Radiology Department Report 2017–2019

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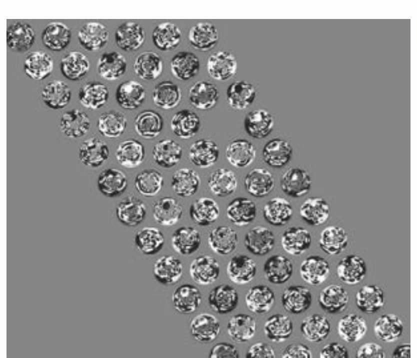
Stanford MEDICINE | Radiology

Cover Image



Shear waves were induced in a cylindrical gelatin phantom using a mechanical vibrator, causing them to scatter and reflect. Their displacements were imaged using a phase-contrast 3T MRI technique (MR elastography). This work highlights the importance of image reconstruction algorithms. Each individual wave image (represented by each circle) is chaotic and difficult to interpret by itself. However, thousands of wave images can be thoughtfully fused together using an image reconstruction algorithm to produce a single image representing the gelatin's mechanical properties. This is symbolized by the careful, structured positioning of the circular wave images into a coherent pattern, which contrasts with the disarray found within each individual wave image. This imaging technique can be used to help clinicians locate elusive tumors in cancer patients. Unfortunately, we are often times limited by the amount of information we can collect, as well as by invalid assumptions made by our algorithm. The void in this image, due to these limitations, symbolizes the gap in our knowledge of the underlying anatomical structures that we are trying to image.

Ningrui Li, PhD Student: Laboratory of Kim Butts Pauly, PhD, Radiological Sciences Laboratory.

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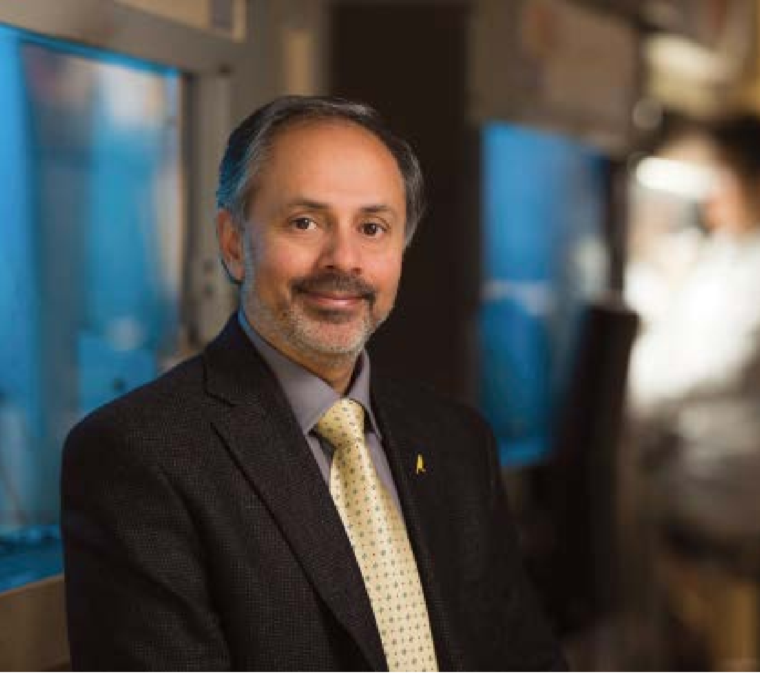
http://radiology.stanford.edu/about/annualreport/



From the Chairman

Dr. Sanjiv Sam Gambhir
Chair, Department of Radiology

IN MY ROLE AS CHAIR of the Stanford Department of Radiology since 2011, I see the department evolving and thriving in many ways. In my previous message to you in the 2017 Department Report, we shared examples of the department's successes and growth in multiple new areas of clinical and research expansion. I am very pleased to say that this growth continues to match our most aggressive expectations.

We remain blessed with the support of so many faculty, staff, and trainees in our department as well as throughout the medical center and university. We persist in pushing the boundaries of what radiology, as a field, will become in the years ahead. "Science without borders" continues to be a key theme during my chairmanship with the goal to bridge scientific and clinical activities throughout the medical school, affiliated hospitals, across the Stanford campus, and beyond.

In recent years, we have made tremendous strides to bring together clinical and scientific efforts to tackle health issues in multiple ways. The PHIND (Precision Health and Integrated Diagnostics) Center is such an example of this effort. PHIND now has the commitment of 94 faculty and scientists across 48 departments at Stanford, all dedicated to longitudinal monitoring and improvement of overall human health on a lifelong basis. In May, following the initial round of funding for 20 projects, the center announced the availability of an additional $1.5 million in seed funding. The goal is to launch additional new research projects and recruit new faculty interested in this important area of research.

We have also made remarkable progress in long-term projects important to us, such as Project Baseline, which was profiled in *The New York Times* in 2019. Project Baseline is a massive enterprise whose goal is to map the many factors that influence human health. The project—a joint effort of Stanford Medicine, Duke University School of Medicine, Verily and Google—started in the summer of 2017 with the goal of enrolling thousands of participants over a four-year period. The first round of data analysis is now beginning on data collected from over 2,500 participants.

The Department of Radiology has further demonstrated our commitment to "science without borders" with the opening of the new AIMI Center (Artificial Intelligence in Medicine and Imaging) in 2018. The center is dedicated to solving clinically important problems in medicine using AI. Drawing on Stanford's interdisciplinary expertise in clinical medical imaging, bioinformatics, statistics, electrical engineering, and computer science, the AIMI Center supports the development, evaluation and dissemination of new AI methods applied across the medical imaging life cycle. The long-term goal is to develop and support transformative medical AI applications and the latest in applied computational and biomedical imaging research to advance patient health. AI provides an unprecedented opportunity to extract meaning from medical imaging data and to develop tools that improve patient care. The Center's key strength is the partnership between clinical and technical experts. See pages 44-49 for more on AIMI.

We have continued to make remarkable innovations in numerous areas that we believe are important to health care in the long-term. These areas include: (1) *Developing a new imaging technique to diagnose tuberculosis in an hour.* This approach, developed by the Rao lab, harnesses a newly created two-piece fluorescent probe that is activated by a saliva sample. (2) *Analytic methods for radiology and pathology fusion.* With an interest in biomedical data integration, the Rusu lab applies data fusion methods to create comprehensive multi-scale representations of biomedical processes and pathological conditions. (3) *Developing novel quantitative imaging biomarkers*. The Kogan lab focuses on the development of early disease markers with novel imaging methods including MRI, PET-MR, and ultra-high field MRI. (4) *Making MRI scans safer for children.* Pediatric Radiology, from work in the Vasanawala lab, has improved MRI scans for children, tailoring MRI equipment to acquire images of young patients much faster. Shorter MRI scan times for children allow physicians to substantially reduce anesthesia, and in many instances, eliminate anesthesia entirely. (5) *Identifying cancer driver mutations for therapeutic decision-making.* Through computational analyses of untreated cancer samples, the Reiter lab showed that driver mutations were present among all metastases of a cancer, thus allowing a single biopsy to capture those important mutations. (6) *Translating ultrasound discoveries for clinical applications.* The Butts Pauly lab applies focused ultrasound to open the blood brain barrier, for neuromodulation, and ablation to treat many diseases throughout the body. (7) *Tissue samples and fluids for diagnosis and disease progression*. The Pitteri lab focuses on the discovery and validation of proteins that can be used as molecular indicators of risk, diagnosis, progression, and recurrence of cancer. (8) *Engineering immune cells to detect and flag cancer in mice.* Research in the Gambhir lab published in Nature Biotechnology, performed in mice, involved modifying a specific class of immune cells (macrophages) to patrol the body for cancer and send a signal through the blood or urine upon detection opening up a new field of immuno-diagnostics. (9) *PET camera for breast imaging.* A new innovative design, from the Levin lab, allows for a portable system to provide information about chemical and biological changes in breast tissue, changes not depicted with other imaging modalities. (10) *Predictive mathematical models to describe cell behavior.* The mathematical models developed in the Mallick lab are used to detect cancer early and describe how they might behave (e.g., aggressive vs. indolent, drug sensitive vs. responsive). (11) *Ultrasound activated nanoparticles enable drug delivery to the brain.* The Airan lab focuses on noninvasive drug delivery to any part of the brain with maximum spatial and temporal resolution. This work has been published in *Neuron*.

> "Science without borders will continue to be a key theme . . . with the goal to bridge scientific and clinical activities throughout the medical school, affiliated hospitals, across the Stanford campus, and beyond."
>
> SANJIV SAM GAMBHIR, MD, PHD

Another major milestone of "science without borders" has been the continued excellence of the MIPS seminar series, IMAGinING THE FUTURE, which is aimed at catalyzing interdisciplinary discussions in all areas of medicine and disease. This seminar series encourages discussion and is open and free to everyone in the Stanford community, as well as anyone from the surrounding community, universities, companies, or institutions. In 2019, so far, we have hosted Nora Volkow, MD, Director of the National Institute on Drug Abuse (NIDA) at the National Institutes of Health; Eric Topol, MD, Professor, Founder and Director of the Scripps Research Translational Institute (SRTI); and Robert S. Langer, PhD, David H. Koch Institute Professor (MIT). By hosting such incredible speakers in a multitude of fields, we continue to emphasize the importance of gathering comprehensive scientific viewpoints in interdisciplinary fields to better understand health and disease.

2017–2019

A significant event at the Stanford University Medical Center this year was the opening of the new Stanford Adult Hospital. With this opening, the department's growth in space and facilities continues. The new hospital includes 368 patient rooms, 20 operating rooms, and a Level 1 trauma center/emergency department twice the size of the current one. Special attention to families and caregivers is also given. In particular, for our clinical imaging needs, there are eight interventional rooms, three MRIs, three CTs, and one intraoperative MRI, leading to exponential growth in our clinical imaging capabilities. Our ability to use cutting-edge equipment ensures that we can achieve our commitment to the highest levels of patient care and innovative approaches.

In preparation for the opening of the new Stanford Adult Hospital, we also transitioned this past year from GE to the Sectra PACS system, to support efficient radiology workflows. Such an enormous undertaking required unlimited patience and many hours of effort from our clinical faculty and hospital staff. I am optimistic that we now have a stable system that we can build upon to accommodate future growth of our clinical needs.

Further, to serve the wider community, we launched our Community Radiology group in 2018, staffing SHC-ValleyCare with Radiology clinicians. ValleyCare provides the Tri-Valley with exceptional, patient-centered community medicine, coupled with specialized Stanford Medicine programs to deliver a full continuum of care. The Community Radiology group will continue to grow the Stanford clinical footprint in the Bay Area.

In addition to hospital growth, we also have plans underway that will expand our research facilities at Porter Drive. We are installing two new clinical scanners (MRI and PET-CT) and also a much needed cyclotron and radiochemistry facility. These resources will benefit both our clinical research as well as our pre-clinical research needs. We look forward to hopefully completing this expansion over the next two years.

I would like to especially acknowledge the success of the department's research efforts and accomplishments. Our Radiology faculty, along with their dedicated research teams, make significant discoveries and advances that allow us to lead in many areas of research. I am particularly proud of the fact that our faculty, through their hard efforts, have received significant NIH funding such that we now rank second for NIH funding among all U.S. medical school departments of radiology. If NIH rankings were normalized to faculty count per department, as a relatively small department, Stanford Radiology would likely rank higher.

The growth in our faculty also reflects the department's commitment to providing excellent patient care and advancing our research capabilities. More than 40 new clinical faculty were recruited to support our growing clinical enterprise and to prepare for the recent opening of the new Stanford Hospital. During the past year, the new Lucile Packard Children's Hospital was also opened; thus, several of the new clinical faculty were recruited to accommodate these new facilities and the increased patient volume. Following this recent clinical hiring cycle, we then turned our attention to the basic sciences faculty structure, and recruited 10 new faculty in the various research divisions. Please see pages 18-25 for a complete list of all new faculty and the divisions they support.

I would also like to highlight the excellent work of Dr. Heike Daldrup-Link who so ably leads our Radiology Diversity Initiative. Each month, the Diversity Newsletter brings to the forefront important diversity issues for our consideration. We are reminded that we all arrived here with different experiences, different opinions, and differing points of view. We are also reminded that it is these very differences that provide opportunity for discussion and discovery that leads to new levels of understanding and acceptance.

Through new initiatives, new faculty, and new resources, the Department of Radiology is experiencing a renewed vitality and energy resulting in novel solutions in imaging and therapy for our patients. As such a dynamic center of healthcare, radiology, as a discipline, has the capability and responsibility to lead the way in coalescing transformative ideas and collaborations across the clinical and academic landscape. It is truly an exciting and rewarding time to be a member of the Stanford Department of Radiology.

All of the great progress in our department is due to the commitment of our highly dedicated faculty and staff. I especially want to thank our two Vice Chairs, Dr. Garry Gold and Dr. David Larson, all Associate Chairs and Division Chiefs for their tremendous efforts and their continued support. It is my pleasure to learn from them each day and to benefit from their collective wisdom, enthusiasm, and support.

Sanjiv Sam Gambhir MD, PhD
Virginia and D. K. Ludwig Professor of Cancer Research
Chair, Department of Radiology

In Memoriam

Juergen Karl Willmann, MD (1972–2018)

Juergen Willmann, MD, a professor of radiology at the Stanford University School of Medicine, passed away on January 8, 2018 in a tragic car accident in Palo Alto. He was 45.

Born in Germany, Dr. Willmann earned his medical degree, summa cum laude, in 1998 at Albert Ludwig University of Freiburg. He traveled between California and Zurich, training in diagnostic radiology at the University of California, San Francisco and in surgery at a teaching hospital of the University of Zurich. Dr. Willmann completed his residency at the University of Zurich, along with his wife Amelie Lutz, MD, whom he met in medical school.

After completing his residency in 2003, Dr. Willmann became an assistant professor and clinical attending physician at the University of Zurich. Later, he and Dr. Lutz joined the Molecular Imaging Program at Stanford (MIPS) under a fellowship, where they worked on multimodality molecular imaging technologies and early cancer detection.

In 2008, after the fellowship, Drs. Willmann and Lutz made a permanent move to the United States, and he became an assistant professor of radiology in the School of Medicine. He received tenure as an associate professor in 2011 due to his remarkable research productivity, excellent teaching and mentoring, and outstanding clinical skills. In 2015, Dr. Willmann was promoted to the rank of professor.

Within radiology, Dr. Willmann assumed several administrative and leadership roles, including division chief of body imaging (2013) and vice chair of strategy, finance and clinical trials (2017). He also led his own research lab, the Translational Molecular Imaging Laboratory, and was a fellow of the American Institute for Medical and Biological Engineering (AIMBE), as well as the Society of Abdominal Radiology.

Dr. Willmann's research in molecular imaging has been recognized internationally. He was a pioneer in imaging and early cancer detection through the development and clinical translation of novel molecular and functional imaging biomarkers, particularly, targeted contrast microbubbles for ultrasound molecular imaging. His research group was the first to use targeted microbubbles in clinical imaging trials, leveraging them to identify ovarian and breast cancer. He also initiated the development of more cancer-specific targeted microbubbles for early detection of breast and pancreatic cancer and pushed forward their clinical translation. Dr. Willmann did not confine his efforts to cancer detection, but pioneered the use of microbubbles to treat tumors, optimizing ultrasound parameters, and designing microbubbles and nanoparticles for drug delivery. Dr. Willmann's overall research goal was to integrate novel imaging and therapeutic strategies into clinical protocols to improve patient care. His clinical skills, focused on body imaging, were just as outstanding, recognized by many referring clinicians, such as our liver transplant team. In addition, he was an enthusiastic and gifted teacher with outstanding interpersonal skills and mentorship abilities.

In 2017, the Academy for Radiology & Biomedical Imaging Research awarded Dr. Willmann its Distinguished Investigator Award. He authored or co-authored nearly 350 peer-reviewed manuscripts and scientific abstracts, many of them garnering awards from numerous American and European societies. He served as the deputy editor for the *Association of University Radiologists* and senior Editorial Board member for the *American Journal of Nuclear Medicine and Molecular Imaging* and was a reviewer for the journal *Radiology* and the *European Journal of Radiology.*

Outside of medicine, Dr. Juergen Willmann loved music, played four instruments, and was a gifted pianist. He considered becoming a professional musician before deciding on a medical career. With integrity and unlimited energy, Dr. Willmann accomplished a number of extraordinary contributions to his field and touched countless lives through his leadership and warmth. He is survived by Amelie Lutz and their two children, Alexander and Juliana Willmann; his parents, Elisabeth and Karl Willmann; and sister Sabine Willmann. He is deeply missed by his many colleagues and friends.

85
Professoriate

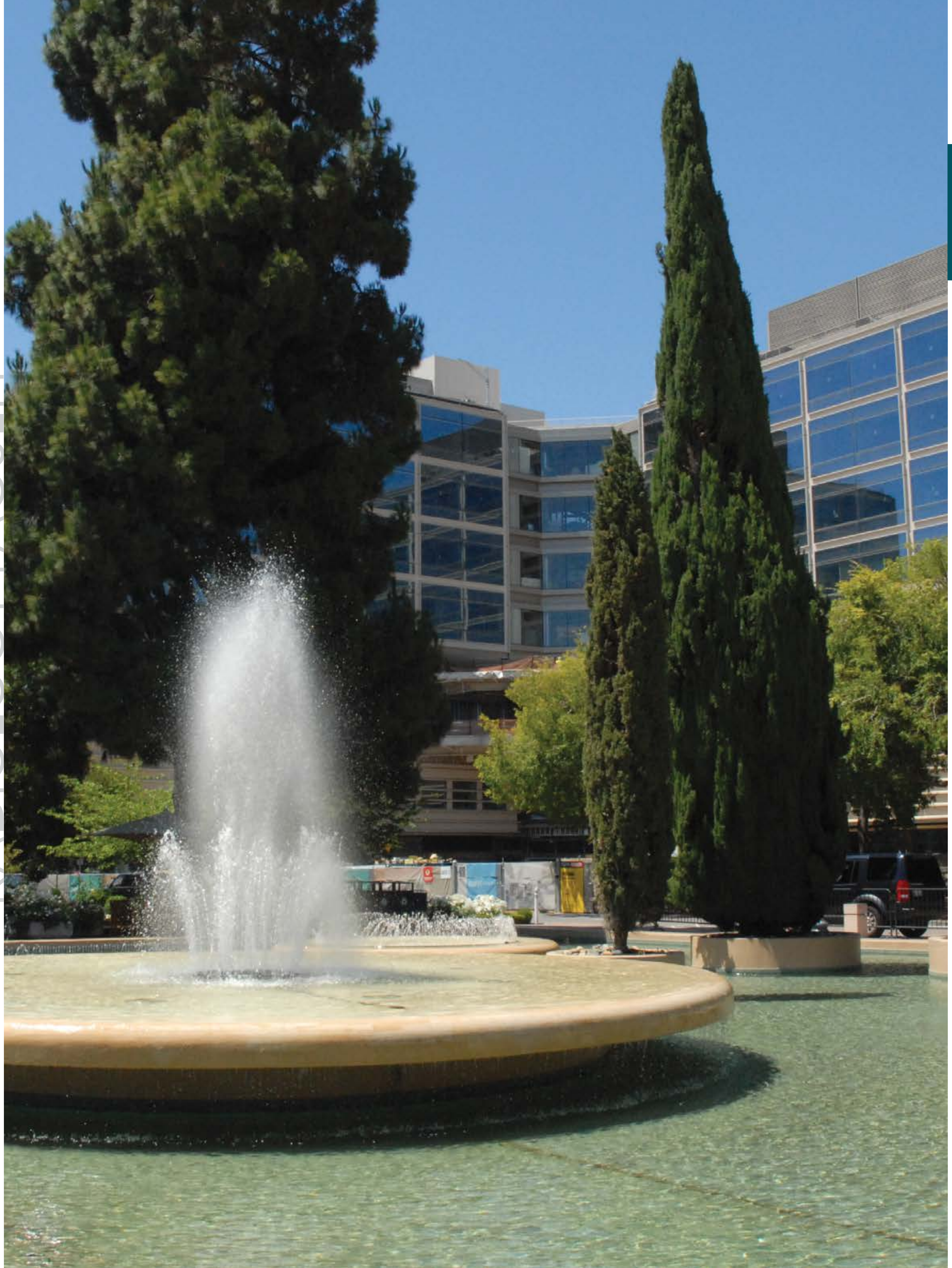
54
Clinical Educators

51
Adjunct Clinical Faculty

37
CE Per Diems/ Affiliated

20
Other Faculty

RADIOLOGY FACULTY



Radiology Faculty

21
AIMBE Fellows*

American Institute for Medical and Biological Engineering

Heike Daldrup-Link, MD
Bruce Daniel, MD
Utkan Demirci, PhD
Katherine Ferrara, PhD
Sanjiv Sam Gambhir, MD, PhD
Gary Glover, PhD
Garry Gold, MD
Brian Hargreaves, PhD
Craig Levin, PhD
Sandy Napel, PhD
Kim Butts Pauly, PhD
Norbert Pelc, ScD
Sylvia Plevritis, PhD
Jianghong Rao, PhD
Daniel Rubin, MD, MS
Brian Rutt, PhD
H. Tom Soh, PhD
Daniel Spielman, PhD
Shreyas Vasanawala, MD, PhD
Joseph Wu, MD, PhD
Gregory Zaharchuk, MD, PhD

*cumulative

25
Distinguished Investigators*

The Academy of Radiology and Biomedical Imaging Research

Francis Blankenberg, MD
Jeremy Dahl, PhD
Heike Daldrup-Link, MD
Bruce Daniel, MD
Utkan Demirci, PhD
Katherine Ferrara, PhD
Sanjiv Sam Gambhir, MD, PhD
Gary Glover, PhD
Garry Gold, MD
Brian Hargreaves, PhD
Robert Herfkens, MD
Craig Levin, PhD
Tarik Massoud, MD, PhD
Michael Moseley, PhD
Sandy Napel, PhD
Ramasamy Paulmurugan, PhD
Kim Butts Pauly, PhD
Norbert Pelc, ScD
Sylvia Plevritis, PhD
Jianghong Rao, PhD
Daniel Rubin, MD, MS
Daniel Spielman, PhD
Shreyas Vasanawala, MD, PhD
Joseph Wu, MD, PhD
Gregory Zaharchuk, MD, PhD

*cumulative

Department Leadership

Office of the Chair

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Chair
Department of Radiology

Yun-Ting Yeh, MBA
Director
Finance and Administration

Vice Chairs

Garry Gold, MD
Vice Chair
Research and Administration

David Larson, MD, MBA
Vice Chair
Education and Clinical Operations

Associate Chairs

Richard Barth, MD
Associate Chair
Pediatric Radiology
Radiologist-in-Chief, LPCH

Christopher Beaulieu MD, PhD
Associate Chair
Clinical Education

Heike Daldrup-Link, MD
Associate Chair
Diversity

Brian Hargreaves, PhD
Associate Chair
Research

DEPARTMENT LEADERSHIP

Robert Herfkens, MD
Associate Chair
Clinical Technology

Gloria Hwang, MD
Associate Chair
Clinical Performance Improvement

R. Brooke Jeffrey, MD
Associate Chair
Academic Affairs

Curtis Langlotz, MD, PhD
Associate Chair
Information Systems

Ann Leung, MD
Associate Chair
Clinical Affairs

Payam Massaband, MD
Associate Chair
VA Palo Alto Health Care System

Hans Ringertz, MD, PhD
Associate Chair
Special Projects

Volney Van Dalsem, MD
Associate Chair
Outpatient Imaging and Community Radiology

Mark Willis, DO
Associate Chair
Quality Improvement

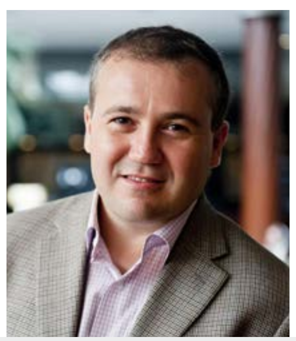
DEPARTMENT LEADERSHIP

Division Chiefs

Richard Barth, MD
Radiologist-in-Chief, LPCH
Division Chief
Pediatric Radiology

Sandip Biswal, MD
Co-Division Chief
Musculoskeletal Imaging

Wendy DeMartini, MD
Division Chief
Breast Imaging



Utkan Demirci, PhD
Co-Division Chief
Canary Center at Stanford
for Cancer Early Detection

Dominik Fleischmann, MD
Division Chief
Cardiovascular Imaging

Sanjiv Sam Gambhir MD, PhD
Co-Division Chief, Canary Center
Division Chief for MIPS and PHIND

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Andrei Iagaru, MD
Division Chief
Nuclear Medicine and
Molecular Imaging

R. Brooke Jeffrey, MD
Acting Division Chief
Body Imaging

Ann Leung, MD
Division Chief
Thoracic Imaging

Amelie Lutz, MD
Co-Division Chief
Musculoskeletal Imaging

Payam Massaband, MD
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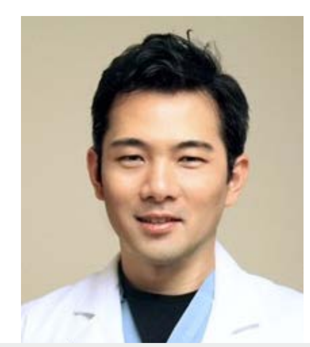
VA Palo Alto Health Care
System - Radiology

Sandy Napel, PhD
Division Chief
Integrative Biomedical Imaging
Informatics at Stanford (IBIIS)

Kim Butts Pauly, PhD
Division Chief
Radiological Sciences
Laboratory (RSL)

George Segall, MD
Division Chief
VA Palo Alto Health Care
System - Nuclear Medicine



Taiyo Shimizu, MD
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Body MRI

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* Courtesy Appointment

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Gregory Zaharchuk, MD, PhD
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Michael Zeineh, MD, PhD
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Sanjiv Sam Gambhir, MD, PhD
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Clinical Instructor

Andrei Iagaru, MD
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Carina Mari Aparici, MD
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Clinical Assistant Professor

Judy Nguyen, MD
Clinical Assistant Professor

Jeffrey Tseng, MD
Adjunct Clinical Assistant Professor

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Professor

Francis Blankenberg, MD
Associate Professor

Johanna Chang, MD
Clinical Instructor

Anjeza Chukus, MD
Adjunct Clinical Instructor

Jeremy Dahl, PhD
Associate Professor

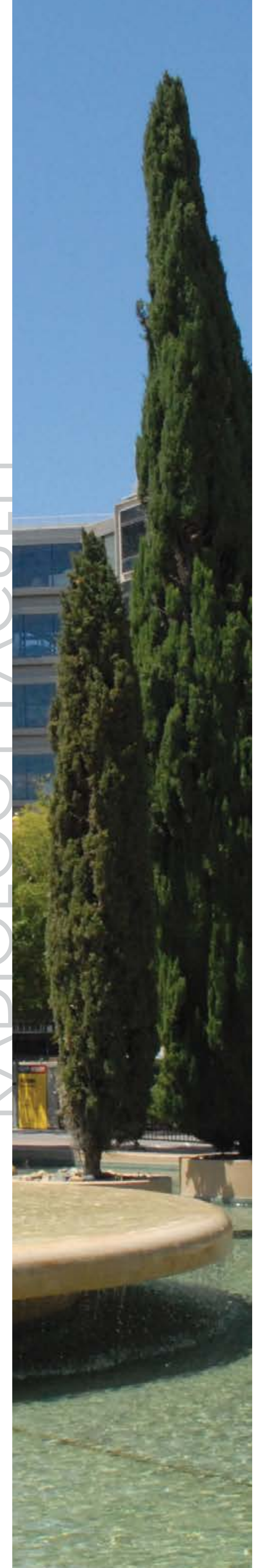
Heike Daldrup-Link, MD
Professor

Lane Donnelly, MD
Professor

Daniel Durand, MD
Adjunct Clinical Assistant Professor

Donald Frush, MD
Professor

Carolina Guimaraes, MD
Clinical Assistant Professor



Safwan Halabi, MD
Clinical Associate Professor

Diego Jaramillo, MD, MPH
Adjunct Clinical Professor

Robert Jones, MD
Adjunct Clinical Instructor

Shellie Josephs, MD
Clinical Professor

Ralph Lachman, MD
Adjunct Professor

Fred Laningham, MD
Clinical Assistant Professor (Affiliated)

David B. Larson, MD, MBA
Associate Professor

Edward Lebowitz, MD
Clinical Professor

Matthew Lungren, MD, MPH
Assistant Professor

Helen Nadel, MD
Clinical Professor

Beverley Newman, MBBCh
Professor

Alex Oshmyansky, MD, PhD
Adjunct Lecturer

Hans Ringertz, MD, PhD
Adjunct Professor

Veronica Rooks, MD
Clinical Professor

Erika Rubesova, MD
Clinical Associate Professor

Matthew Schmitz, MD
Adjunct Clinical Instructor

Jayne Seekins, DO
Clinical Assistant Professor

F. Glen Seidel, MD
Clinical Professor

Avnesh Thakor, MD, PhD
Assistant Professor

Kristen Yeom, MD
Associate Professor

Evan Zucker, MD
Clinical Assistant Professor

Precision Health and Integrated Diagnostics (PHIND) Center at Stanford

Sanjiv Sam Gambhir, MD, PhD
Professor

Pablo Paredes, PhD
Instructor

Sindy Tang, PhD*
Associate Professor

Radiological Sciences Laboratory (RSL)

Audrey Fan, PhD
Instructor

Gary Glover, PhD
Professor

Brian Hargreaves, PhD
Professor

Marc Levenston, PhD*
Associate Professor

Jennifer McNab, PhD
Associate Professor

Michael Moseley, PhD
Professor

Kim Butts Pauly, PhD
Professor

Norbert Pelc, ScD
Professor, Emeritus

Allan Reiss, MD
Professor

Brian Rutt, PhD
Professor

Daniel Spielman, PhD
Professor

Adam Wang, PhD
Assistant Professor

Thoracic Imaging

H. Henry Guo, MD, PhD
Clinical Associate Professor

Curtis Langlotz, PhD
Professor

Ann Leung, MD
Professor

Margaret Lin, MD
Clinical Associate Professor

Emily Tsai, MD
Clinical Assistant Professor

VAPAHCS Radiology

Stephanie Chang, MD
Clinical Assistant Professor (Affiliated)

Bao Do, MD
Clinical Associate Professor (Affiliated)

Daniel Ennis, PhD
Associate Professor

Christine Ghatan, MD
Clinical Assistant Professor (Affiliated)

