Institute for Data, Systems, and Society

The MIT Institute for Data, Systems, and Society (IDSS) advances education in analytical methods in statistics and data science, information and decision systems, and the social sciences, and it applies these methods to research that addresses complex societal challenges in a diverse set of areas such as finance, energy systems, urbanization, social networks, and health. IDSS academic programs and research labs and centers are interdisciplinary and draw faculty from all five MIT schools.

The 2018–2019 year saw the introduction of the MicroMasters in Statistics and Data Science, the official launch of the new Interdisciplinary Doctoral Program in Statistics, growth in industry connections, the announcement of the new MIT Stephen A. Schwarzman College of Computing (which IDSS is set to officially join when it launches in fall 2019), and a major new research collaboration with Moroccan phosphate company OCP (Office Chérifien des Phosphates).

Faculty and Leadership

The director of IDSS is Munther Dahleh, the William A. Coolidge Professor in the Department of Electrical Engineering and Computer Science (EECS). For the 2019 academic year, IDSS faculty leadership included the following:

- Noelle Eckley Selin, an associate professor in IDSS and the Department of Earth, Atmospheric and Planetary Sciences, was named director of the Technology and Policy Program.

- Alberto Abadie, professor of economics, was associate director of IDSS.

- John Tsitsiklis, Clarence J. Lebel Professor of Electrical Engineering and Computer Science, was associate director of IDSS and director of the Laboratory for Information and Decision Systems (LIDS).

- Ali Jadbabaie, JR East Professor of Engineering, was associate director of IDSS and director of the Sociotechnical Systems Research Center.

- Devavrat Shah, professor of electrical engineering and computer science, was director of the MIT Statistics and Data Science Center.

IDSS academic leadership over the past year was as follows:

- Stephen Graves, Abraham J. Siegel Professor of Management Science and Professor of Mechanical Engineering and Engineering Systems, served as IDSS graduate officer.

- Ali Jadbabaie was program chair and admissions chair for the Doctoral Program in Social and Engineering Systems (SES).

- Professor Alexander "Sasha" Rakhlin was program chair for the Interdisciplinary Doctoral Program in Statistics.

- Professor Shah and Professor David Gamarnik co-chaired the curriculum committee for the minor in statistics and data science.

The approximately 80 IDSS faculty members include core and affiliate faculty members from 13 MIT departments. IDSS also had three visiting faculty members in 2018–2019.

In 2018–2019, IDSS hired Cathy Wu to join the institute's faculty. After serving as a visiting scientist at the Laboratory for Information and Decision Systems, Wu will officially join IDSS and Department of Civil and Environmental Engineering (CEE) faculty as an assistant professor starting in the summer of 2019.

Guy Bresler and Suvrit Sra (EECS and IDSS core faculty members), Tamara Broderick and Stefanie Jegelka (EECS and IDSS affiliate faculty members), and Dean Eckles (Sloan School of Management and IDSS affiliate faculty member) were promoted to associate professor without tenure. Sertac Karaman (Department of Aeronautics and Astronautics and IDSS core faculty member) and Saurabh Amin (Civil and Environmental Engineering and IDSS affiliate faculty member) were promoted to associate professor with tenure. Hamsa Balakrishnan (Aeronautics and Astronautics and IDSS affiliate faculty member) was promoted to full professor.

Awards

Faculty awards and grants for 2018–2019 include:

- Dimitri Bertsekas, the Jerry McAfee (1940) Professor of Engineering, and Professor Tsitsiklis jointly received the John von Neumann Theory Prize from the Institute for Operations Research and the Management Sciences.

- Professor Broderick received a Notable Paper Award (for "A Swiss Army Infinitesimal Jackknife") at the International Conference on AI and Statistics and a Junior Bose Award for outstanding educational contributions from the School of Engineering.

- Emery Brown, Edward Hood Taplin Professor of Medical Engineering and Computational Neuroscience and professor of health sciences and technology, was the 2018 recipient of Carnegie Mellon University's Dickson Prize in Science for his substantial achievements in the area of statistical analysis of neuronal data.

- A team led by Professor Jadbabaie has been awarded a Multidisciplinary University Research Initiative grant from the US Army Combat Capabilities Development Command's Army Research Laboratory. Fellow IDSS professor Elchanan Mossel (Mathematics) is also a member of the project team.

- Tommi Jaakkola, Thomas Siebel Professor in EECS and IDSS, was named among the Top 100 AI Leaders in Drug Discovery and Advanced Healthcare by Deep Knowledge Analytics.

- Professor Rakhlin was presented the 2019 Joseph A. Martore Award for Excellence in Teaching in IDSS.

- Associate Professor of Mathematics Philippe Rigollet was awarded a grant from the National Science Foundation (NSF).

- Professor Suvrit Sra, Edgerton Career Development Associate Professor of EECS, received a National Science Foundation CAREER Award. He was also awarded a Transdisciplinary Research in Principles of Data Science grant.

- Associate Professor of Energy Studies Jessika Trancik received a 2018 Campus Sustainability Incubator Fund grant from the MIT Office of Sustainability.

- EECS associate professor Caroline Uhler received a Simons Investigator Award in the Mathematical Modeling of Living Systems category from the Simons Foundation.

- Professor Mossel received a Simons Investigator Award in the Mathematics category from the Simons Foundation.

- EECS professor emeritus Alan Willsky received the Institute of Electrical and Electronics Engineers 2019 Jack S. Kilby Signal Processing Medal for outstanding achievements in signal processing.

- Professor Wu was the recipient of the Council of University Transportation Centers Milton Pikarsky Memorial Award, which recognizes the best doctoral dissertation in the field of science and technology in transportation studies.

Major Events

Retail Conference

October 24, 2018. The retail sector is undergoing fundamental changes as a result of data analytics and computer science. The IDSS Retail Conference 2018 brought together experts from academia and industry to discuss a variety of topics addressing data-driven disruption in the retail sector.

