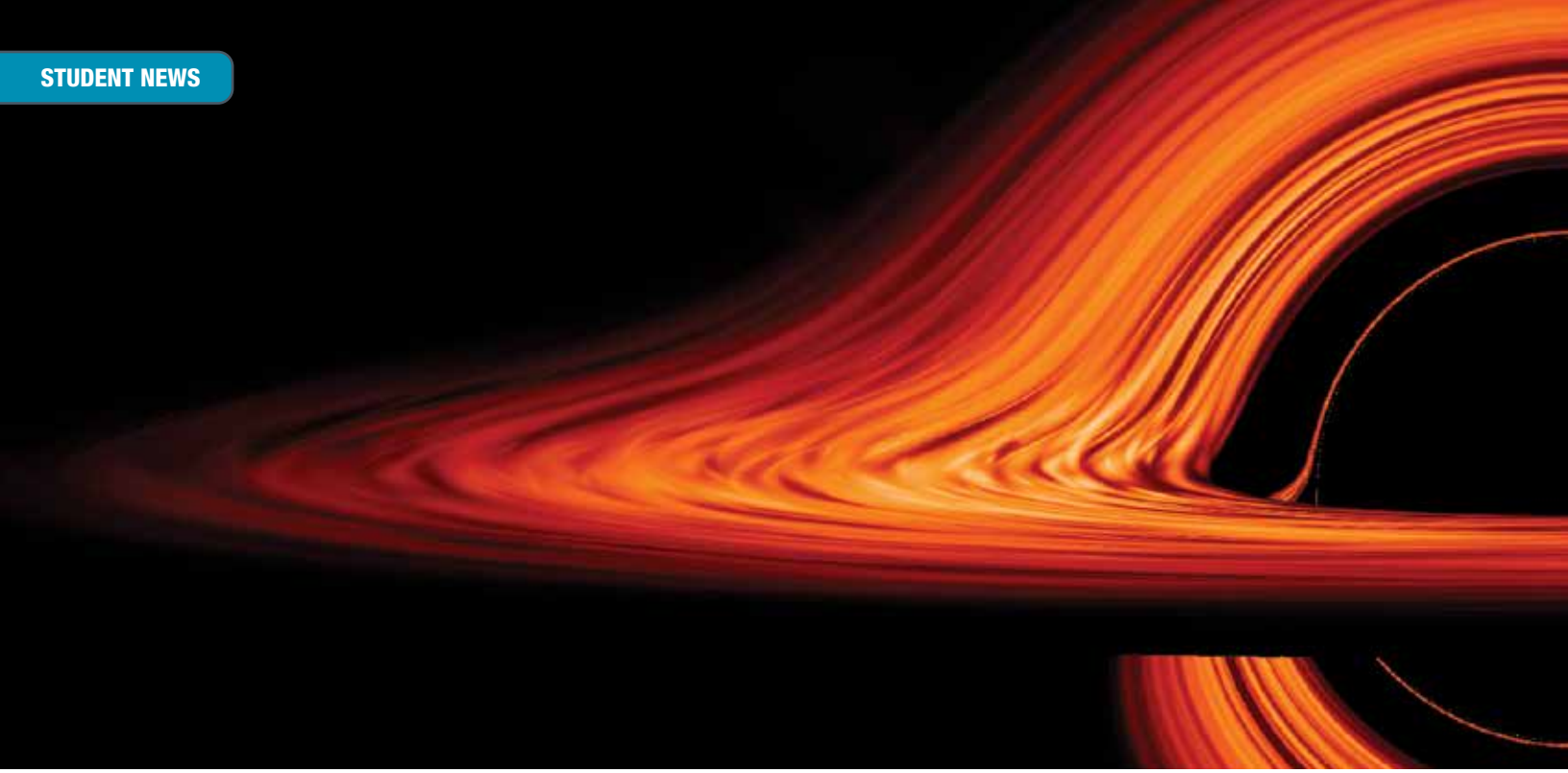
Moayeri wasn't able to attend the workshop, so the paper "Neural Symbolic Music Genre Transfer Insights" was presented by his supervisor and mentor Gino Brunner, who joined many scholars giving papers about applications to music and machine learning. Accepted papers are published by Springer Verlag under their Lecture Notes in Computer Science series.

