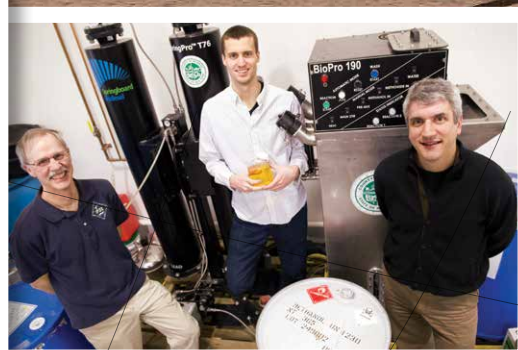# R·I·T

DOCTORAL **PROGRAMS**

Thank you for your interest in the doctoral programs at Rochester Institute of Technology! I invite you to explore RIT's exceptional Ph.D. programs to learn about our areas of research and scholarship, and to meet some of our outstanding students and alumni. Graduate education at RIT is infused with the spirit of innovation and imagination. Our unique portfolio of programs offers a strong foundation in the STEM disciplines, while offering several options for interdisciplinary enrichment with the humanities and the arts.

Along with providing outstanding opportunities for hands-on research in cutting-edge fields from Earth remote sensing and astrophysics to sustainability and engineering, we also stress the importance of applying fundamental research insights to promote inquiry and to solve real-world problems. RIT welcomes an international student body that represents all 50 states and more than 100 countries. RIT attracts competitive and diverse graduate students from around the world, including several Fulbright fellows. Our graduate students earn prestigious fellowships from federal agencies and private and international foundations. The degrees our students pursue enable them to become active global citizens and leaders engaged in the search for solutions to the world's most pressing problems. Our alumni go on to pursue a wide range of careers in the private and not-for-profit sectors, government, industry, and academia.

You will study in facilities that house modern, sophisticated equipment and state-of-the-art laboratories for computing, biological sciences, fabrication of integrated circuits, biomedical imaging and computer simulation, engineering technology, and nanopower research. RIT is also developing advanced green technologies through our programs in sustainability.

I invite you to join our dynamic community of lifelong learners as you prepare for world-class research and leadership at RIT and beyond.

Twyla J. Cummings, Ph.D.
Dean of Graduate Education

Engineering: Engineers solve problems, and we are addressing fundamental and applied research problems of global importance for the 21st century. We focus on problems arising from four key sectors: transportation, energy, health care, and communications. These problems impact every individual on the planet and demand highly trained engineers with deep disciplinary skills and a thorough contextual understanding for their research efforts. We educate doctoral engineers from all engineering disciplines and our students develop and apply a variety of technical tools to address societal needs.

Astrophysical Sciences and Technology
College of Science

Andrew Robinson, Ph.D.
Program Director

Astrophysical sciences and technology: A new generation of advanced, ground-based and space-borne telescopes, coupled with powerful computing capabilities, has revolutionized astronomy and astrophysics. This program focuses on exploiting these capabilities to study the physical processes governing phenomena beyond Earth as well as the development of the technologies—the instruments, analysis, and modeling techniques—that will enable further advances in our understanding of the universe.

There has never been a more exciting time to study the universe beyond the confines of the Earth. The doctoral program in astrophysical sciences and technology (AST) focuses on the underlying physics of phenomena beyond the Earth, and on the development of the technologies, instruments, data analysis, and modeling techniques that will make possible the next advances in the field.

With tracks in astrophysics, computational astrophysics, and astronomical technology, the program offers a wide range of intellectually challenging options within an informal, student-centered, and supportive environment. The program provides the opportunity to work with internationally prominent researchers in any of three research centers of excellence: The Laboratory for Multiwavelength Astrophysics, the Center for Computational Relativity and Gravitation, and the Center for Detectors.