Women in Data Science

March 4, 2019. For the third year, Harvard, MIT, and Microsoft Research New England collaborated with Stanford University to bring the Women in Data Science conference to Cambridge. This technical conference gathered local academic leaders, industrial professionals, and students to hear about the latest data science–related research in a number of domains, to learn how leading-edge companies are leveraging data science for success, and to connect with potential mentors, collaborators, and others in the field.

SDSCon 2019

April 5, 2019. The MIT Statistics and Data Science Center (SDSC) hosted this event bringing together the statistics community and showcasing data science projects. Discussions covered applications of statistics and data science across a wide range of fields and approaches.

MIT Policy Hackathon

April 5–7, 2019. Run by IDSS students, the second annual MIT Policy Hackathon placed students and researchers on interdisciplinary teams to work on solutions to real societal challenges presented by sponsors who shared relevant large data sets. Specific challenges in health care, artificial intelligence, cybersecurity, and climate were addressed.

Conference on Synthetic Controls and Related Methods

May 20–21, 2019. Researchers shared ideas on a statistical method gaining prominence in economics at a two-day event hosted by IDSS and sponsored by the National Science Foundation and the National Bureau of Economic Research. The conference was organized by Professor Abadie along with fellow MIT Economics and IDSS professor Victor Chernozhukov.

Learning for Dynamics and Control

May 30–31, 2019. Over the next decade, devices that sense and control the physical world are expected to be the biggest generator of data. From autonomy and robotics to smart cities, this data explosion—paired with advances in machine learning—will create new possibilities for designing and optimizing technological systems that use their own data generated in real time to make decisions. To address the many scientific questions and application challenges posed by the real-time physical processes of these "dynamical" systems, researchers from MIT and elsewhere organized a new annual conference, Learning for Dynamics and Control. Dubbed L4DC, the inaugural conference was hosted at MIT by IDSS.

Series and Seminars

In addition to major events, IDSS continued to present the following ongoing seminar series:

- IDSS Distinguished Seminar Series
- IDSS Special Seminars
- Stochastics and Statistics Seminar Series
- LIDS Seminar Series

Distinguished Seminar Series

- September 2018: Science for Policy (Vladimir Sucha, Joint Research Centre)
- October 2018: Can Machine Learning Survive the Artificial Intelligence Revolution? (Francis Bach, INRIA)
- November 2018: The Regression Discontinuity Design: Methods and Applications (Rocio Titiunik, University of Michigan)
- December 2018: The Opportunity Atlas: Mapping the Childhood Roots of Social Mobility (Raj Chetty, Harvard University)
- February 2019: Collective Decision Making: Theory and Experiments (Leeat Yariv, Princeton University)
- March 2019: A Theory for Representation Learning via Contrastive Objectives (Sanjeev Arora, Princeton University)
- April 2019: A Particulate Solution: Data Science in the Fight to Stop Air Pollution and Climate Change (Francesca Dominici, Harvard University)
- May 2019: Design and Analysis of Two-Stage Randomized Experiments (Kosuke Imai, Harvard University)

Special Seminars

- August 2018: Resource-efficient ML in 2 KB RAM for the Internet of Things (Prateek Jain, Microsoft Research)

- September 2018: Text as Data in Social Science: Discovery, Measurement and Causal Inference (Brandon Stewart, Princeton University)

- November 2018: Censored: Distraction and Diversion Inside China's Great Firewall (Margaret Roberts, University of California at San Diego)

- March 2019: Using Computer Vision to Study Society: Methods and Challenges (Timnit Gebru, Google)

The Topics in Information and Inference Seminar Series was a special series of seminars focusing on information theory, inference, causality, estimation, and non-convex optimization, as follows.

- September 2018: Strong Data Processing Inequalities and Information Percolation (Yury Polyanskiy)

- September 2018: Graphical Models Under Total Positivity (Caroline Uhler)

- October 2018: Local Geometric Analysis and Applications (Lizhong Zheng)

- October 2018: Stein's Method for Markov Chains and Application to Random Graphs (Guy Bresler)

- October 2018: Randomness and Information I (Abbas El Gamal)

- November 2018: Randomness and Information II (Abbas El Gamal)

- November 2018: Negative Dependence and Stable Polynomials in ML (Suvrit Sra)

- November 2018: Time Is of the Essence, But What's the Essence of Time (Series)? (Devavrat Shah)

Industry Connections

IDSS receives corporate support through its industry partner program. Current industry partners are Booz Allen Hamilton, Breca, WorldQuant, Inditex, and the OCP Group. Their funding supports fellowships and certain programming costs (e.g., costs related to conferences and workshops). Partners are invited to join the external advisory board.

In the summer of 2018, IDSS launched a new program: the Industry Alliance. This program is designed for companies that would like to begin engaging with IDSS but are not ready to do so at the industry partnership level. These firms are invited to attend conferences, recruit students, interact with faculty at a series of events, and access exclusive content via a web portal. Current alliance members are C6 Bank and Amazon.

Michael Hammer Fellowship

Hammer Fellowships remember Michael M. Hammer '68, SM '70, PhD '73, a much-lauded educator, visionary engineer, and pioneering business leader and author. These fellowships are awarded annually to IDSS doctoral students in the Social and Engineering

Systems program and IDSS postdoctoral scholars. They are made possible thanks to a generous endowment gift from Phyllis Thurm Hammer and the Hammer family.

Hammer Fellows selected in 2018–2019 were Kiran Garimella (postdoctoral fellow) and Cate Heine, Manxi Wu, and Leon Yao (student fellows). Student Hammer Fellows selected for AY2020 are Sirui Li, Manon Revel, Arnab Sarker, and Erin Walk.

Postdoctoral Associates

IDSS postdoctoral associates hired in 2018–2019 included Hammer Fellow Kiran Garimella and SDSC Wiener Fellow Jingbo Liu.

Research

A new research collaboration among IDSS, the Moroccan phosphate company OCP, and King Mohammed VI Polytechnic in Morocco plans to use data from technologically advanced farms to better predict the value of intervention in under-performing farms in Africa. Ultimately, the goal is to create a platform for sharing data and risk among invested parties, from farmers and lenders to insurers and equipment manufacturers.