Patrick Lee, MD
Adjunct Clinical Associate Professor

Sachin Malik, MD
Clinical Assistant Professor

Payam Massaband, MD
Clinical Associate Professor

Chandan Misra, MD
Clinical Instructor (Affiliated)

Michelle M. Nguyen, MD
Clinical Assistant Professor (Affiliated)

Eric Olcott, MD
Professor

Thomas Osborne, MD
Clinical Assistant Professor (Affiliated)

Christopher Parham, MD, PhD
Clinical Instructor (Affiliated)

Joshua Reicher, MD
Clinical Assistant Professor (Affiliated)

Amanda Rigas, MD
Clinical Assistant Professor (Affiliated)

Rajesh Shah, MD
Clinical Associate Professor

Lewis Shin, MD
Adjunct Clinical Associate Professor

Ali Tahvildari, MD
Adjunct Clinical Assistant Professor

Katherine To'o, MD
Clinical Assistant Professor

VAPAHCS Nuclear Medicine

Christine Keeling, MBBS
Clinical Associate Professor

George Segall, MD
Professor

Minal Vasanawala, MBBS
Clinical Assistant Professor (Affiliated)

* Courtesy Appointment

New Faculty Appointments Since September 2017

NEW FACULTY APPOINTMENTS

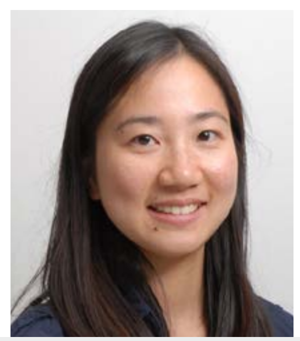

Christopher Baker, MD
Adjunct Clinical Asst Professor
Neuroimaging


Kristen Bird, MD
Clinical Instructor
Body Imaging


Robert Boutin, MD
Clinical Professor
Musculoskeletal Imaging


Ryan Brunsing, MD, PhD
Clinical Instructor
Body MRI


Myrna Castelazo, MD
Clinical Instructor
Community Radiology

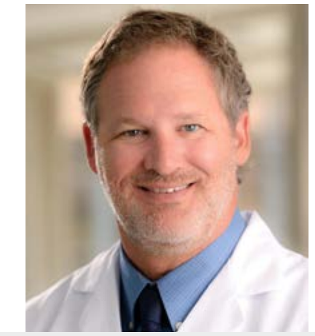

Lauren Chan, MD
Adjunct Clinical Instructor
Interventional Radiology


Stephanie Chang, MD
Clinical Asst Professor (Affiliated)
VAPAHCS


Ryan Chao, MD
Clinical Instructor
Community Radiology


Ruchir Chaudhari, MD
Adjunct Clinical Instructor
Neuroimaging


Anjeza Chukus, MD
Adjunct Clinical Instructor
Pediatric Neuroimaging


Lane Donnelly, MD
Professor
Pediatric Radiology


Daniel Durand, MD
Adjunct Clinical Asst Professor
Pediatric Radiology


Gozde Durmus, PhD
Assistant Professor
MIPS


Yehia ElGuindy, MD
Adjunct Clinical Instructor
Musculoskeletal Imaging


Daniel Ennis, PhD
Associate Professor
VAPAHCS, RSL


Audrey Fan, PhD
Instructor
RSL


Katherine Ferrara, PhD
Professor
MIPS


Brett Fite, PhD
Instructor
MIPS

New Faculty Appointments

Since September 2017

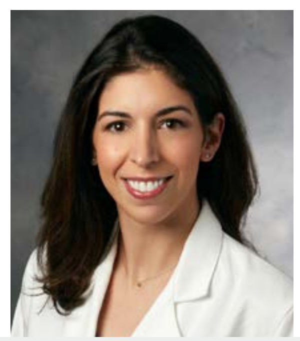
Marta Flory, MD
Clinical Instructor
Body Imaging

Josquin Foiret, PhD
Instructor
MIPS

Ben Franc, MD, MBA
Clinical Professor
Nuclear Medicine

Donald Frush, MD
Professor
Pediatric Radiology

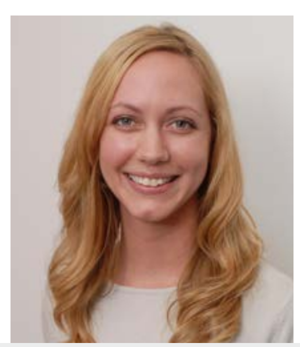
Benjamin Ge, MD
Clinical Assistant Professor
Interventional Radiology



Christine Ghatan, MD
Clinical Asst Professor (Affiliated)
VAPAHCS

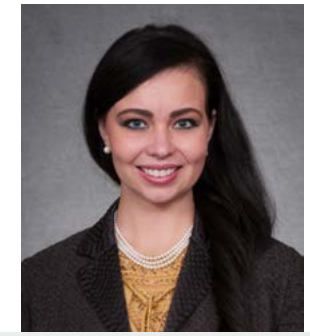
Aron Gould-Simon, MD
Clinical Instructor
Nuclear Medicine

Carolina Guimaraes, MD
Clinical Assistant Professor
Pediatric Neuroimaging



Chivonne Harrigal, MD
Clinical Assistant Professor
Breast Imaging

NEW FACULTY APPOINTMENTS



Kristina Hawk, MD, PhD
Clinical Instructor
Nuclear Medicine

Jeremy Heit, MD, PhD
Assistant Professor
Neurointervention

Shellie Josephs, MD
Clinical Professor
Pediatric IR

Mohammed Kaleel, MD
Adjunct Clinical Instructor
Musculoskeletal Imaging

Feliks Kogan, PhD
Assistant Professor
Musculoskeletal Imaging

Fred Laningham, MD
Clinical Asst Professor (Affiliated)
Pediatric Radiology

Margaret Lin, MD
Clinical Associate Professor
Thoracic

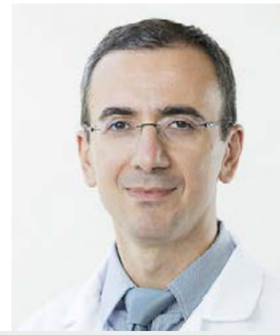
Carina Mari Aparici, MD
Clinical Professor
Nuclear Medicine

AJ Mariano, MD
Clinical Assistant Professor
Body Imaging

New Faculty Appointments Since September 2017

Chandan Misra, MD
Clinical Instructor (Affiliated)
VAPAHCS

Gregory Moore, MD, PhD
Adjunct Clinical Professor
Neuroimaging



Farshad Moradi, MD, PhD
Clinical Assistant Professor
Nuclear Medicine

Helen Nadel, MD
Clinical Professor
Pediatric Radiology

Judy Nguyen, MD
Clinical Assistant Professor
Nuclear Medicine

Jason Oppenheimer, MD
Adjunct Clinical Instructor
Musculoskeletal Imaging

Thomas Osborne, MD
Clinical Asst Professor (Affiliated)
VAPAHCS

Pablo Paredes, PhD
Instructor
PHIND

Chirag Patel, MD, PhD
Clinical Assistant Professor
MIPS

NEW FACULTY APPOINTMENTS

Tanvi Patel, MD
Clinical Assistant Professor
Community Radiology

Andrew Picel, MD
Clinical Assistant Professor
Interventional Radiology

Sarah Pittman, MD
Clinical Assistant Professor
Breast Imaging

Joshua Reicher, MD
Clinical Asst. Professor (Affiliated)
VAPAHCS

Johannes Reiter, PhD
Assistant Professor
Canary Center

Amanda Rigas, MD
Clinical Asst. Professor (Affiliated)
VAPAHCS

Albert Roh, MD
Adjunct Clinical Instructor
Body MRI

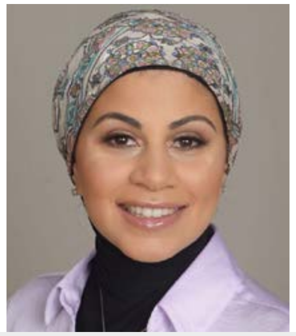
Veronica Rooks, MD
Clinical Professor
Pediatric Radiology

Eric Rosen, MD
Clinical Professor
Breast Imaging

New Faculty Appointments Since September 2017

NEW FACULTY APPOINTMENTS

Mirabela Rusu, PhD
Assistant Professor
IBIIS

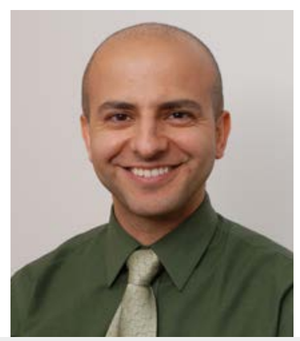


Nelly Salem, MD
Clinical Assistant Professor
Breast Imaging

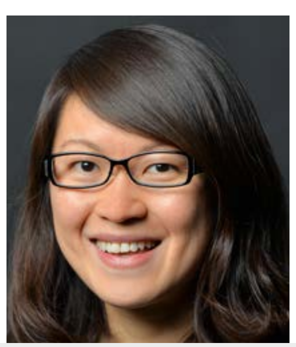
Emir Sandhu, MD
Adjunct Clinical Instructor
Musculoskeletal Imaging

Luyao Shen, MD
Clinical Assistant Professor
Body Imaging

Vipul Sheth, MD, PhD
Assistant Professor
Body MRI

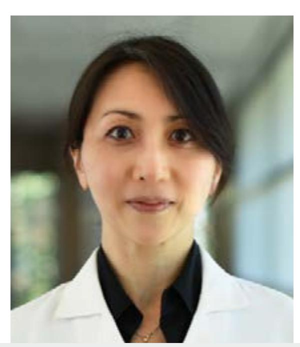


Anobel Tamrazi, MD, PhD
Adjunct Clinical Asst Professor
Interventional Radiology

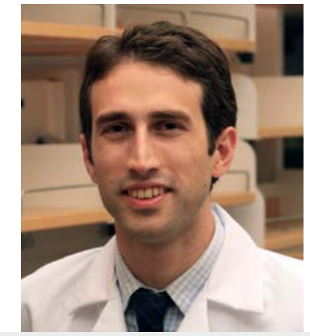


Sindy Tang, PhD
Associate Professor (Courtesy)
PHIND

Nicholas Telischak, MD
Clinical Assistant Professor
Neurointervention



Elizabeth Tong, MD
Clinical Instructor
Neuroimaging



Alexander Vezeridis MD, PhD
Assistant Professor
Interventional Radiology

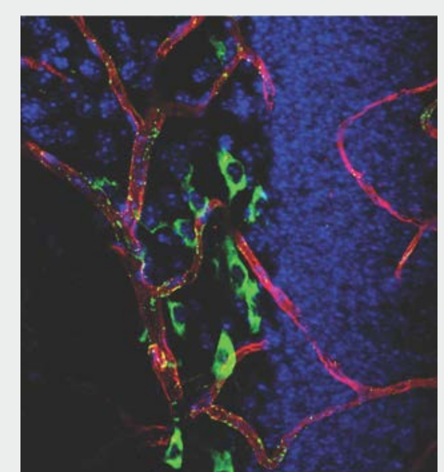
Adam Wang, PhD
Assistant Professor
RSL

Sabrina Ward, MD
Clinical Instructor
Musculoskeletal Imaging

Martin Willemink, MD, PhD
Instructor
Cardiovascular Imaging

Marc Willis, DO
Clinical Professor
Musculoskeletal Imaging

Luke Yoon, MD
Clinical Associate Professor
Body Imaging



Marc Stevens, PhD, Postdoctoral Fellow

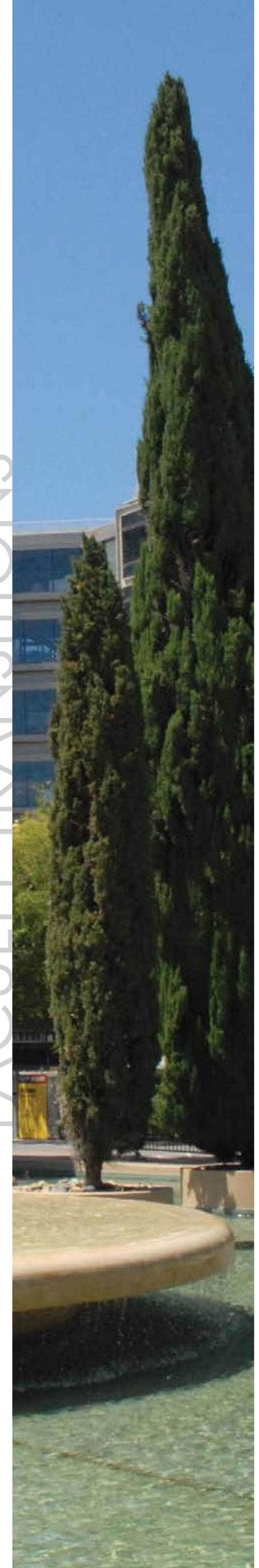
Laboratory of Michelle James, PhD, Molecular Imaging Program at Stanford (MIPS)

Image of a mouse brain section obtained using fluorescence microscopy. The image represents the neurovascular interface, with plasma crossing into the brain. The vasculature is red (CD31, a marker for endothelial cells), plasma is colored green (Atto 647, a far-red dye but depicted here in false color), and the cells of the dentate gyrus are a solid wall of blue (Hoechst, a DNA dye). The image was captured with a Zeiss LSM880 confocal microscope on a PFA-fixed, 40 μM thick brain section.

Faculty Leadership Appointments

Christopher Beaulieu, MD, PhD	Associate Chair, Clinical Education
Sandip Biswal, MD	Co-Division Chief, Musculoskeletal Radiology
Lawrence Chow, MD	Director, Emergency Radiology
Heike Daldrup-Link, MD	Associate Chair, Diversity
Bruce Daniel, MD	Director, IMMERS
Utkan Demirci, PhD	Co-Division Chief, Canary Center at Stanford for Cancer Early Detection
Lane Donnelly, MD	Chief Quality Officer, LPCH
Daniel Ennis, PhD	Director, Radiology Research, VAPAHCS
Donald Frush, MD	Medical Director, Operations for Pediatric Radiology, LPCH
Sanjiv Sam Gambhir, MD, PhD	Director, PHIND Center
Garry Gold, MD	Vice Chair, Research and Administration
Safwan Halabi, MD	Director, Radiology Clinical Informatics, LPCH
Brian Hargreaves, PhD	Associate Chair, Research; Co-Director, IMMERS
Gloria Hwang, MD	Associate Chair, Clinical Performance Improvement
Shellie Josephs, MD	Director, Pediatric Interventional Radiology
Aya Kamaya, MD	Director, Ultrasound
Curtis Langlotz, MD, PhD	Director, AIMI Center
David Larson, MD, MBA	Vice Chair, Education and Clinical Operations
Mathew Lungren, MD, MPH	Associate Director, AIMI Center
Amelie Lutz, MD	Co-Division Chief, Musculoskeletal Radiology
Linda Nayeli Morimoto, MD	Director, Radiography and Fluoroscopy
Helen Nadel, MD	Director, Pediatric Nuclear Medicine
Thomas Osborne, MD	Chief Medical Information Officer, VAPAHCS
Bhavik Patel, MD, MBA	Director, Clinical Trials
Geoffrey Riley, MD	Director, Radiology CME; Director of Community Radiology
Rajesh Shah, MD	Director, Interventional Radiology, VAPAHCS
Taiyo Shimizu, MD	Division Chief, Community Radiology
Daniel Spielman, PhD	Director, Basic Science Education and Statistics Core
Volney Van Dalsem, MD	Associate Chair, Outpatient Imaging and Community Radiology
Marc Willis, DO	Associate Chair, Quality Improvement
Kristen Yeom, MD	Interim Director, Pediatric Neuroimaging

FACULTY TRANSITIONS



Sylvia Plevritis Appointed to Chair of Biomedical Data Science

Sylvia Plevritis, PhD, biomedical data science and radiology, has been appointed chair of the Department of Biomedical Data Science (BDS), which was established in 2015. In her new leadership role as of April 1, 2019, Dr. Plevritis has taken over the responsibilities of Dr. Carlos Bustamante, PhD, the inaugural chair of BDS.

"An accomplished scientist, researcher and educator, Dr. Plevritis' collaborative vision, depth of expertise, and leadership skills make her uniquely qualified to lead the department as it develops novel computational and statistical methods that transform healthcare," says Lloyd Minor, MD, dean of the School of Medicine. "Dr. Plevritis has focused her research on computational modeling of cancer biology and cancer outcomes, and her findings have forged new pathways that have advanced the medical community's understanding of the disease."

Dr. Plevritis is the director of the Stanford Center for Cancer Systems Biology (CCSB) and of the Cancer Systems Biology Scholars (CSBS) Program, and a principal investigator of NCI's Cancer Intervention and Surveillance Modeling Network (CISNET). She has also served as the co-division chief of Integrative Biomedical Imaging Informatics (IBIIS) at Stanford from 2008 to 2019. Outside of Stanford, she serves on the scientific advisory board of the National Cancer Institute, and is a fellow of the American Institute for Medical and Biological Engineering (AIMBE) and Distinguished Investigator in the Academy of Radiology Research.

Dr. Plevritis has a PhD in electrical engineering from Stanford and a master's degree in health services research, with a focus on cancer screening evaluation, also from Stanford. The research focus of her lab is cancer systems biology, parsing the molecular mechanisms of cancer progression and cancer outcomes through integrative computational modeling.

As the new chair of BDS, Dr. Plevritis has said she has two overarching goals that she wants to pursue in collaboration with its faculty: (1) further enhance the educational mission through direct connections with the biomedical informatics graduate program, and (2) continue deepening collaborative research opportunities for BDS as a whole.

"As biomedical research increasingly turns to data sciences for answers, there is an opportunity to build new approaches to analyze, visualize, and derive insights from complex data sets," says Dr. Plevritis. "Right now, we are at the center of a tremendous revolution where we can use these data and insights to think about the whole person, how to maintain health, quickly identify early signs of disease, and treat disease with the right therapies at the right time."

Her colleagues in the Department of Radiology wish her the best in this new leadership role.

> "Right now, we are at the center of a tremendous revolution where we can use these data and insights to think about the whole person, how to maintain health, quickly identify early signs of disease, and treat disease with the right therapies at the right time."
>
> DR. SYLVIA PLEVRITIS

Work Cited: Armitage, Hanae. "Sylvia Plevritis appointed chair of biomedical data science." *Stanford Medicine, Stanford Medicine: School of Medicine*, 17 April 2019, med.stanford.edu/news/all-news/2019/04/sylvia-plevritis-appointed-chair-of-biomedical-data-science.

Faculty Retirements and Recalls

Patrick Barnes, MD
Professor, Emeritus
Pediatric Radiology

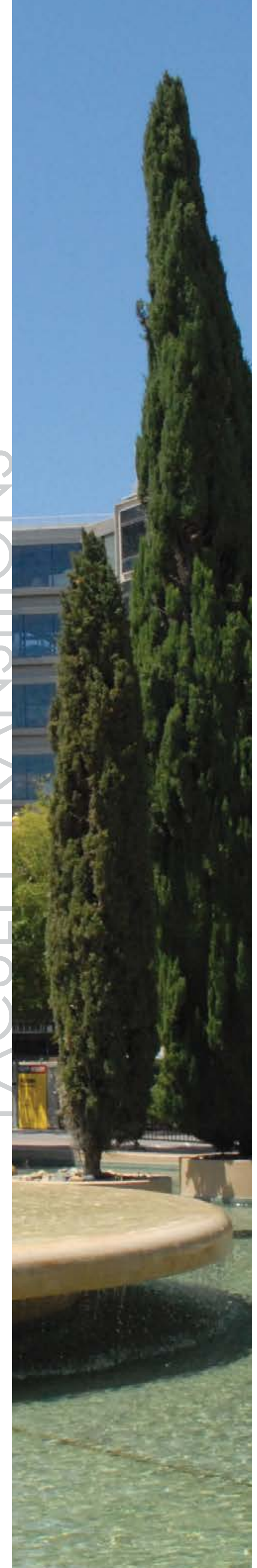
Michael Federle, MD
Professor, Emeritus
Body Imaging

Michael Marks, MD
Professor, Emeritus
Neurointervention

Norbert Pelc, ScD
The Boston Scientific Applied Biomedical Engineering Professorship, Emeritus
RSL

F. Glen Seidel, MD
Clinical Professor
Pediatric Radiology

FACULTY TRANSITIONS



Faculty Departures

Quazi Al-Tariq, MD
Adjunct Clinical Instructor

Benedict Anchang, PhD
Instructor

Imon Banerjee, PhD
Instructor

Audra Brunelle, MD
Clinical Assistant Professor

Joshua Cates, PhD
Instructor

John Chang, MD, PhD
Adjunct Clinical Instructor

Joseph Cheng, PhD
Instructor

Ahmet Coskun, PhD
Instructor

Sanjay Gupta, MD
Adjunct Clinical Instructor

Andrew Kesselman, MD
Clinical Instructor

Sirisha Komakula, MBBS
Adjunct Clinical Assistant Professor

Charles Lau, MD, MBA
Clinical Associate Professor (Affiliated)

Bo Li, MD
Clinical Instructor

Erik Mittra, MD, PhD
Clinical Associate Professor

Suchismita Mohanty, PhD
Instructor

Connie Montgomery, MD
Adjunct Clinical Instructor

Viswam Nair, MD, MS
Clinical Assistant Professor

Sheena Prakash, MD
Clinical Instructor

Shervin Rafie, MD
Clinical Instructor

Bryan Smith, PhD
Instructor

Shyam Srinivas, MD, PhD
Clinical Instructor

Stuart Stein, MD
Adjunct Clinical Assistant Professor

Brandon Sur, MD
Clinical Instructor

Linda Tang, MD
Adjunct Clinical Assistant Professor

Vikas Vij, MD
Adjunct Clinical Assistant Professor

Jana Waldes, MD
Adjunct Lecturer

Thomas Yohannan, MD
Clinical Instructor

Cristina Zavaleta, PhD
Instructor

Navid Zenooz, MD
Clinical Instructor

Faculty Honors and Awards

Raag Airan, MD, PhD	ASCI Young Physician-Scientist Award (2018) Finalist for the Science-PINS Prize for Neuromodulation (2017)
Richard Barth, MD	Elected to the American College of Radiology Board of Chancellors and Chair, Commission on Pediatric Radiology (2018)
Francis Blankenberg, MD	Distinguished Investigator Award-Academy for Radiology & Biomedical Imaging (2019)
Jeremy Dahl, PhD	Distinguished Investigator Award-Academy for Radiology & Biomedical Imaging (2018)
Heike Daldrup-Link, MD	SCARD Leadership Program with GE Healthcare Women's Imaging Network Inducted into the AIMBE College of Fellows (2018)
Terry Desser, MD	Clinical Science Teacher of the Year, Department of Radiology (2019)
Bao Do, MD	Director's Commendation Award at the VA Palo Alto Health Care System (2018)
Lane Donnelly, MD	RSNA Honored Educator Award (2019) Christopher G. Dawes Director in Quality, LPCH Endowed Directorship (2019)
Gozde Durmus, PhD	Named McCormick-Gabilan Faculty Fellow, Stanford University School of Medicine (2019) Named Rising Star in Biomedicine, Broad Institute of MIT and Harvard (2018)
Michael Federle, MD	SCBT-MR Gold Medal (2017)
Katherine Ferrara, PhD	World Molecular Imaging Society Gold Medal Award (2019) Distinguished Investigator Award-Academy for Radiology & Biomedical Imaging (2019) Association for Women in Science (AWIS) Judith Pool Award (2019)
Donald Frush, MD	Society of Pediatric Radiology (SPR) Gold Medal (2019)
Sanjiv Sam Gambhir, MD, PhD	IEEE Marie Sklodowska-Curie Award, IEEE Advancing Technology for Humanity (2019) Basic Science Teaching Award, Stanford University School of Medicine, Radiology Residency Program (2018) Highly Cited Researcher of 2018 (Top 1% by Citations for Field and Year, Web of Science) Benedict Cassen Prize for Research in Molecular Imaging (2018) Distinguished Investigator Award-Academy for Radiology & Biomedical Imaging (2018)
Gary Glover, PhD	Presents ISMRM Lauterbur Lecture (2018) Outstanding Teacher Award, ISMRM (2018)
Brian Hargreaves, PhD	Inducted into the AIMBE College of Fellows (2019)
Rusty Hofmann, MD	Appointed new Medical Director of Digital Health Care Integration for Stanford Health Care (2018)
Andrei Iagaru, MD	Physician of the Year award, Department of Radiology (2018)
Michelle James, PhD	Basic Science Teacher of the Year Award, Department of Radiology (2019) Alavi-Mandell Award, SNMMI (2019)
Feliks Kogan, PhD	Named to Council of Early Career Investigators (CECI^2)-Academy for Radiology & Biomedical Imaging Research (2018)

FACULTY HONORS AND AWARDS

David Larson, MD, MBA	RSNA Honored Educator Award (2018)
Charles Lau, MD	Stanford VA Palo Alto Radiology Faculty Teacher of the Year (2019)
Ann Leung, MD	Appointed to Executive Committee of the Fleischner Society
Craig Levin, PhD	Women's Cancer Innovation Award from the Stanford Cancer Institute (2019)
Payam Massaband, MD	Director's Commendation Award, VA Palo Alto Health Care System (2018)
Tarik Massoud, MD, PhD	Distinguished Investigator Award-Academy for Radiology & Biomedical Imaging (2019)
I. Ross McDougall, MD, PhD	Lifetime Honorary Medical Staff Award, Stanford Health Care (SHC) (2018)
Michael Moseley, PhD	Awarded International Honorary Membership to the Japanese Society of Radiological Technology (2019)
Helen Nadel, MD	Lifetime Achievement Award, European Society of Pediatric Nuclear Medicine, 10th Meeting (2019)
Bhavik Patel, MD, MBA	Elected a Fellow of SCBT-MR (2018)
Ramasamy Paulmurugan, PhD	Distinguished Investigator Award-Academy for Radiology & Biomedical Imaging Research (2018)
Sharon Pitteri, PhD	Invited to join California Breast Cancer Research Council Named Chair, Department of Biomedical Data Science (2019)
Jianghong Rao, PhD	Inducted into the AIMBE College of Fellows (2018)
Joshua Reicher, MD	Director's Commendation Award, Palo Alto Health Care System (2018)
Johannes Reiter, PhD	Wissen schaf[f]t Zukunft Award, Lower Austria (2018) ASciNA Young Scientist Award from the Austrian Federal Ministry of Education, Science, and Research (2019)
Daniel L. Rubin, MD, MS	Inducted into the SIIM College of Fellows (2018) Inducted into the AIMBE College of Fellows (2018) Distinguished Investigator Award-Academy for Radiology & Biomedical Imaging Research (2017)
H. Tom Soh, PhD	Elected a Fellow of the National Academy of Inventors (2017)
Ali Tahvildari, MD	Affiliated Clinical Faculty Teacher of the Year Award, Department of Radiology (2019)
Victoria Tan, MD	Radiology Fellow Teacher of the Year Award, Department of Radiology (2018-19)
Katherine To'o, MD	Junior Faculty Teacher of the Year Award, Department of Radiology (2019)
Shreyas Vasanawala, MD, PhD	Inducted into the AIMBE College of Fellows (2019)
Max Wintermark, MD, MBA, MAS	Appointed President of the American Society of Functional Neuroradiology (ASFNR) RSNA Honored Educator Award (2018)
Joseph Wu, MD, PhD	Highly Cited Researcher of 2018 (Top 1% by Citations for Field and Year, Web of Science)

HONORS AND AWARDS

3
NAE Members
National Academy of Engineering

Katherine Ferrara, PhD
Gary Glover, PhD
Norbert Pelc, ScD

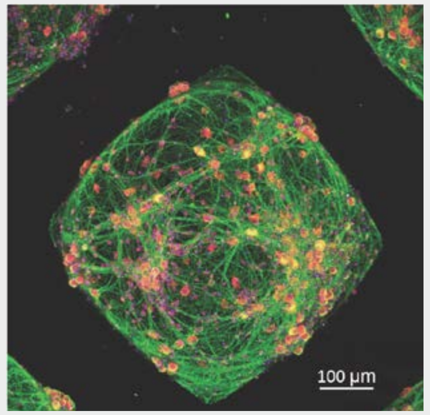
2
NAM Members
National Academy of Medicine

Sanjiv Sam Gambhir, MD, PhD
Joseph Wu, MD, PhD

2
NAI Members
National Academy of Inventors

Sanjiv Sam Gambhir, MD, PhD
H. Tom Soh, PhD

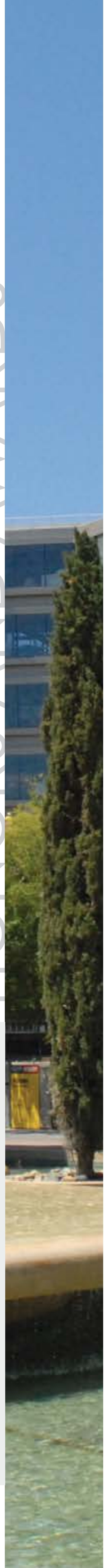
Radiology Group Picture 2019



Tanchen Ren, PhD, Postdoctoral Scholar:

Laboratory of Utkan Demirci, PhD, Canary Center for Cancer Early Detection

Micro-brain surrogate on a chip. Confocal microscopy fluorescence image of neuronal micro-tissue representing inhibitory neurons (green) and excitatory neurons (red). The brain micro-surrogate, with interconnecting excitatory and inhibitory neurons, was fabricated using UV light-based 3-D printing which can be used for mimicking neuronal activity and for the study of disease pathology.



FEATURE

IMMERS
Incubator for Medical Mixed and Extended Reality at Stanford

IMMERS is the *Incubator for Medical Mixed and Extended Reality at Stanford*. Centered in the P170 lab space on the ground floor of the Lucas Center, the *incubator* was established in July, 2018 with a mission to transform patient care by leveraging the power of mixed reality and extended reality visualization of medical images and other information. During its first year, the incubator has focused on outreach, education, and research. IMMERS is led by Bruce Daniel, MD (Director) and Brian Hargreaves, PhD (Co-Director).

Bruce Daniel, MD (Director)

Brian Hargreaves, PhD (Co-Director)

At the incubator, clinicians interested in applying mixed reality to project patient data (images, measurements, interventional plans) onto the patient's body have initiated nascent collaborations for application in various surgeries including: breast cancer, pediatric airway, thoracic, plastic, orthopedic, neurosurgery, and interventional neurology. The *incubator* also serves as a hub, working in parallel with other researchers in the Augmented Reality/Virtual Reality/Mixed Reality/Extended Reality field at Stanford, including the Stanford Center for Image Systems Engineering (SCIEN), the Stanford Virtual Heart, and CardinalSim.