Current research areas span forefront topics in cosmology; observational, theoretical, and computational astrophysics; general relativity and gravitational wave astronomy; and astronomical instrumentation and detectors. Faculty and students study star and planet formation, stellar evolution, supermassive black holes, galaxy evolution, and other topics using multi-wavelength observations obtained with major facilities such as the Hubble, Chandra, and Spitzer Space Telescopes, the Gemini Observatory, and the Atacama Large Millimeter Array. In the new era of gravitational wave astronomy, students can join teams searching for signals in data from the Laser Interferometer Gravitational-Wave Observatory. Those interested in computational astrophysics or numerical relativity have access to a dedicated on-site supercomputer lab, or national peta-scale supercomputing facilities. The technically inclined can help develop detectors or instruments for next-generation observatories, such as the James Webb Space Telescope, or dedicated instruments for deployment aboard sub-orbital rockets, using the advanced facilities available in the Rochester Imaging Detector Laboratory.
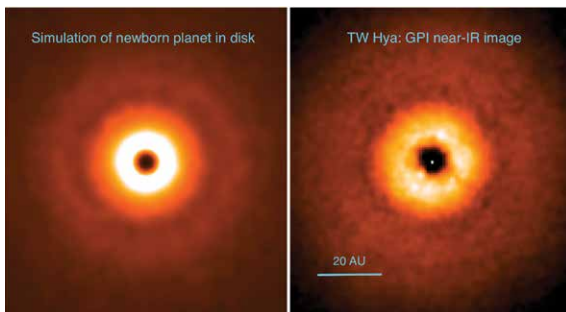
Comparison of a simulation of a sub-Jupiter-mass planet carving a gap in a protoplanetary disk (left), with a coronographic near-infrared image of the disk orbiting the nearby young star TW Hya (right), that was obtained by a team led by 2015 AST Ph.D. recipient Valerie Rapson, using the Gemini 8-meter telescope and its new extreme adaptive optics Gemini Planet Imager camera. The comparison indicates that a newborn planet with a few tenths of Jupiter's mass is present within TW Hya's disk at an orbit similar to that of Uranus in our solar system.

Triana Almeyda, a fifth-year doctoral student in astrophysical sciences and technology, is funded by a NASA grant to model the structure and geometry of dusty clouds surrounding supermassive black holes that reside in the center of galaxies. She is a key member of an RIT-led international team that is using data from 2½ years of observations with the Spitzer Space Telescope to study the circum-nuclear dust "torus" in several active galaxies. She has developed a computer program that she is using to model the observed changes in the infrared dust emission.

Manuela Campanelli, Ph.D., director of RIT's Center for Computational Relativity and Gravitation, is a leading expert in computational general relativity, the astrophysics of black holes and gravitational waves. Her groundbreaking work on numerical simulations of binary black hole space times enabled precise modeling of the signal measured in the first direct detection of gravitational waves by the Laser Interferometer Gravitational-Wave Observatory. Another of her papers was among those selected for a collection of landmark papers marking the centenary of general relativity.

Color Science
College of Science

Mark Fairchild, Ph.D.
Program Director

Color has been a topic of intense interest and inquiry for thousands of years. Philosophers (Aristotle), poets (Goethe), physicists (Newton), and mathematicians (Schrödinger) have all contributed to our understanding of color. Color science can be defined as the quantification of color appearance. Its mastery requires an interdisciplinary educational approach encompassing physics, chemistry, physiology, psychology, and computer science. Color science is used in the design and control of most man-made colored materials including textiles, coatings, and polymers and to specify the properties of diverse materials such as soil and wine. It is used extensively in color imaging, including digital photography, desktop and projection display, and printing.

The color science program is designed for students whose undergraduate majors are in physics, chemistry, mathematics, computer science, engineering, experimental psychology, imaging, or any applied discipline pertaining to the quantitative description of color.


The TangiPaint system represents a first step toward developing digital art media that look and behave like real materials. James A. Ferwerda, Ph.D., right, developed TangiPaint along with Ben Darling, a graduate student in color science.

Jennifer Kruschwitz was encouraged to go into color science after speaking with female professionals who were successful in the field. These mentors pushed her to learn all she could to excel. It's fitting that Kruschwitz was named the Technology Woman of the Year by Digital Rochester.

The doctoral student was working at Bausch & Lomb when she first became acquainted with RIT's Munsell Color Science Laboratory. A few years later she decided to pursue an advanced degree and her experience at the Munsell Lab drew her back to RIT. "The Munsell Color Science Laboratory has been in the forefront of color difference evaluation, color appearance, and many other high-profile areas within the OSA, CIE, and SPIE," says Kruschwitz. "Graduates of the program are in high demand at companies all over the globe and the reason is because of the caliber of course work and laboratories."