Seed Grants

The IDSS Seed Fund Program supports innovative, early-stage research projects with a focus on societal challenges. Through these grants, IDSS seeks to encourage researchers from across MIT to collaborate and open up new avenues for interdisciplinary research that brings together the full range of Institute capabilities. Grants support projects undertaken by SES PhD students or postdocs working with two IDSS faculty members. Funded recipients are as follows:

- Daron Acemoglu (Economics) and Asu Ozdaglar (EECS) (Credit Freezes in Financial Networks)
- Fotini Christia (Political Science) and Constantinos Daskalakis (EECS) (Assessing Syrian Refugee Integration Using Call Detail Records from Turkey)
- Saurabh Amin (CEE) and Nazli Choucri (Political Science) (Security of Global Undersea Networks: Models, Defenses, and Policy Mechanisms)

Micro Projects

In AY2019, IDSS offered funding for a "micro project" to David Rand, IDSS affiliate and associate professor of management and brain and cognitive sciences, and David Karger, professor of electrical engineering. The project seeks to provide a better understanding of why news consumers believe or distrust the accuracy of news articles they consume online via a series of experiments in which participants are shown articles and asked to assess the validity of the claims made while explaining their reasoning.

MIT Institute for Foundations of Data Science

Professors Rigollet and Shah were co–principal investigators on a multi-year NSF project designed to foster breakthrough discoveries in data science. As the first phase of this project, Rigollet, Shah, and their collaborators founded the MIT Institute for Foundations

of Data Science (MIFODS), an interdisciplinary effort to develop the theoretical foundations of data science through integrated research and training activities.

Additional investigators include 14 IDSS, SDSC, and LIDS core and affiliate faculty: Guy Bresler, Tamara Broderick, Victor Chernozhukov, Costis Daskalakis, David Gamarnik, Tommi Jaakkola, Stefanie Jegelka, Jonathan Kelner, Aleksander Madry, Ankur Moitra, Elchanan Mossel, Pablo Parillo, Suvrit Sra, and Caroline Uhler.

In January 2019, MIFODS hosted the four-day Non-Convex Optimization and Deep Learning workshop and bootcamp.

Academic Programs

IDSS academic programs include the Doctoral Program in Social and Engineering Systems (SES), the Technology and Policy Program (TPP), and (through the Statistics and Data Science Center) an undergraduate minor in statistics and data science and the Interdisciplinary Doctoral Program in Statistics. SDSC also offers professional education via the online Statistics and Data Science MicroMasters program and the online course Data Science and Big Data Analytics: Making Data-Driven Decisions, a collaboration with MIT xPRO.

Doctoral Program in Social and Engineering Systems

The Doctoral Program in Social and Engineering Systems is a unique research program focused on addressing concrete and societally significant problems by combining the analytical tools and methods of engineering and information sciences with social science tools and methods.

Program Milestones

In September 2018, SES's third class of four students started the program. In addition, the first SES doctoral candidates passed their oral qualifying examination.

Admissions

Over the past year, 267 students applied to the program, and 17 were admitted. Seven students will begin the program in AY2020.

Student Support

Incoming students will be supported through fellowships; continuing students are primarily covered by graduate assistantships and fellowships.

Honors and Recognition

Incoming SES students Sirui Li, Manon Revel, Arnab Sarker, and Erin Walk were named Hammer Fellows. Doctoral candidate Ian Schneider was among 16 MIT students named to the Siebel Scholars Class of 2019.

Graduates

The legacy Engineering Systems Division doctoral program graduated seven students in AY2019. The program is on track to graduate its final student in 2020.

Technology and Policy Program

Formed in 1975, the Technology and Policy Program is an interdisciplinary graduate program that educates students to address issues that involve science, technology, and society. Our educational philosophy centers on the idea that effectively informing policy decision making requires understanding not only classical science and engineering concepts but also the theory and practice of policy and policy-making.

Students

TPP offers a two-year master of science program and encourages its students to pursue doctoral research in disciplines related to technology and policy. TPP's applicant cohort is diverse, with applications coming from students in undergraduate programs around the world, many of whom have additional practical work experience. Approximately one third of TPP students pursue a second master's degree in another department. The annual program intake averages 35 students, more than 40% of whom are women and just under 40% of whom are international students.

Graduation and Employment

In AY2019, 38 students graduated with an SM in technology and policy, eight of whom earned a second SM. This year, four of these graduating students are entering PhD programs and one is entering law school. Four TPP graduates will continue their US military service. Other graduates take jobs in industry, government service, start-ups, or consulting. Of the roughly 1,350 graduates of TPP over its history of more than 40 years, about 40% currently work in industry, 20% in consulting, 15% in academia, 12% in government, and the rest in other industries (e.g., law, nonprofit).

Research

TPP student research spans the Institute, in both institutional and intellectual scope, and addresses the major challenges faced by modern society (e.g., sustainability, health, security). For example, many TPP students are affiliated with the MIT Energy Initiative (MITEI), where they study the challenges of energy choices, sustainability policy, and environmental responsibility. TPP students hold research appointments with programs and centers across the campus, including the Joint Program on the Science and Policy of Global Change, the Center for Energy and Environmental Policy Research, the Center for Complex Engineering Systems, the Computer Science and Artificial Intelligence Laboratory, the Lean Advancement Initiative, the Sociotechnical Systems Research Center, and the Humanitarian Response Lab. Students also hold research positions with Draper Laboratory and Lincoln Laboratory programs and work with MIT initiatives including the MIT Internet Policy Initiative, the Environmental Solutions Initiative, Work of the Future, and the MIT Initiative on the Digital Economy.

Fellowships

TPP students received several MIT fellowships, including fellowships from MITEI, the Tata Center for Technology and Design, and Lincoln Laboratory. In addition, internal Kesavan, de Neufville, and Bernard Rabinowitz Fellowships were awarded to students from the program. External fellowships awarded to TPP students included fellowships from the National Science Foundation, Fulbright Chile, Fulbright Australia, and the Belgian American Education Fund.