"Imagine if you could feed your favorite classical piece to a machine and have the machine render it as a jazz piece," says Moayeri, who wrote a 30-page thesis and combined his work with another student's. "Specifically, I studied and developed an architecture based on autoencoders and generative adversarial networks. Additionally, I aggregated a dataset of hundreds of thousands of melody segments in a variety of genres, trained multiple genre classifiers for either isolated melodies or full multi-track musical segments and used attribution techniques to better explain the decisions of the deep networks and reveal structural patterns of each genre domain."

Moayeri's educational odyssey began when he contacted swiss computer scientist Roger Wattenhofer, a professor at ETH Zurich, about working in his lab on algorithmic and systems aspects in computer science and information technology. Being accepted in Wattenhofer's lab paved the way for Moayeri to be admitted to the ETH Zurich program for the spring 2019 semester. He is the first Harvey Mudd student admitted to this study abroad program, which typically doesn't accept students from colleges that do not award doctorates; Moayeri was granted an exception.

He completed a five-course Coursera Deep Learning specialization during winter break and spent several more weeks before the 2019 spring semester intensively studying relevant literature. After the summer research ended, Moayeri said he spent several weeks "pushing my research as far as I could, ultimately culminating in the publication."

"This research was the most difficult academic task I have ever undertaken, and with that came a ton of apprehension," Moayeri says. "As someone who had virtually zero experience in this field (deep learning), hopefully my experience can encourage others, like me, who get pretty scared and intimidated when faced with a new challenge."



Senior Publishes Two Physics Papers in Major Journals

Math-physics major Matthew Fox '20 has published two single-author papers in high-impact journals. *Physical Review D* published "Palatini $f(R,L_m,R_{\mu\nu}T^{\mu\nu})$ gravity and its Born-Infeld semblance" in June 2019, and the *Journal of Mathematical Physics* published "Multipole hair of Schwarzschild-Tangherlini black holes" in October, 2019. In December 2019, in a seminar slot usually reserved for graduate students, postdocs and faculty, Fox gave a talk on his black hole research to the Particle Theory Group at University of California, Riverside. Here, Fox describes his research.

"Palatini $f(R,L_m,R_{\mu\nu}T^{\mu\nu})$ gravity and its Born-Infeld semblance"

There are many outstanding problems in physics. One is the dark energy problem: A judicious look at the sky will reveal that the universe is expanding at an ever-increasing rate. We say the universe expands because of "dark energy." To me, the phrase "dark energy" comes off as some supremely technical term that only people with advanced degrees really understand. But there is no there there. Dark energy is just a label we give to the thing that causes the universe to expand. You can call it whatever you like! We simply don't know what dark energy is. We only know what it does.

A particle physicist or cosmologist might encourage a particular way of thinking about dark energy. They might say it is some fantastical fluid-like substance that permeates all of space and that also pushes space apart.

Indeed, this is how it is often modeled. But there is another view, a view in which dark energy is not some substance, some thing, but instead it is a trait, a feature, of the gravitational force. In this view, dark energy (i.e., the expansion of the universe) is effectively encoded in the DNA of gravity. Thus, from this perspective, where there is gravity, there is dark energy forcing the universe to spread out.

My paper concerns a very specific model that belongs to this latter perspective. The model is called Palatini $f(R, L_m, RT)$ gravity. Basically, it is a generalization of Einstein's theory of general relativity, which is the contemporary theory of how gravity works. The details of my theory aren't all that important. What is important is its relation to an interesting anomaly that arises in Einstein's great theory, having to do with the notion of infinity.

In my paper, I seek to unify two fundamentally different modified theories of gravity. One theory, the Palatini $f(R, L_m, RT)$ theory I mentioned, can account for the dark energy problem under certain circumstances. The other, called Eddington-inspired Born-Infeld (EiBI) gravity, cures the curvature singularities at the nuclei of black holes. This is interesting since the unified theory might engender models that explain dark energy and remove infinities at the centers of black holes. Two birds with one stone!

Credit: NASA's Goddard Space Flight Center/Jeremy Schnittman

"Multipole hair of Schwarzschild-Tangherlini black holes"

Another major problem in physics (perhaps the greatest unsolved problem in physics today) concerns reconciling gravity and quantum mechanics. We don't understand how quantum mechanics (the theory of small things) relates to gravity (which is a force concerning large things like planets and stars).