Dr. Kruschwitz is now an assistant professor in the Institute of Optics at University of Rochester. She is a member of the Optical Society of America and the International Society for Optical Engineers, and has published more than 15 journal articles. She also has served on the board of The New Agenda, which seeks to improve the lives of women and girls, and on the Optical Society of America International Society Board of Directors.

Computing and Information Sciences
B. Thomas Golisano College of Computing and Information Sciences

Pengcheng Shi, Ph.D.
Program Director
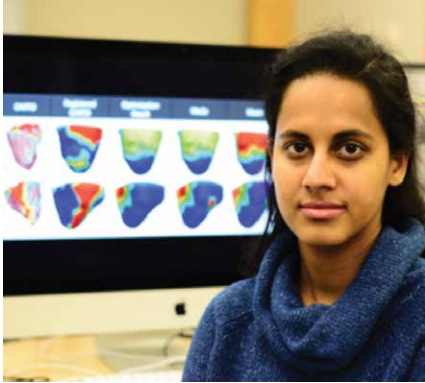
Jwala Dhamala, a third-year doctoral student in computing and information sciences, presented her paper "Spatially-adaptive multi-scale optimization for local parameter estimation: application in cardiac electrophysiological models" at the prestigious 2016 Medical Imaging Computing and Computer-Assisted Intervention Conference in Athens, Greece. Dhamala's research lies in the program's focus on cyber-enabled personalized medicine, investigating the uncertainty of patient-specific large-scale simulation models so they can be reliably adopted in clinical settings for personalizing treatment and predicting disease progression. "It is a rare opportunity to work on a research effort that both pushes the frontiers of computer science and has a direct real-life application," she says. To carry out this interdisciplinary research, Dhamala is not only trained in computing and information sciences, but also has collaborated with scientists and clinicians from other disciplines, including multi-scale cardiac modeling at Johns Hopkins University, high-performance computing at Rutgers University, and clinical applications at Johns Hopkins and Dalhousie universities.
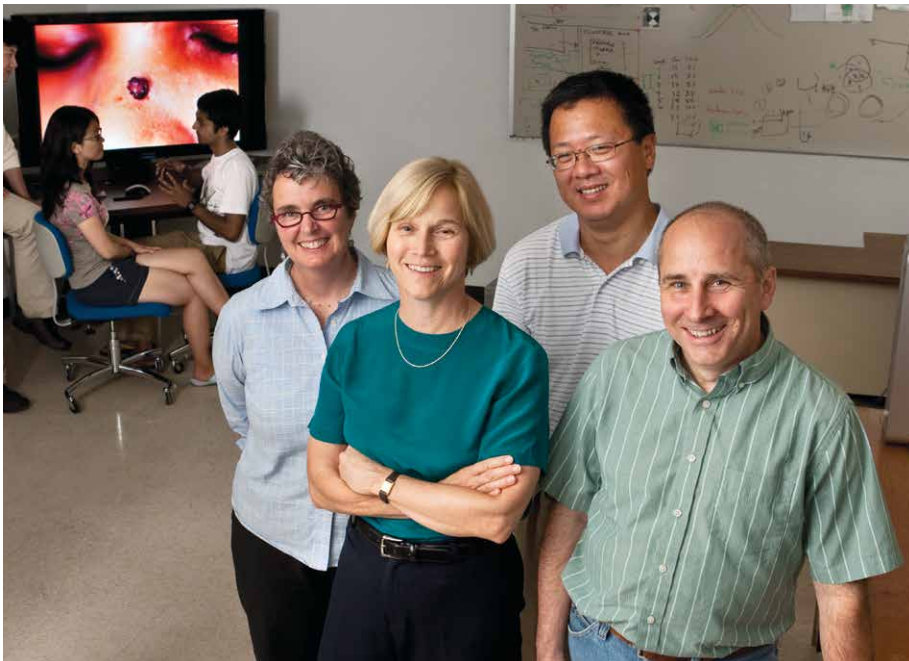
When collecting, retrieving, and analyzing complex biomedical images, many dermatologists are now using computer databases to assist with managing and manipulating large amounts of data. However, these systems often do not provide the same level of nuanced assessment or have the experiential advantage of human analysts. Cara Calvelli (dermatologist), Anne Haake (human-computer interaction), Pengcheng Shi (data analytics), and Jeff Pelz (eye tracking) are leading an RIT team that is seeking to advance the use of these systems by modeling the expert knowledge of dermatologists and using it to make image retrieval systems more "human."