Policy Engagement

An annual trip to Washington, DC, gives students an opportunity to build professional networks with others working at the intersection of science, technology, and policy. Fourteen TPP students representing six countries participated in this trip in March 2019. During the trip, TPP alumni hosted presentations at the National Aeronautics and Space Administration (NASA), the Office of Management and Budget, the Federal Emergency Management Agency, the US Department of Energy, the US Department of Defense, the US Forest Service, the Union of Concerned Scientists, and the World Bank. During the trip, TPP hosted a networking reception for students and alumni.

During the summer of 2019, TPP funding provided stipend support for several students with otherwise unpaid or partially funded internships. TPP students interned with Cap-Net UNDP, in the House of Representatives with Representative Ben Ray Lujan, and at the World Bank. Other TPP students participated in paid internships at various agencies and corporations including FireEye, NASA Ames, the NASA Jet Propulsion Lab, Bechtel Enterprises, Boston Consulting Group, and Ausnet Services. TPP also sponsored the third MIT Policy Hackathon in April 2019, during which more than 100 students, researchers, and professional data analysts gathered on campus in interdisciplinary teams to analyze data sets and create policy proposals addressing real challenges submitted by academic groups and local government. The hackathon was entirely organized and run by students from TPP and IDSS.

Conferences and Workshops

Over the past year, TPP students presented papers and posters at conferences and workshops around the world.

TPP is a founding member of the Technology Management and Policy Graduate Consortium, which includes programs in North America, Europe, and Asia. The annual meetings of this consortium afford TPP students and MIT doctoral students in fields related to technology and policy the opportunity to share their research and network with students across the globe. More than 50 students and faculty from 11 universities typically participate in the event. This year's consortium meeting was hosted by George Washington University in Washington, DC. Through the generosity of a private donor, TPP was able to provide travel funds for four TPP and IDSS engineering systems doctoral students and the TPP director of education. Engineering systems doctoral candidate Magdalena Klemun won the award for the best senior paper for "Soft and Hard Factors Affecting the Cost Evolution of Low-Carbon Energy Technologies."

The annual MIT Energy Conference, MIT India Conference, MIT Global Startup Workshop, and MIT Energy Night leadership teams featured several TPP students. Our students are involved in leadership of a number of organizations and initiatives across the Institute, including the MIT Energy Club, the MIT Clean Energy Prize, the Science Policy Initiative, the Graduate Student Council, LBGT@MIT, Graduate Women at MIT, MIT house committees, the MIT Digital Currency Initiative, the Title IX Advisory Board, and the Transportation Club.

Student Honors and Awards

TPP students received honors and awards from MIT and beyond. For instance, graduating student Casey Evans was named one of *Aviation Week*'s 20 Twenties, Manon Revel was named an IDSS SES Hammer Fellow; Uyiosa Olamide was named a Stanford Knight-Hennessy Scholar, Miles Lifson was awarded a Belgian American Educational Fund fellowship, and several TPP students were selected to represent MIT at COP24 in Katowice, Poland. In addition, TPP students received prizes as members of the winning teams for Hacking for Freedom (to stop sex trafficking), the Social Security Hackathon, and the Tech for Truth Hackathon.

Student Society

The Technology and Policy Student Society (TPSS) engages students with an interest in technology and policy topics, from programmatic support and community engagement to networking and professional development. The group's two largest events are the Inter-Year Retreat and the Winter Trip, which are overnight trips that strengthen the TPSS community. Other events include the TPSS Pizza Policy Nights, at which students make presentations on a technology and policy topic not related to their research; past topics have included biomedical ethics, dog agility training, and vexillology. Additionally, TPSS hosts career panels and networking coffee sessions.

Alumni Engagement

With more than 1,300 alumni, TPP continues to foster a strong alumni community. TPP alumni host students at their organizations during annual Washington, DC, visits. During the academic year, local alumni and visiting alumni are encouraged to visit TPP to give presentations or meet informally with current students. Our alumni have offered ongoing support to student and program initiatives including funding for summer internships, recruitment and outreach, and support for women in technology and policy.

Leadership

Noelle Selin was named director of TPP in August 2018. Frank Field is TPP's director of education.

IDSS Student Council

The IDSS Student Council continued its work of community building, event planning, and serving as an advisory body for IDSS leadership on student issues. In 2018–2019, the council's student members were:

- Marco Miotti (Doctoral Program in Social and Engineering Systems)

- Jason Cheuk Nam Liang (Laboratory for Information and Decision Systems)

- Saeyoung Rho (Technology and Policy Program)

- Max Vilgalys (Doctoral Program in Social and Engineering Systems)

Professor Jadbabaie is the council's faculty advisor.

Laboratory for Information and Decision Systems

The major research lab within IDSS, the MIT Laboratory for Information and Decision Systems (LIDS) is an interdepartmental research center committed to advancing research and education in the analytical information and decision sciences.

Munther Dahleh
Director
William A. Coolidge Professor
Professor of Electrical Engineering and Computer Science

Sociotechnical Systems Research Center

The MIT Sociotechnical Systems Research Center (SSRC) is an interdisciplinary research center that seeks to develop collaborative, multidisciplinary, systems-theoretic approaches to complex societal challenges. SSRC administers research that brings together faculty, researchers, students, and staff from across MIT to study complex enterprises that span government, industry, the service sector, and health care.

SSRC supports IDSS faculty research and comprises several ongoing research programs. Its total research volume in FY2019 was approximately $13.3 million. SSRC's major research partners include the Center for Biomedical Innovation, the Center for Complex Engineering Systems, the Consortium for Engineering Program Excellence, MIT Connection Science, the Ali Jadbabaie research group, the OCP Group of Morocco, and the Systems Engineering Advancement Research Initiative. The following sections highlight key activities for each of these groups in FY2019.