Many theories that try and understand this invoke something wholly unfamiliar: extra dimensions of space. Never mind the reasons why we don't see these extra dimensions. Physicists are clever, and there are bona fide ways to keep these extra dimensions hidden from us in our daily lives. The point is that, in principle, there is no reason for extra dimensions to not exist. It makes sense, therefore, to study physical phenomena (using mathematics) assuming extra dimensions of space, in order to gain a better understanding about how things would work in a world with more dimensions. (If things don't work like we see them assuming more dimensions, then there can't be extra dimensions, since things do work in our day-to-day lives!)

The topic of my paper is black holes. A black hole is what you get when you have a lot of material stuff packed so tightly that the mutual gravity of everything overwhelms all the interparticle forces pushing out. When this happens, the thing collapses in on itself, producing a region of space from which not even light can escape (hence black hole).

In three dimensions, which is the canonical setting of Einstein's theory of gravity, these black holes are suspiciously simple creatures. … When you go to higher dimensions, black holes are not so simple anymore. In higher dimensions, not all black holes are topologically spherical. Rather, you can get black holes that resemble a higher dimensional version of a torus (a surface with a hole in it, like a donut), among other things. This suggested to me that perhaps there is some physical way to change the topology of a higher dimensional black hole.

I studied the effect of electrically charging up a specific higher dimensional black hole, known as a Schwarzschild-Tangherlini black hole (in many respects, this is the simplest type of black hole you can have in higher dimensions). The process itself is quite straightforward: I have some uncharged thing (the Schwarzschild-Tangherlini black hole), and I want to charge it. So all I do is deposit some charge on to it. Then the thing is charged! What is so interesting about this is what actually happens to the topology of the original black hole.

In three dimensions, nothing interesting really happens. I start with an uncharged black hole, which is topologically a sphere, that turns into a charged black hole that retains its spherical topology. The topology doesn't change because Hawking's theorem says it can't!

In higher dimensions, things get weird. Hawking's work doesn't extend to higher dimensions. So, when charge is deposited on to the higher dimensional black hole, it could lose its spherical topology. I showed it does lose its spherical topology! This has at least two fascinating technical implications. One is that higher dimensional black holes can sport some hair, they are not characterized by just their mass, charge and angular momentum. They have additional features! The second is that the topology of the original black hole is no longer a sphere. In other words, infalling electric charges change the topology of Schwarzschild-Tangherlini black holes.

I don't know what the topology of the charged-up black hole is, but I do know it is not a sphere. In this sense, the electric charges act a bit like a nail and the black hole a bit like a piece of wood. You start out with some surface with no holes in it (the wood), but a sufficiently driven nail will puncture a hole right through the surface. My results suggest that electric charges do a similar thing to the surfaces of higher dimensional black holes!

2019–2020 Mathematics Senior Theses

Marcelo Almora Rios: **Radial Singular Solutions to Semilinear Elliptical Partial Differential Equations**
Advisor: Alfonso Castro, McAlister Professor of Mathematics

Savana J. Ammons: **A Discrete Analogue for the Poincaré-Hopf Theorem**
Advisor: Francis Su, Benediktsson-Karwa Professor of Mathematics

Havi Ellers: **On the Mysteries of Interpolation Jack Polynomials**
Advisors: Michael Orrison, professor of mathematics and associate department chair; Hadi Salmasian, associate professor of mathematics, University of Ottawa

Matthew Fox: **Leptogenesis via Higgs-like scalar particle decays through right-handed neutrinos**
Advisor: Brian Shuve, assistant professor of physics

Lily E. Friedberg: **Social Justice and Post-Secondary Mathematics Education**
Advisor: Dagan Karp, associate professor of mathematics

Hanna Hoffman: **Pascal's Mystic Hexagon in Tropical Geometry**
Advisor: Dagan Karp, associate professor of mathematics; Prof. Dr. Hannah Markwig, mathematics, Eberhard Karls Universität Tübingen

Forest Kobayashi: **Where the Wild Knots Are**
Advisor: Francis Su, Benediktsson-Karwa Professor of Mathematics

Hannah Larson: **Agent-Based Modeling of Locust Foraging and Social Behavior**
Advisor: Andrew Bernoff, professor of mathematics; Jasper Weinburd

Cassidy Lê: **Use of Kalman Filtering in State and Parameter Estimation of Diabetes Models**
Advisor: Lisette de Pillis, professor of mathematics and Norman F. Sprague Jr. Professor of Life Sciences; Blerta Shtylla, mathematics, Pomona College