The Ph.D. program in computing and information sciences is a use-inspired research program that is designed to produce independent scholars, well-prepared educators, and cutting-edge researchers to excel in computing and inter-disciplinary careers in academia, industry, and government. It highlights the breadth of RIT's educational offerings and the scholarly emphasis on discovering solutions to real-world problems by balancing theory and practice. The program focuses on both the theoretical and practical aspects of cyberinfrastructure, as well as domain problems in arts, business, engineering, humanities, medicine, and science that can be assisted, enabled, and inspired by computing technology. About one-third of our graduates have moved on to pursue academic careers in the U.S. and overseas, while the remaining are thriving in industry R&D ranging from Google and IBM to Silicon Valley startups and Wall Street.

Active research areas in computing technology: algorithms & theory, artificial intelligence, communication & networking, data management & analytics, graphics & visualization, human-computer interaction, mobile & pervasive computing, machine learning & data mining, natural language processing, security & privacy, social computing, software engineering, and more.

Active research areas in domain application: access technology, bio-computing & health IT, computational sustainability & green IT, education informatics, geographic information system, personalized medicine, urban analytics, and more.

Engineering
Kate Gleason College of Engineering

Edward Hensel, Ph.D.
Program Director

Olivia Scheibel entered the engineering Ph.D. program in fall 2015. Her work is focused on the development of novel intracellular electrochemical sensing technologies using templated manufacturing of carbon nanotubes. Her adviser is Dr. Michael Schrlau, director of the Nano-Bio Interface Lab in mechanical engineering. Her work is focused on developing carbon nanotube pipettes to inject genes into stem cells and enable advances in treatment of central nervous system diseases. The long-term goal of her work is to develop a revolutionary intracellular electrochemical probe for use by other researchers seeking to understand the onset and treatment of diseases, such as Parkinson's, in living cells.

The engineering doctoral program will educate the next generation of engineering leaders in a manner enabling them to tackle daunting problems of global importance. The program is built around an interdisciplinary framework to address grand challenges and prepare graduates for careers in industry, government, or academia. Students learn by conducting research under the mentorship of RIT faculty and by taking rigorous course work in their discipline and application domain. The program is designed for students with a background in any engineering discipline such as biomedical, chemical, computer, electrical, industrial, mechanical, or microelectronic engineering.

This interdisciplinary program produces market-driven, technically strong, high-impact graduates with deep disciplinary skills and strong contextual understanding for their research efforts. Graduates will develop socially relevant engineering solutions using the skills and knowledge acquired through education and independent inquiry.

Research strengths of faculty and Ph.D. students in the Kate Gleason College of Engineering include manufacturing & materials, signal & image processing, robotics & mechatronics, heat transfer & thermo-fluids, performance & power-aware computing, access & assistive technologies, simulation modeling & optimization, safety & security, and nano-science & engineering.

Addressing Societal Needs: Breton Minnehan, a member of the first class of students in the Ph.D. program, is working to develop an autonomous system for unmanned aircraft to provide high-resolution information in areas where there is limited mapping information, such as disaster zones. Brett is advised by Dr. Andreas Savakis of the computer engineering department.

Imaging Science
College of Science

David Messinger, Ph.D.
Program Director

For over 30 years, RIT imaging scientist John Schott has been a key figure in the design and deployment of the Landsat series of satellites. The NASA- and USGS-led effort represents the largest widely used, annually updated source of global remote sensing data and provides a wealth of information on historical changes in the environment around the world. One of Schott's many contributions to the Landsat program includes collection of ground truth temperature readings to improve satellite calibration.

In today's world images are everywhere—from mobile phones with high-resolution cameras and displays to images of the Earth from satellite systems. Daily life offers numerous interactions with images. The doctoral program in imaging science emphasizes a broad, interdisciplinary perspective in the science and engineering of all types of imaging systems, including those for consumer devices, Earth remote sensing, astronomical imaging, and the imaging of cultural documents.

The program prepares graduates to contribute immediately to research and product development across the imaging field. Recent graduates have found employment in the consumer imaging and defense industries, national research laboratories, universities, and government agencies.