Jadbabaie Group

SSRC supports and manages Professor Jadbabaie's Vannevar Bush Fellowship from the Office of Secretary of Defense. This five-year fellowship totaling $3 million supports basic research efforts at the interface of complex networks as well as quantitative and computational social science. During the past year, several ongoing research collaborations between Professor Jadbabaie and MIT political science faculty members who are IDSS affiliates have been funded. This includes research on the spread of misinformation using large-scale call detail records to measure the social network effects of US drone strikes in Yemen.

A team led by Professor Jadbabaie has been awarded a Multidisciplinary University Research Initiative grant from the US Army Combat Capabilities Development Command's Army Research Laboratory for a project titled Foundations of Decision Making with Behavioral and Computational Constraints. In addition to Professor Jadbabaie, the project team members are fellow IDSS professor Elchanan Mossel, MIT professor Joshua Tenenbaum, and Cornell University professors Austin Benson, Joseph Halpern, and Jon Kleinberg.

This project, one of 24 selected for funding from a merit-based review of 295 proposals, is designed to support research teams pursuing basic research spanning multiple scientific disciplines. Awards of approximately $1.5 million per year for three to five years have been given to teams located across 73 US academic institutions.

IDSS and SSRC hosted the inaugural Learning for Dynamics and Control (L4DC) conference in May with Professor Jadbabaie as a co-organizer. L4DC, sponsored by the National Science Foundation, the US Air Force Office of Scientific Research, the Office of Naval Research, and the Army Research Office, explored an emerging scientific area at the intersection of artificial intelligence and machine learning, control theory, robotics, and optimization. More than 400 participants attended the event.

Center for Biomedical Innovation

The MIT Center for Biomedical Innovation (CBI) integrates the Institute's technical, scientific, and management expertise to solve complex biopharmaceutical challenges and improve the impact of biomedical innovation on society. CBI advances cross-stakeholder collaboration and practice through a range of multidisciplinary real-world initiatives. These activities bring parties together for mutual advantage and create system-scale health-care impact. CBI is primarily funded through consortium activities and supports staff, students, outreach, and research activities.

Initiatives

NEW Drug Development ParaDIGmS (NEWDIGS) is a collaborative "think and do" effort with the mission of enhancing the capacity of the global biomedical innovation system to reliably, efficiently, and sustainably deliver new, better, and affordable therapeutics to the right patients. Major NEWDIGS projects over the past year were FoCUS (Financing and Reimbursement of Cures in the US) and LEAPS (Learning Ecosystems Accelerator for Patient-centered, Sustainable innovation).

FoCUS addresses the pressing need for innovative financing and reimbursement models for curative therapies that ensure timely access for patients in need, affordability for payers, and incentives for sustainable innovation by manufacturers. Launched in May 2016, the FoCUS project has 18 sponsoring bodies and more than 170 participants. This year, FoCUS has participated in 23 speaking engagements and been featured 24 times in print media. The project is now focusing on implementation barriers and obstacles for financing solutions and dissemination through events (e.g., Paying for Cures in Washington, DC, in February 2019, which attracted more than 250 attendees), research briefs, and publications.

LEAPS continues to progress with the planning of a Massachusetts pilot that will focus on "downstream innovation" to improve patient outcomes and health-care efficiency by transforming how stakeholders collaboratively produce and use evidence. Centered on rheumatoid arthritis "regimen optimization" (i.e., getting the right treatment to the right patient at the right time), the project is in the second year of a two-year feasibility and design phase. Multi-functional, multi-stakeholder teams are engaged in the planning and development of two initial platforms: Real World Discovery and Adaptive Point of Care.

The Biomanufacturing Consortium (BioMAN) is a collaborative pre-competitive group comprising 11 biopharmaceutical manufacturers and technology and service providers. During the past year, BioMAN hosted two workshops attended by consortium members, MIT faculty, and guests: "Process Intensification" in September 2018 and "Raw Material Variability: The Impact and Opportunity for Pre-competitive Collaboration" in May 2019. In December 2018 the consortium hosted its 10th annual BioMAN Summit, Driving Innovation in Cell and Gene Therapy Manufacturing, where approximately 200 attendees from academia, industry, and government explored the lessons learned from recent product approvals and the critical role technology innovation plays in ensuring that important biologic medicines reach the patients who need them. BioMAN also co-organized (with University College London) the June 2019 Vaccines Bioprocess and Commercialization workshop, which explored critical issues at various stages of vaccine development.

The Consortium on Adventitious Agent Contamination in Biomanufacturing (CAACB) is a collaborative pre-competitive consortium with 22 biopharmaceutical manufacturers and technology and service providers. CAACB hosted two workshops at MIT over the past year: "Adventitious Agent Control for New Manufacturing Modalities" in October 2018 (attended by 83 members) and "Evolving Challenges in Microbial Control in Biomanufacturing" in April 2019 (attended by 78 members). Outcomes of the group's research projects were presented at two workshops during 2018–2019. A paper on the topic of facility segregation was published by the *PDA Journal of Pharmaceutical Science and Technology* in the April/May 2019 online edition.

BioACCESS, a global health initiative, aims to enable universal access to biotherapeutics, especially for non-communicable diseases in resource-constrained settings, through innovative approaches to systems analysis, technology development, policy design, and education. In February 2019, BioACCESS hosted its inaugural seminar, "Meeting the Challenge of Ensuring Global Access to Insulin."

Center for Biomedical Innovation Educational Activities

CBI offered 7.458/7.548/10.03/10.53 Advances in Biomanufacturing in spring 2019. Guest lecturers, including regulators and subject-matter experts from industry, offered a deep dive on a focused topic. "Principles of Biomanufacturing" was offered on xPRO in winter 2019 for 125 professionals.

The National Institute for Innovation in Manufacturing Biopharmaceuticals, established in 2017 as a member of the Manufacturing USA network of public-private partnerships, focuses on innovation in biopharmaceutical manufacturing and the associated US workforce. CBI personnel continued to play key roles in the institute's development and growth, providing significant support to all structural efforts including proposal writing, local and national team building, fundraising and partner negotiations, and the launch of the first two project calls. CBI is part of a team led by Professor Krystyn Van Vliet that was awarded $1.3 million from the National Institute for Innovation in Manufacturing Biopharmaceuticals for the workforce development project "Blended Learning for Training of Cell Therapy Manufacturing Personnel." The team is working with the Worcester Polytechnic Institute and three industry partners to create an online course on the fundamentals of cell therapy manufacturing coupled with a hands-on training component.