Nuo (Ivy) Liu: **Reconstructing Gene Family Evolution in Microbes Using DTLOR Algorithm**
Advisor: Eliot Bush, professor of biology

Brooks M. Macdonald: **Investigation of the Regulatory Function of OGG1 in the Mitochondria of S. Cerevisiae**
Advisor: Karl Haushalter, associate professor of chemistry and biology

Cole Kurashige: **An Introduction to Type Checking, Inference, and Row Types**
Advisors: Chris Stone, professor of computer science; Jeff Polakow '98, Awake Security

Nick Richardson: **Composing Probabilistic Graphical Models with Adaptive Basis Methods**
Advisor: Nick Pippenger, professor of mathematics

Mengyi Shan: **Geometric Unified Method in 3D Object Classification**
Advisor: Weiqing Gu, McAlister Professor of Mathematics

Ricky Shapley: **An Exploration of Combinatorial Interpretations for Fibonomial Coefficients**
Advisor: Art Benjamin, Smallwood Family Professor of Mathematics

2019–2020 Mathematics Clinic Projects

COMPUTER SCIENCE/MATHEMATICS CLINIC
Sustainable Claremont: Addressing the Effects of Traffic on Air Quality at Claremont
High School Liaisons: Angela Oakley, Stuart Wood
Advisors: Alfonso Castro, Julie Medero
Students: Kylie Hetzel (PM), Daniel Ashcroft, Isaiah Fujii Bresnihan, Jasmine Seo
Sustainable Claremont, a local non-profit organization, is concerned about the health of children who are exposed to vehicle emissions and air pollution during school drop-off and pick-up times. The team measured the air quality at Claremont High School with air sensors, mathematically modeled the potential effects of traffic, and worked alongside the students to initiate healthier commuting behavior and raise awareness of environmental issues.

MATHEMATICS CLINIC
23andMe: Schedule and Resource Optimization Across Wide Timescale Workflows
Liaison: Arnold de Leon '90
Advisor: Alfonso Castro
Students: Samuel Tan (PM), Michael Gao, Alberto Garcia, Prakarsh Pandey
23andMe is a leader and founder in individualized, personalized genomics. The company's primary product is a genetic testing kit that provides health and ancestry information given a sample of saliva. The goal of this project is to optimize the decision-making process through which such kits are shipped to customers. To that end, we developed a production-ready API which helps the company decide which shipping avenues to take to save costs while ensuring deliveries are made on time.

Ice911 Research: Visualizing the Effects on California of a Global Climate Restoration
Strategy Liaisons: Leslie Field, Subarna Bhattachryya
Advisor: Andrew Bernoff
Students: Gabriella Giordano (PM), Michael Streinz, Parker Andrews, Cade Curry, Matthew vonAllmen
Anthropogenic global warming is altering the Earth's climate; the polar ice caps have shrunk, and the loss of reflective ice is accelerating global warming. Ice911 Research has developed a climate restoration technology that increases sea ice reflectivity, potentially slowing global warming. Ice911 Research has produced high-quality simulations of this intervention which are data rich but difficult to distill into graphics and conclusions understandable by decision makers. The Ice911 Clinic Team is using this data to provide clear and concise illustrations of regional and global climate impacts of this intervention.

Proofpoint: Malicious Message Clustering
Liaisons: Adam Starr, Thomas Lynam
Advisor: Weiqing Gu
Students: Vikram Amin, Xinyu (Carrie) Yang, Winston Li, Princewill Okoroafor, Joseph Gardi
Proofpoint is a leader at identifying email threats. This project seeks to accurately identify emails from the same attack campaign. The team designed and tested software tools to support this investigation, culminating in a retrieval pipeline that, given a query email, returns similar emails from a database.

Tradeweb Markets Inc.: High-performance Credit-Market Data Filtering
Liaisons: Stefan Kutko, Justin Peterson '85
Advisors: Talithia Williams, Jessalyn Bolkema
Students: Anna Serbent (PM-S), Mingyu Zheng (PM-F), Tse Yang (T.Y.) Lim, Cat Ngo, Jeremy Jess
Tradeweb would like to explore alternative architectures for its credit market filter, with the goal of making it more horizontally scalable. The Tradeweb Clinic team has built out a MongoDB-centered filter and testbench for monitoring the filter's performance. The entire pipeline (testbench and filter) has been deployed on AWS to match the scale of standard trading activity and to see if the database-centered approach can achieve the desired performance metrics.