IMMERS students in a mixed reality session

As part of the education focus, the *incubator* has taught three classes including an entirely new three-credit class, Rad 206 Mixed-Reality in Medicine, as well as re-designed IMMERS-specific lab sessions for Rad 220 Intro to Imaging and Image-based Anatomy, and BioE 301B Clinical Needs and Technology. Students were able to experience mixed reality applications, and develop new content (apps) as well. This effort was supported with a negotiated long-term loan agreement of mixed reality equipment between Stanford and Microsoft. Further, IMMERS offers internship openings to full-time summer students through a range of REU (Research Experience for Undergraduates) projects.

One major IMMERS research project is focused on improving breast cancer surgery. Under-excision is a constant concern with lumpectomy, with positive margins occurring in up to 25% of cases. Over-excision is also problematic, with surgeons removing, on average, 2.3 times the amount necessary. Under- and over-excision occur because surgeons cannot see or feel the tumor in the breast during surgery. The goal of this research initiative is to project a 3D MRI-based rendering of the tumor onto the patient to guide surgical planning, and eventually excision. Our system is currently being used in the operating room, and improves on the accuracy of tumor size estimation significantly compared to estimates without using the system. This project has received support from Stanford Bio-X, the California Breast Cancer Research Program (CBCRP), and the Stanford Women's Cancer Center "Under One Umbrella" program.

Another major project is to guide transcranial magnetic stimulation (TMS), supported by the NIH. TMS is an important, noninvasive treatment option that places electromagnetic coils close to the head to stimulate dorsolateral prefrontal cortex (DLPFC) circuits for the treatment of depression. 2D image-based neuro-navigation methods are accurate, but present a few significant challenges—they are complex to set up and use, and require the operator to divide his or her attention between the coils, controls, patient, electromyogram, and the neuro-navigation display.

A mixed reality setup to guide TMS treatment.

To address these challenges, a mixed reality setup is proposed that projects all the relevant targeting information directly into the field of view of the clinician. The clinician wears a mixed reality headset, such as the Microsoft HoloLens, which allows identification of brain areas such as the DLPFC or specific functional networks directly overlaid on the patient's head. An IRB-approved study has already demonstrated proof-of-principle that clinicians can use the system to activate the motor cortex. This project has received NIH funding from the National Institute of Mental Health (R21 MH116484, PI: J. McNab) and has been presented at several national meetings.

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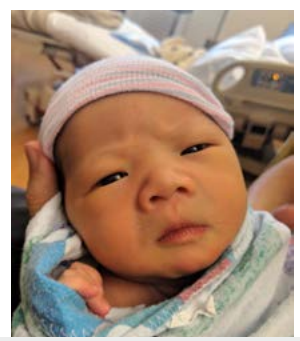

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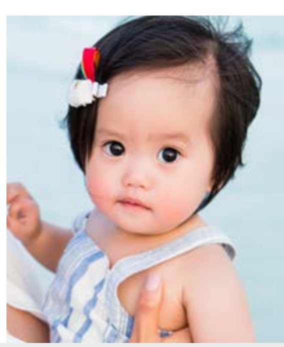

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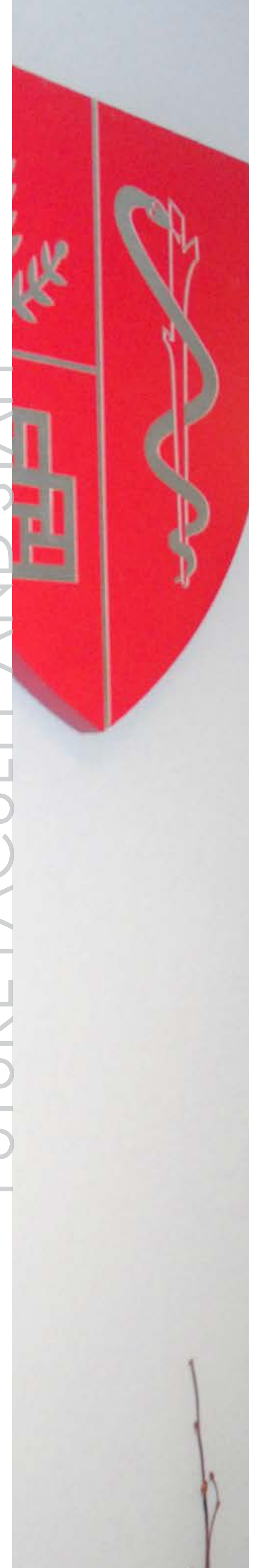

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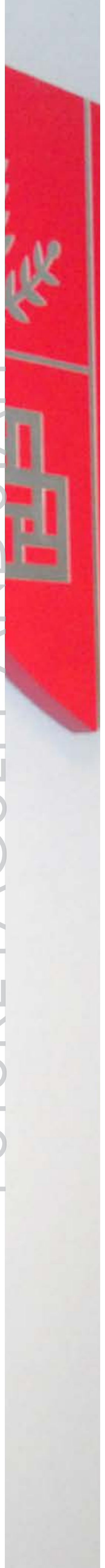
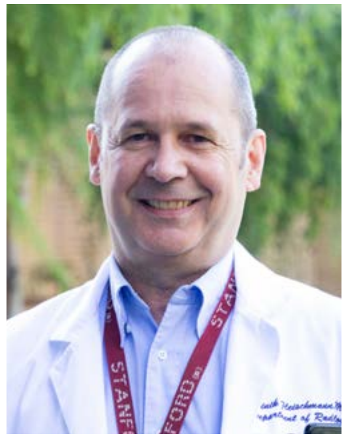


FEATURE

3DQ Lab

Sandy Napel, PhD
Scientific Director



Dominik Fleischmann, MD
Clinical Director

The Stanford Radiology 3D and Quantitative Imaging Lab (3DQ Lab) supports the mission of the Department of Radiology by developing and providing alternative visualizations and quantitative analysis of images for Stanford's patients. Since 1996, the 3DQ Lab has grown steadily and now consists of 19 technologists performing advanced 3D reconstruction and quantification for many clinical entities, including Stanford Health Care and Lucille Packard Children's Hospital. Highlights include:

3D Printing: Over the last two years, the 3DQ Lab has increased its clinical applications in 3D printing. Major growth areas have been: 3D prints for guidance before and during breast-flap reconstruction surgery, and 3D-printed slicing guides for pathologists to mimic MRI orientation of the prostate. Several abstracts and awards have resulted from partners collaborating with the 3DQ Lab on these new clinical applications.

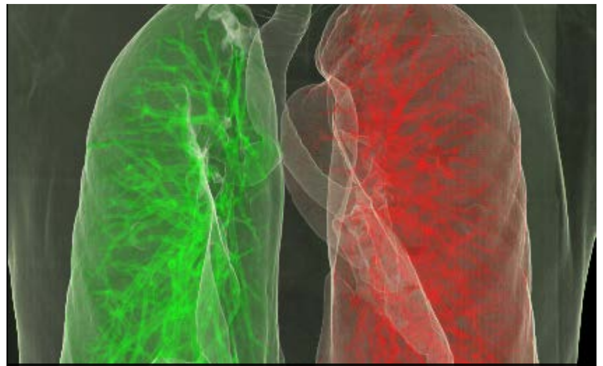
Neuroimage Processing: The 3DQ Lab recently expanded neuroimage processing beyond functional Magnetic Resonance Imaging and Diffusion Tractography Imaging to now include: longitudinal measurements of Fractional Tumor Burden, 3D visualization and printing of epilepsy depth electrodes, and mapping of specific nerves to guide High Intensity Focused Ultrasound targeting for reducing essential tremor.

Percutaneous Valve Replacements: During the last several years, the 3DQ Lab has moved beyond aortic and pulmonary valve replacement planning and is now also providing advanced planning for percutaneous mitral valve replacements. The increasing number of patient cases requiring percutaneous valve replacement validates the direction of the 3DQ Lab in expanding its expertise in this area over the last decade.

Standardized Tumor Response Assessments: The 3DQ Lab continues to provide tracking and standard reports of measurements of tumor response to therapy. To date, nearly 100 clinical trials at Stanford have leveraged this service, which provides a standardized approach to identifying, measuring, and labeling lesions. Furthermore, standardization continues into the storage, display, and criteria-based report generation for each imaging time point. The final reports are uploaded to the medical records for all involved physicians to use as needed.

Machine Learning for Aortic Segmentation and Classifying Aortic Features: The next step in the 3DQ Lab activities related to Aortic Dissection is to improve the process of identifying, segmenting, and parameterizing the aorta. Early results show promise that the aorta and various lumina can be identified, labeled, and segmented. A major goal after this will be to track changes in all such metrics automatically throughout the patient history.

The 3DQ lab is led by Sandy Napel, PhD (Scientific Director), Dominik Fleischmann, MD (Clinical Director), and Roland Bammer, PhD (Consulting Technical Director), with management support by Shannon Walters (Executive Manager) and Linda Horst and Marc Sofilos (Co-Managers).



Volumetric surface rendering of air-tissue interfaces with green highlighting of the right lung and red highlight of the left lung on a patient with relatively healthy lungs.

Demonstrates cinematic-rendered Chest/Abdomen/Pelvis CT exam with global cut-plane to visualize vascular anatomy.

Equipment

The Department of Radiology has outstanding clinical facilities on the Stanford Campus and throughout the San Francisco Bay Area. The on-campus locations include: Stanford Healthcare's Adult Hospital, Blake Wilbur Outpatient Center, Stanford Advanced Medicine Center (Cancer Center), Stanford Neuroscience Health Center, Hoover Pavilion, and Lucile Packard Children's Hospital. In particular, with opening of the Lucile Packard Children's Hospital Expansion in December 2017 and the new Stanford Hospital in 2019, the latest equipment allows the department to continue its commitment to patient care at the highest level. While focused on clinical care, research studies are also performed on the equipment at many of these clinical locations.

NEW STANFORD HOSPITAL

4 MRIs (including one intraoperative MRI), 3 CTs, X-ray, ultrasound, angiography equipment (4 Single-Plane systems, 3 Bi-Plane systems, 2 Hybrid systems)

LUCILE PACKARD CHILDREN'S HOSPITAL EXPANSION

2 MRIs (including one intraoperative MRI), PET-MR, SPECT-CT, SPECT, X-ray, Fluoro, DEXA, 2 interventional radiology angiography suites (1 Bi-Plane system, 1 Single-Plane system)

CLINICAL IMAGING EQUIPMENT

(does not include research systems)

54
Total
Major Modalities in SHC and LPCH as of 10/2019

22
MR*
Across 11 Sites

* Includes intraoperative MRIs

2
PET-MR
Across 2 Sites

15
CT
Across 9 Sites

5
PET-CT
Across 3 Sites

10
Mammography Tomosynthesis
Across 5 Sites


New Stanford Hospital
Photo Credit: Paul Keitz Photography


New Stanford Hospital


New Stanford Hospital


Lucile Packard Children's Hospital Expansion


Lucile Packard Children's Hospital Expansion


Lucile Packard Children's Hospital Expansion

Industry Collaborations

Bridging Discoveries and Biomedical Innovation

L–R: Andrea Tichy, Garry Gold, Susan Spielman, Rajan Munshi

Research collaborations between radiology faculty and industry partners are essential to translating biomedical research breakthroughs to clinical practice. These collaborations support the department's long-term commitment to excellence in patient care, medical diagnostics, biomedical imaging, and minimally invasive therapies. These collaborations can take many different forms—from a simple material transfer agreement, to an unfunded collaboration, to a sponsored research agreement. Industry-sponsored research can vary in size from a small pilot study to larger multi-project studies focused on specific therapeutic goals. Given the broad scope of clinical care offered by the department, faculty have developed research collaborations with large device manufacturers, molecular imaging biotechnology companies producing radiotracers, and start-ups. At any given time, radiology faculty collaborate with 20+ industry partners across 50+ agreements, not including clinical trials (see separate Feature on Clinical Trials on page 83). The department greatly values these relationships with industry partners, and in support of them, offers resources to assist with the development and contracting of new projects, as well as maintenance and expansion of existing collaborations.

Andrea Tichy, PhD, Senior Industry Collaborations Manager in Radiology, is the first point of contact for any questions related to collaborating with industry partners. In her role, she provides guidance during the initial stages when often there are questions about confidentiality, intellectual property, data ownership, and, more recently, access to clinical data owned by Stanford. Once the scope of the collaboration has been defined, she assists faculty with navigating the budgeting and contracting processes for investigator-initiated projects, including those resulting from initial contact by industry. A typical process for industry collaborations is illustrated below. Once a sponsored project is underway, Dr. Tichy tracks deliverables and payments to ensure that the collaboration is moving forward as envisioned. She works closely with Garry Gold, MD (Vice Chair of Research and Administration), Susan Spielman (Senior Director, Strategic Programs and Projects), and Rajan Munshi, PhD, MSIS (Deputy Director, Scientific Program Management) to manage the department's many relationships with industry.

Typically, Stanford's Industrial Contracts Office (ICO) negotiates non-clinical trial research agreements with industry partners on behalf of the University. ICO Director Glennia Campbell and Christine Watson (Industrial Contracts Officer) have been invaluable in supporting and advising the department on all aspects on industrial collaborations. Depending on the particular collaboration, ICO may consult with or seek review and advice from other Stanford offices, such as the Privacy Office or the Office of the General Counsel. Listed below are general considerations that faculty and researchers should be cognizant of when considering a collaboration with an industry partner.

Sponsored Research Agreements: The most common form of collaboration with industry within Radiology is the Sponsored Research Agreement (SRA). The SRA includes a scope of work, deliverables, and budget, as well as required research agreement provisions, such as intellectual property, confidentiality, indemnification and publication terms.

Master Agreements: For industry partners who frequently engage in collaborations or anticipate multiple research projects either with a single department or several departments, Stanford's ICO develops and negotiates master agreements with those partners to minimize the time and resources required before a research project begins. Generally, master agreements govern the standard legal terms and conditions of industry collaborations (e.g., intellectual property, publication, liability, indemnification, data ownership, confidentiality, equipment, payment terms, etc.) so that the parties can simply negotiate individual statement of work terms relating to a particular project rather than negotiating a new set of terms every time.

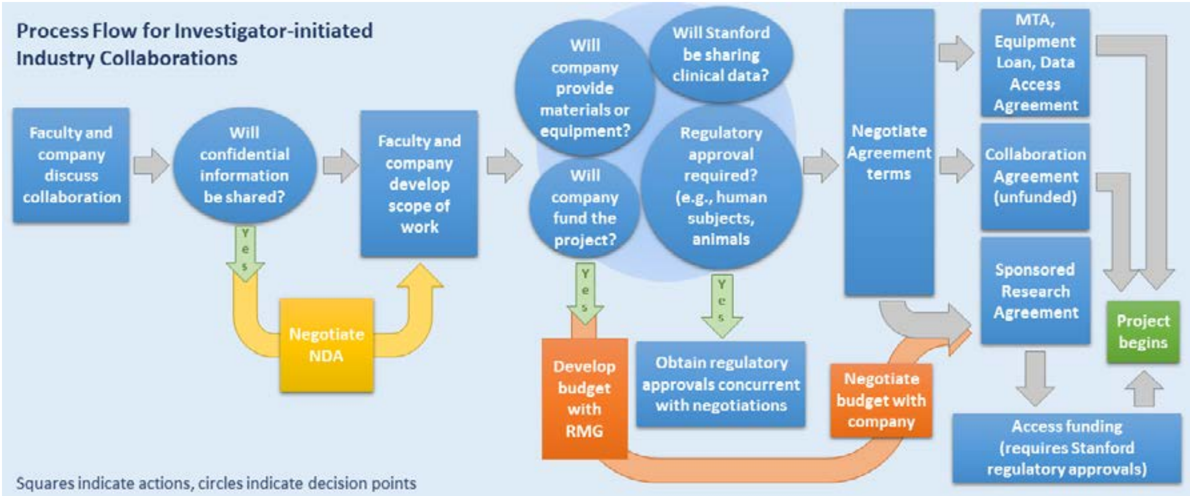
Intellectual Property (IP): Stanford's Office of Technology Licensing (OTL) manages the IP assets developed at Stanford. ICO is an organization within OTL, and ICO Contract Officers work closely with OTL Licensing Associates to draft research agreements terms that align with Stanford's IP policies. In general, Stanford researchers assign any right, title and interest in patentable inventions to Stanford and Stanford owns the IP generated by its researchers in connection with a research project. When a Stanford researcher collaborates with an industry partner on an invention and they, together, make a joint intellectual contribution, Stanford and the industry partner may share joint ownership of the IP developed together depending on the circumstances. Industry funding of a project, alone, does not confer joint ownership for the industry partner. In some instances, an industry partner may negotiate a license or an option for a license in the research agreement.

Data Access: A relatively new and evolving subject of negotiation, as artificial intelligence (AI)-based and machine learning-based approaches in biomedical research become more of an industry focus, is data access. For any research agreement that provides access to Stanford-owned data, a separate review and approval by Stanford's Privacy Office is required in addition to ICO's review process.

Material Transfer Agreement (MTA) and other Standard Agreements: Most standard agreements, such as MTAs, Equipment Loans, and Collaboration Agreements (unfunded) with industry partners, also are negotiated on a regular basis by ICO Contract Officers.

21
Industry Partners

41
Sponsored Projects



Radiology Translational Research: Innovation through Collaboration

The field of radiology continues to play a significant role in translational research. This is, in part, due to the inherent nature of the field that draws from both the quantitative (physics, mathematics, computer science) and biological sciences (physiology, anatomy, cell and molecular biology) to develop better and more effective imaging and treatment methodologies. Clinical and research faculty in the department are acutely aware of this need to integrate different disciplines to achieve the goal of translating research into everyday clinical care.

Interdisciplinary solutions are more important today than at any time in the past. Advances in computer technology and artificial intelligence have resulted in a rapid increase in these types of applications within the field of medicine. These methodologies are transforming not only the way clinical care is provided to patients, but also the way diseases are being detected, treated, and monitored.

In the following pages (44-53), we highlight three translational research programs with each sharing a story of the “bench-to-bedside” paradigm as a result of collaborations between physicians and researchers from multiple disciplines, all with the common goal of improving clinical care.

(1) Artificial Intelligence in Radiology.

(2) Theragnostics: Combining Diagnostic and Therapeutic Radiopharmaceuticals to Fight Cancer.

(3) Diagnostic Ultrasound through a Different Lens.

These translational stories are possible only because of the shared long-term commitment of clinicians and researchers to focus on the needs of the patient. The department continues to support this vision while encouraging innovative, translational research built on the extensive resources and facilities available at Stanford.

PROJECT NAME

Artificial Intelligence in Radiology

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Heike Daldrup-Link, MD
Guido Davidzon, MD
Utkan Demirci, PhD
Terry Desser, MD
Bao Do, MD
Lane Donnelly, MD
Gozde Durmus, PhD
Ahmed El Kaffas, PhD
Daniel Ennis, PhD
Katherine Ferrara, PhD
Benjamin Franc, MD
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Carolina Guimaraes, MD
Henry Guo, MD, PhD
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Brian Hargreaves, PhD
Lawrence "Rusty" Hofmann, MD
David Hovsepian, MD
Andrei Iagaru, MD
Michael Iv, MD
Aya Kamaya, MD
Curtis Langlotz, MD, PhD
David Larson, MD, MBA
Craig Levin, PhD
Matthew Lungren, MD, MPH
Jennifer McNab, PhD
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Brian Rutt, PhD
Rajesh Shah, MD
Shreyas Vasanawala, MD, PhD
Adam Wang, PhD
David Wang, MD
Martin Willemink, MD, PhD
Kristen Yeom, MD
Gregory Zaharchuk, MD, PhD

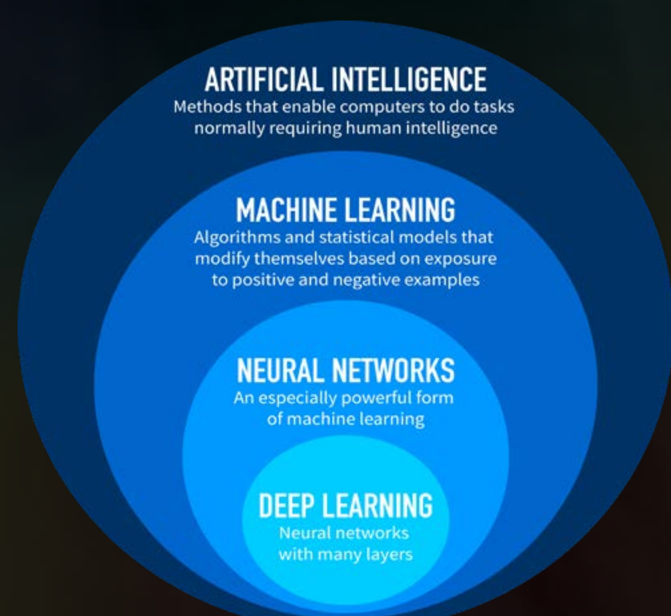
See Figure 3 caption page 46.

Artificial Intelligence in Radiology

ARTIFICIAL INTELLIGENCE IN RADIOLOGY

Artificial Intelligence (AI) is likely to transform radiology practice. The promise of AI lies in its ability to analyze massive datasets to learn patterns that assist clinicians in making better patient care decisions. In radiology, AI tools have already proven their ability to prioritize for immediate interpretation any imaging studies that show serious illness. These evolving algorithms aim to more rapidly and accurately detect and diagnose disease, determine the optimal treatment for a patient, and even predict whether a healthy person will develop disease in the future.

These revolutionary possibilities are enabled through cutting-edge research and development. Stanford Radiology is an international leader in AI research, with efforts addressing all organ systems and throughout the imaging life cycle (which includes test selection, image reconstruction, quality control, triage, detection, classification, and image reporting). We have developed an AI community and a research infrastructure to construct these powerful AI algorithms (Figure 1), including innovative methods that enable AI applications to tackle clinical problems that are especially difficult for physicians, such as making clinical predictions.



AIMI CENTER

The Center for Artificial Intelligence in Medicine and Imaging (AIMI) was established in May 2018 with a primary mission to develop computational and biomedical methods that enable innovative medical AI applications. The AIMI Center is a long-term scholarly initiative that requires both technical and clinical skill, and like many informatics initiatives, depends critically on interdisciplinary collaboration among clinicians, computer scientists, statisticians, and informatics professionals. Stanford's preeminence in this field relates both to the active collaborations between the schools of Medicine and Engineering and to the dynamic engagements with corporate partners who can deliver innovations to clinicians and patients. Our strategic objectives include developing intelligent devices, augmenting clinicians, democratizing medical AI, and improving health.

To support this mission, the AIMI Center is developing a robust research IT infrastructure in collaboration with the School of Medicine, including the latest tools for cohort generation, dataset curation, and image annotation. The AIMI Center also catalyzes extramural funding through its seed grant program, which stimulates and supports the creation of innovative high-impact ideas to improve patient care. The AIMI Center's industry affiliates program fosters collaboration on AI research projects and accelerates the commercialization of research at scale to achieve societal impact. The AI for Healthcare Bootcamp, established as an interdisciplinary collaboration with Professor Andrew Ng's laboratory in the Department of Computer Science, gives Stanford students an opportunity to work on high-impact research problems with AIMI Center faculty.

Stanford faculty are invited to become affiliated faculty of the Center. Additional opportunities for engagement by members and friends of the Stanford community can be found on the AIMI Center's website at https://aimi.stanford.edu. AIMI Center leadership includes Curtis Langlotz, MD, PhD (Director), Matthew Lungren, MD, MPH (Associate Director), and Johanna Kim, MBA, MPH (Executive Director).

RADIOLOGY AI APPLICATIONS

The following vignettes provide a brief overview of a few of the ongoing research projects led by radiology faculty, including collaborations throughout Stanford and elsewhere. These vignettes encompass a spectrum of AI efforts within the department—from the development of methodology to eventual clinical application.

Building the AI Community: Federated Learning of AI Applications

Figure 1: A major unsolved challenge with AI in medicine is the ability to generalize results of a model trained on data from a single institution. Creating large centralized collections of images from different hospitals raises patient privacy concerns. A possible alternative is "federated learning" where the algorithm is brought to the data (instead of the reverse), permitting institutional collaboration without sharing data. Infrastructure for this consists of a central server sharing parameters of AI models trained individually at different sites, with each site sharing the model weights (but not patient data) during training.[1]

INAUGURAL ACTIVITY

- The AIMI Center: 95+ affiliated faculty members from 20+ departments across three Schools.
- Seven innovative projects received total of $525,000 in AIMI seed grant awards (2019).
- More than 30 peer-reviewed manuscripts published in inaugural year; publication describing expert-level pneumonia detection cited over 330 times to date.
- Affiliated faculty publicly released four large annotated datasets (knee MRI, chest radiographs, bone radiographs, brain CT), comprising over 550,000 imaging studies, advancing the field of machine learning.

FOUNDATIONAL APPROACHES IN AI METHODOLOGY DEVELOPMENT

Collaborative Collection of Images to Build Powerful Deep Learning Models

In medicine, most clinical images have no labels. Manual image labeling is a tedious task unless supported by robust software tools. To address this need, Dr. Daniel Rubin's laboratory has developed the electronic Physician Annotation Device (ePAD; http://epad.stanford.edu), an open-source web-based software program that enables the community to view and label radiology images easily. Image labels can include clinical data such as diagnoses, visible abnormalities, and anatomic locations. ePAD promotes large-scale collections of labeled images for AI research, and is being used by 400+ users who have created over 50,000 image annotations in more than 500 projects to date.[2]

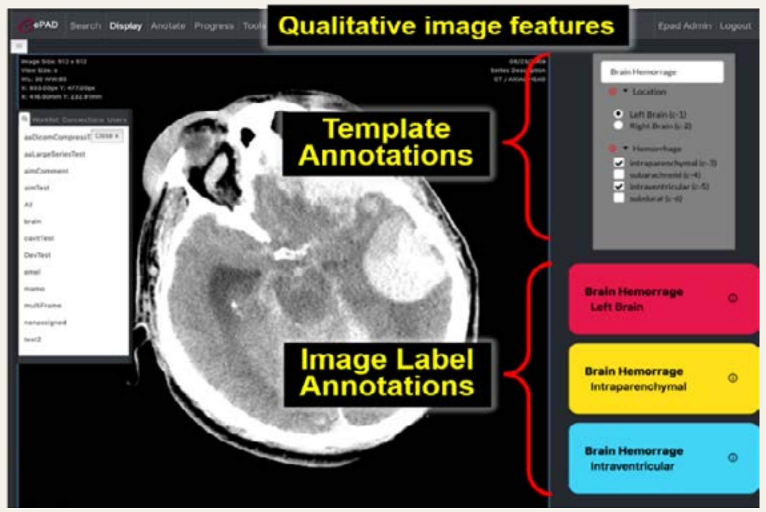


Figure 2: The web-based ePAD interface that permits users to quickly view images and assign labels (shown on the right).

Clinical Prediction with Images

Stanford radiologists are developing new AI technologies that can improve image formation and reconstruction. Gregory Zaharchuk, MD, PhD is developing deep learning methods to transform one type of image to another. His laboratory uses existing images to predict new images with improved resolution or other advantageous features, such as lower radiation dose or lower contrast dose. Dr. Zaharchuk's research suggests that, in some cases, PET radiation dose can be reduced by 99% when MR images are available. Similar methods can produce synthetic PET images of cerebral blood flow and brain metabolism from MR images, predicting what PET images would look like if they had been obtained. These synthetic studies may avert the need for patients to make multiple trips to radiology clinics for imaging.[4a,b]

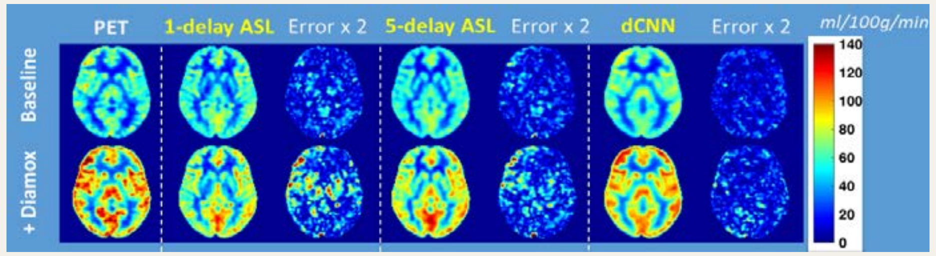


Figure 4: Predicted PET images ("PET" column) compared with actual cerebral blood flow and brain metabolism images ("1-delay ASL," "5-delay ASL," and "dCNN" columns), and the difference from the predicted PET images ("Error X 2").

CLINICAL APPLICATIONS OF AI IN RADIOLOGY

Weakly Supervised Deep Learning for Automated Triage

"Automated triage" is a new AI-enabled paradigm that flags for prompt review by a radiologist any imaging studies likely to contain important pathology. Matthew Lungren, MD, MPH (Radiology), Chris Ré, PhD (Computer Science), and Jared Dunnmon, PhD (Computer Science) have developed an AI algorithm to triage likely abnormal chest radiographs for immediate interpretation. This team is developing innovative ways to create "noisier" image labels to train their AI-based algorithms. These labeling methods, while less accurate, are as effective as smaller amounts of human-labeled data, and easy to automate. Weak supervision holds the key to ensuring that AI algorithms can be retrained and updated rapidly with changes in patient populations, scanning hardware, and diagnostic criteria.[3]

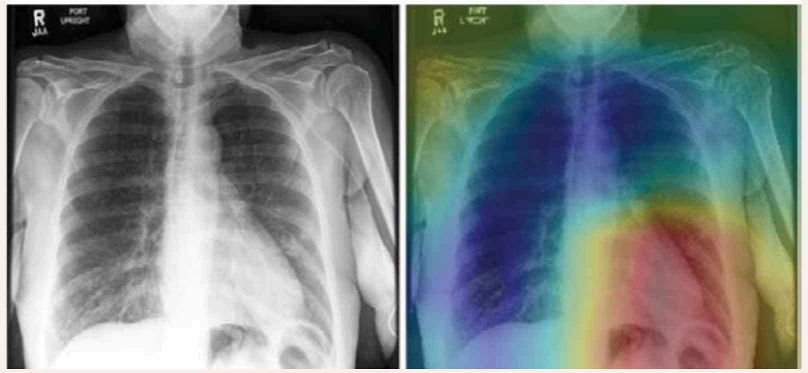


Figure 3: AI output for a borderline case of enlarged heart; raw radiograph at left, AI heat map at right that shows the areas of the image that are most (red) and least (blue) responsible for an abnormal classification, and flags the image as one needing prompt attention by the radiologist.