Research Highlights

NEWDIGS continues to develop and host design labs for exploring the efficacy to effectiveness clinical trial strategy and implementation with the Johns Hopkins and Tufts University Trial Innovation Center. In addition, NEWDIGS was awarded a seed grant from the Harvard-MIT Center for Regulatory Science for research into the extension of a cloud-based regulatory system to include information on performance-based contracts for payers.

Along with researchers from the School of Engineering, the School of Science, and the Sloan School of Management, CBI was awarded a $5 million grant from the US Food and Drug Administration (FDA) to study and improve the use of data analytics in biomanufacturing. The group's three-year project, Smart Data Analytics for Risk-Based Regulatory Science and Bioprocessing Decisions, offers key opportunities for innovation in machine learning, process data analytics, and artificial intelligence to improve regulatory science and manufacturing.

In a collaboration with the School of Engineering and the School of Science, CBI was awarded a $1.8 million grant from the FDA Center for Biologics Evaluation and Research for a three-year project to develop continuous viral vector manufacturing based on mechanistic modeling and novel process analytics.

CBI is engaged in research as part of the Sloan School of Management's emerging Food Supply Chain Analytics and Sensing Initiative, which will focus on three major areas: supply chain design and optimization, access to healthy food, and food supply analytics. Supported by a $1.6 million per year Walmart Foundation grant, CBI is working on projects in the supply chain and supply analytics focus areas.

CBI will work on a flagship research project for the Singapore-MIT Alliance for Research and Technology's Critical Analytics for Manufacturing Personalized Medicine (SMART CAMP) group. The project, a collaboration with the Agency for Science, Technology and Research, will be supported by the National Research Foundation.

Paula (Gigi) Hirsch is the executive director of CBI, and Stacy Springs is the senior director of programs.

Center for Complex Engineering Systems

The Center for Complex Engineering Systems (CCES) is based jointly at MIT and the King Abdulaziz City for Science and Technology (KACST), Saudi Arabia's national science agency. Since its inception in 2011, CCES has been part of KACST's Joint Centers of Excellence Program (JCEP). JCEP's core mission is to foster the necessary research environment to improve competitiveness and capacity for innovation through scientific inquiry and to participate in a rigorous training program, the Technology Leaders Program, which is designed to train and qualify a new generation of leaders, decision makers, and scholars. The program's researchers are selected from the top 0.5% of applicants from across the Kingdom.

CCES has a notably high research output as well as high acceptance rates to top-tiered schools of engineering. To date, 17 CCES researchers (eight women and nine men) have

been admitted to master's and doctoral programs in departments, labs, and centers across MIT (e.g., Computer Science and Artificial Intelligence Laboratory, Department of Civil and Environmental Engineering, Media Lab). More than 40 researchers who have participated in the collaboration have been accepted to top-tier schools across the world, including Oxford, Cambridge, Stanford, the California Institute of Technology, the University of California at Berkeley, Cornell, and the Georgia Institute of Technology (Georgia Tech). There are approximately 100 people involved in the collaboration, split equally between MIT and KACST.

CCES research volume and quality remain strong. Since the inception of the collaboration, hundreds of publications have been accepted by leading peer-reviewed journals and competitive conferences. These publications and discoveries are an important resource for business leaders and policymakers in Saudi Arabia and beyond who are focused on the modernization of economies and infrastructure.

The co-directors of CCES are Professor Kamal Youcef-Toumi (at MIT) and Ahmad Alabdulkareem (at KACST). Alabdulkareem was the first PhD graduate of the CCES Technology Leaders Program.

Consortium for Engineering Program Excellence

The research efforts of the Consortium for Engineering Program Excellence (CEPE) focus on improving program performance by examining the relationships and interactions between diverse functions and stakeholders involved in complex engineering programs. The research is framed through the lenses of program management, systems engineering and product development, lean management, and organizational change fields. Strategic partners in this work are the Project Management Institute and the Brightline Initiative. Over the past year, five conference papers were accepted and presented. Additionally, three professional publications, two professional conference presentations, two panel presentations, and a global webinar were delivered. During this period, six CEPE-advised master's theses were completed, and another two master's theses were begun.

Professor Warren Seering is CEPE's principal investigator, and Eric Rebentisch is research lead.

MIT Connection Science

Professor Alex "Sandy" Pentland's Connection Science research program is a global community of researchers and practitioners from leading organizations who are working together to invent the future of artificial intelligence, blockchain, and big data. In 2019, the initiative continued to receive major funding from SwissCom, Fidelity Investments, IBM, EY, and WestPac Bank. This funding supports research that uses artificial intelligence and machine learning to understand and change real-world human behavior. "Living labs" have been established in Israel, Senegal, China, Italy, and Colombia through an MIT-developed system called "OPAL" that represents a breakthrough in trusted computation on the Internet. This work supports the emerging personal data ecosystem in which people, organizations, and computers can manage access to their data more efficiently and equitably.

Office Chérifien des Phosphates Group of Morocco

As part of the OCP Morocco–MIT collaboration, IDSS director Munther Dahleh launched a research project on smart services and digital farming. The project focuses on data-driven decisions for digital farming in Africa and includes Moroccan university partner King Mohammed VI Polytechnic (UM6P). The long-term goal of this new line of research is to empower farmers, particularly in rural Africa and other developing countries, to improve their production through investments in technologies. In addition to the research program, the project award includes a visualization lab and visiting postdoctoral fellows. The award totals $7 million over five years and is managed by SSRC.

In FY2019, IDSS professor Richard de Neufville also received a three-year grant from OCP totaling $750,000. Visiting postdoctoral fellows from UM6P will help conduct research on improved flexibility in infrastructure planning.