The imaging science curriculum includes general courses in Fourier methods, radiometry, the human visual system, computer vision, and optics. Students augment these courses with ones in their specific area of research, including courses related to astrophysics, detectors, remote sensing, and virtual reality systems. Applicants typically have undergraduate degrees in physics, optics, electrical engineering, mathematics, chemistry, or computer science.

More than 40 active research faculty from across RIT participate in the imaging science program. The center's externally funded research revenues top $6 million annually. The faculty and students are active participants in international professional societies and routinely attend conferences around the world.

Alexandra Artusio-Glimpse was awarded a prestigious fellowship from the National Science Foundation Graduate Research Fellowship Program for her project, "Optical Lift: Innovating Devices that Fly by Light." Artusio-Glimpse, a doctoral student in imaging science, is focusing on the application of optical lift for steering solar sails—spacecraft that accelerate solely due to radiation pressure from the sun. "We discovered if you take a transparent particle shaped like a very simplified plane wing, it will actually fly like a plane wing will fly. Nobody else has ever tried this type of thing before. It's new territory," says Artusio-Glimpse. "It's amazing how diverse the imaging field is. You need to know about aerodynamics, topology, optics, wave theory." Initial work from this project has already been published in *Nature Photonics*.

Mathematical Modeling
College of Science

Elizabeth Cherry, Ph.D.
Program Director

Elizabeth Cherry has devoted her career to developing, analyzing, solving, and applying mathematical models to improve the understanding of cardiac arrhythmia mechanisms. She received a BS in mathematics and American studies from Georgetown University and a Ph.D. in computer science from Duke University. She has worked at the UCLA School of Medicine, Hofstra University Department of Physics, and Cornell University College of Veterinary Medicine and is presently an associate professor in the School of Mathematical Sciences at the Rochester Institute of Technology and director of the Ph.D. program in mathematical modeling. Her research is interdisciplinary by nature and combines knowledge and techniques from mathematics, physiology, computer science, and physics.

Many current problems in science and technology are of such size and complexity that their solution requires sophisticated techniques drawn from computational and applied mathematics as well as the increasing participation of mathematicians in the interdisciplinary teams of scientists that attack them. Mathematical modeling involves formulating, solving, and interpreting the difficult equations that govern complex mechanisms inherent to many fields such as the biological sciences, computational neuroscience, computational physics and astrophysics, scientific computing, medical sciences, defense, social sciences, traditional business and e-business solutions, economics, reconfigurable devices and materials development, medical devices and drug delivery, and the prediction and function of financial systems.

The program integrates applied mathematics with scientific computing, including high-performance computing, and is interdisciplinary in nature, encompassing the physical, life, medical, and computational sciences. Through extensive research, graduates of this program will have the expertise not only to use the tools of mathematical modeling in various application settings, but also to contribute in creative and innovative ways to solving complex interdisciplinary problems and to communicate effectively with domain experts in various fields.

The mathematical modeling program is designed for students whose undergraduate majors are in science, technology, engineering, and mathematics and whose study provides sufficient mathematics background. Faculty from RIT's School of Mathematical Sciences, School of Physics and Astronomy, Department of Chemical Engineering, and National Technical Institute for the Deaf contribute to the mathematical modeling program.
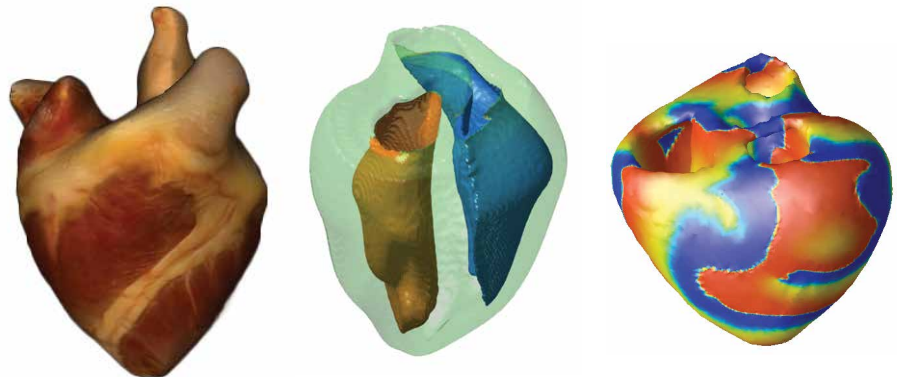
Mathematical modeling of cardiac arrhythmias begins by considering a real heart (left) and developing a digitized structural representation (center) of the muscle and chambers. Then differential equations describing the electrical activity of cardiac cells are coupled together and solved numerically in the realistic structure (right). Here, spiral waves of electrical activity characteristic of ventricular fibrillation can be seen as red wave fronts propagating into quiescent blue regions. The electrical waves trigger contraction, which in this arrhythmic case is poorly coordinated and compromises blood flow.