Augmenting Experts with AI: How Humans Perform When Given AI

Recently, AIMI researchers have developed and validated a deep learning algorithm that classifies clinically important abnormalities in chest radiographs at an accuracy comparable to practicing radiologists. CheXNeXt, a deep learning algorithm to concurrently detect 14 clinically important diseases on chest radiographs, was trained on one of the largest public repositories of radiographs, containing 112,120 frontal-view chest radiographs of 30,805 unique patients. Once current prospective testing in clinical settings is completed, the algorithm could expand patient access to chest radiograph diagnostics.[5]

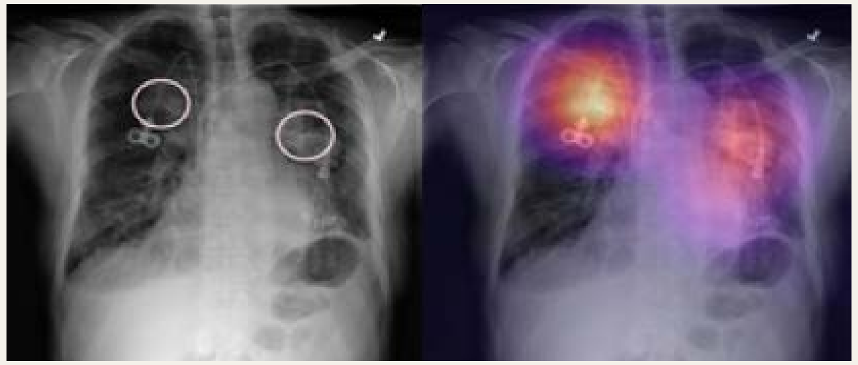


Figure 5: Interpreting network predictions using class activation mappings (CAMs), often called "heat maps". Frontal chest radiograph (left) demonstrates two upper-lobe pulmonary masses without (left) and with (right) heat maps.

Automatic Detection and Classification of Diseases: Brain Aneurysms

Deep learning has the potential to augment clinician performance in medical imaging interpretation and reduce time to diagnosis through automated segmentation. Led by Stanford faculty, Kristen Yeom, MD (Radiology), and Andrew Ng, PhD (Computer Science), researchers are developing and applying an AI tool to help radiologists identify brain aneurysms. Their neural network segmentation algorithm, called HeadXNet, is capable of generating precise voxel-by-voxel predictions of intracranial aneurysms on head computed tomographic angiography (CTA) imaging. This tool could enable clinicians to find six more aneurysms per 100 positive scans. This algorithm also improved consensus among the interpreting clinicians. The team is focusing on prospective multi-center clinical trials to further evaluate generalizability of the AI tool.[6]

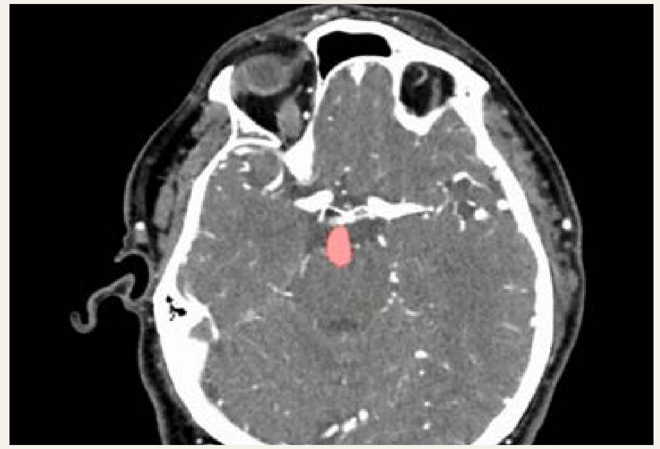


Figure 6: In this brain scan, the location of an aneurysm is indicated by HeadXNet using a transparent red highlight. (Image credit: Allison Park)

Prospective, Multi-Center Clinical Trial for the Stanford AI Bone Age Tool

Stanford radiologists and researchers have developed an AI algorithm that can predict the skeletal age from a single hand x-ray. This algorithm can estimate the patient's skeletal age with an accuracy similar to that of an expert radiologist and existing automated models. The AIMI Center is currently performing a prospective, multi-institutional randomized controlled trial to validate the generalizability of the bone age tool at nine other sites including Boston Children's Hospital, Children's Hospital of Philadelphia and Cincinnati Children's Hospital. This is one of the first multi-institutional attempts to validate and deploy an AI algorithm in a clinical setting.[7]

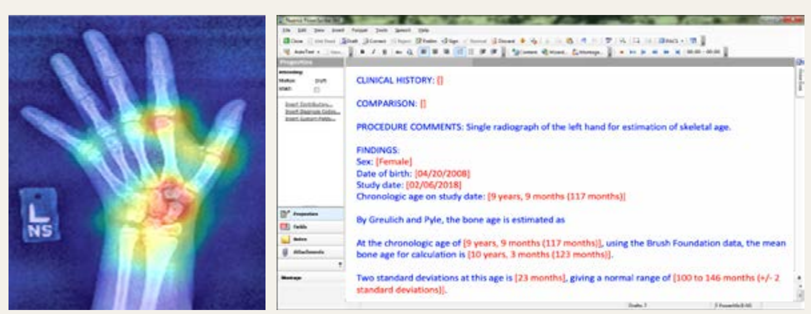


Figure 7. Original image with superimposed saliency map for a radiographic hand image in a child. The AI-generated radiology report is shown on the right, where text in "red" indicates results from the model. The AI-generated report is reviewed by the supervising radiologist to confirm accuracy of the model prior to finalizing the report.

ARTIFICIAL INTELLIGENCE

MRNet: Deep-Learning-Assisted Diagnosis for Knee Magnetic Resonance Imaging

More musculoskeletal magnetic resonance (MR) examinations are performed on the knee than on any other region of the body. In a study published in PLOS Medicine, Stanford AIMI researchers developed a deep learning algorithm for detecting anterior cruciate ligament [ACL] tears, meniscal tears, and other abnormalities on knee MR exams. The effect of providing the model's predictions to clinical experts during interpretation was then measured. Algorithm assistance resulted in a mean increase of 0.048 (4.8%) in ACL specificity, which equates to approximately 5 out of 100 healthy patients who would be saved from being unnecessarily considered for surgery. The results show that AI algorithms are most effective when used to augment the expertise of human clinicians.[8]

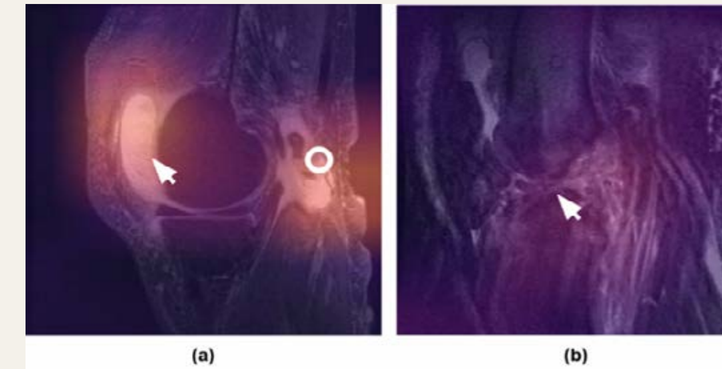


Figure 8: (a) Sagittal T2-weighted image of the knee shows a large effusion (arrow) and rupture of the gastrocnemius tendon (ring), correctly classified as abnormal, shown by the heat map. (b) Sagittal T2-weighted image of the knee complicated by a significant motion artifact demonstrating complete anterior cruciate ligament (ACL) tear (arrow), which was correctly classified and localized by the model.

PUBLICATIONS:

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3. Dunnmon JA, Yi D, Langlotz CP, Ré C, Rubin DL, Lungren MP, Assessment of Convolutional Neural Networks for Automated Classification of Chest Radiographs, *Radiology* 290(2):537-544, 2019.

4a. Zaharchuk G, Gong E, Wintermark M, Rubin D, Langlotz CP, Deep learning in Neuroradiology, *Am J Neurorad* 39:1776-84, 2018.

4b. Chen K, Gong E, Macruz F, Xu J, Boumis A, Khalighi M, Poston KL, Sha SJ, Greicius MD, Mormino E, Pauly J, Srinivas S, Zaharchuk G, Ultra-low Dose 18F-florbetaben Amyloid PET Imaging using Deep Learning with Multi-Contrast MRI Inputs, *Radiology* 290:649-656, 2019.

5. Rajpurkar P, Irvin J, Ball RL, Zhu K, Yang B, Mehta H, Duan T, Ding D, Bagul A, Langlotz CP, Patel BN, Yeom KW, Shpanskaya K, Blankenberg FG, Seekins J, Amrhein TJ, Mong DA, Halabi SS, Zucker EJ, Ng AY, Lungren MP, Deep Learning for Chest Radiograph Diagnosis: A Retrospective Comparison of the CheXNeXt Algorithm to Practicing Radiologists, *PLOS Medicine* 15(11): e1002686, 2018.

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7. Larson DB, Chen MC, Lungren MP, Halabi SS, Stence NV, Langlotz CP, Performance of a Deep-Learning Neural Network Model in Assessing Skeletal Maturity on Pediatric Hand Radiographs, *Radiology*, 287(1):313-322, 2018.

8. Bien N, Rajpurkar P, Ball RL, Irvin J, Park A, Jones E, Bereket M, Patel BN, Yeom KW, Shpanskaya K, Halabi S, Zucker E, Fanton G, Amanatullah DF, Beaulieu CF, Riley GM, Stewart RJ, Blankenberg FG, Larson DB, Jones RH, Langlotz CP, Ng AY, Lungren MP, Deep-learning-assisted Diagnosis for Knee Magnetic Resonance Imaging: Development and Retrospective Validation of MRNet, *PLoS Med* 15(11):e1002699, 2018.

Theragnostics:

Combining Diagnostic and Therapeutic Radiopharmaceuticals to Fight Cancer

PROJECT NAME

Theragnostics: Combining Diagnostic and Therapeutic Radiopharmaceuticals to Fight Cancer

CONTRIBUTORS

Carina Mari Aparici, MD

Andrei Iagaru, MD

Honorable Mention image, see Pg 59 for full caption

Chemotherapy can be an effective treatment against cancer. However, because many chemotherapies are not targeting cancer cells only, one disadvantage is the damage done to healthy tissues. Despite obvious benefits, there are poorly-tolerated treatment-related adverse events like heart failure, kidney, lungs and nerve damage, which may preclude continuation/completion of chemotherapy.

An almost-always asked question by researchers and clinicians is: Is it possible to get rid of cancer cells inside the body with less damage to healthy tissues? The team in the Division of Nuclear Medicine and Molecular Imaging (NMMI) within the Department of Radiology at Stanford believes it is. We work closely with other disciplines to develop and translate to the clinic the patient-tailored "theragnostics" approach.

Emerging as a specific, safe, and effective discipline, theragnostics focuses on patient-centered care. It provides to the patient a transition from conventional medicine to personalized medicine at the molecular diagnostic and therapeutic levels. In the theragnostics approach, the first phase is diagnostic, where a molecular probe targeting the patient's malignancy is attached to a radionuclide with diagnostic emissions (gamma rays or positrons), and introduced into the body to obtain high quality images of where the cancer is located. If these probes find the cancer, the next phase is to deliver the therapy to the patient, using the same molecular probe but this time attached to a radionuclide with therapeutic emissions (alpha or beta radiation). The ability to analyze in vivo the biology behind various cancers using these paired theragnostic radiopharmaceuticals allows the development of a specific diagnostic and therapeutic plan tailored for each patient's malignancy. The radiation emitted has low penetration (from microns to a few millimeters), allowing for effective treatment, while minimizing damage to adjacent healthy tissues. Thus, theragnostics offers a transition from "trial and error" medicine to informative, predictive and personalized medicine.

The NMMI faculty and staff at Stanford are intimately involved in the bench-to-bedside translation of theragnostics and work closely with colleagues in Oncology, Endocrinology, Radiation Oncology, Urology and Surgery to provide patients with access to early clinical trials, and help expedite FDA approval of theragnostic agents. The FDA-approval of 68Ga-DOTA-TATE (June 2016) and 177Lu-DOTA-TATE (January 2018), a theragnostic pair for diagnosis and therapy in patients with neuroendocrine tumors (NET), ignited the clinical use of modern theragnostics in the United States. Pamela Kunz, MD and Erik Mittra, MD, PhD were the co-investigators at Stanford in the pivotal phase III trial (NETTER-1) that led to regulatory approval. This international multicenter phase III trial was conducted at 41 centers in eight countries worldwide; the Stanford team successfully enrolled the second highest cohort of participants. The Theragnostics Clinic at Stanford has been offering 68Ga-DOTA-TATE and 177Lu-DOTA-TATE since January 2014 and August 2016, respectively. Starting in January 2019, we have been providing Lutathera® up to four times a week. This has allowed us to promptly address a fast-developing backlog of NET patients referred for the new therapy. Furthermore, the commercial success of theragnostics in NET has led to enthusiasm for other uses, such as in prostate cancer. There are now phase I/II and phase III trials evaluating prostate specific membrane antigen (PSMA) theragnostic pairs. In addition, gastrin-releasing peptide receptors (GRPRs) are other targets for theragnostics in prostate cancer, but also in other malignancies such as breast and ovarian cancer. In line with our commitment to advance patient care, the Theragnostics Clinic at Stanford participates in several of these trials. These are exciting times for everyone involved, and Stanford is helping to lead the way in making theragnostics an indispensable part of patient care.

An important piece of the theragnostics puzzle at Stanford is designating a new space for the program. The leadership of the Department of Radiology and Stanford Health Care recently approved funds for renovation of a space in NMMI. This will become a state-of-the-art Theragnostics Center and is scheduled to open in early 2021. This Center is a commitment of Stanford Medicine's recognition of the value of theragnostics and the rapid pace with which it is becoming an integral aspect of providing excellent patient care in cancer treatment.

Like any new development in advancing patient care, theragnostics will require high-quality studies to evaluate the optimal clinical scenarios for use in cancer patients. Early results are very encouraging and captivating for the treating physicians, pharmaceuticals industry, and patient advocacy groups. NMMI at Stanford is very well positioned to help patients and to continue as a flagship in the theragnostic world.

68GA-DOTA-TATE

Before Lutathera®

After Lutathera®

Diagnostic Ultrasound Through a Different Lens

ULTRASOUND THROUGH A DIFFERENT LENS

PROJECT NAME

Diagnostic Ultrasound Through a Different Lens

CONTRIBUTOR

Jeremy Dahl, PhD

Carl Herickhoff, PhD

SELECTED FUNDING

Clutter Suppression in Echocardiography Using Short-Lag Spatial Coherence Imaging. NIH/NIBIB R01-EB013661-07 (Dahl)

High Sensitivity Flow Imaging of the Human Placenta with Coherence-Based Doppler Ultrasound. NIH/NICHD R01-HD086252 (Dahl)

SELECTED PUBLICATIONS

Hyun D, Crowley AL, LeFevre M, Cleve J, Rosenberg J, and Dahl JJ. Improved visualization in difficult-to-image stress echocardiography patients using real-time harmonic spatial coherence imaging. *IEEE Transactions on Ultrasonics, Ferroelectrics and Frequency Control*, 66(3):433–441, 2019.

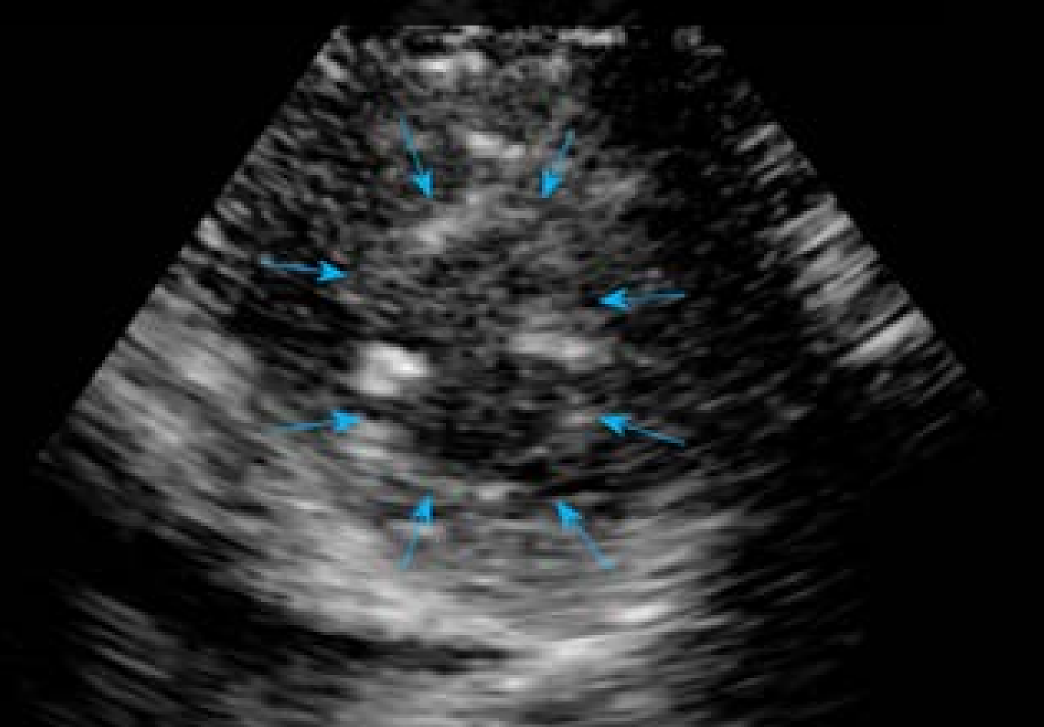
Li Y, Hyun D, Abou-Elkacem L, Willmann JK, and Dahl JJ. Visualization of small-diameter vessels by reduction of incoherent reverberation with coherent flow power Doppler. *IEEE Transactions on Ultrasonics, Ferroelectrics and Frequency Control*, 63(11):1878–1889, 2016.

See Figure 1 Caption at right.

Diagnostic ultrasound, also called sonography or diagnostic medical sonography, is a noninvasive imaging method that uses high-frequency sound waves, higher than those audible to humans (>20,000 Hz), to produce images of structures within a body. Because ultrasound does not utilize ionizing radiation (unlike X-ray and computed tomography (CT) images), is portable, and is a relatively inexpensive imaging modality, it is a powerful and very safe imaging tool that can provide valuable information for diagnosing and treating many diseases and conditions. Although ultrasound is widely known for its use in observing the fetus during pregnancy, ultrasound has other applications as well. The first known use of ultrasound for medicine was made by an Austrian neurologist, Karl Theo Dussik, in 1941 to identify the ventricles of the brain; and the first major breakthrough in ultrasound as a medical imaging tool was made in the field of cardiology in 1953 when physician Inge Edler and engineer Carl Hellmuth Hertz built a system to visualize the movements of the heart.

Nowadays, diagnostic ultrasound imaging systems are much more sophisticated than those made in the 1950s. In addition to regular ultrasound images that show anatomy, Doppler ultrasound can show blood flow in arteries and veins. An often unknown aspect of today's diagnostic ultrasound imaging systems is that they generate upwards of 8.4 gigabytes of data per second (equivalent of 170 digital X-ray images per second). In order to handle this amount of data and display images in real-time, an ultrasound system needs to compress this data into a smaller and more manageable form for display. The main process by which this happens is called beamforming. The ultrasound beamformer is responsible for compressing the ultrasound data, directing the ultrasound energy to the desired location, and affects the overall image quality. The common style of beamforming in all diagnostic ultrasound imaging systems is called delay-and-sum beamforming.

In the Ultrasound Research Laboratory, led by Jeremy Dahl, PhD, researchers explore and develop technologies to improve the clinical diagnostic capabilities of ultrasound. For example, the Dahl Lab has been developing alternative beamforming approaches to improve ultrasound image quality in overweight and obese individuals and to improve the sensitivity of ultrasound Doppler imaging to small vessel blood flow.



In the overweight and obese population, ultrasound imaging can be severely compromised by the additional layers of subcutaneous fat and connective tissue. Obesity has dramatically risen over the last several decades; currently, 68.5% of the United States population is overweight (Body Mass Index (BMI) >25; a value between 18.5 and 24.9 is considered healthy). Approximately 25% of the population in the United States is obese (BMI >30), which creates a significant challenge in the ability for diagnostic ultrasound systems to provide high quality images. For this overweight and obese population, the Dahl Lab, in collaboration with researchers at Duke University, has developed a "coherence beamforming" technique to improve the quality of ultrasound images. The coherence beamformer compresses the ultrasound data in a different way to avoid the limitations that commonly affect ultrasound images in overweight and obese individuals.

In a recently published study, the coherence beamformer was applied to high BMI individuals in stress echocardiography. Stress echocardiography involves ultrasound imaging of the heart during rest and during exercise (or stress) to determine if the heart is functioning properly. If the interior border of the heart, the endocardium, is not visible, the function of the heart cannot be determined. Often, contrast agents are used to assist in visualizing the endocardium, but this prolongs exam time and some individuals cannot be given contrast agents due to adverse reactions. In this pilot study, coherence beamforming was compared to conventional delay-and-sum beamforming in its ability to visualize segments of the endocardial border. Overall, conventional delay-and-sum beamforming was able to visualize 58% of the endocardial segments in the study, while coherence beamforming was able to visualize 75% of the endocardial segments. This means that roughly 10% more overweight and obese patients would not be required to receive a contrast agent injection for their stress echocardiogram, thereby saving on healthcare costs, reducing exam times, and decreasing patient stress.

In addition to tackling the problem of obesity in medical imaging, coherence beamforming can also be applied to Doppler imaging to improve its sensitivity to low-speed blood flow. Because separating the movement of tissue from the movement of blood can be difficult, current Doppler imaging techniques can only detect high-speed blood flow; low-speed blood flow is often too difficult to detect but can provide valuable information about the vasculature and perfusion of organs and diseases. Researchers in the Dahl Ultrasound Research Laboratory are currently employing coherence beamforming in conjunction with long Doppler ensembles to create high-sensitivity flow imaging of low-speed blood flow in the placenta as part of the Human Placenta Project, a collaborative research effort with the NIH's Eunice Kennedy Shriver National Institute of Child Health and Human Development (NICHD) to understand the role of the placenta in health and disease. In addition, the Dahl Laboratory is applying these techniques in the neonate brain to detect disease conditions associated with blood flow, such as intraventricular hemorrhaging.

In the study involving imaging of the neonate brain, coherence beamforming with long Doppler ensembles was able to show images of the brain vasculature with blood flow as slow as 4 millimeters per second and in vessels less than 0.5 millimeter in diameter. In addition, coherence beamforming suppresses a common Doppler imaging artifact, called flash artifact. Flash artifact occurs when tissue movement is too fast for (e.g., the baby is moving or sucking on a pacifier). In these cases, coherence beamforming suppresses flash artifacts, allowing the radiologist to observe the blood flow during motion, make diagnoses, and gather information that was otherwise previously unattainable.

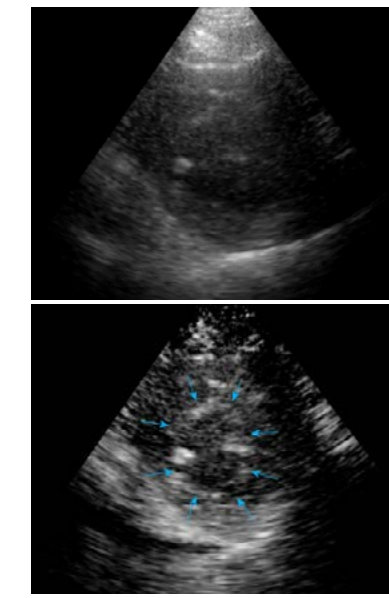


Figure 1: Comparison of ultrasound images formed by conventional beamforming (top) and coherence beamforming (bottom) in a short-axis (i.e., cross-section) view of the heart in an individual with a high body-mass index. The endocardium is difficult to visualize with conventional beamforming, but is well visualized with the coherence beamforming. [Reproduced from Hyun et al.]

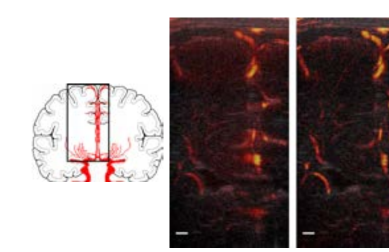


Figure 2: Images depicting blood flow in the brain of a neonate (the blood flow image is overlayed on an ultrasound image). The illustration on the left shows a coronal (frontal) view of the brain and its main vasculature, with a box depicting the location of the images in the center and right panels. A blood flow image is formed using conventional beamforming (center) and coherence beamforming (right). The coherence beamforming suppresses flash artifact (e.g., blurring of the blood vessels) and enhances the visibility of the blood vessels during free-hand scanning. Brain tissue is shown by the grayscale/dark background, while the blood is visualized by the red/yellow overlay. [Image: M. Jakovljevic]

VICE CHAIR, EDUCATION AND CLINICAL OPERATIONS

David Larson, MD, MBA

ASSOCIATE CHAIR, CLINICAL EDUCATION

Christopher Beaulieu, MD, PhD

RADIOLOGY RESIDENCY

Payam Massaband, MD
Bruce Daniel, MD
Gloria Hwang, MD
Bryan Lanzman, MD
Margaret Lin, MD
Ed Lo, MD
Jayne Seekins, DO

DUAL PATHWAY NUCLEAR MEDICINE AND DIAGNOSTIC RADIOLOGY RESIDENCY

Benjamin Franc, MD

INTEGRATED INTERVENTIONAL RADIOLOGY-DIAGNOSTIC RADIOLOGY RESIDENCY

William Kuo, MD
Andrew Picel, MD

INDEPENDENT INTERVENTIONAL RADIOLOGY RESIDENCY

John Louie, MD

SCIT PROGRAM

Stanford Cancer Imaging Training
Sandy Napel, PhD
Bruce Daniel, MD

SMIS PROGRAM

Stanford Molecular Imaging Scholars
Craig Levin, PhD

TBI^2 PROGRAM

Predoctoral Training in Biomedical Imaging & Instrumentation
Kim Butts Pauly, PhD
Norbert Pelc, ScD

CSBS PROGRAM

Cancer Systems Biology Scholars
Sylvia Plevritis, PhD
Garry Nolan, PhD

CANCER-TNT PROGRAM

Cancer-Translational Nanotechnology Training
Jianghong Rao, PhD
Dean Felsher, MD, PhD

CANARY CREST PROGRAM

Canary Cancer Research Education Summer Training
H. Tom Soh, PhD
Utkan Demirci, PhD

TRAINING PROGRAMS

Training Programs

The Department of Radiology offers clinical and research training programs (56-73): four clinical residency programs, ten clinical postdoctoral fellowship programs, and six NIH-funded undergraduate, graduate, and postdoctoral research training programs. These programs encompass all radiology subspecialties and modalities and are strongly aligned with the department's commitment to providing exceptional, compassionate clinical care and to develop the next generation of clinicians and scientists. The training programs are directed by dedicated faculty with strong management and administrative support to comprehensively oversee all aspects of the program and ensure that every trainee receives a structured, well-organized, and positive learning experience.

The four residency programs (pages 57-59) provide broad-based clinical training necessary to develop the competencies required to become outstanding radiologists capable of managing diverse patients with a broad range of diseases, while adhering to the highest ethical and professional standards of medical care.

The clinical fellowships offered by the department (pages 62-63) are designed to further advance the breadth of knowledge and clinical competence in subspecialty areas through extensive clinical, research, and teaching opportunities, and to prepare individuals to be scholars and national leaders in their fields. The goal is to positively impact the lives of patients through their leadership, research contributions, and excellence in patient care.

The department's research training programs (pages 70-72) prepare individuals for careers in interdisciplinary biomedical and clinical research at the graduate and postdoctoral level, and also undergraduate students specifically for summer research. These mentored training programs provide research and career development opportunities by preparing talented students to conduct hypothesis-driven investigative research in cancer imaging, molecular imaging, early detection of cancer, physics and instrumentation, systems biology, and nanotechnology.

4

RSNA Honored Educators*

Lane Donnelly, MD
David Larson, MD
Daniel Rubin, MD, MS
Max Wintermark, MD, MBA, MAS

*cumulative

Clinical Training Programs

The Department of Radiology continues to offer comprehensive clinical training in all radiology subspecialties through four residency and multiple clinical fellowship programs. These programs offer an exceptional training experience by encouraging trainees to interact and learn from dedicated faculty who are devoted to teaching, outstanding patient care, and translational research. The robust learning experience is coupled with the opportunity to rotate through Stanford University Hospital, the Lucile Packard Children's Hospital, the VA Palo Alto Health Care System, and Santa Clara Valley Medical Center. Trainees function as part of a clinical team responsible for the performance and interpretation of inpatient and outpatient cases. Because Stanford Radiology faculty are actively engaged in research, residents and fellows alike are exposed to outstanding research opportunities with close ties to leading engineers, and physicists, thereby allowing for participation and presentation at national meetings, conferences, and workshops.

The training programs are overseen by David Larson, MD, MBA and Christopher Beaulieu, MD, PhD in their roles as the Vice Chair for Education and Clinical Operations, and the Associate Chair of Education, respectively.

Radiology Residency Programs

The department offers four residency training programs: (1) the Diagnostic Radiology Residency Program, (2) the dual pathway Nuclear Medicine Residency Program and Diagnostic Radiology Residency Program, (3), the Interventional Radiology-Diagnostic Radiology (IR-DR) Integrated Residency Program, and (4) the Independent Interventional Radiology (IR) Residency Program. These programs provide a supportive yet rigorous environment for residency training that prepares individuals to provide excellent patient care. The Diagnostic Radiology Residency Program has historically been the largest and longest-offered program at Stanford Radiology, and has anchored the development of the three new pathways to broaden the scope of training options.

Clinical Fellowship Programs

The department offers 10 one- and two-year postdoctoral fellowships across the different clinical divisions. Fellowships begin July 1 of each year.

TRAINING PROGRAMS

Radiology Residency Programs

Diagnostic Radiology Residency Program

The goal of the Stanford Diagnostic Radiology Residency Program is to train future leaders in radiology, while leveraging the clinical strength of Stanford Health Care, the research prowess of Stanford University, and the culture of innovation in Silicon Valley. Trainees will continue to help develop the diagnostic and therapeutic modalities of tomorrow, performing cutting-edge research, and translational clinical work. Graduates of the Stanford Diagnostic Radiology Residency Program have established leadership roles in academic radiology departments, research programs, and within industry.