Systems Engineering Advancement Research Initiative

The Systems Engineering Advancement Research Initiative (SEAri) continued several sponsored research projects funded by the US Department of Defense and by the Naval Postgraduate School. SEAri leads MIT's continuing participation in the Systems Engineering Research Center (SERC) of the US Department of Defense. SEAri is actively engaged in collaboration with other universities involved in the SERC research program, including Purdue, the Stevens Institute, Georgia Tech, and the University of Southern California. Ten master's-level graduate students from several degree programs performed research with the group.

SEAri published one journal paper, five publicly available government research reports, and five refereed conference papers. SEAri researchers gave six invited talks at government-sponsored forums and participated in a research conference invited panel session. In addition, SEAri researchers continued as instructors in the MIT xPRO certificate program Architecture and Systems Engineering: Models and Methods to Manage Complex Systems.

Donna Rhodes is SEAri's principal investigator, and Adam Ross is a collaborating research scientist.

Ali Jadbabaie
Director, Sociotechnical Systems Research Center
Associate Director, Institute for Data, Systems, and Society
JR East Professor of Engineering

Statistics and Data Science Center

The mission of the Statistics and Data Science Center (SDSC) is to serve as an MIT-wide focal point for advancing research and education programs related to statistics and data science by developing new academic programs in this field.

Leadership

Professor Devavrat Shah (Electrical Engineering and Computer Science [EECS]) is the center's director. Additional leadership comes from SDSC members who partially represent the diversity of research foci the center embraces. These members include Alexander "Sasha" Rakhlin (Brain and Cognitive Sciences), Victor Chernozhukov (Economics), David Gamarnik (Management), and Philippe Rigollet (Mathematics).

Professor Rakhlin is program chair for the Interdisciplinary Doctoral Program in Statistics. Professors Shah and Gamarnik co-chair the curriculum committee for the minor in statistics and data science.

Promotions

SDSC core faculty member Ankur Moitra (Mathematics) and affiliate member Aleksander Madry (EECS) were promoted to associate professor with tenure.

Awards

SDSC faculty awards, grants, and recognition during 2018–2019 include the following:

- EECS associate professor Tamara Broderick won a Notable Paper Award at the International Conference on AI and Statistics for "A Swiss Army Infinitesimal Jackknife." She also received a Junior Bose Award for outstanding educational contributions from the School of Engineering.

- Emery Brown, Edward Hood Taplin Professor of Medical Engineering and Computational Neuroscience and professor of health sciences and technology, was presented the 2018 Carnegie Mellon University Dickson Prize in Science for his substantial achievements in statistical analysis of neuronal data.

- EECS professor Constantinos Daskalakis won the 2018 Rolf Nevanlinna Prize, one of the most prestigious international awards in mathematics. He also received the Grace Murray Hopper Award from the Association for Computing Machinery (ACM), a Bodossaki Foundation Scientific Prize, and an EECS Frank Quick Faculty Research Innovation Fellowship.

- Tommi Jaakkola, Thomas Siebel Professor in EECS and the Institute for Data, Systems, and Society was named one of the Top 100 AI Leaders in Drug Discovery and Advanced Healthcare by Deep Knowledge Analytics.

- Professor Moitra Rockwell International Career Development Associate Professor, was awarded a 2018 Teaching Prize from the School of Science for his graduate course 18.409 Algorithmic Aspects of Machine Learning.

- Professor of mathematics Elchanan Mossel received a Simons Investigator Award in the Mathematics category from the Simons Foundation. In addition, Professor Mossel is part of a project team led by Ali Jadbabaie that was awarded a Multidisciplinary University Research Initiative grant from the US Army Combat Capabilities Development Command's Army Research Laboratory.

- Professor Rakhlin won the 2019 Joseph A. Martore Award for Excellence in Teaching in IDSS.

- Professor Rigollet was awarded a grant from the National Science Foundation.

- Professor Shah won the 2019 ACM Sigmetrics Test of Time Paper Award. The award recognizes an influential performance evaluation paper whose impact is still felt 10 to 12 years after its initial publication.

- David Sontag, Hermann von Helmholtz Associate Professor of Medical Engineering, and Peter Szolovits, professor of computer science and engineering, jointly received the Burgess (1952) and Elizabeth Jamieson Prize for Excellence in Teaching from EECS. Also, Professor Szolovits was named among the Top 100 AI Leaders in Drug Discovery and Advanced Healthcare by Deep Knowledge Analytics.

- Suvrit Sra, Edgerton Career Development Associate Professor in EECS, received a National Science Foundation CAREER Award. He was also awarded a Transdisciplinary Research in Principles of Data Science grant.

- John Tsitsiklis, director of the Laboratory for Information and Decision Systems and Clarence J. Lebel Professor in EECS, and Dimitri Bertsekas, the Jerry McAfee (1940) Professor of Engineering, jointly received the John von Neumann Theory Prize from the Institute for Operations Research and the Management Sciences.

- EECS associate professor Caroline Uhler received a Simons Investigator Award in the Mathematical Modeling of Living Systems category from the Simons Foundation.

- EECS professor Alan Willsky (retired) was awarded the Institute of Electrical and Electronics Engineers 2019 Jack S. Kilby Signal Processing Medal for outstanding achievements in signal processing.

Education

Minor in Statistics and Data Science

In 2018–2019, 21 MIT undergraduates applied to the minor in statistics and data science program. Twenty students graduated with the minor.

Interdisciplinary Doctoral Program in Statistics

The Interdisciplinary Doctoral Program in Statistics (IDPS) is a dual doctoral program for students currently enrolled in a participating MIT doctoral program who wish to develop their understanding of 21st-century statistics within their chosen field of study. In 2018–2019, Behavioral and Cognitive Sciences joined the list of participating MIT doctoral programs, which also includes Aeronautics and Astronautics, Economics, Mathematics, Political Science, and IDSS's own Social and Engineering Systems program.

Ten students are currently enrolled in the program. SDSC graduated three IDPS students in 2018–2019: Vira Semenova (Economics), Jan-Christian Hütter (Mathematics), and Jonathan Weed (Mathematics).