Leadership Awards

Tona Gonzalez '22, **Outstanding Emerging Leader**
Anna Krutsinger '22, **The Ben Huppe Class of '14 Memorial Internship for a Sustainable World**
Tom Fu '22, **The New Millennium Experiential Learning Fund**
Jorge Canedo '22 and Sophia Cheng '21, **Shirlynn Spacapan Memorial Scholarship**

Class of 2020 Departmental Recognition

Departmental Honors
Savana Ammons, Carl Aslund, Tom Dougherty, Havi Ellers, Ina Flood, Michael Gao, Jonathan Hayase, Hanna Hoffman, Evan Johnson, Forest Kobayashi, Cole Kurashige, Joon Lee, Evan Liang, Danny Liu, Mazda Moayeri, Cody Newman, Laurel Newman, Cat Ngo, Tyler Sam, Ricky Shapley, Sam Tan, Jake Williams, Carrie Yang

Giovanni Borrelli Mathematics Prize
Havi Ellers

Stavros Busenberg Prize in Applied Mathematics
Xinyu (Carrie) Yang

Henry A. Krieger Prize in Decision Sciences
Tyler Jiang Sam and Samuel S. Tan

Alvin White Prize
Rikki Marie Lapato Walters and Thomas Martinez

Fred Hollinger '65: While I transferred out of HMC after my fifth semester, HMC was extremely important to my development. We had and have shared values. I had what I call a mid-life crisis early that semester when I realized I was not really cut out for math and science. I got my degree in history at UCSB, then, with the draft looming, I became an Air Force officer. I spent seven years in ICBMs, including four on a Titan II crew at Little Rock. I finished with 17 years in political-military affairs, 10 as a Japan specialist and seven running a portion of a U.S.-German cooperative program. I got to live 11 years overseas; I've been to 47 states and a sixth of the countries of the world. I retired as a colonel and moved to Atlanta where I still work full time in IT for Truist (previously SunTrust) Bank. My wife of 43 years, Gay, and I were both single parents when we met. She worked as an occupational health nurse, although while raising the kids she had all kinds of fun part-time gigs, including two years working as a technical writer for the IT section of Chase Bank in the middle of Tokyo. I'm almost done with a memoir, *How Did I Get so Lucky?*

Nadine Malcolm '70: Michael Malcolm '68 and I celebrated our 50th wedding anniversary with a National Geographic/MIT alums Panama Canal cruise in January/February. Just in time! Tiny ship; only 50 passengers. Wonderful engineering lectures and naturalist led rain forest hikes. No stops in cities. We came home to a different world, returning via airports in chaos due to the COVID-19 travel ban. Nobody even bothered to look at our customs forms. I'm now working at an AI startup company (www.quantellia.com) on a product to help keep organizations—and their members, students, employees, patrons, citizens and congregations—safe as we re-open facilities and public spaces and keep them safely open during this pandemic. No COVID downtime for me. Been working 70-hour weeks. On the other hand, I'm not bored. And I'm safe; we've always been a work-from-home company.

▲ **Robert Jardine '71:** Our second granddaughter arrived on June 16. I retired from Google in 2016. My wife had previously retired. Now, I split most of my time between reading, worrying about climate change (and doing occasional activism, mostly marching) and listening to music. I also travel, whenever possible, mostly focusing on total solar "eclipses" (more technically, solar occultations). So far, 10 successful trips, one clouded out (last year at a location near Pitcairn Island). I am also an active amateur astronomer. Attached photo is me and an old high school buddy and our wives on an Occultation trip to the Faroe Islands a few years ago.

Tony Li '82: I'm continuing to work on internet routing protocols, aka real-time computational graph theory.

Orna Amir '95: Almost five years ago, I joined Google in Tel Aviv. Initially, I worked at Waze, managing a large data science group and working on machine learning models to improve Waze's predictions for estimated time of arrival. Recently, after shifting to working from home, I moved to a new team in Google where I lead a data science team focused on notifications quality. I'm getting to know my new team through video calls from home and enjoying having time for lunch with my kids. I love having the chance to solve complicated data problems as a data scientist and complicated organizational problems as a manager.