Payam Massaband, MD
Program Director

The residency program provides a supportive yet rigorous environment to learn from an internationally acclaimed faculty, known for superb teaching, outstanding patient care, and world-class research. Our program offers a rich clinical exposure through a variety of rotations that provide care to diverse patient populations, and by understanding the role of imaging within the larger context of patient health care.

The curriculum of the Diagnostic Radiology Residency Program affords residents the flexibility to pursue personal and professional endeavors about which they feel truly passionate. Most residents devote time during their four-year residency to perform research, advance informatics, launch innovative companies, hone clinical skills through early clinical subspecialization, learn medical design innovation, and participate in hospital-wide quality improvement projects. In 2018, we began offering the Early Specialization in IR (ESIR) and the 16 month ABR/ABNM pathway for dual boarding in Nuclear Medicine and Diagnostic Radiology. All residents choose one or two areas of focus in their final year of residency.

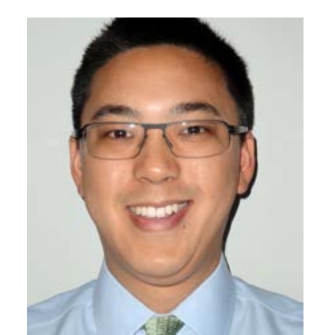
Since July 2015, the residency program has been directed by Payam Massaband, MD, a radiologist at the VA Palo Alto since graduating from Radiology residency and fellowship at Stanford in 2010. He is also the Chief of Radiology at the VA Palo Alto, concentrating on clinical excellence, process improvement and residency education. Dr. Massaband is supported by dedicated associate program directors (Drs. Bruce Daniel, Gloria Hwang, Bryan Lanzman, Margaret Lin, Ed Lo, and Jayne Seekins) and two program managers, who oversee different aspects of the program.

Bruce Daniel, MD
Associate Program Director

Gloria Hwang, MD
Associate Program Director

Bryan Lanzman, MD
Associate Program Director

Margaret Lin, MD
Associate Program Director



Ed Lo, MD
Associate Program Director

Jane Seekins, DO
Associate Program Director

Dual Pathway Nuclear Medicine Residency Program and Diagnostic Radiology Residency Program

Benjamin Franc, MD
Program Director

The department pioneered the first five-year ACGME-approved dual pathway Nuclear Medicine Residency Program and Diagnostic Radiology Residency Program in the United States starting in 2015. This pathway leads to certification by both the American Board of Nuclear Medicine and the American Board of Radiology. Our faculty are committed to educating the next generation of worldwide leaders in academic diagnostic radiology, nuclear medicine, and molecular imaging. The program includes education in all aspects of the basic sciences, diagnostics, and therapy as they relate to nuclear medicine. Ample research opportunities are provided to take advantage of resources such as the Molecular Imaging Program at Stanford (MIPS), and the Research PET-MRI Program at Stanford. Clinical training takes place at Stanford Health Care, Lucile Packard Children's Hospital at Stanford, and the VA Palo Alto Health Care System.

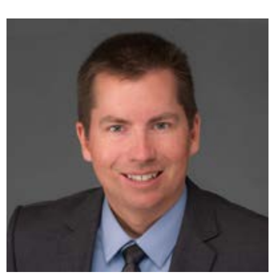
Trainees spend one year in the Nuclear Medicine program, followed by the next four years in the Diagnostic Radiology program; the final year is spent with a focus on research and clinical training in nuclear medicine and molecular imaging.

Trainees are selected by a committee including both nuclear medicine and radiology faculty who function within the National Residency Matching Program framework. We have had success each year in the Match program since this dual pathway was implemented. The trainees are fully integrated into both ACGME-accredited programs (Nuclear Medicine and Diagnostic Radiology). Our training model has been adopted by several other institutions in the U.S. and has received accolades from various groups.

The dual pathway Nuclear Medicine Residency Program and Diagnostic Radiology Residency Program is directed by Benjamin Franc, MD, Clinical Professor of Radiology/Nuclear Medicine.

Integrated Interventional Radiology-Diagnostic Radiology Residency Program

William Kuo, MD
Program Director



Andrew Picel, MD
Associate Program Director

The Integrated Interventional Radiology-Diagnostic Radiology (IR-DR) Residency Program is a five-year ACGME-accredited program that integrates three years of diagnostic radiology (DR) with two final years of dedicated interventional radiology (IR) training. The program offers a robust educational curriculum spanning the full spectrum of image-guided interventions and beyond, including cutting-edge protocols and treatments pioneered by Stanford Interventional Radiology. Candidates may enter the integrated IR-DR Residency Program directly from medical school following a one-year surgical internship. After completing the residency, graduates will qualify to obtain a dual IR-DR certificate from the American Board of Radiology.

The Stanford Division of Vascular and Interventional Radiology is a tertiary and quaternary referral center that accepts complex cases from around the country and around the world, ensuring that our trainees are exposed to a broad and intriguing case mix. In addition to advanced specialty training at Stanford University Medical Center, the residency program integrates clinical training across multiple sites and disciplines including the VA Palo Alto Health Care System, Lucile Packard Children's Hospital, Santa Clara Valley Medical Center, outpatient Interventional Radiology Clinics, multidisciplinary clinical electives and a dedicated Cardiovascular ICU rotation.

The Integrated IR-DR Residency Program is directed by William Kuo, MD, Professor of Radiology/Interventional Radiology, with support from Associate Program Director Andrew Picel, MD, Clinical Assistant Professor of Radiology.

TRAINING PROGRAMS

Independent Interventional Radiology Residency Program

Starts in July 2020

John Louie, MD
Program Director

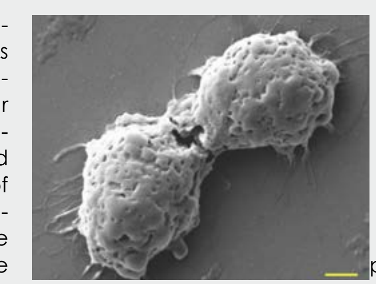
The Independent Interventional Radiology (IR) Residency Program is an ACGME-accredited program that offers one or two years of dedicated IR training following completion of a diagnostic radiology (DR) residency. DR residents who successfully complete Early Specialization in Interventional Radiology (ESIR) may enter the Independent IR Residency in the second or final year of the program. After completing Independent IR Residency, graduates qualify to obtain a dual IR-DR certificate from the American Board of Radiology. As with the IR-DR Residency Program, specialty training at Stanford University Medical Center is integrated with clinical training across multiple sites and disciplines, multidisciplinary clinical electives, and a dedicated Cardiovascular ICU rotation.

The program is directed by John Louie, MD, Clinical Associate Professor.

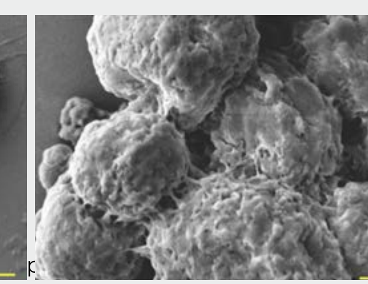
Jie Wang, PhD, Postdoctoral Scholar

Laboratory of Utkan Demirci, PhD, Canary Center for Cancer Early Detection

The images represent our designed multifunctional biomimetic silica particles using a "live pristine macrophage template" strategy which involves cellular endocytosis and unique surface topography of living immunocytes combined with surface chemistry modification of an antibody that can specifically recognize cancer cells. The image on the right is our biomimetic silica particle phage (left image) as a template; it can perfectly replicate the left topographic cell structure. Our "smart" particles with topographic, magnetic, cell-targeting, and stimulus-responsive properties can achieve improved capture efficiency of target cells and on-demand cell release. Images were taken by a scanning electron microscope (SEM). Scale bar: 2 µM.



SEM (scanning electron microscope) image of pristine macrophage.



SEM image of the biomimetic silica particle prepared using the "live template" strategy.

Graduating Residents 2017-2018


Angela Fast, MD

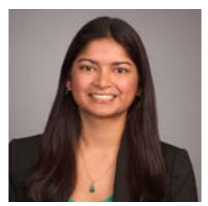

Roger Goldman, MD, PhD


Lewis Hahn, MD


Wilson Lin, MD


Nathaniel Moradzadeh, MD


Aleema Patel, MD


Preeti Sukerkar, MD, PhD


Powen Tu, MD, PhD


Yingding Xu, MD


Byung Yoon, MD, PhD

TRAINING PROGRAMS

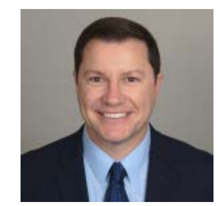
Graduating Residents 2018-2019


Adam Bartret, MD, MS

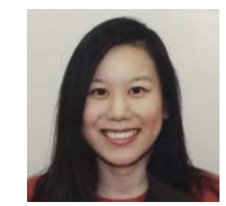

Eric Bultman, MD


Karin Kuhn, MD, DPT


Vivek Patel, MD, PhD


Aaron Reposar, MD


Emir Sandhu, MD, MBA


Jody Shen, MD


Stephen Vossler, MD

Current Residents

36 Residents Diagnostic Radiology

4 Residents Dual Pathway Nuclear Medicine

8 Residents Integrated IR-DR

Clinical Fellowship Programs

BODY IMAGING FELLOWSHIP | 11 POSITIONS

The one-year clinical fellowship in body imaging consists of four-week clinical rotations on the core body services including CT, ultrasound, and MRI. Three elective rotations are available and can include rotations in image-guided biopsies, cardiovascular imaging, musculoskeletal imaging, breast imaging, etc. Fellows will receive experience in all cross-sectional studies of the chest, abdomen, pelvis, and musculoskeletal system. Fellows will also receive training in vascular scanning, imaging-guided biopsies, CT colonography, and other procedures.

BODY MRI FELLOWSHIP | 4 POSITIONS

The Body MRI Fellowship provides a year of intensive training in clinical MRI across a wide range of diagnostic and therapeutic applications. Fellows are responsible for managing the clinical services, including protocols, initial interpretations, MR-guided procedures, scanner-side exam optimization and troubleshooting, translational research, and teaching. The clinical service consists of twenty-five scanners across all vendors, the majority of which are 3T MRIs including PET-MR scanners.

BREAST IMAGING FELLOWSHIP | 3 POSITIONS

Stanford's Breast Imaging Fellowship offers training in digital mammography with CAD; breast tomosynthesis; breast ultrasound; core biopsies and preoperative needle localization under ultrasound, stereotactic, tomosynthesis, and MR-guidance; interpretation of breast MRI for breast cancer and implants; a research program in contrast-enhanced mammography; and outcome analysis of new technology. Research time is provided during the fellowship for academic projects.

CARDIOVASCULAR IMAGING FELLOWSHIP | 2 POSITIONS

The Cardiovascular Imaging (CVI) Fellowship provides one year of training in noninvasive cardiovascular imaging using CT and MRI. Fellows receive detailed training in the principles and use of state-of-the-art multidetector row CT and cardiovascular MR imaging systems within the context of a busy clinical cardiovascular imaging service. Fellows study cardiovascular diseases in adults as well as in children thereby substantially enhancing the fellowship through a close working relationship with adult and pediatric cardiologists, surgeons, and interventional radiologists.

INTERVENTIONAL NEURORADIOLOGY FELLOWSHIP | 2 POSITIONS

The Interventional Neuroradiology Fellowship is a key component of the Stanford Stroke Center providing a large number of referrals for intra-arterial thrombolysis, angioplasty, and aneurysm treatment. The division is also an integral component of an international referral center for the treatment of arteriovenous malformation (AVM) with a multimodality treatment program including charged-particle radiosurgery, microsurgery, and endovascular therapy.

TRAINING PROGRAMS

INTERVENTIONAL RADIOLOGY FELLOWSHIP | 6 POSITIONS

The Interventional Radiology Fellowship experience encompasses the entire range of IR involving both vascular and nonvascular interventions. Fellows perform a wide variety of treatments including loco-regional tumor therapy, transplant and hepatobiliary interventions, angioplasty, catheter-directed thrombolysis, IVC filtration, venous reconstruction, vascular stenting, fibroid embolization, vascular anomaly ablation, pediatric interventions, TIPS, and aortic stent grafting. The Interventional Radiology service is an integral component of the Vascular Center at Stanford.

MUSCULOSKELETAL IMAGING FELLOWSHIP | 3 POSITIONS

The key features of the one-year Musculoskeletal Imaging Fellowship include extensive involvement in musculoskeletal MRI with an emphasis on sports injuries. In addition, a moderate volume of plain radiographic studies, arthrograms, and tenograms are performed. Dedicated time for research is provided. Fellows are expected to participate actively in research with faculty radiologists as well as Stanford's world-renowned imaging physicists and engineers.

NEUROIMAGING FELLOWSHIP | 14 POSITIONS

The Neuroimaging Fellowship is designed as a training program that encompasses all of the basic and advanced clinical and research areas of both adult and pediatric neuroradiology. Neuroimaging fellows will be exposed to all imaging modalities used to evaluate neurologic disease, including CT, MRI, myelography, angiography, and ultrasound during the course of the fellowship. Fellows will also actively participate in state-of-the-art interventional neuroradiology procedures.

PEDIATRIC RADIOLOGY FELLOWSHIP | 5 POSITIONS

The Pediatric Radiology Fellowship is jointly sponsored by the Lucile Packard Children's Hospital and Stanford University Hospital. The fellowship provides a comprehensive pediatric radiology imaging program utilizing state-of-the-art imaging technology, including two fluoroscopy suites, three ultrasound rooms, as well as 3.0T MRI, 1.5T MRI, and CT imaging suites. Fellows rotate through a series of services, including pediatric MR, pediatric CT, PET-CT, pediatric fluoroscopy, pediatric ultrasound, pediatric neuroradiology, nuclear medicine, interventional radiology, and general radiography.

THORACIC IMAGING FELLOWSHIP | 2 POSITIONS

The Thoracic Imaging Fellowship is designed to be an academic training program that provides exposure to basic and advanced clinical applications in cardiothoracic imaging including lung cancer screening and cardiac imaging. Clinical training consists of rotations on chest (eight months), cardiovascular (three months), and thoracic interventional (one month) services. One day per week of research time is allotted.

Graduating Fellows
2017-2018


Farhan Amanullah, MD
Body Imaging


David Burrowes, MD
Body Imaging


Hailey Choi, MD
Body Imaging

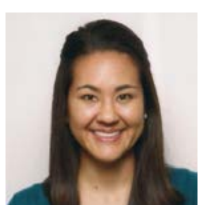

Kevin Day, MD
Body Imaging

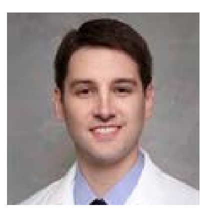

Anthony Jedd, MD
Body Imaging


Yoan Kagoma, MD
Body Imaging


Linda Kelahan, MD
Body Imaging

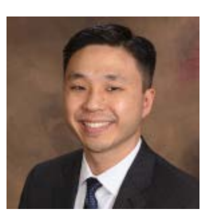

Aladin Mariano, Jr, MD
Body Imaging


Jennifer Mulkerin, MD
Body Imaging


Alexander Tassopoulos, MD
Body Imaging

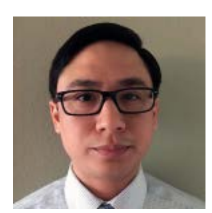

Feng Zhang, MD
Body Imaging


Farzin Imani, MD, PhD
Body MRI


Albert Roh, MD
Body MRI


Jamil Shaikh, MD
Body MRI


Kim Vu, MD
Body MRI


Matthew Assing, MD
Breast Imaging


Crystal Chang, MD
Breast Imaging


Murad Bandali, MD
Cardiovascular Imaging


Arash Bedayat, MD
Cardiovascular Imaging


Lauren Chan, MD
Interventional Radiology

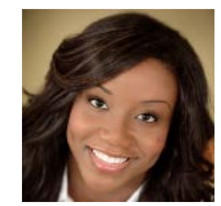
TRAINING PROGRAMS

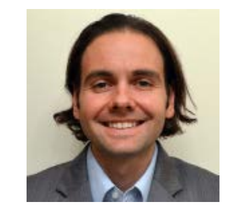

Zlatko Devcic, MD
Interventional Radiology

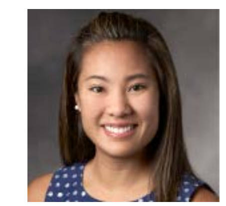

Christopher Goettl, MD, MBA
Interventional Radiology


Ankaj Khosla, MD
Interventional Radiology

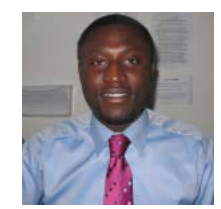

Hansol Kim, MD
Interventional Radiology


Chrystal Obi-Lorenzo, MD
Interventional Radiology


Christopher DeNucci, MD, PhD
Musculoskeletal Imaging


Stephanie Go, MD
Musculoskeletal Imaging


Mark Sun, MD
Musculoskeletal Imaging

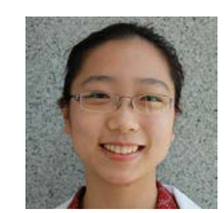

Henry Andoh, Jr., MD
Neuroimaging

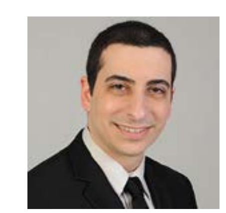

Ruchir Chaudhari, MD
Neuroimaging


Anjeza Chukus, MD
Neuroimaging


Kevin Hsu, MD
Neuroimaging


Young Kim, MD
Neuroimaging

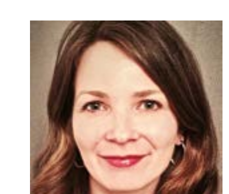

Mingming Ma, MD
Neuroimaging


Amin Saad, MD
Neuroimaging


Muhammed Manzoor, MD
Neurointervention


Richard Jones, MD
Pediatric Radiology


Matthew Muranka, MD
Thoracic Imaging


Melanie Stenback, MD
Thoracic Imaging

Graduating Fellows 2018-2019

TRAINING PROGRAMS


Amarpreet Bhowra, MD
Body Imaging


Kristen Bird, MD
Body Imaging


Myrna Castelazo, MD
Body Imaging

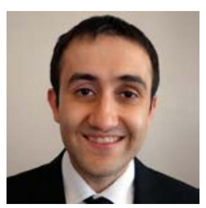

Marta Flory, MD
Body Imaging


Kevin Kadakia, MD
Body Imaging

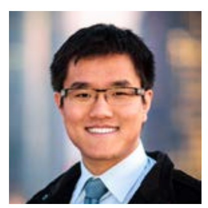

Aman Khurana, MD
Body Imaging


Khaled Malkawi, MD
Body Imaging


Andrew Nguygen, MD
Body Imaging

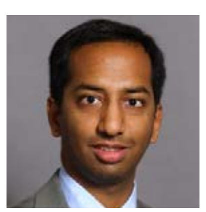

Hersh Sagreiya, MD
Body Imaging

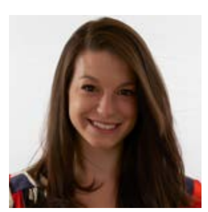

Victoria Tan, MD
Body Imaging

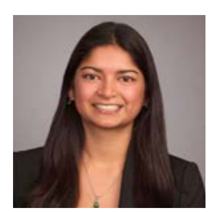

Roy Yang, MD
Body Imaging

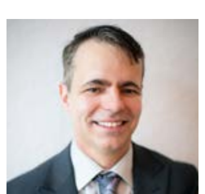

Ryan Brunsing, MD, PhD
Body MRI


Signy Holmes, MD
Body MRI

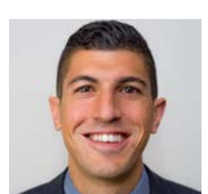

Vipul Sheth, MD, PhD
Body MRI


Angela Fast, MD
Body MRI/MSK


Preeti Sukerkar, MD, PhD
Body MRI/MSK


James Covelli, MD
Breast Imaging


Aleema Patel, MD
Breast Imaging


Rafik Zarifa, MD
Breast Imaging


Lewis Hahn, MD
Cardiovascular Imaging


Mohammed Madani, MD
Cardiovascular Imaging


Hannah Chung, MD
Interventional Radiology


Roger Goldman, MD, PhD
Interventional Radiology

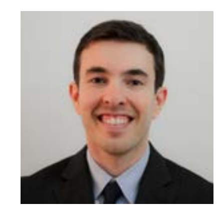

Keshav Menon, MD
Interventional Radiology


John Ponting, MD
Interventional Radiology

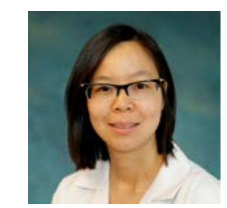

Varun Rachakonda, MD
Interventional Radiology


Aaron Rohr, MD, MS
Interventional Radiology


Yeha ElGuindy, MD
Musculoskeletal Imaging

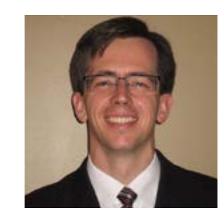

Scott Honowitz, MD
Musculoskeletal Imaging

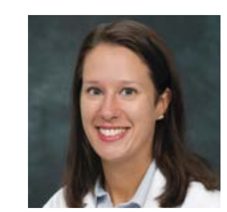

Yingding Xu, MD
Musculoskeletal Imaging


Cynthia Chan, MD
Neuroimaging


Zeshan Chaudhry, MD
Neuroimaging

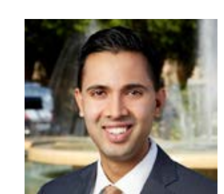

Jay Choi, MD
Neuroimaging


Douglas Martin, MD, PhD
Neuroimaging


Vera Mayercik, MD
Neuroimaging


Elizabeth Tong, MD
Neuroimaging


Michael Wang, MD
Neuroimaging


Aditya Iyer, MD
Neurointervention


Mahesh Atluri, DO
Pediatric Radiology

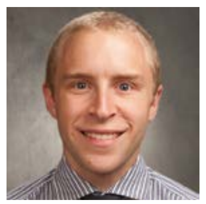

Crystal Farrell, MD
Pediatric Radiology

Jesse Sandberg, MD
Pediatric Radiology

Fidaa Wishah, MD
Pediatric Radiology

Frederick Wittber, MD
Pediatric Radiology

Alexander Bratt, MD
Thoracic Imaging



Zachary Guenther, MD
Thoracic Imaging

52
Current Fellows
Breakdown by
Division

11
Body Imaging
Fellows

4
Body MRI
Fellows

3
Breast Imaging
Fellows

2
Cardiovasular
Imaging
Fellows

2
Interventional
Neuroradiology
Fellows

6
Interventional
Radiology
Fellows

4
Musculoskeletal
Imaging
Fellows

15
Neuroimaging
Fellows

3
Pediatric
Imaging
Fellows

2
Thoracic
Imaging
Fellows

TRAINING PROGRAMS

Research Training Programs

NIH-Funded Training Programs

The Department of Radiology is home to six NIH-funded training and education programs, each reflecting specialized strengths of our highly regarded research divisions: Canary Center at Stanford for Cancer Early Detection, Integrative Biomedical Imaging Informatics at Stanford (IBIIS), Molecular Imaging Program at Stanford (MIPS), and the Radiological Sciences Laboratory (RSL). These programs comprehensively cover a broad range of imaging related topics such as advanced cancer imaging, molecular imaging, physics and instrumentation, systems biology, and nanotechnology. Five of these programs, taken together, support and train a total of over 30 graduate and postdoctoral trainees each year. The sixth program, the Canary CREST summer program, is targeted specifically for undergraduate students and is fully focused on cancer early detection; this program hosts 25 students each summer. See pages 70-72 for details of all NIH-funded training programs.

4
T32 Programs
3 Postdoctoral
1 Predoctoral

2
R25 Programs
1 Postdoctoral
1 Undergraduate

50
Trainees/Year
Supported on
NIH Training Programs

SCIT Program

Stanford Cancer Imaging Training Program

NIH/NCI 5 T32 CA009695-26

PIs: Sandy Napel, PhD and Bruce Daniel, MD
Program Manager: Sofia Gonzales, MS

The SCIT Program is a two-year program that offers a unique research opportunity in cancer imaging. Currently in its 26th year of training, the goal of the program is to provide MD and/or PhD research fellows advanced training in cancer-related imaging research with a focus that is primarily driven by physics and technology development and application. Since its inception in 1992, the SCIT program has provided support for the training of more than 40 fellows.

CURRENT TRAINEES	MENTORS
Masoud, Badiei, PhD	Lei Xing, PhD
Muna Aryal Rizal, PhD	Jeremy Dahl, PhD and Raag Airan, MD, PhD
Maxine Umeh, PhD	Melanie Hayden Gephart, MD

SMIS Program

Stanford Molecular Imaging Scholars Program

NIH/NCI 2 T32 CA118681-13

PI: Craig Levin, PhD
Program Manager: Sofia Gonzales, MS

The SMIS Program is a three-year cross-disciplinary postdoctoral training program at Stanford University. The centerpiece of the SMIS program is the opportunity for trainees to conduct innovative molecular imaging research that is co-mentored by faculty in complementary disciplines. The SMIS program, with its distinctive focus on biology and chemistry, is in its 13th year and has provided training and support for 35 fellows to date.

CURRENT TRAINEES	MENTORS
David Huland, PhD	Sanjiv Sam Gambhir, MD, PhD
Diana Jeong, PhD	Craig Levin, PhD
Brian Lee, PhD	Sanjiv Sam Gambhir, MD, PhD
Guolan Lu, PhD	Eben Rosenthal, MD and Garry Nolan, PhD
James Wang, PhD	Katherine Ferrara, PhD

TRAINING PROGRAMS

TBI^2 Program

Predoctoral Training in Biomedical Imaging Instrumentation Program

NIH/NIBIB 5 T32 EB009653-09

PIs: Kim Butts Pauly, PhD and Norbert Pelc, ScD
Program Manager: Barbara Bonini

The TBI^2 program, jointly led by faculty in Radiology and Bioengineering, offers unique multidisciplinary research training in biomedical imaging technologies across all spatial scales, spanning magnetic resonance, computed tomography and radiography, optical imaging, ultrasound, PET, and hybrid imaging such as PET-CT and PET-MR, as well as image processing and analysis for diagnosis, radiation therapy, and basic science. Since recruitment began in 2010, the program has provided training and support for 29 graduate student trainees.

CURRENT TRAINEES	MENTORS
Tyler Cork	Daniel Ennis, PhD
Rastko Ciric	Russell Poldrack, PhD
Aidan Fitzpatrick	Amin Arbabian, PhD
Laurel Hales	Feliks Kogan, PhD
Jeremiah Hess	mentor on rotation

CSBS Program

Cancer Systems Biology Scholars Program

NIH/NCI 5 R25 CA180993-05

PIs: Sylvia Plevritis, PhD and Garry Nolan, PhD
Program Manager: Theresa McCann

The CSBS program is a two-year postdoctoral training program at Stanford University focused on innovative, multidisciplinary cancer research education that seamlessly integrates experimental and computational biology to systematically unravel the complexity of cancer. The program brings together 36 Stanford faculty mentors from 19 departments or divisions bridging the Schools of Medicine, Engineering, and Humanities and Sciences. The CSBS Program has trained a total of 10 postdoctoral scholars from September 2015 through August 2019.

CURRENT TRAINEES	MENTORS
Gina Bouchard, PhD	Sylvia Plevritis, PhD and Amato Giaccia, PhD
Roozbeh Dehghannasiri, PhD	Julia Salzman, PhD and Steven Artandi, MD, PhD
Aaron Horning, PhD	Michael Snyder, PhD and Christina Curtis, PhD
Loukia Karacosta, PhD	Sylvia Plevritis, PhD and Sean Bendall, PhD
Barzin Nabet, PhD	Max Diehn, MD, PhD, Andrew Gentles, PhD, and Robert Tibshirani, PhD

Cancer-TNT Program

Cancer-Translational Nanotechnology Training Program

NIH/NCI 5 T32 CA196585-05

PIs: Jianghong Rao, PhD and Dean Felsher, MD, PhD
Program Manager: Billie Robles

The Cancer-TNT Program is a diverse and synergistic three-year postdoctoral training program bringing together 28 faculty and nine departments from the Schools of Medicine, Engineering, and Humanities and Sciences to train the next generation of interdisciplinary leaders who will pursue challenges in cancer research and clinical translation. Trainees develop interdisciplinary research skills in cancer nanotechnology translation with two complementary mentors to bridge multiple disciplines such as chemistry, molecular biology, bioengineering, molecular imaging, nanoengineering, and clinical cancer medicine. Trainees will be able to advance cancer research, diagnosis, and management. The Cancer-TNT Program has trained a total of 12 postdoctoral scholars to-date.

CURRENT TRAINEES	MENTORS
Min Chen, PhD	Jianghong Rao, PhD
Razieh Khalifehzadeh, PhD	Sanjiv Sam Gambhir, MD, PhD and Zhenan Bao, PhD
Christina Lee, PhD	Dean Felsher, MD, PhD
Elaine Ng, PhD	Shan Wang, PhD and Jianghong Rao, PhD
Chunte (Sam) Peng, PhD	Steven Chu, PhD and Jianghong Rao, PhD

Canary CREST Program

Canary Cancer Research Education Summer Training Program

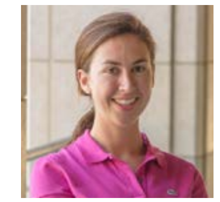
NIH/NCI 1 R25 CA217729-02

PIs: H. Tom Soh, PhD and Utkan Demirci, PhD
Program Manager: Stephanie van de Ven, MD, PhD

The Canary CREST Program recruits and trains 25 undergraduate students each year through a 10-week summer program in cancer early detection research. The program is led by Drs. Tom Soh, Utkan Demirci, and Stephanie van de Ven at the Canary Center for Cancer Early Detection, together with a team of 25 mentors. Students experience hands-on research in the laboratory of one of the program mentors, attend educational seminars and career development sessions, and present their work at a research symposium at the end of the summer. During the five-year award, the Canary CREST Program will train a total of 125 young scientists and introduce them to the significance of cancer early detection. This program is also supported by the Stanford Cancer Institute.