Microsystems Engineering
Kate Gleason College of Engineering

Bruce Smith, Ph.D.
Program Director

The microsystems engineering doctoral program fulfills a critical need for an expanded knowledge base and expertise in the innovation, design, fabrication, and application of micro- and nano-scale devices, components, and systems. RIT is an internationally recognized leader in education and research in the fields of microsystems and nano-scale engineering. Activities in the program involve the collaboration with industry, government, and other institutions to carry out a broad array of projects involving fundamental challenges and innovative applications. The program is designed for students with a strong background in engineering and the physical sciences, and with an interest in hands-on exploration into new fields of micro- and nano-systems.

The integrative program enables students to build a solid foundation in science and engineering, focus their study and research in a particular discipline of microsystems, and share their findings with others. Students work with world-renowned, multidisciplinary faculty who share resources and expertise ranging from nanoelectronics to microfluidics to MEMS, NEMS, and many more. Unique, state-of-the-art research laboratories provide a focus for microsystems and nano-scale engineering research across traditional disciplinary boundaries. Graduates have discovered exciting opportunities in new technology frontiers.

Michael Slocum received a three-year NASA Space Technology Research Fellowship for work in the area of nano-structured photovoltaics for space power. Slocum's work involves the development of quantum dot nano-structures for high-efficiency, space solar applications including radiation-tolerance. "Long-term goals for this project are to realize an intermediate-band solar cell where the semiconducting material has an intermediate band between the valence and conduction bands, which results in three distinct absorption bands," says Slocum. "The intermediate-band solar cell is an area of high interest to the solar community, because it is seen as one of the few ways to reach conversion efficiencies greater than 50 percent."

NASA fellowships help to accelerate the development of technologies to support future space science and exploration needs of NASA, other government agencies, and the commercial space sector. Slocum will conduct research at NASA's Glenn Research Center in Ohio.

Stefan F. Preble, Ph.D., associate professor of microsystems engineering and leader of RIT's Integrated Photonics, examines photonic devices designed and fabricated by his team. The researchers make extensive use of RIT's Lobozzo Photonics and Optical Characterization Laboratory, a facility established with a gift from Joseph M. Lobozzo II, the founder of Rochester-based JML Optical Industries Inc.

Sustainability
Golisano Institute for Sustainability

Thomas Trabold, Ph.D.
Program Director

The Institute for Sustainability is housed in a LEED platinum-certified facility that features a variety of sustainable material and energy technologies, as well as over 1,000 sensors for monitoring building performance.

The sustainability program infuses a hands-on curriculum to prepare modern sustainable innovators with the technical knowledge needed to succeed. The LEED platinum building that houses the program provides six technology testbeds and 10 laboratories for a unique research-focused learning experience in the areas of sustainable energy, production, mobility, and environmentally benign information technology (eco-IT).

The program's requisite courses span science, engineering, economics, policy, and design for an interdisciplinary learning approach, and then apply this knowledge toward cutting-edge sustainability research. Encouraged activities include advancing sustainability in the local community and working with local nonprofits, industries, and schools to enact sustainable change. Graduates of the program typically discover opportunities as academic faculty; research scientists in national labs, government agencies, and industrial R&D; corporate sustainability directors; environmental policy analysts; and more.

After completing her dual BS degrees in environmental engineering and materials engineering at RPI, **Michele Bustamante** began her Ph.D. studies at RIT under Dr. Gabrielle Gaustad as part of the Critical Materials Research Group.

Her work is aimed at enabling clean energy through a better understanding of challenges and opportunities concerning potentially scarce raw materials that are vital to emerging technologies. Bustamante's work has focused specifically on improving the modeling of supply risk, environmental impact, and policies' risk mitigation potential for rare materials that are key to emerging solar technologies but are only mined as minor byproducts. Her work has been published in several peer-reviewed journals and proceedings, and she has given talks on her work at four internationally attended conferences. Outside of her research, Bustamante dedicates a great deal of time to leadership and volunteer work in the community.