Elisha Peterson '00: I was recently appointed to the principal professional staff at the Johns Hopkins University Applied Physics Laboratory, the lab's highest professional classification. The classification recognizes contributions to the field of cyber situational awareness and the creation of software, including a dependency modeling tool (Dagger) and a visual analytics tool (Galaxy). Both software programs are widely used by JHU/APL sponsors and were featured as part of the lab's 75 years of defining innovations. I am currently chief scientist of the Analytic Capabilities Group at the lab, with recent work focused on the application of AI/ML to cyber defense and the development of analytic tools supporting the national COVID-19 response effort. In some ways, my current work evolved directly out of summer research work with Francis Su over 20 years ago. We created a Java Applet version of the Fair Division Calculator, and since that time I have spent my career looking for better ways to connect people—whether students or sponsors—with data, information and the patterns and drivers behind them.

Karl Mahlburg '01: I've begun a new career in mathematical finance, as a quantitative researcher at Susquehanna International Group.

Colin Little '02: I moved to Portland, Oregon, and started working for Oregon Health and Science University as an emergency physician. COVID has obviously been the big event for my specialty just as it has for everyone, and it's been a sobering experience. But the silver lining is that my background in math from HMC has been very valuable for tracking this disease, and because of that I'm taking on the role of clinical informatics director for the emergency department as well as continuing to work shifts seeing patients. At the risk of getting political, the federal response to this pandemic is horrendous and is costing lives. Please call your representatives, give money/time, support #getUsPPE, and do whatever you can to try to help. Hope everyone is safe and healthy!

Jeffrey Hellrung '05: I'm now in my eighth year at Google Los Angeles (with a few other Mudders). My spouse, Sirian, recently also joined Google. I successfully snowboarded once last season after a two-year hiatus due to a torn MCL. We had a second trip to Mammoth lined up that got derailed by COVID-19 mountain closures, and we made the best of it by visiting some sites along Highway 395. We've been filling the time sheltering in place with puzzle-solving and rewatching *The X-Files*, in which I was surprised to learn that "Harvey Mudd" offered a doctoral program in aeronautical engineering. The other effect of the COVID-19 closures was setting a lifetime record for hair length; my hair has since been cut. I wish everyone the best of luck staying safe and healthy.

Joshua Swanson '10: PhD obtained, University of Washington, 2018. Postdoc in progress, UCSD, starting third and final year in the fall. Papers expanding to fill all available time (and sometimes space). Next step? Ask in February.

Katarina Hoeger '13: Last fall, I started in the Intermedia MFA program at UMaine. It is an art program that feels very much like it aligns with the spirit of a Mudd education. For me, Mudd encouraged considering exposing myself to multiple ways of approaching a problem and picking and choosing the appropriate method to solve it. As an intermedia artist, while I have preferred media, the goal is to investigate topics and present them in a way that makes the audience think. Therefore, media changes to what is most appropriate given the topic, my presentation of it, and how the audience is expected to experience it. My projects often center around exploring the connections between humans and helping each individual realize they are not alone, that they belong and are lovely humans as they are. I use all the tools at my disposal to investigate and make my final projects. Research habits, random mathematical knowledge from CORE and major classes, lab notebook organization, LaTeX documentation and practice with project management are some of the more practical ways my Mudd education helps. All of my time is currently spent on getting the most out of the experience of being an intermedia student artist. I work on projects, apply to programs and grants, work on my virtual presence and research whatever I have an interest in. I miss the Mudd community and look forward to reading what each of you are up to!

Sam Gutekunst '14: In May, I finished my PhD in operations research at Cornell University. In August, I started as the John D. and Catherine T. MacArthur Assistant Professor of Data Science at Bucknell University, a joint appointment between the departments of Mathematics and of Computer Science.

Max Comstock '16: Up until recently, I worked for the pharmacy company PillPack, where I was focused on increasing the scale and reliability of automation within the pharmacies using cloud technology. I'm currently taking some time off before I start a PhD program in computational science and engineering at Georgia Tech in the fall.

▲ **Porter Adams '18:** In the two years since I've graduated, I have done a lot to live up to Mudd's mission statement. For me, the most important contribution is helping solve missing persons cases, especially missing children, by assisting law enforcement with open source intelligence. I've also started a company to remove people's personal information from the internet, helped an ed-tech startup improve the education system and volunteered at a nonprofit to help increase diversity in the cybersecurity field. I have been cited as an expert in several online publications, and I am in the process of writing my first book *Why Hackers Win and How To Stop Them*. If you have an idea on how I can make the world a better place, please reach out to me on social media. I am always learning and trying to improve. Also, if you are not sure how you can make a difference in the world, please talk to me and I will help you find a way to accomplish that. I live in Washington, DC, with my dog.