TRAINING PROGRAMS

Graduating PhDs 2018–2019


Marianne Black, PhD
Advisor: Brian Hargreaves, PhD


Chen-Ming Chang, PhD
Advisor: Craig Levin, PhD


David Freese, PhD
Advisor: Craig Levin, PhD


Su Hong, PhD
Advisor: Zhen Cheng, PhD

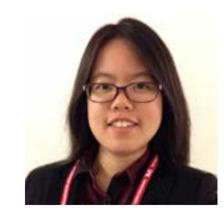

David Hsu, PhD
Advisor: Craig Levin, PhD

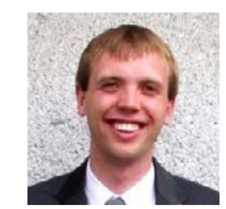

Brian Lee, PhD
Advisor: Craig Levin, PhD

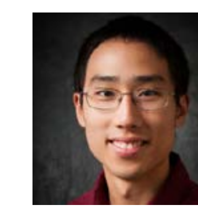

Mihir Pendse, PhD
Advisor: Brian Rutt, PhD

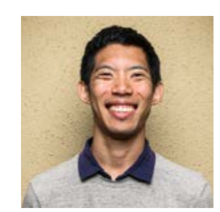

Paurakh Rajbhandary, PhD
Advisor: Norbert Pelc, ScD

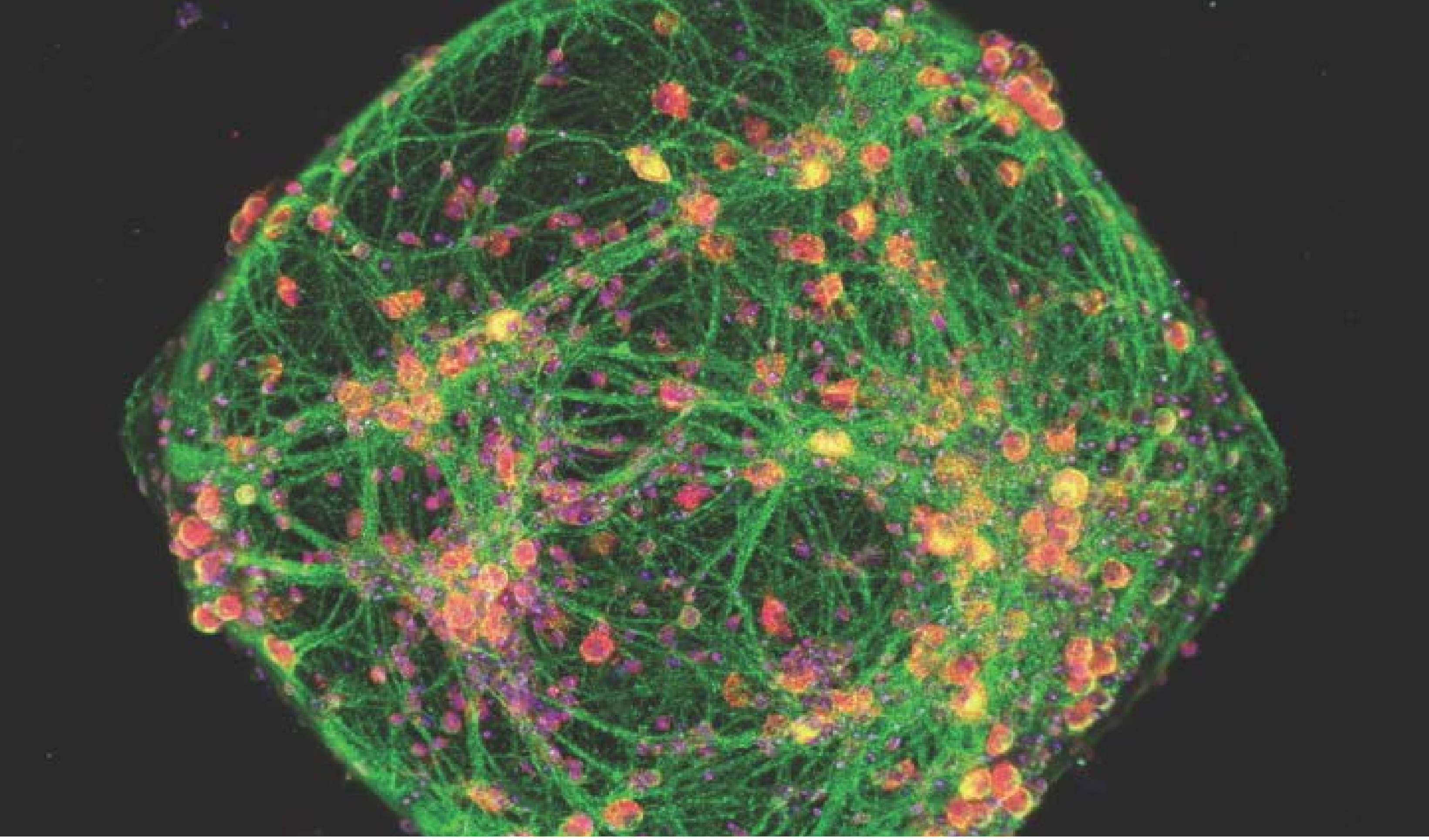

Xinwei Shi, PhD
Advisor: Brian Hargreaves, PhD


Picha Shunhavanich, PhD
Advisor: Norbert Pelc, ScD

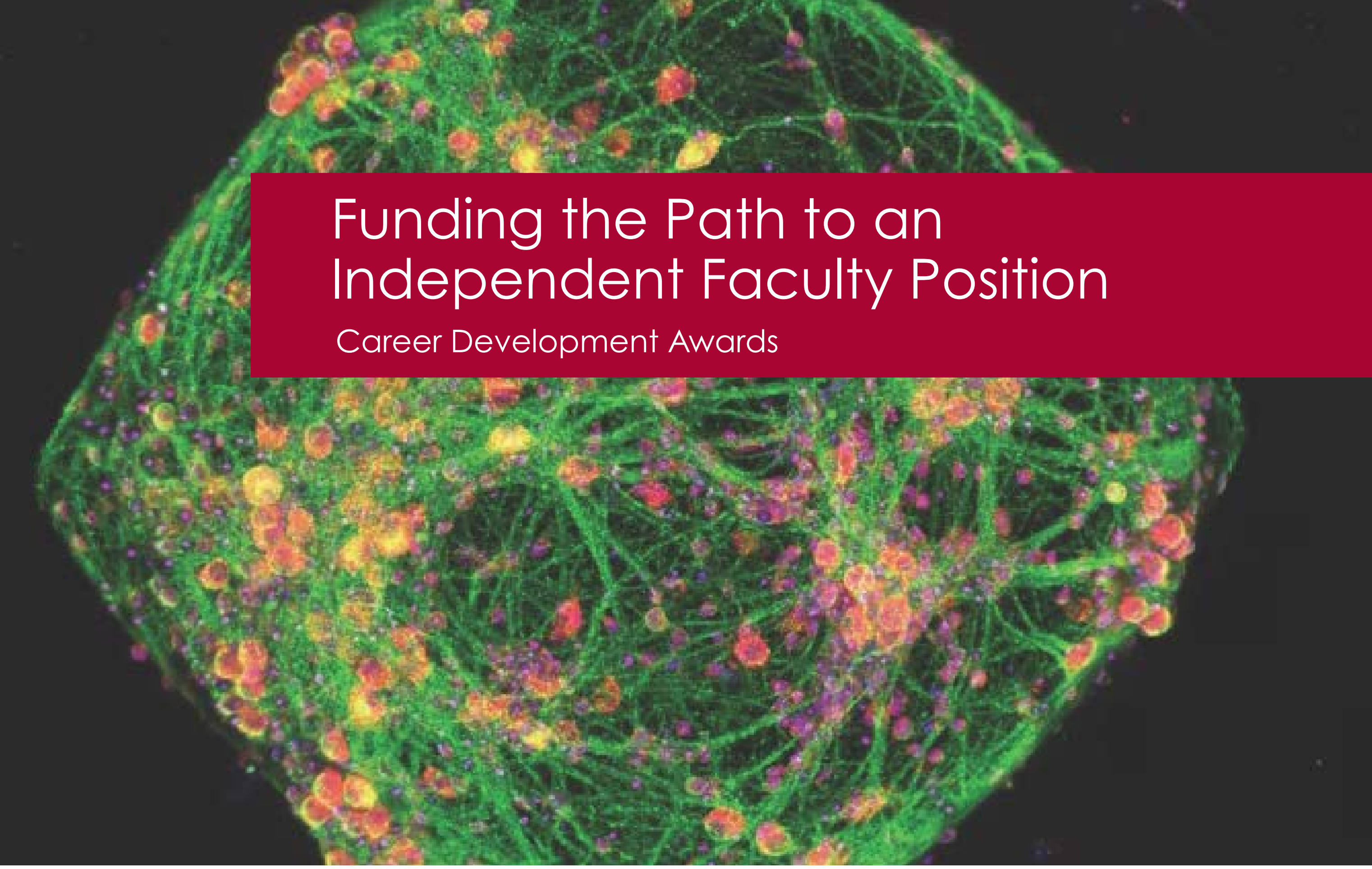

Taylor Webb, PhD
Advisor: Kim Butts Pauly, PhD


Grant Yang, PhD
Advisor: Jennifer McNab, PhD


Patrick Ye, PhD
Advisor: Kim Butts Pauly, PhD



PATH TO AN INDEPENDENT FACULTY POSITION



Funding the Path to an Independent Faculty Position

Career Development Awards

40
Submitted
Transition to Faculty Proposals from 38 Postdoctoral Fellows

13
Awarded
Number of Transition to Faculty Awards Received

33%
Success
Percent of Proposals Awarded

12
Transition to Faculty
Awardees Now in Faculty Positions

Proposals and awards include all "Transition to Faculty" funding types (i.e., K99, K22, K25 and Burroughs Wellcome Fund) submitted and awarded during FY13–Y18.

Independent research funding is key to success for early-stage investigators. According to the National Institutes of Health, the average age of biomedical researchers at their first faculty appointment is 38. Career development awards, such as the NIH K99/R00 "Transition to Independence" and Burroughs Wellcome Fund's Career Awards at the Scientific Interface (CASI)[1], considerably accelerate the transition to independent faculty positions for promising young scientists. The NIH and other biomedical funding organizations invest in career development awards because "new investigators bring fresh ideas and innovative perspectives to the research enterprise, which are critical to sustaining our ability to push the frontiers of science." These prestigious awards support mentored training in new research areas and the development of ideas into independent research programs. Awardees experience greater than 90% success rate of obtaining a faculty position within two years of receiving such an award.

While the benefits of these awards for postdoctoral and clinical fellows is clear, the application process is very competitive. The average funding success rate for the K99/R00 award was approximately 30% in 2018 across all participating NIH Institutes and Centers. Successful applicants need to demonstrate well thought-out research goals along with a comprehensive mentored training plan.

The primary purpose of a career development award is to attract qualified and promising researchers early in their career and provide them the opportunity and resources to establish themselves in their specific area of research. Stanford Radiology is committed to supporting talented young investigators through all other transition to independence awards. This Feature article highlights how the department and the Stanford University environment contribute to their success.

[1] NIH K99/R00 "Transition to Independence" awards provide up to five years of funding for new scientists planning to become independent researchers; funding is provided across a mentored postdoctoral research position (up to two years) through to an independent, tenure-track or equivalent faculty position (up to three years). Burroughs Wellcome Fund's Career Awards at the Scientific Interface (CASI) provides $500,000 over five years to bridge advanced postdoctoral training and the first three years of faculty service.

GOZDE DURMUS, PHD: MY STORY

Award: Burroughs Wellcome Fund Career Awards at the Scientific Interface (BWF CASI) | 1018148.01

Title: Levitating Rare Biological Materials to Decode the Fundamentals

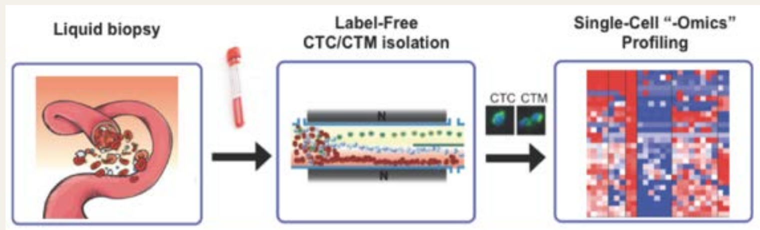


Figure 1: Schematic overview of the proposed study.

My research lies at the interface of biology, engineering, nanotechnology and medicine. As a postdoctoral research fellow at the Stanford Genome Technology Center with Drs. Ronald Davis and Lars Steinmetz, I submitted a proposal to the BWF's CASI program to develop the first biomarker-free platform to detect rare circulating cells and clusters from metastatic cancer patient's blood, based on their unique levitation signatures. In-depth "-omics" profiling of these rare cell populations will help to reveal fundamental mechanisms, new sub-types of circulating cells, and biomarkers (Figure 1). The resulting system will be broadly applicable to an array of cancers and metastatic mechanisms. My goal is to leverage the foundational research and career development opportunities provided by the BWF CASI award to develop a transformative, independent program in cancer research at the interface of bioengineering, genomics, and oncology. My PhD in biomedical engineering and nanomedicine, coupled with my postdoctoral training in microfluidics, cancer biology, and genomics brings a unique and highly interdisciplinary perspective to the intersection of these fields, and uniquely prepares me to move toward the era of precision medicine. I envisioned this BWF CASI award to play a critical role in my scientific and career development by providing me the opportunity to train with Dr. Davis, a world leader in biotechnology and the development and application of recombinant DNA and genomic methodology to biological systems, and work with clinicians and researchers in molecular imaging technologies for early detection of cancer.

Dr. Durmus is an Assistant Professor in the Molecular Imaging Program at Stanford in the Department of Radiology at Stanford University.

AHMET COSKUN, PHD: MY STORY

Award: NIH K25 | K25 AI140783

Title: Spatial Epigenomic Profiling of Immune Cell Signatures at Subcellular Resolution in Health and Disease

Using quantitative multiplex imaging and computational analysis tools, my research explores how the "spatial" nature of cell-to-cell interactions and subcellular variations lead to fascinating developmental programming in healthy individuals and devastating abnormal formation in leukemias and breast cancers. My doctoral training at UCLA in bioengineering involved designing imaging tools to visualize biological systems. Following postdoctoral research at Caltech and later at the Department of Microbiology and Immunology at Stanford, I became an Instructor in the Molecular Imaging Program at Stanford in 2018. My primary mentor, Dr. Garry Nolan, introduced me to a multiplexed ion beam imaging (MIBI) technology for spatial analysis of tumors. For the K25 career development award, my proposal aimed to leverage a 3D MIBI method to study subcellular features of epigenetic changes in B cells from 20 acute lymphocytic leukemia (ALL) patients toward development of exciting epigenetic therapies in pediatric cancers (Figure 2). NIH funding, along with the expansive Stanford environment and resources, including those supporting my efforts to submit the K25 application, have contributed significantly to my personal success of attaining independence as an assistant professor.

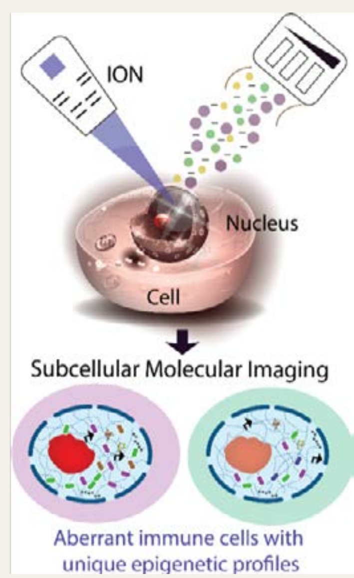
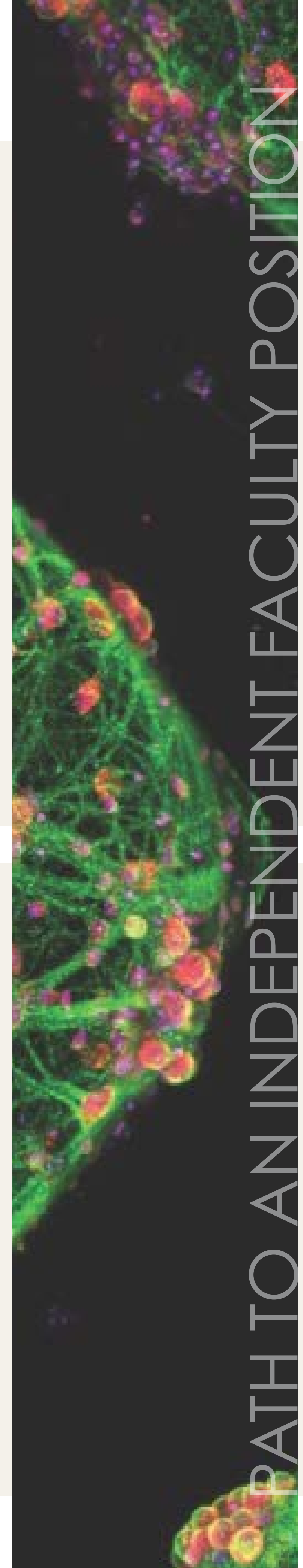


Figure 2: Imaging subcellular details of epigenetic changes helps understand molecular mechanisms of acute lymphocytic leukemia (ALL) patients in abnormal immune signatures.

Dr. Coskun is an Assistant Professor in the Department of Biomedical Engineering at the Georgia Institute of Technology.



FELIKS KOGAN, PHD: MY STORY

Award: NIH K99/R00 | R00 EB022634

Title: Quantitative Assessment of Early Metabolic and Biochemical Changes in Osteoarthritis

Although osteoarthritis (OA) affects more than 30 million adults in the United States and is the leading cause of disability, treatment options remain limited, in part, due to the lack of non-invasive techniques to quantify disease progression and response to therapies. While the role of cartilage degeneration is extensively studied with MRI, the role of bone activity has largely been ignored. My K99/R00 award aims to develop simultaneous PET and MRI techniques to study bone formation in early OA and its relationship to cartilage changes while providing me with training in novel MRI (mentors Drs. Garry Gold and Brian Hargreaves) and nuclear medicine techniques (mentors Drs. Craig Levin, Andrei Iagaru, and Sanjiv Sam Gambhir) to develop an independent research program in this interdisciplinary area (Figure 3). This work will allow clinicians to simultaneously and quantitatively track early and reversible changes in OA, providing new insights into OA development and leading to new treatment targets and therapies to slow or halt the degenerative process of the disease.

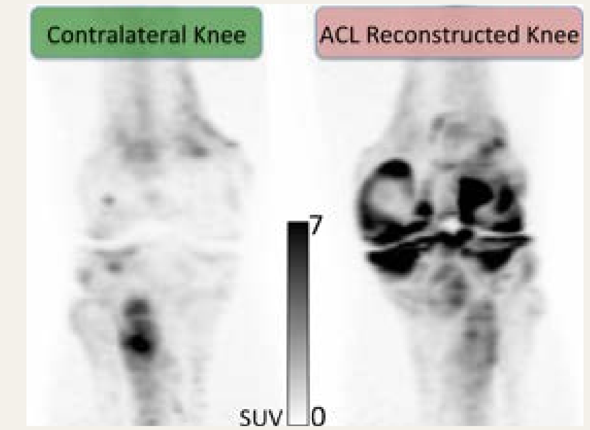


Figure 3: Sodium fluoride PET can detect abnormal bone activity in ACL injured knees, which are known to be at increased risk of developing painful arthritis.

Dr. Feliks Kogan is an Assistant Professor in the Division of Musculoskeletal Imaging in the Department of Radiology at Stanford University.

AUDREY FAN, PHD: MY STORY

Award: NIH K99/R00 | K99 NS102884

Title: Quantitative PET/MRI of Brain Oxygenation in Cerebrovascular Disease

I am an electrical engineer by training, and am passionate about the interface of medical imaging, signal processing, and neuroscience. My doctoral training was in development of advanced MRI tools, but I realized that close interactions with my mentor in neuroradiology (Dr. Gregory Zaharchuk) and clinical collaborators in Neurosurgery and the Stanford Stroke Center would be essential for my MRI tools to have maximum clinical impact. My mentors helped me to critically evaluate the mission of my K99/R00 award, which uses imaging to choose optimal therapies for patients with carotid stenosis at high risk of stroke (Figure 4).

I consider myself extremely fortunate to have benefited from the Stanford Radiology network while preparing my K99/R00 application. Several faculty and instructors willingly shared their own proposals and review statements—successful and unsuccessful—to guide me in structuring my own application; this was invaluable. As my hypotheses evolved, I again benefited greatly from each mentor's feedback during the entire proposal development process. Additionally, my application was subjected to a "mock review" by senior faculty who participate in the Radiology Internal Grant Review (RIGR) Program, a departmental initiative to assist faculty and postdoctoral researchers seeking funding. Gaining perspectives from colleagues not directly involved in the research enhanced the clarity of my proposal and taught me grant-writing skills that I will continue to hone throughout my career.

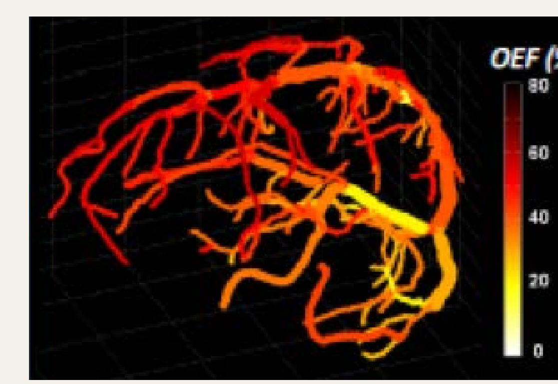


Figure 4: Quantitative oxygenation venogram MRI displays absolute oxygen extraction fraction (OEF) along brain vessels.

Dr. Fan will be joining the Department of Neurology at the University of California, Davis as an Assistant Professor in January 2020.

JOHANNES REITER, PHD: MY STORY

Award: NIH K99/R00 | R00 CA229991

Title: Inferring the Roots of Metastases and their Effects on Patient Survival

I grew up on a farm in the Alpine foothills of Austria but was always more interested in mathematics and computers than in driving tractors. I eventually obtained a BS degree in computer science and although I knew nothing about academic research, I pursued a PhD in computational and mathematical biology at the Institute of Science and Technology Austria, partly because I attended an inspiring lecture by Dr. Martin Nowak about Evolutionary Game Theory. I coincidentally got involved in a project on the evolution of resistance in tumors in response to targeted therapy and have been fascinated by the evolution of tumors ever since. After my postdoctoral work at Harvard, I joined the Canary Center at Stanford for Cancer Early Detection in 2017 as an Instructor. My mentor, Dr. Sanjiv Sam Gambhir, introduced me to researchers with diverse backgrounds and I developed a K99/R00 proposal based on the hypotheses that metastatic cancers with many genetically distinct tumor cell populations lead to worse patient outcomes. We proposed to utilize reconstructed cancer phylogenies to quantify metastatic spread and identify predictive features in a cohort of 49 pancreatic and 17 colorectal cancer subjects and thereby establish new opportunities for a more personalized treatment plan (Figure 5).

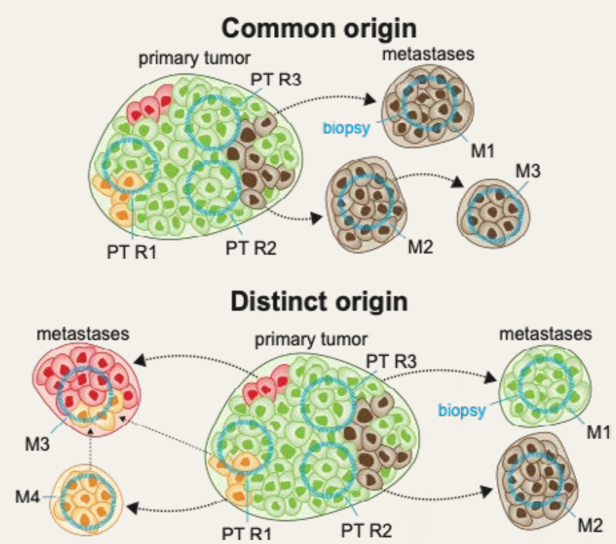
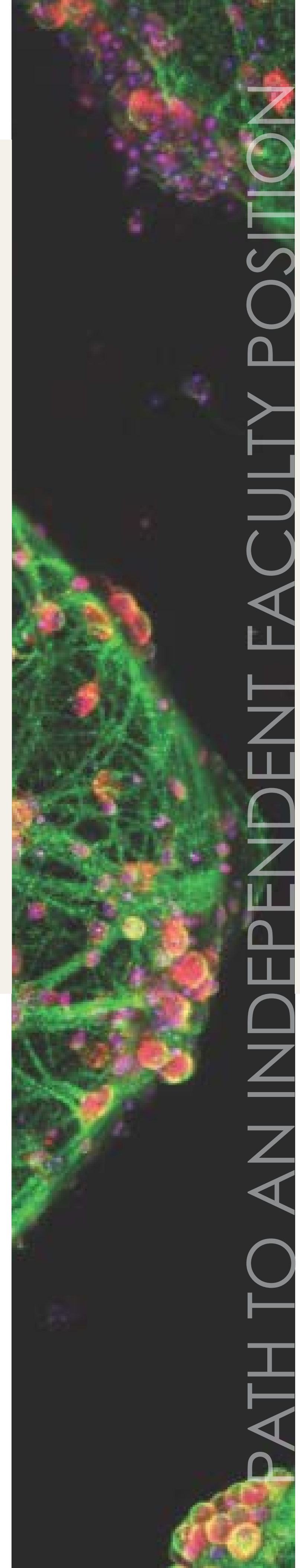


Figure 5: Cancers with distinct origins of metastases may lead to worse patient outcomes than cancers with common origin of metastases.

The support of my mentors, the department, and a large advisory committee was crucial in putting together a competitive proposal. I also attended several grant writing workshops and read many other funded proposals, which significantly helped me to understand what aspects are considered (and also not considered) by committees during the review of proposals. Last, starting the proposal process well in advance of the submission due date was invaluable in allowing me to iteratively revise my proposal and prepare a strong application.

Dr. Reiter is an Assistant Professor at the Canary Center at Stanford for Cancer Early Detection in the Department of Radiology at Stanford University.



KATHERYNE WILSON, PHD: MY STORY

Award: NIH K99/R00 | K99 EB023279

Title: Spectroscopic Photoacoustic Molecular Imaging for Breast Lesion Characterization

Breast cancer continues to present an important health focus; the disease claimed more than 41,000 lives in the United States in 2018. Current screening methods, mammography and ultrasound, suffer from low sensitivity and low positive predictive value, respectively, particularly in patients with dense breast tissue. Therefore, a non-invasive method of distinguishing between benign and malignant lesions that could be incorporated with current screening modalities is critically needed. My K99/R00 proposal combined concepts of designed contrast agents and machine learning-based spectral recognition algorithms to develop a novel screening strategy with photoacoustic, ultrasound, and fluorescence imaging for breast lesion detection and characterization and intraoperative tumor margin assessment (Figure 6).

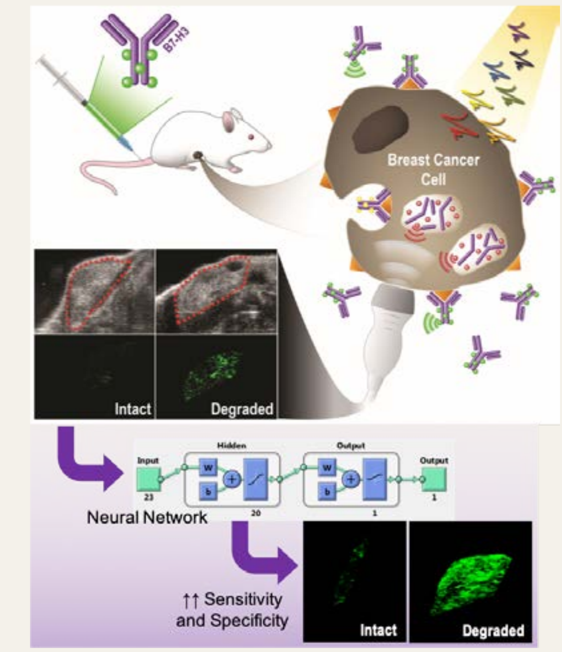


Figure 6: Schematic of novel contrast agent development (anti-B7-H3-ICG), highly specific molecular imaging harnessing dynamic optical absorption spectra, and enhanced spectral recognition ML-based algorithms as proposed in the K99.

The training aspect of my proposal, required to accomplish my research goals, was designed with mentors with specific clinical and technical expertise (Dr. Juergen Willmann and, after his passing, Dr. Eben Rosenthal) and a diverse advisory committee with experts in clinical breast imaging (Dr. Debra Ikeda), optical imaging and intraoperative guidance (Dr. Christopher Contag), and clinical breast surgery (Dr. Irene Wapnir). My longer term career goals include translating spectroscopic photoacoustic molecular imaging methods combined with novel contrast agents to the clinic for cancer detection and differentiation. Additionally, my research will focus on developing machine learning algorithms for increasing the sensitivity of molecular imaging modalities and exploring novel preclinical applications and approaches for detection, monitoring, and treatment of disease.

Dr. Wilson is an Instructor in the Molecular Imaging Program in the Department of Radiology at Stanford University and is actively pursuing a faculty position.