Many student research projects combine laboratory experiments with modeling to assess sustainability aspects of emerging energy technologies such as batteries, fuel cells, solar PV, and biofuels.

Research and Scholarship

RIT is home to more than 70 inter-disciplinary research centers, institutes, and organizations that bring together faculty and students from across the university. These entities explore a wide range of topics and cover everything from business and entrepreneurship to biomedical sciences, nanolithography, printing, social computing, remanufacturing, microsystems fabrication, environmental sustainability, and visual perception. A sampling of RIT's selected centers and institutes includes:

Center for Advanced Device Research

Center for Advancing the Study of Cyberinfrastructure

Center for Applied and Computational Math

Center for Bioscience Education and Technology

Center for Computational Relativity and Gravitation

Center for Detectors

Center for Education Research Partnerships

Center for Electronic Manufacturing and Assembly

Center for Excellence in Lean Enterprise

Center for Integrated Manufacturing Studies

Center for Nanolithography Research

Center for Quality and Applied Statistics

Center for Remanufacturing and Resource Recovery

Center for Student Innovation and Entrepreneurship

Center for Sustainable Mobility

Center for Sustainable Packaging

Center for Sustainable Production

Center on Access Technology

Chester F. Carlson Center for Imaging Science

Computational Biomedicine Laboratory

Digital Imaging and Remote Sensing Laboratory

Golisano Institute for Sustainability

Laboratory for Multiwavelength Astrophysics

Munsell Color Science Laboratory

Science, Mathematics and Education Research Center

Sustainable Systems Research Center

Fellowships, awards, and partnerships

Research conducted by RIT graduate students has earned prestigious fellowships, awards, and scholarships from federal agencies and private and international foundations.

Department of Defense Fellowships

Environmental Protection Agency Science to Achieve Results Fellowship

Excellence in Engineering Education Award

Ford Foundation Grants

Fulbright Scholars

Franc Grum Memorial Scholarship in Color Science

Howard Hughes Medical Institute Med-into-Grad Fellowship

Kaufman Fellowship in Entrepreneurship

Macbeth-Engel Fellowship in Color Science

Ronald McNair Scholars

Edmund S. Muskie Fellows

NASA Space Technology Research Fellowship

National Endowment for the Humanities Awards

National GEM Fellows

National Science Foundation Awards

New York Foundation for the Arts Fellowship

Semiconductor Research Corp. Doctoral Fellowship

Alfred P. Sloan Foundation Grants

U.S. Dept. of Education Graduate Assistance in the Areas of Need Fellowship

List of employers

Many of RIT's doctoral alumni have gone on to work in the private sector, for not-for-profit organizations, and at prestigious universities worldwide. At right is a sampling of where our doctoral alumni are making an impact.

Apple

Applied Materials

Army Research Laboratory

Brookhaven National Laboratory

California Institute of Technology

Canadian Institute for Theoretical Astrophysics

European Southern Observatory

General Dynamics

General Electric Healthcare

Google

Guelph University

Harris Corporation

Harvard-Smithsonian Center for Astrophysics

IBM

INRIA: French National Institute for Research in Computer Science and Control

Integrity Applications

Intel

Michigan State University

Microsoft

MITRE

Motorola Mobility

NASA

Naval Research Laboratory

Netherlands Institute for Space Research

Praxair

Qualcomm

Rapiscan Systems

Ricoh Innovations

Rochester Regional Health System

SRC Inc.