Mehdi Drissi '19: I left my last job working at a LIDAR startup due to layoffs in March. I spent a couple of months taking a break and enjoying being back with my family. In June, I began working at TikTok on recommender systems.

Savana Ammons '20: I've been virtually participating in the University of Illinois: Urbana-Champaign's Summer Predoctoral Institute. This gives incoming graduate students a chance to work with potential graduate advisors during the summer and to become more accustomed to graduate school culture. I'm specifically working with my advisor on an independent study course in functional analysis. I'm also a grader for Summer Math.

Evan Johnson '20: I'm trying to keep myself busy! I've been working on a few small programming projects on Kaggle. I'm also trying to go through the textbook for Bayesian stats, since that course became optional and fell by the wayside during the semester. Finally, I'm watching a great series of video lectures on GR (international school of gravity and light) which has been confusing but overall fun!

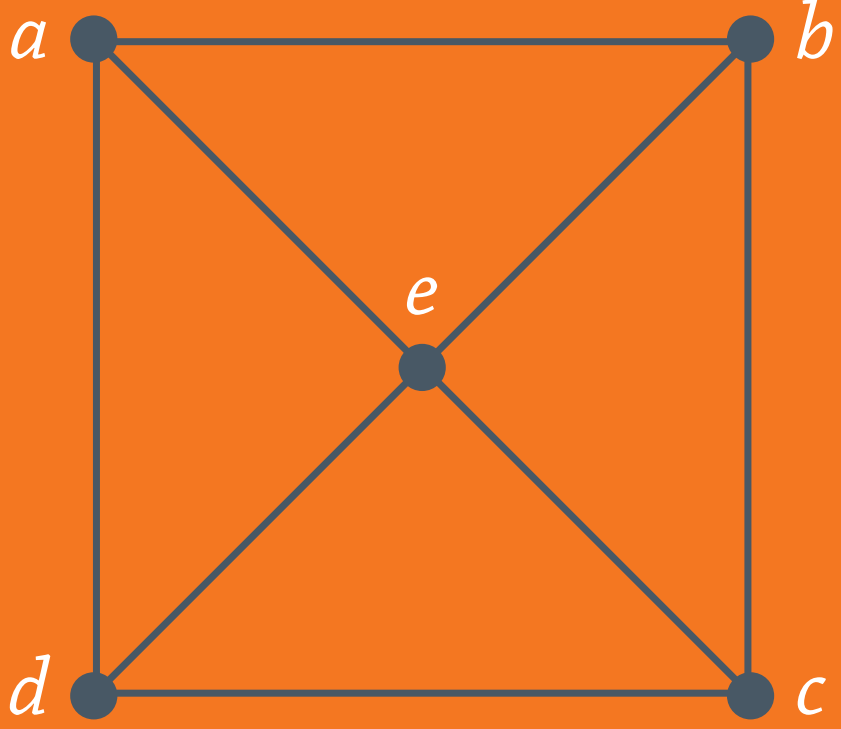
PUZZLE

The Game of Cycles

Consider the following graph of dots and edges. Two players take turns marking one unmarked edge with an arrow pointing along the edge in one direction or the other. The arrows must obey a sink-source rule: players are not allowed to create a sink (a dot all of whose edges are all marked pointing toward that dot) or a source (a dot all of whose edges are marked pointing away from that dot). Each edge can admit only one arrow, and arrows serve the same function in the game no matter who marks them. Players must make a move if they have a move available.

The object of the game is to produce a cycle cell: a single triangle in the board whose boundary edges are all marked by arrows all cycling in the same direction (either clockwise or counterclockwise). The winner of the game is the player who produces the first cycle cell or makes the last possible move. Who has a winning strategy: Player 1 or Player 2?

This game was introduced in Francis Su's book *Mathematics for Human Flourishing*.



Solution

Player 2 has a winning strategy. One such strategy is to complete a cycle cell if possible, and otherwise to "rotate-reverse" whatever Player 1 does—this means whatever move Player 1 makes, Player 2 rotates that arrow by 180 degrees, about the center vertex e, then reverses the direction of the arrow. For instance, if Player 1 plays an arrow from a to e, Player 2 should play the arrow from e to c (unless there is a cycle cell that can be completed on that turn). You might enjoy proving that this strategy is always possible to play without violating the sink-source rule.