Trainee Honors and Awards

Amin Aalipour, MS	Molecular Imaging Young Investigator Prize Finalist, Stanford University (2017)
Emily Anaya	NeuroTech Training Program Fellowship at the Wu Tsai Neurosciences Institute's Center for Mind, Brain, Computation and Technology (2019) Stanford Graduate Fellowship (2019)
Corinne Beinat, PhD	3rd place SNMMI Radiopharmaceutical Sciences Young Investigator (2019) WMIC Young Investigator of the Year Finalist (2019) Women in Molecular Imaging Network (WIMIN) Scholar Award, World Molecular Imaging Society (WMIS)/World Molecular Imaging Congress (WMIC) (2019)
Aisling Chaney, PhD	WMIC Young Investigator of the Year Winner (2019) Women in Molecular Imaging Network (WIMIN) Scholar Award, World Molecular Imaging Society (WMIS) (2019) Best Oral Presentation, Stanford Neuroscience Forum (2019) ERF-SNMMI Postdoctoral Molecular Imaging Scholar Program Grant, Education and Research Foundation-SNMMI (2018-2020)
Chen-Ming Chang	AAPM Sylvia & Moses Greenfield Paper Award (2018)
Akshay Chaudhari, PhD	2x Magna Cum Laude Merit Award, ISMRM (2018) Best Junior Investigator Abstract, 11th Intl. Workshop on Osteoarthritis (2018) Best Overall Poster & Best Healthcare Poster, NVIDIA GPU Technology Conference (2018) Best Young Investigator Award, 12th Intl. Workshop on Osteoarthritis (2019) Outstanding Teacher Award, ISMRM (2018) W.S. Moore Young Investigator Award, ISMRM (2019) Young Investigator Award, Imaging Elevated Symposium (2019)
Anjea Chukus, MD	Stanford Radiology Fellow Teacher of the Year (2018) Roentgen Ray Research Award, RSNA (2019)
Arjun Desai	Graduate Research Fellowship by NSF (2019)
Pooja Gaur, PhD	Young Investigator Award, FUS Symposium (2018)
Ali Ghoochani, PhD	DoD Early Investigator Award (2019)
Alexander Grant, PhD	AAPM Sylvia & Moses Greenfield Paper Award (2018)
Andrew Nicholas Groll, PhD	Ford Foundation Postdoctoral Fellowship Competition Awardee (2018)
David F.C. Hsu, PhD	SNMMI Alavi-Mandell Award (2018)
Marko Jakovljevic, PhD	CHRI Eureka Institute Award (2018)
Yoan Kagoma, MD	Stanford Radiology Fellow Teacher of the Year (2018)
Brian J. Lee, PhD	AAPM Sylvia & Moses Greenfield Paper Award (2018)
Min Sun Lee, PhD	IEEE NPSS Ronald J. Jaszcak Graduate Award (2019)

TRAINING PROGRAMS

Steve Leung	Siebel Scholar (2018)
Valentina Mazzoli, PhD	Rubicon Grant, Netherlands Organization for Scientific Research (NWO) (2019)
Surya Murty, PhD	Travel Award, World Molecular Imaging Society (WMIS)/World Molecular Imaging Congress (WMIC) (2019)
Tomomi Nobashi, MD	Wagner-Torizuka Fellowship (SNMMI) (2018)
Roy Pinakpani, MD	Stanford Radiology Fellow Teacher of the Year (2017)
Mehdi Razavi, PhD	Stanford Bio-X Poster Session Winner (2019)
Meghan Rice, PhD	DoD Early Investigator Award (2018)
Stephan Rogalla, MD	Digestive Disease Week Poster Award (2019)
Emir Sandhu, MD	James M. Moorefield, MD, Fellowship in Economics & Health Policy (2018)
Travis Shaffer, PhD	Travel Award, World Molecular Imaging Society (WMIS)/World Molecular Imaging Congress (WMIC) (2019)
Marc Stevens, PhD	1st place SNMMI Radiopharmaceutical Sciences Young Investigator (2019) Wallenberg Foundation Postdoctoral Fellowship, Knut and Alice Wallenberg Foundation (2017-2019) MIPS Molecular Imaging Young Investigator (MIYI) Award (2019)
Victoria Tan, MD	Stanford Radiology Fellow Teacher of the Year (2019)
Li Tao, PhD	Valentin T. Jordanov Radiation Instrumentation Travel Grant (2017)
Neil Thakur, MD	Stanford Radiology Fellow Teacher of the Year (2017)
Alexander Toews	Graduate Scholarship, Natural Sciences and Engineering Research Council of Canada (NSERC) (2019)
Akira Toriihara, MD, PhD	Wagner-Torizuka Fellowship (SNMMI) (2018)
Sarah Totten, PhD	Katharine McCormick Advanced Postdoctoral Fellowship (2017)
Justin Tse, MD	President's Award: Resident in Radiology Award, American Roentgen Ray Society (ARRS) (2019) Roentgen Resident Research Award, Radiological Society of North America (RSNA) (2019)
Andrew Wentland, MD, PhD	RSNA Resident/Fellow Research Grants (2019)
Dylan Wolman, MD	RSNA Resident/Fellow Research Grants (2019) Moskowitz Research Grant, Stanford Department of Radiology (2017-2018)
Vivek Yedavalli, MD	ACR-AUR Research Scholar Program (2018)

*Please see Sponsored Research for projects awarded funding.

2019 Welcome Party

2018 Alumni Dinner

2018 Alumni Dinner

2018 MIPS Retreat

2018 Winter Party

2018 Winter Party

2019 Welcome Party

2019 Welcome Party

2018 Welcome Party

2018 Welcome Party

Radiology Clinical Research and Trials

Bhavik Patel, MD, MBA
Assistant Professor
Director Clinical Trials

Risa Jiron, BS
CCRC Manager &
Operations Lead, Clinical Trials

The Department of Radiology Clinical Trials Program is led by Dr. Bhavik Patel, Assistant Professor of Radiology and Risa Jiron, Clinical Research Manager. Together, they manage a team of six research coordinators who support 47 different clinical research studies in the Department of Radiology. Of these, 33 studies are currently open to accrual with 13 studies in start-up stage. Also, of the 33 studies recruiting subjects, 20 are cancer studies and 13 are non-cancer. While most studies are diagnostic, the department also conducts studies with therapeutic intervention. At the present time, the team manages three studies with treatment components that are led by faculty in the Theragnostics Clinic within the Nuclear Medicine and Molecular Imaging Division. Please read more about the department's research efforts in the powerful field of theragonstics on page 50 of this Report.

Radiology Studies by Modality

MR Studies: Stanford Radiology has been a leader in MR imaging for more than 30 years with four MR systems dedicated to research, and more than 15 systems dedicated to clinical imaging.

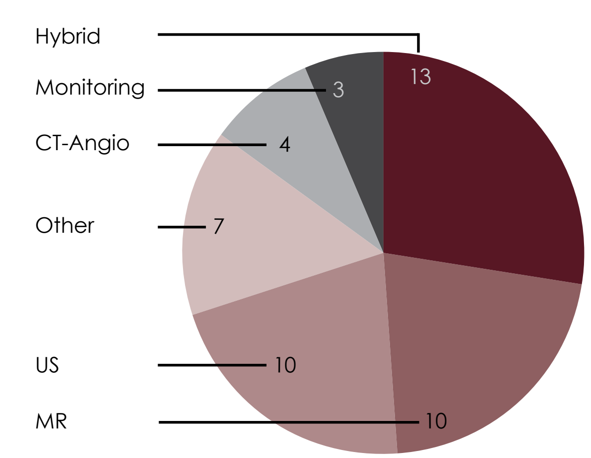
Hybrid Imaging: An increasing number of our clinical research studies use hybrid imaging techniques that combine more than one imaging modality, such as PET-MR, PET-CT, SPECT-CT or MRgFUS. Hybrid imaging allows the investigator to simultaneously collect anatomical information and metabolic function data, or in other cases, to treat certain conditions. Clinicians and imaging scientists at Stanford Radiology work collaboratively to improve results of hybrid imaging and to ensure dose reduction to avoid unnecessary radiation exposure.

Ultrasound: Over the past three years, clinical research studies using ultrasound have doubled in number. The growth in use of ultrasound imaging can be attributed to improved technology, a growing movement to reduce radiation exposure, a focus on translational medicine, and the ease of use of this portable technology. Over the past five years, the department has strategically recruited three faculty with expertise in ultrasound methodology and applications: Katherine Ferrara, PhD (in 2017, from the University of California, Davis), Raag Airan, MD, PhD (in 2016, from Johns Hopkins University), and Jeremy Dahl, PhD (in 2014, from Duke University). All three have formed growing collaborations with Kim Butts Pauly, PhD and Pejman Ghanouni, MD, PhD from radiology and others across the Stanford campus.

Clinical research requires careful compliance with strict guidelines to safeguard the participants and to ensure the validity of these invaluable studies. The department's dedicated and professional team bridge the gap between the clinical, research, and administrative environments to do so, and also ensure the most comfortable and advanced experience for all patients and volunteers in Radiology-led clinical research studies and trials.

Radiology Clinical Research Team (L-R): David Marcellus, Andrea Otte, Krithika Rupnarayan, Mahima Goel, Anika Mahavni, Pranav Hegde, and Risa Jiron, Team Manager.

Study Types



FEATURE

CLINICAL DIVISION CHIEFS

Richard Barth, MD
Radiologist-in-Chief, Lucile Packard Children's Hospital
Division Chief, Pediatric Imaging

Sandip Biswal, MD
Amelie Lutz, MD
Co-Division Chiefs, Musculoskeletal Imaging

Wendy DeMartini, MD
Division Chief, Breast Imaging

Dominik Fleischmann, MD
Division Chief, Cardiovascular Imaging

Lawrence "Rusty" Hofmann, MD
Division Chief, Interventional Radiology

Andrei Iagaru, MD
Division Chief, Nuclear Medicine and Molecular Imaging

Brooke Jeffrey, MD
Interim Division Chief, Body Imaging

Ann Leung, MD
Associate Chair, Clinical Affairs
Division Chief, Thoracic Imaging

Payam Massaband, MD
Associate Chair, VA Palo Alto Health Care System
Division Chief, VA Palo Alto Health Care System

George Segall, MD
Division Chief, VA Nuclear Medicine

Shreyas Vasanawala, MD, PhD
Division Chief, Body MRI

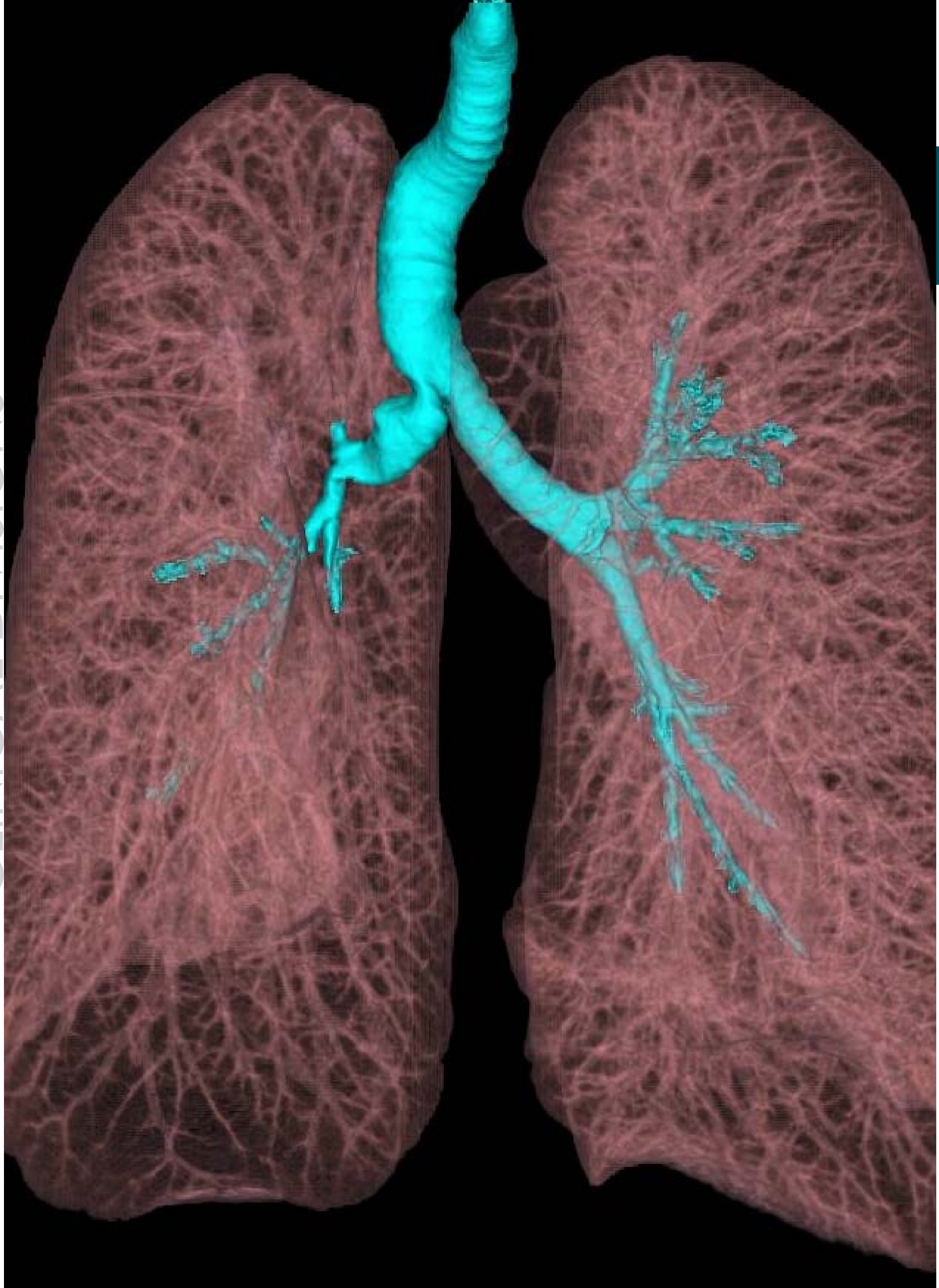
Max Wintermark, MD, MAS, MBA
Division Chief, Neuroimaging and Neurointervention

5
AIMBE Fellows*
Clinical Divisions

Heike Daldrup-Link, MD
Bruce Daniel, MD
Garry Gold, MD
Shreyas Vasanawala, MD, PhD
Gregory Zaharchuk, MD, PhD

*cumulative

CLINICAL DIVISIONS



Volume rendering inspiratory phase transparent lungs and opacified trachea. Relatively healthy lungs. Image provided by the 3DQ Lab.

Clinical Divisions

The department's 12 clinical divisions provide advanced comprehensive medical care to patients in all imaging modalities. Each division is led by a skilled chief who oversees the division's clinical, research, and educational activities, and is staffed by radiologists, instructors, technologists, coordinators, and administrators. Collectively, they provide compassionate patient care, conduct research in medical imaging, and carry out the multidisciplinary research and training activities offered by the divisions.

The clinical divisions serve more than 10 hospital and outpatient clinic sites, as well as numerous satellite locations. Using the most technologically advanced equipment, the goals of the divisions are to implement imaging approaches to diagnose, characterize, treat, and monitor diseases; and provide imaging guidance to perform minimally invasive diagnostic and therapeutic procedures. The department's medical imaging capabilities range from computed tomography (CT), magnetic resonance imaging (MRI), positron emission tomography (PET), single-photon emission computed tomography (SPECT), to focused ultrasound (FUS), and hybrid imaging techniques of PET-CT, PET-MR, photoacoustic imaging, and MRgFUS.

The clinical divisions are: Body Imaging, Body MRI, Breast Imaging, Cardiovascular Imaging, Interventional Radiology, Musculoskeletal Imaging, Neuroimaging and Neurointervention, Pediatric Radiology, Nuclear Medicine and Molecular Imaging, Thoracic Imaging, VAPAHCS Nuclear Medicine, and VAPAHCS Radiology. The following (86-91) pages describe these clinical divisions, their groups, and their achievements that represent the department's commitment to excellent patient care and clinical research.

178
Clinical Faculty

12
Clinical Divisions

Front row L-R: Bhavik Patel, Gabriela Gayer, Aya Kamaya, Brooke Jeffrey, Bruce Daniel; Back row L-R: Nayeli Morimoto, Luyao Shen, Andrew Shon, Volney Van Dalsem, Luke Yoon, AJ Mariano, Edward Lo; Not pictured: Kristen Bird, Lawrence Chow, Terry Desser, Mike Federle, Marta Flory, Peter Poullos

Body Imaging

R. Brooke Jeffrey, MD

https://med.stanford.edu/bodyimaging.html

The Body Imaging Division consists of 16 nationally and internationally renowned faculty, eight adjunct faculty and 11 body fellows who are specialized in the interpretation of diseases of the abdomen and pelvis, as well as additional body parts, such as the thyroid, carotid, and peripheral venous system. With experts in CT, MRI, ultrasound, molecular imaging, X-ray and fluoroscopy, our division is committed to training the next generation of body radiologists while delivering cutting-edge clinical care. The breadth of experience among the faculty is reflected in the wide scope of their academic pursuits, including clinical assessment of dual-energy and low dose CT protocols, novel pulse sequences in MRI, ultrasound contrast agents, and augmented reality for breast-conserving surgery.

- Collectively, our faculty have published over 30 papers in peer reviewed journals, books and book chapters, and have several NIH and industry grants.
- Brooke Jeffrey, MD filed a patent with the Stanford Office of Technology Licensing (OTL) for capsule ultrasound.
- Aya Kamaya, MD (Director, Body Ultrasound) received the 2018 ARRS Certificate of Merit Award.
- Justin Tse, MD and Andrew Wentland, MD, PhD (Residents) received 2019 RSNA Research Resident/Fellow Grants (Dr. Kamaya as mentor).
- Justin Tse, MD (Resident) received the 2019 ARRS President's Research Award (Dr. Kamaya as mentor).

Front row L-R: Robert Herfkens, Shreyas Vasanawala, Signy Holmes, Marissa Lee; Back row L-R: Brian Hargreaves, Bruce Daniel, Ryan Brunsing, Pejman Ghanouni, Vipul Sheth, Andreas Loening

Body MRI

Shreyas Vasanawala, MD, PhD

http://bodymri.stanford.edu/

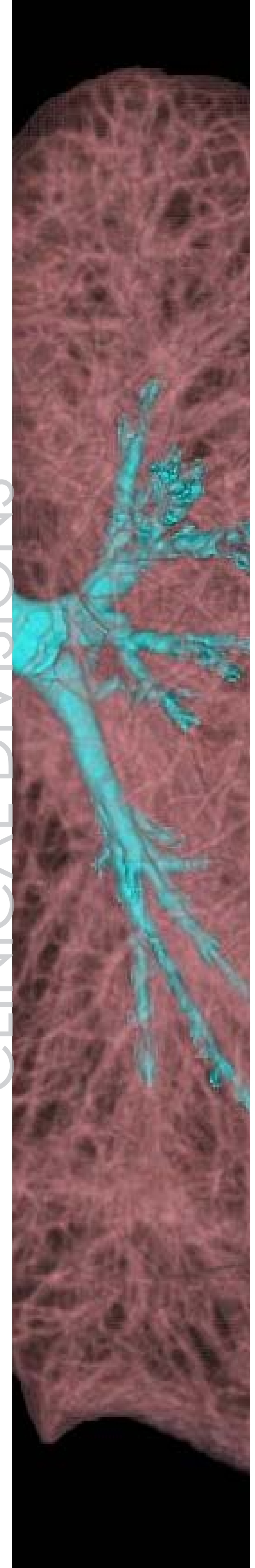
The Body MRI Division aims to provide outstanding patient care, lead innovations in the practice of Body MR imaging, and train the next generation of clinician scientists, while developing a strong association between diagnosis and therapy for highly personalized care.

We provide services that are personally tailored for each patient and delivered with state-of-the-art MRI technology and highly trained staff. Most exams use techniques developed and uniquely available here at Stanford. Faculty members are internationally recognized experts in body MRI, and have deep experience developing new methods to improve diagnostic precision.

Body MRI research at Stanford is fostered by close collaboration and long-standing relationships between clinicians and research scientists in the Department of Radiology, the University, and throughout the Bay Area.

- Launched dynamic pelvic MRI services with the Pelvic Health Center.
- Launched a novel high-resolution MR lymphangiography service.
- Launched an MRI-guided cryoablation therapy service.

CLINICAL DIVISIONS



Top row L-R: W. DeMartini, D. Ikeda, J. Lipson, S. Pal;
Bottom row L-R: N. Salem, B. Daniel, N. Morimoto, X. Ye, T. Patel

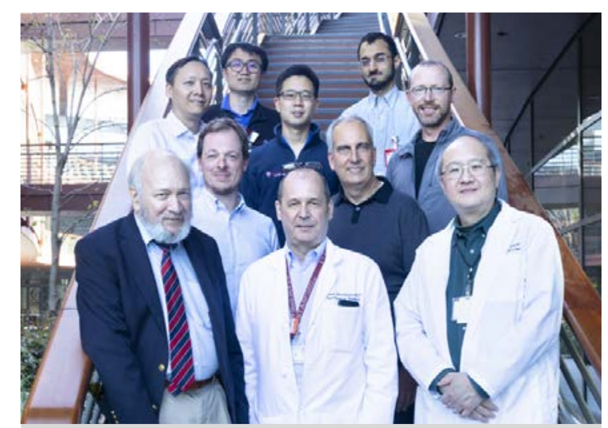
Breast Imaging

Wendy DeMartini, MD

https://med.stanford.edu/breastimaging.html

The Breast Imaging Division provides compassionate and evidence-based patient care, conducts research, and trains future leaders in the field. Our state-of-the-art breast imaging clinical care includes newly designed patient and family spaces, mammography performed using digital breast tomosynthesis, breast MRI obtained using 3T magnets, and localization for surgery performed using wireless non-radioactive devices. We will soon offer automated whole breast ultrasound for supplemental breast cancer screening. Our faculty are internationally recognized experts in breast imaging with particular emphasis on breast MRI. Our research includes (1) investigating factors contributing to false negative screening mammograms, (2) understanding comparative effectiveness of breast imaging tests to guide personalized care, (3) improving breast MRI techniques using high temporal resolution and novel sequences, and (4) developing a mixed/augmented reality breast cancer surgery system

- Newly designed patient and family spaces emphasizing a calming sensory experience and privacy at our Palo Alto diagnostic imaging site.
- Mammography studies using 3D-like digital breast tomosynthesis and synthetic 2D techniques, improving diagnostic accuracy while using only "single mammogram" radiation dose.
- Breast surgery localization options include wireless non-radioactive methods that can be performed up to months before surgery.
- Breast biopsies can be offered on the same day as diagnostic imaging, decreasing the number of patient visits and time to diagnosis.



1st row L-R: Robert Herfkens, Dominik Fleischmann, Frandics Chan; 2nd row L-R: Koen Nieman, Hans-Christoph Becker; 3rd row L-R: Humburto Wong, Lewis Hahn, Daniel Ennis; 4th row L-R: Jai Wang, Mohammad Madani; Not Shown: Payam Massaband, Margaret Lin, Sachin Malik, Richard Hallett, Horacio Murillo, Jody Shen, Victoria Tan, Jean Sullivan and Aparna Sai Ramesh

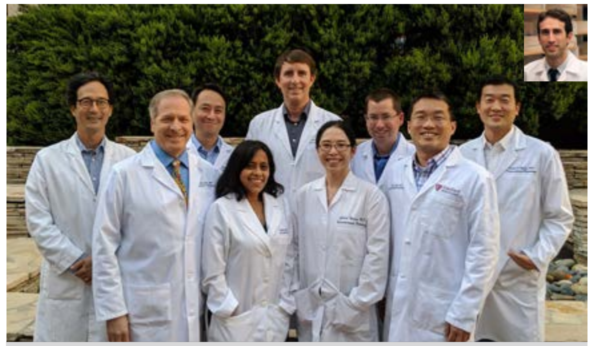
Cardiovascular Imaging

Dominik Fleischmann, MD

https://med.stanford.edu/cvimaging.html

The Cardiovascular Imaging (CVI) Division uses the latest magnetic resonance and computed tomography technology for the noninvasive imaging of the heart and vascular system in children and adults. Sophisticated post-processing techniques provide unprecedented 3D and 4D visualization of complex cardiovascular anatomy and pathology to facilitate treatment planning for surgical or endovascular procedures, some of which are pioneered at and unique to Stanford. The CVI Division provides a fellowship training program for cardiovascular radiologists and participates in educational curricula of trainees in radiology, cardiology, cardio-thoracic and vascular surgery. Clinical research topics include the imaging of the aorta, heart valves, and blood flow. Research in pediatric cardiovascular imaging includes radiation dose reduction strategies in pediatric cardiac CT as well as new MRI and CT techniques applied to the clinical management of congenital heart disease.

- Coronary Calcium Score screening to modify risk factors and stabilize current disease state.
- Coronary CTA (CCTA) allows coronary artery imaging without coronary catheterization.
- Working together as a team of radiologists, basic scientists, and technologists to reduce radiation exposure according to international safety principles of ALARA (As Low As Reasonably Achievable).



Front row L-R: David Hovsepian, Nishita Kothary, Gloria Hwang, John Louie; Back row L-R: Daniel Sze, William Kuo, Lawrence "Rusty" Hofmann, Andrew Picel, David Wang; Top row: Alexander Vezeridis

Interventional Radiology

Lawrence "Rusty" Hofmann, MD

http://interventionalradiology.stanford.edu/

The mission of Interventional Radiology (IR) is to investigate and promote image-guided therapies to fulfill unmet medical needs. IR offers the entire range of vascular and non-vascular image-guided procedures. We are experts in treating endovascular arterial disease, stenting (expanding) occluded blood vessels, endograft repair of aneurysms, deep vein thrombosis (DVT), and chronic venous occlusions. We also specialize in image-guided tumor treatments including chemoembolization, radiofrequency ablation, cryoablation, NanoKnife ablation, and radioembolization. As pioneers of minimally invasive surgery, we employ advanced imaging techniques to eliminate the need for open surgery and allow shorter recovery times.

- First cohort of Stanford IR residents started their residency as part of the second program nationwide to start this training pathway.
- Andrew Picel, MD developed a program focused on prostate artery embolization, for treatment of benign prostate hypertrophy.
- Alex Vezeridis, MD, PhD developed a research program in ultrasound contrast agents and the use of AI in IR.
- David Wang, MD is actively enrolling patients in clinical trials leveraging IR techniques for cancer immunotherapy.
- Nishita Kothary, MD presented and published on the role of virtual reality in planning endovascular procedures.
- Stanford IR has reported the longest (25 years) experience of safety and efficacy outcomes for patients undergoing venous stenting in the lower extremities.

L-R: Geoffrey Riley, Kate Stevens, Sandip Biswal, Christopher Beaulieu, Joseph DeMartini, Amelie Lutz, Garry Gold

Musculoskeletal Imaging

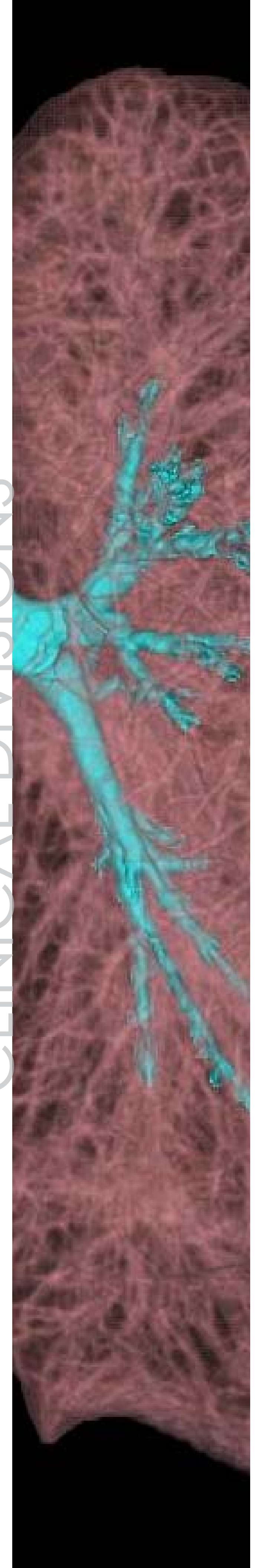
Sandip Biswal, MD and Amelie Lutz, MD

https://med.stanford.edu/msk.html

The Musculoskeletal Imaging Division is composed of 16 (core and extended division) specialists in the imaging, image interpretation and image-guided intervention of musculoskeletal and peripheral nerve diseases arising from inflammation, trauma, sports injuries, cancer, autoimmune diseases, and other conditions. Our members serve roles in departmental leadership, are active in quality improvement, lead in educational efforts, conduct clinical trials and have basic science/clinical research programs supported by the NIH and other funding entities. Clinical volumes realize double-digit growth annually, and we provide specialty training for three to four fellows per year who go on to private practice or academia.

- Bao Do, MD, Payam Massaband, MD, and Joshua Reicher, MD received the VA Palo Alto Director's Commendation for developing software to improve management of radiology operations in the Veterans Health Administration.
- Christopher Beaulieu, MD, PhD and Bao Do, MD received the Man vs. Machine Award for the scientific abstract, Human vs. Machine: Distinguishing Enchondroma from Chondrosarcoma with a Bayesian Network; Society of Skeletal Radiology (SSR) Annual Meeting (2018).
- Amelie Lutz, MD and collaborators started patient recruitment into the first U.S. clinical trial of VEGFR2-targeted molecular ultrasound in ovarian cancer.
- Sandip Biswal, MD and collaborators recruited 150+ patients for clinical trials to identify pain generators using [18F]FDG or an [18F]-labeled sigma-1 receptor radioligand with PET-MRI.

CLINICAL DIVISIONS



Front row L-R: Susan Mir, Nancy Fischbein, Michael Wang, Cynthia Chan, Elizabeth Tong, Vera Mayercik, Raag Airan, Eric Tranvinh, Patty Smith; Back row L-R: Mario Landeros Wences, Syed Hashmi, Michael Iv, Max Wintermark, Gregory Zaharchuk, Doug Martin, Sean Creeden, Zeshan Chaudhry, Vivek Patel, Yang Guo, Dann Martin, Jay Choi, Bryan Lanzman, Tarik Massoud, Austin Trinh, Malika Curry

Neuroimaging & Neurointervention

Max Wintermark, MD, MAS, MBA

https://med.stanford.edu/neuroimaging.html

Our division consists of 16 world-renowned neuroradiology faculty and 17 fellows who specialize in (1) interpreting imaging studies of the brain, spine, head and neck, and (2) neurointervention. We offer minimally invasive treatment of cerebral aneurysms and other cerebral vascular malformations, stenting of carotid arteries, vertebroplasty, and image-guided biopsy. We offer unique expertise in advanced neuroimaging techniques including dual-energy CT, functional MRI, diffusion tensor imaging and tractography, spectroscopy, and perfusion imaging, including noncontrast methods. We are the only Bay Area center to offer the brain "stress test", an advanced blood flow imaging technique evaluating cerebrovascular reserve. We offer quick, dedicated stroke MR and CT imaging differentiating between completed stroke and "at-risk" tissue, with automated decision support software validated in multicenter trials.

- Tarik Massoud, MD, PhD received an NIH R21 grant (2018) for multiple sclerosis research and published two books (2019): Glioblastoma and Basilar Artery.
- Elizabeth Tong, MD received an RSNA Scholar Grant for research on AI applied to brain imaging for stroke.
- Gregory Zaharchuk, MD, PhD mentored 1st Place Team recipients, Stanford Healthcare AI Hackathon 2018, Stroke De-coded.
- Michael Zeineh, MD, PhD received an NIH R01 for Alzheimer's research, and published an article, Longitudinal changes in hippocampal subfield volume associated with collegiate football, Journal of Neurotrauma (2019).