Online MicroMasters Program in Statistics and Data Science

Courses for the new MIT Statistics and Data Science MicroMasters program launched in fall 2018. The program, which consists of four online courses and a virtually proctored exam, provides learners with the foundational knowledge essential to understanding the methods and tools used in data science, including hands-on training in data analysis and machine learning.

Learners who successfully complete the MITx MicroMasters receive the MicroMasters credential, which makes them eligible to earn credit at a number of universities across the globe to fast track their pursuit of a full master's degree. The list of eligible universities is expanding each semester.

In 2018–2019, 1,353 learners purchased all four courses as a bundle. The number of learners who enrolled in the four courses are listed below.

- 6.431x Probability—The Science of Uncertainty and Data (an introduction to probabilistic models, including random processes and the basic elements of statistical inference, as well as the foundations of data science): 31,896 enrolled (1,568 verified) during September to December 2018 and 32,639 enrolled (1,718 verified) for May to July 2019

- 14.310Fx Data Analysis in Social Science—Assessing Your Knowledge (methods for harnessing and analyzing data to answer questions of cultural, social, economic, and policy interest): 9,047 enrolled (358 verified) during November and December 2018 and 3,404 enrolled (397 verified) during April and May 2019

- 18.6501x Fundamentals of Statistics (enables learners to develop a deep understanding of the principles that underpin statistical inference, including estimation, hypothesis testing, and prediction): 23,625 enrolled (775 verified) during February to June 2019

- 6.86x Machine Learning with Python: From Linear Models to Deep Learning (an in-depth introduction to the field of machine learning, from linear models to deep learning and reinforcement learning, with hands-on Python projects): 36,686 enrolled (1,413 verified) for June to September 2019

Data Science and Big Data Analytics: Making Data-Driven Decisions

The seven-week online professional education course Data Science and Big Data Analytics: Making Data-Driven Decisions is designed for data scientists and data analysts as well as professionals who wish to turn large volumes of data into actionable insights.

The course ran four times between July 2018 and June 2019, with 1,640 registrants and 1,262 certificates issued. This brings the total number of learners for this course to 7,109, 5,501 of whom have been certified. On average, 77% of learners have received certificates.

Learners for this course come from all over the world. Over the past year, 18 countries had 25 or more enrolled learners: the United States, Canada, the United Kingdom, India, Brazil, Spain, Australia, Mexico, Germany, Thailand, France, Switzerland, Singapore, Hong Kong, Colombia, Peru, Chile, and the United Arab Emirates.

Workshops and Conferences

SDSCon 2019

The third annual SDSCon was a celebration of MIT's statistics and data science community organized by SDSC on April 5, 2019. The conference featured presentations from established academic leaders, industry innovators, and rising stars in the field of statistics and data science. Discussions covered a wide range of theory and application representing the latest research and breakthroughs in the field. More than 200 people attended SDSCon 2019.

Stochastics and Statistics Seminar Series

This signature series of weekly seminars hosted by SDSC features top statisticians and data scientists from around the world. Seminars in fall 2018 and spring 2019 included:

- Variational Problems on Random Structures and Their Continuum Limits (Dejan Slepcev, Carnegie Mellon University [CMU])

- An Information-Geometric View of Learning in High Dimensions (Gregory Wornell, MIT)

- Unsupervised Ensemble Learning (Boaz Nadler, Weizmann Institute)

- Reverse Hypercontractivity Beats Measure Concentration for Information Theoretic Converses (Jingbo Liu, MIT)

- Efficient Algorithms for the Graph Matching Problem in Correlated Random Graphs (Tselil Schramm, Harvard University)

- Locally Private Estimation, Learning, Inference, and Optimality (John Duchi, Stanford University)

- Algorithmic Thresholds for Tensor Principal Component Analysis (Aukosh Jagannath, Harvard University)

- On the Cover Time of Two Classes of Graph (Alan Frieze, CMU)

- Joint Estimation of Parameters in Ising Model (Sumit Mukherjee, Columbia University)

- Optimal Hypothesis Testing for Stochastic Block Models with Growing Degrees (Zongming Ma, University of Pennsylvania)

- Model-X Knockoffs for Controlled Variable Selection in High Dimensional Nonlinear Regression (Lucas Janson, Harvard University)

- Bias Reduction and Asymptotic Efficiency in Estimation of Smooth Functionals of High-Dimensional Covariance (Vladimir Koltchinskii, Georgia Tech)

- Reducibility and Computational Lower Bounds for Some High-dimensional Statistics Problems (Guy Bresler, MIT)

- Large Girth Approximate Steiner Triple Systems (Lutz Warnke, Georgia Tech)

- Optimization of the Sherrington-Kirkpatrick Hamiltonian (Andrea Montanari, Stanford University)

- Medical Image Imputation (Polina Golland, MIT)

- TAP Free Energy, Spin Glasses, and Variational Inference (Zhou Fan, Yale University)

- Capacity Lower Bound for the Ising Perceptron (Nike Sun, MIT)

- Why Aren't Network Statistics Accompanied by Uncertainty Statements? (Eric Kolaczyk, Boston University)

- Univariate Total Variation Denoising, Trend Filtering and Multivariate Hardy-Krause Variation Denoising (Aditya Guntuboyina, University of California at Berkeley)

- Subvector Inference in Partially Identified Models with Many Moment Inequalities (Alex Bellioni, Duke University)

- Optimization of Random Polynomials on the Sphere in the Full-RSB Regime (Eliran Subag, New York University)

- Exponential Line-Crossing Inequalities (Aaditya Ramdas, CMU)

- Logistic Regression: The Importance of Being Improper (Dylan Foster, MIT)

- Robust Estimation: Optimal Rates, Computation and Adaptation (Chao Gao, University of Chicago)

- Optimal Adaptivity of Signed-Polygon Statistics for Network Testing (Tracy Ke, Harvard University)

- Counting and Sampling at Low Temperatures (Will Perkins, University of Illinois at Chicago)

Devavrat Shah
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