The Game of Cycles can be played on other connected planar graphs. Who has a winning strategy for these other boards? More research about what is known may be found at **https://arxiv.org/abs/2004.00776**.

Harvey Mudd College
Department of Mathematics
301 Platt Boulevard | Claremont, CA 91711

math.hmc.edu

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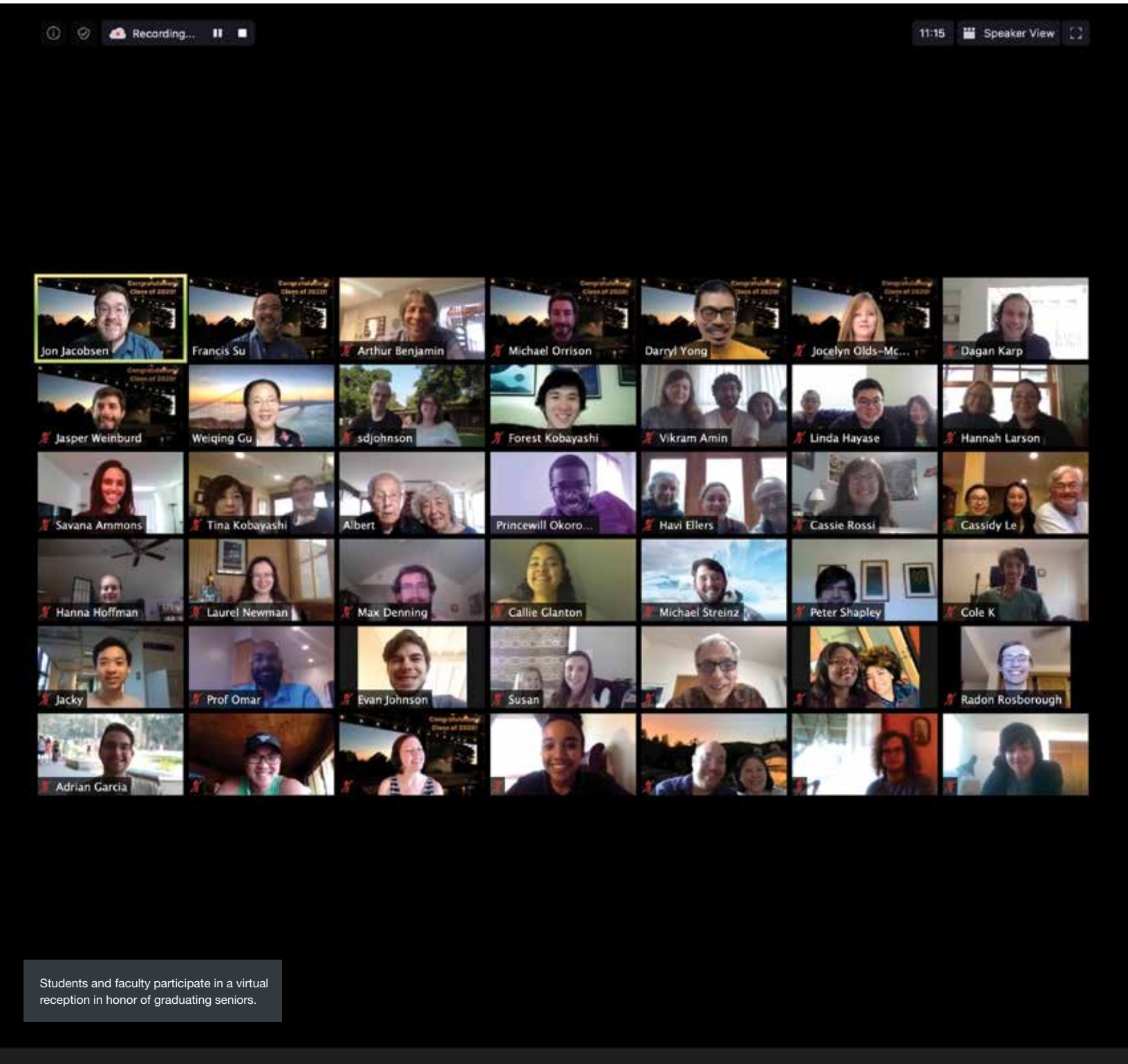

Students and faculty participate in a virtual reception in honor of graduating seniors.