United States Air Force

University of Massachusetts Boston

University of South Dakota

Vanderbilt University

Vencore

West Virginia University

Yale University

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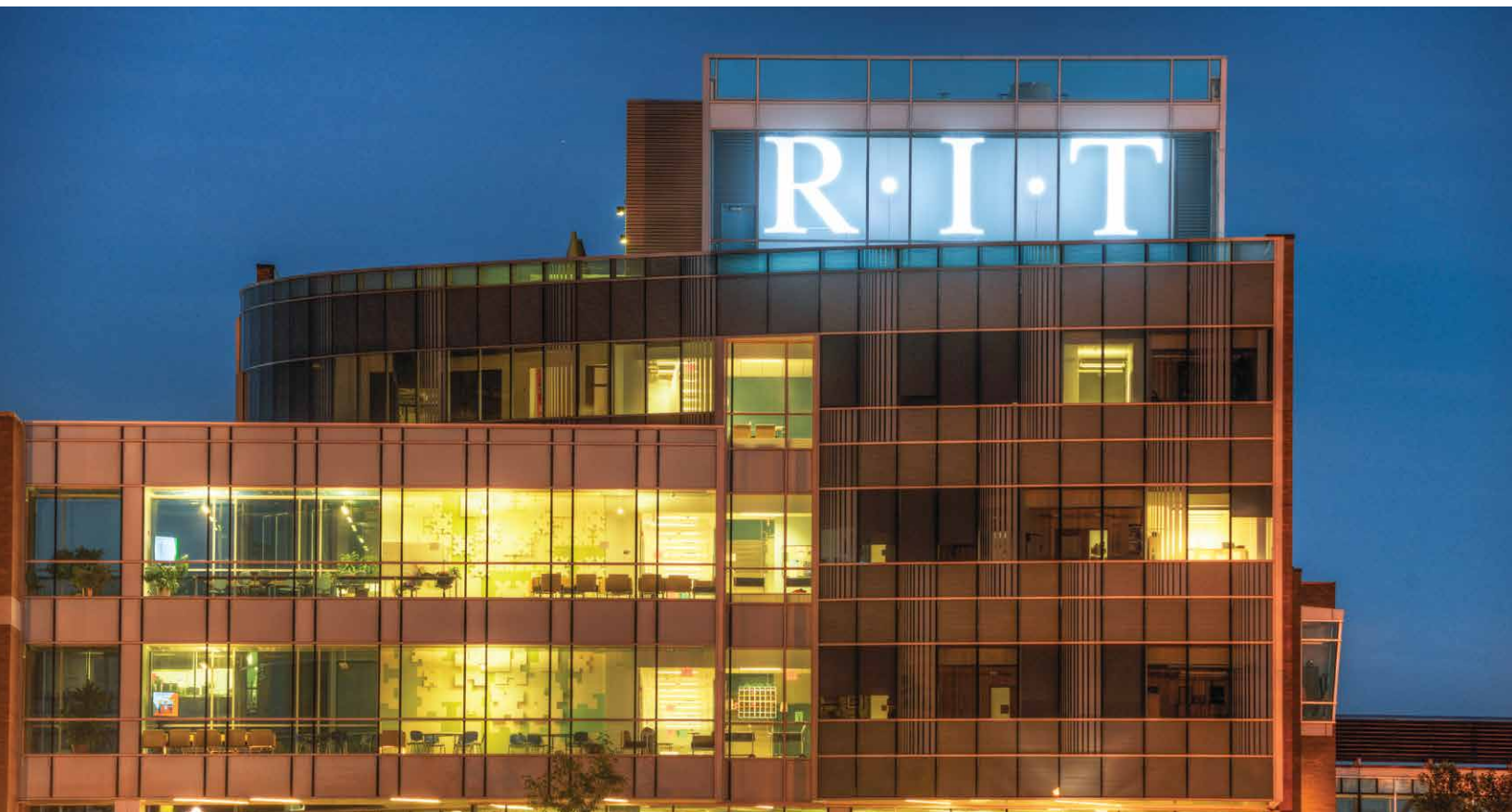
www.rit.edu/phd

RIT IN BRIEF

Colleges:

College of Applied Science and Technology
Saunders College of Business
B. Thomas Golisano College of Computing
    and Information Sciences
Kate Gleason College of Engineering
College of Health Sciences and Technology
College of Imaging Arts and Sciences
College of Liberal Arts
National Technical Institute for the Deaf
College of Science

Other degree-granting academic units:

Golisano Institute for Sustainability
School of Individualized Study

Founded: 1829

Type: Private; coeducational

Student body: Approximately 15,400 under-graduate students, 3,200 graduate students

Graduate degrees offered:

Master of Architecture (M.Arch.)
Master of Business Administration (MBA)
Master of Engineering (ME)
Master of Fine Arts (MFA)
Master of Science (MS)
Master of Science in Teaching (MST)
Doctor of Philosophy (Ph.D.)

For more information:

Graduate Enrollment Services
Phone: 585-475-2229, or toll-free
    866-260-3950
Fax: 585-475-7164 / Email: grad@rit.edu
Web: www.rit.edu/phd