Back row L-R: Lane Donnelly, Safwan Halabi, Donald Frush, Fredrick Wittber, Fidaa Wishah, Jesse Sandberg, Mahesh Atluri; Front row L-R: Kristen Yeom, Shreyas Vasanawala, Jayne Seekins, Carolina Guimaraes, Helen Nadel, Richard Barth, Crystal Farrell, Erika Rubesova, Evan Zucker, Heike Daldrup-Link, Beverley Newman; Inset: Francis Blankenberg, Shellie Josephs, Matthew Lungren, Avnesh Thakor

Pediatric Radiology

Richard Barth, MD

http://pedrad.stanford.edu/

The Pediatric Radiology Division aims to improve the health of children through excellence in clinical imaging and image-guided diagnosis and therapy, translation of pediatric-specific innovations into clinical practice, and the education of future leaders in pediatric radiology. Pediatric Radiology at LPCH offers a comprehensive program that uses state-of-the-art technology. Children are not small adults and present unique challenges including different physiology, small anatomy, and radiation sensitivity. The pediatric radiology faculty are internationally recognized and have collaboratively developed safe, minimally invasive, non-radiation, high resolution imaging methods to benefit the care of children.

- Donald Frush, MD received the Gold Medal from the Society for Pediatric Radiology.
- Helen Nadel, MD received a Lifetime Achievement Award from the European Society of Pediatric Nuclear Medicine, 10th meeting, for contributions to the only free-standing meeting of pediatric nuclear medicine.
- First clinical deployment of deep learning for MR image reconstruction (Vasanawala).
- Validation of effectiveness of deep learning network for automated assessment of Brasfield scores (severity of pulmonary disease) on chest X-rays in cystic fibrosis patients (Zucker, Barnes, Lungren, Shpanskaya, Seekins, Halabi, Larson).
- Introduction of intraoperative MRI scans for pediatric neurosurgical evaluation of the brain and spine (Yeom, Dahmoush, Guimaraes).

Front row L-R: Vinh Nguyen, Guido Davidzon, Zachary Leonard; Middle row L-R: Carina Mari Aparici, Jessica King, Chris Fuji, Teresita Padron, Helen Nadel, Nora Gurevich, Alana McKnight, Valentina Ferri; Back row L-R: Sarina Smith, Andrei Iagaru, Hong Song, Craig Levin, Tomomi Nobashi, Negin Hatami, Paulo Castaneda, Ben Franc, Ken Luong, JongJin Lee

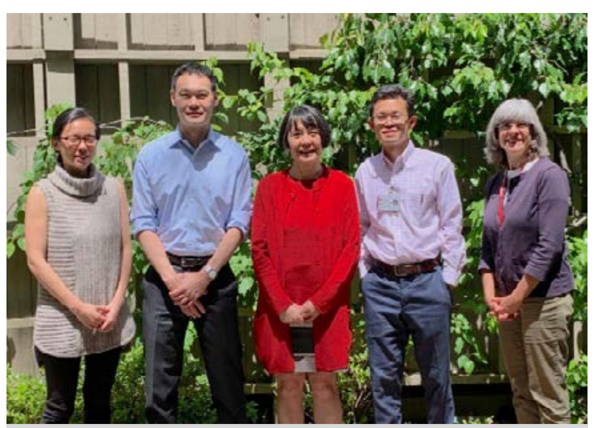
Nuclear Medicine & Molecular Imaging

Andrei Iagaru, MD

https://med.stanford.edu/nuclearmedicine.html

The Division of Nuclear Medicine and Molecular Imaging at Stanford University offers a broad range of diagnostic tests including SPECT, SPECT-CT, PET-CT, PET-MR, as well as advanced targeted radionuclide therapy. Multiple trials are conducted in our clinical space. Our faculty and staff support collaborations across academia, as well as with industry. We are committed to improving health through excellence in image-based patient care, research, and education.

- Lucia Baratto, MD (Research Fellow) and Caitlyn Harrison, MD (Resident) received Trainee Best Paper Awards, SNMMI 2017.
- Ross McDougall, MB, ChB, PhD (Professor Emeritus) received the Lifetime Honorary Medical Staff Award, Stanford Health Care (SHC) 2018.
- Akira Toriihara, MD, PhD, and Tomomi Nobashi, MD (Research Fellows) were recipients of the Wagner-Torizuka Fellowship, SNMMI meeting, 2018.
- Andrei Iagaru, MD received the Physician of the Year award, SHC 2018.
- Comprehensive targeted radionuclide therapy program for prostate cancer, neuroendocrine tumors, thyroid cancer, and hyperthyroidism.



L-R: Dr. Emily Tsai, Dr. Charles Lau, Dr. Ann Leung, Dr. Henry Guo, and Roberta Brissette.

Thoracic Imaging

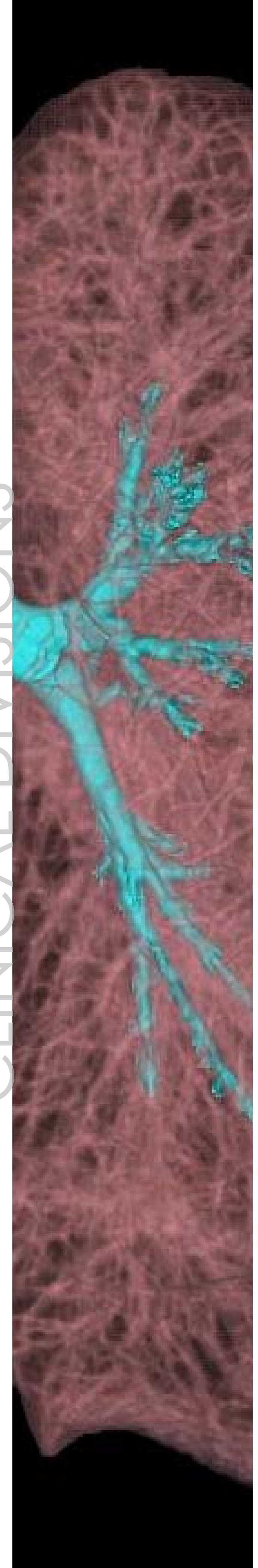
Ann Leung, MD

https://med.stanford.edu/thoracicimaging.html

The Thoracic Imaging Division aims to sustain and improve health through high-quality, state-of-the-art imaging of the chest. The division will expand with the arrival of two new faculty members, Kristen Bird, MD and Margaret Lin, MD. As part of the daily provision of clinical care, our fellowship-trained thoracic radiologists work closely with referring physicians including pulmonologists, oncologists, and surgeons to enable multidisciplinary care that directly benefits patients.

- Appointment of Ann Leung, MD to the Executive Committee of the Fleischner Society.
- ACR accreditation of the Stanford CT Lung Cancer Screening Program.

CLINICAL DIVISIONS



Front row L-R: Jen-Shi Liu, Wendy Logan, Clarita Domingo, Christine Taylor, Christina Jacobson; Back row L-R: Joanne Delano, Richard Huntington, Chris Tran, George Segall, Kent Hutchings, Russell Acob; Not pictured: Minal Vasanawala, Rodney Rodriguez, Lisa Ceile

VAPAHCS Nuclear Medicine

George Segall, MD

https://med.stanford.edu/va-radiology.html

https://med.stanford.edu/nuclearmedicine/patient_care/va.html

The Nuclear Medicine Service provides a full range of diagnostic and therapeutic procedures using radionuclides, including general nuclear medicine, PET-CT, SPECT-CT, and cardiac stress testing. We are a referral center for patients requiring targeted radionuclide therapy for neuroendocrine tumors with ^{177}Lu-DOTATATE, and also treat patients with ^{131}I for thyroid cancer, ^{223}Ra-dichloride for prostate cancer metastases to bone, and ^{90}Y radioembolization of liver tumors with Interventional Radiology. We participate in cardiac imaging and neurologic imaging research, including the ADNI trials. We train radiology and nuclear medicine residents, as well as cardiology fellows in advanced imaging techniques.

- VA tertiary referral center for cancer imaging and targeted radionuclide therapy.
- One of two VA facilities to have a PET-MR scanner, 2019.
- Only VA facility to have an accredited nuclear medicine technologist training program.

L-R: Stephanie Chang, Michelle Nguyen, Chandan Misra, Bao Do, Katherine To'o, Christine Ghatan, Payam Massaband, Eric Olcott, Charles Lau, Amanda Rigas, Sachin Malik, Rajesh Shah

VAPAHCS Radiology

Payam Massaband, MD

https://med.stanford.edu/va-radiology.html

The VA Palo Alto, a flagship of the U.S. Department of Veterans Affairs for clinical care and teaching, maintains one of the top three research programs in the VA. A tertiary care center with a 900+ bed system, it includes three inpatient facilities and eight outpatient clinics throughout northern California and the Bay Area. Over $1 billion in capital projects are planned. Current expansion projects include construction on the new radiology department, projected to open in February 2020. The VA Palo Alto serves 85,000+ veterans, including patients with polytrauma; multi-organ system disease; and traumatic brain and spinal cord injuries. These clinical needs drive significant collaborations between the VA Palo Alto, Stanford Hospital, and Stanford University.

- Joshua Reicher, MD, Bao Do, MD, and Payam Massaband, MD received the Director's Commendation for developing UNITY enterprise software for VA, improving patient care at VA Palo Alto.
- The Women's Imaging Center opened at VA Palo Alto (October 2018) supervised by Stephanie Chang, MD.
- Daniel Ennis, PhD and his team started their Radiological Sciences Lab at VA Palo Alto to develop advanced cardiovascular MRI methods for quantitatively evaluating structure, function, flow, and remodeling (NIH/NHLBI R01 grant).
- Rajesh Shah, MD was awarded a Stanford AIMI Center grant for "Using Machine Learning-based Radiomics to Distinguish Lung Cancer on CT from a Multi-Center VA Cohort".
- Joshua Reicher, MD co-authored a paper (Nature Medicine) on using a Google developed AI to predict the risk of lung cancer on lung cancer screening CTs.

RESEARCH DIVISION LEADERSHIP

Garry Gold, MD
Vice Chair for Research and Administration

Brian Hargreaves. PhD
Associate Chair for Research

Susan Kopiwoda, MS, MPH
Director Strategic Research Development

Sanjiv Sam Gambhir, MD, PhD
Utkan Demirci, PhD
Stephanie van de Ven, MD, PhD
Canary Center

Sandy Napel, PhD
IBIIS

Sanjiv Sam Gambhir, MD, PhD
Gunilla Jacobson, PhD
MIPS

Sanjiv Sam Gambhir, MD, PhD
Ryan Spitler, PhD
PHIND

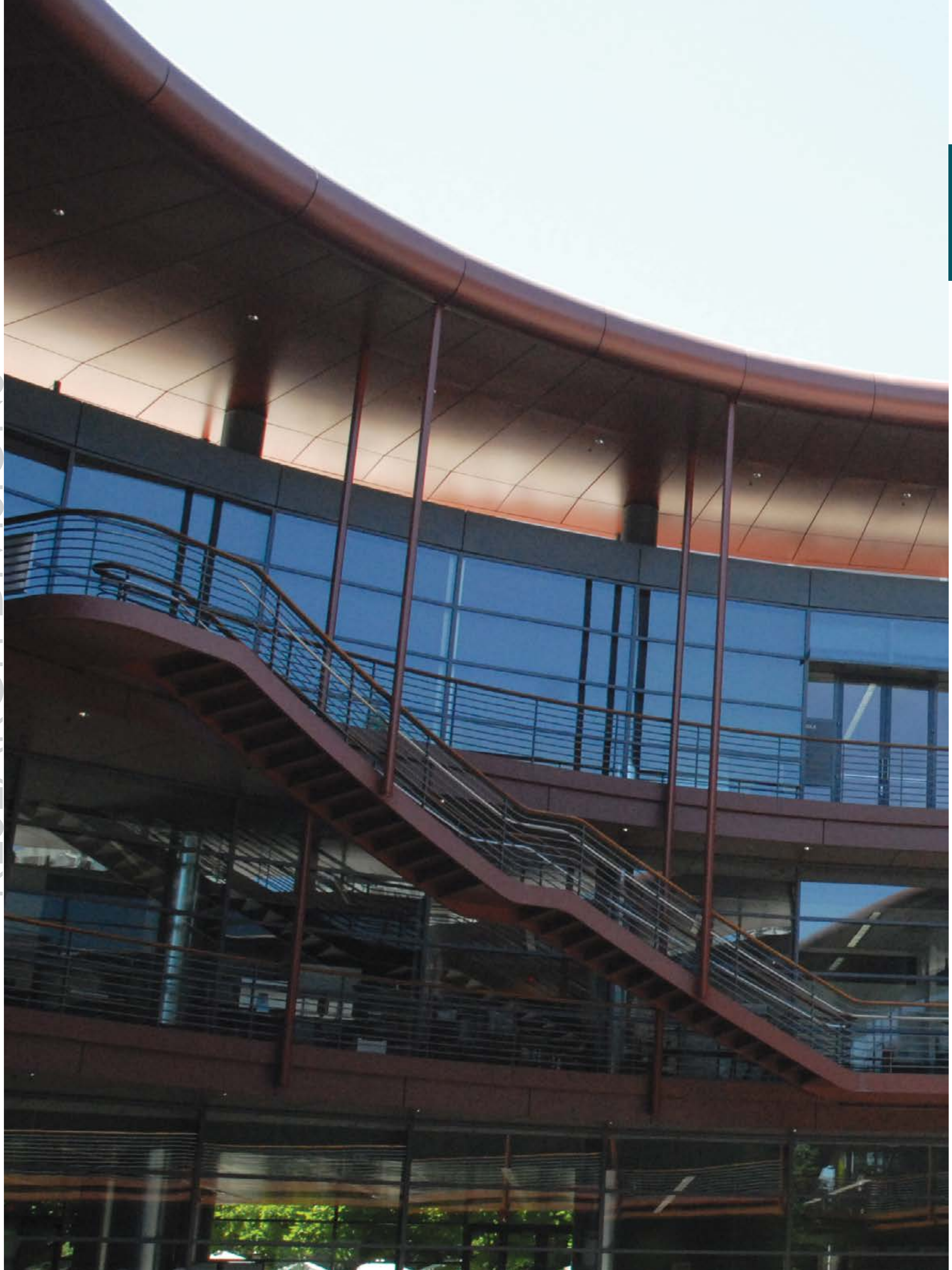
Kim Butts Pauly, PhD
Carl Herickhoff, PhD
RSL

RESEARCH DIVISIONS

2
RSNA Outstanding Researchers*

Sanjiv Sam Gambhir, MD, PhD
Norbert Pelc, ScD

*cumulative



Research Divisions

The Stanford University Department of Radiology is composed of five research divisions, each with its own specific area of focus.

I. Canary Center at Stanford for Cancer Early Detection
Discovers and implements minimally invasive diagnostic and imaging strategies for the detection and prognostication of cancers at early, curable stages.

II. Integrative Biomedical Imaging Informatics at Stanford (IBIIS)
Translates and disseminates methods in the information sciences that integrate imaging, clinical, and molecular data to understand biology and to improve clinical care.

III. Molecular Imaging Program at Stanford (MIPS)
Creates an environment in which noninvasive imaging technologies that permit studies of tumor initiation, progression, metastasis, and response to therapy are adopted by basic scientists studying cancer.

IV. Precision Health and Integrated Diagnostics (PHIND) Center at Stanford
Provides longitudinal monitoring and improvement of overall human health on a lifelong basis.

V. Radiological Sciences Laboratory (RSL)
Focuses on the areas of MRI, X-Ray/CT, and Ultrasound working in collaboration to develop improved imaging methods for scientific, diagnostic, and therapeutic applications.

Stanford Radiology has been among the top ten NIH-funded radiology departments each year since 2004. Our dedicated faculty, staff, and trainees maintain the department as a strong academic leader with excellence in clinical and basic research. In FY19, more than $45M in new sponsored funding (includes all years of all new awards that were awarded in 2019) was awarded to the department. The mission of their investigative laboratories is to elucidate the underlying causes of disease, develop new methodologies, offer new therapies, and train the next generation of multidisciplinary scientists to advance the field of medical imaging. The department's research efforts continue to expand interdisciplinary research efforts in magnetic resonance imaging (MRI), ultrasound, X-ray, computed tomography (CT), positron emission tomography (PET), single-photon emission computed tomography (SPECT), spectroscopy, chemistry, molecular imaging, genomics/proteomics, bioinformatics, computational sciences, and artificial intelligence, precision health, biomedical data science, and nanotechnology.

These accomplishments are made possible by a diverse group of researchers that include faculty and associated faculty members, visiting scholars, staff scientists, postdoctoral fellows, and graduate and undergraduate students. The following pages (94-137) offer a summary of the outstanding research in the laboratories and groups within these divisions.

DIVISION LEADERSHIP

Sanjiv Sam Gambhir, MD, PhD

Utkan Demirci, PhD

Stephanie van de Ven, MD, PhD

DIVISION FACULTY

Sharon Hori, PhD

Parag Mallick, PhD

Sharon Pitteri, PhD

Johannes Reiter, PhD

H. Tom Soh, PhD

Tanya Stoyanova, PhD

3

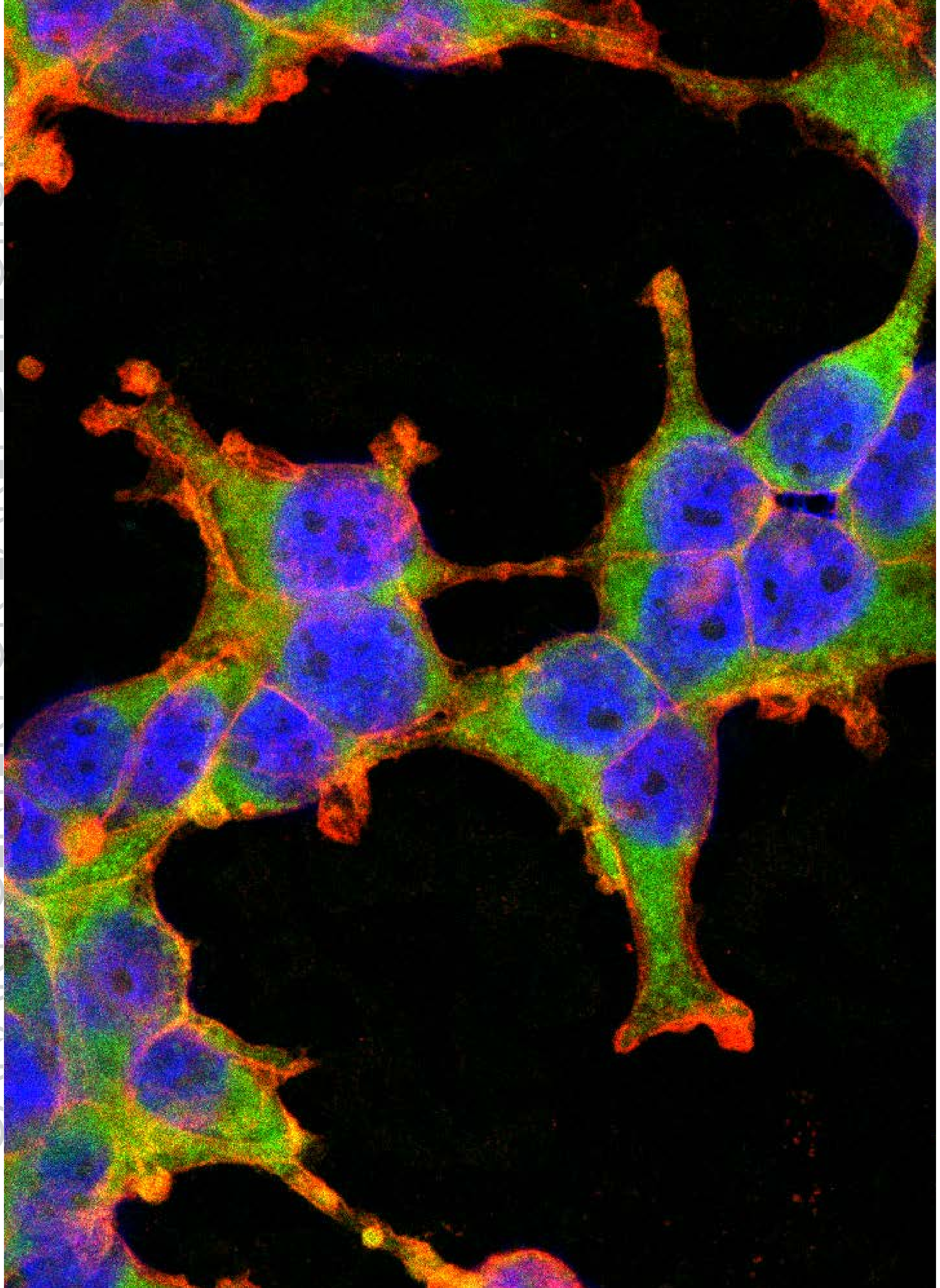
AIMBE Fellows*
Canary Center

Utkan Demirci, PhD
Sanjiv Sam Gambhir, MD, PhD
H. Tom Soh, PhD

*cumulative

The submitted image is a confocal microscopy image of prostate cancer cells expressing Trop2 Oncogene and CD98 protein. Courtesy of Stoyanova lab

CANARY CENTER FOR EARLY DETECTION



Canary Center at Stanford for Cancer Early Detection

The Canary Center at Stanford is a world-class research facility dedicated to early cancer detection programs. The mission is to discover and implement minimally invasive diagnostic and imaging strategies for the detection and prognostication of cancers at early, curable stages. The Canary Center is the first in the world to integrate research on in vivo and in vitro diagnostics to deliver these tests, by housing state-of-the-art facilities and collaborative research programs in molecular imaging, proteomics, chemistry, cell and molecular biology, bioengineering and bioinformatics. These initiatives have extensive links to the Stanford Cancer Institute, forming a direct pipeline for translation of early cancer detection research into clinical trials and practice. The Canary Center also educates the next generation of cancer researchers through various initiatives, including a competitive summer training program for undergraduate students.

NOTABLE ACHIEVEMENTS

- Initiated an international collaboration between the Canary Center at Stanford and the Cancer Research UK Cambridge Centre to jointly fund innovative research projects to help diagnose cancer earlier.
- Developed engineered immune cells (macrophages) as highly sensitive cancer diagnostics.
- Advanced magnetic levitation as a tool used to observe changes in phenotypic properties of cancer cells.
- Improved the sensitivity of ultrasound molecular imaging using the coherence-based beamforming technique.
- Developed an intravascular magnetic wire for high-throughput retrieval of circulating tumor cells.
- Established an annual Early Detection of Cancer Conference in collaboration with Cancer Research UK and Oregon Health & Science University Knight Cancer institute.

canarycenter.stanford.edu

CANARY CENTER FOR CANCER EARLY DETECTION

Front row L-R: Rakhi Gupta, Shreya Deshmukh, Mehmet Ogut, Rajib Ahmed, Utkan Demirci, Fatih Inci, Merve Karaaslan, Jie Wang, Rami El-Assal; Back row L-R: Tanchen Ren, Mehmet Ozen, Colin Grant, Elliot Chin , Brendon Cai, Kayla Marks, His-Min Chan

Bio-Acoustic MEMS in Medicine Lab

Utkan Demirici, PhD

https://bammlabs.stanford.edu/

Our lab has made seminal contributions to the development of microfluidic bio-imaging/sensing platforms for point-of-care diagnostics to solve real world problems in medicine. We have developed novel tools to i) isolate circulating tumor cells and aggregates, ii) focus on isolating exosomes for cancer early detection and iii) mimic the cancer microenvironment for investigating metastasis. Our work has applications in label-free rare cell sorting and point-of-care diagnostics, which founded the basis of 3-D bioprinting of cells and biomaterials. This led to development of a portable biosensor to rapidly monitor HIV infected CD4+ T cells at the point-of-care, which has been successfully tested in Tanzania. Our microfluidic technologies on novel sperm selection methods have been widely used by fertility clinics in assisted reproductive technologies that have led to over 10,000 live child births globally.

- DxNow received FDA clearance for ICSI and ZyMōt multi sperm separation devices designed for use in assisted reproductive technology procedures.
- The Demirci group develops SPARTAN (Simple Periodic Array for Trapping And IsolatioN), an innovative device to sort and select healthy sperm cells for IVF treatment.
- Dr. Demirci awarded "2018 Basic Scientist of the Year" by the Department of Radiology.

Clockwise: Joanna Sylman, Justin Carden, Hunter Boyce, Gautam Machiraju, Parag Mallick, Michelle Atallah, Michelle Hori

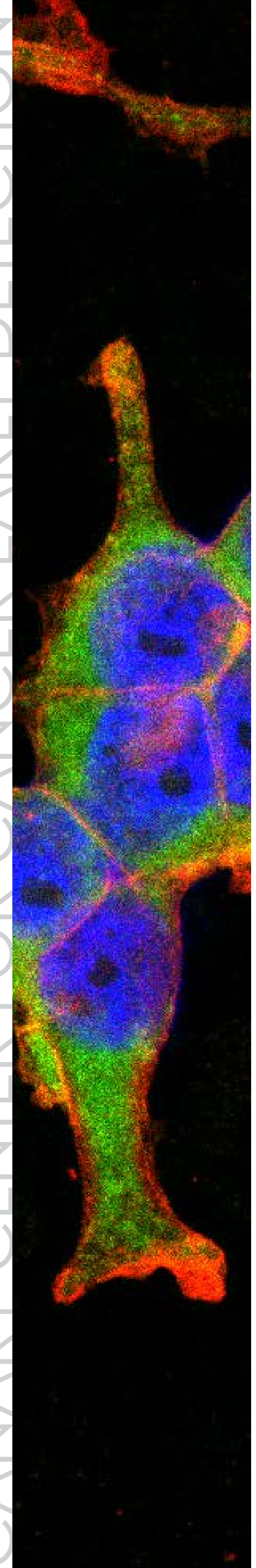
Multi-scale Diagnostics Lab

Parag Mallick, PhD

http://mallicklab.stanford.edu/

An ideal diagnostic workup allows the interrogation of detailed molecular phenomena from a handful of low cost and minimally invasive measurements. Unfortunately, as a medical research community, we do not yet have a good understanding of how measurements in the blood, urine or saliva reflect the molecular details of emerging tumors. Our group uses a combination of experimental and computational approaches to describe the complex series of relationships among cells, tissues, and peripheral fluids.

- Developed new tools to imitate pathologist assessments with interpretable and context-based neural network models.
- Developed a new bayesian active learning approach for inferring signaling networks.
- Newly part of the Physics of Artificial Intelligence (PAI) DARPA program.



L-R: Jessica Zuniga, Alisha Birk, Abel Bermudez, Sharon Pitteri, Catherine Going, Fernando Garcia Marques, Sarah Totten.

Cancer Molecular Diagnostics Lab

Sharon Pitteri, PhD

https://med.stanford.edu/pitterilab.html

The Pitteri Lab focuses on early detection of aggressive cancer and developing in vitro diagnostics. We study molecules in blood, tissue, and other bodily fluids to find disease biomarkers. We exploit aberrant glycosylation, a well-established but poorly understood feature of tumorigenesis, to better understand tumor biology. Our recent work is in breast and prostate cancers and distinguishing benign from malignant lesions, and indolent from aggressive cancer. We collaborate to apply technologies to study clinical samples, cell lines, and mouse models.

- Created extensive maps of protein glycosylation sites and composition in human prostate cancer and normal tissues.
- Defined protein signatures of aggressive versus indolent prostate cancer.
- Collected interstitial fluid from women with suspicious breast lesions in the Stanford Breast Imaging Clinic to identify new breast cancer biomarkers.

L-R: Stefano Avanzini, Johannes Reiter, Susan Singh

Translational Cancer Evolution Lab

Johannes Reiter, PhD

https://reiterlab.stanford.edu/

Our research focuses on the stochastic biological processes underlying cancer evolution. We develop computational and statistical methods to infer the evolutionary history of cancer from next-generation sequencing data. We design stochastic mathematical models to generate novel hypotheses and explain observations on a mechanistic level. Our long-term goal is to identify the evolutionary rules governing tumor initiation and progression to advance cancer precision medicine by providing new clinically-actionable information for an accurate diagnosis and optimal treatment of cancer.

- Demonstrated that a single tumor biopsy is typically sufficient to capture the essential information for initial therapeutic decision-making (published in Science, 2018).
- Renuka Ramanathan (Summer Intern) won best poster award, Canary CREST Poster Symposium, 2018.
- Johannes Reiter, PhD was honored with the Wissen schaf[f]t Zukunft Award (2018) of the province of Lower Austria, for his work on the subclonal evolution of cancer.
- Inferred a large time window of ~8 years for cancer early detection during the step-wise progression of pancreatic precursor lesions to invasive pancreatic cancers (published in Nature, 2018).
- Johannes Reiter, PhD received an NIH/NCI K99/R00 Pathway to Independence Award.

Front row L-R: Ji Won Seo, Alyssa Cartwright, Sharon Newman, Diana Wu, Dehui Kong, Leighton Wan, Amani Hariri, Mahla Poudineh; Back row L-R: H. Tom Soh, Xizhen Lian, Liwei Zheng, Kaiyu Fu, Nicolo Maganzini, Daniel Mamerow, Ian Thompson, Brandon Wilson, Vladamir Kesler, Dashiell Corbett

Advanced Molecular Diagnostics Lab

H. Tom Soh, PhD

https://sohlab.stanford.edu/

Our lab develops novel technologies to enable accurate detection of diseases at their earliest stages. We utilize the power of "directed evolution" to create synthetic reagents that specifically bind to biomarkers and integrate them into biosensor devices. We are currently focused on developing technologies for: (1) measuring biomarkers continuously in the body, (2) simultaneously measuring multiple biomarkers over a broad concentration range, and (3) extremely small and disposable biosensors to lower the cost of healthcare.

- Sharon Newman awarded the prestigious NSF Fellowship (2018).
- First closed-loop delivery of small molecule drugs in live subjects.
- (Closed-Loop Control of Circulating Drug Levels in Live Animals, Nature Biomedical Engineering, 2017).
- H.T. Soh, PhD was selected to be a Chan-Zuckerberg Investigator (2017).
- H.T. Soh, PhD was inducted into the National Academy of Inventors (2017).

L-R: Kashyap Koul, Tanya Stoyanova, Merve Aslan, En-chi Hsu, Meghan Rice, Ali Ghoochani, Shiqin Liu, Mark Buckup and Toni Benevento

Molecular Targets for Cancer Diagnosis and Treatment Discovery Lab

Tanya Stoyanova, PhD

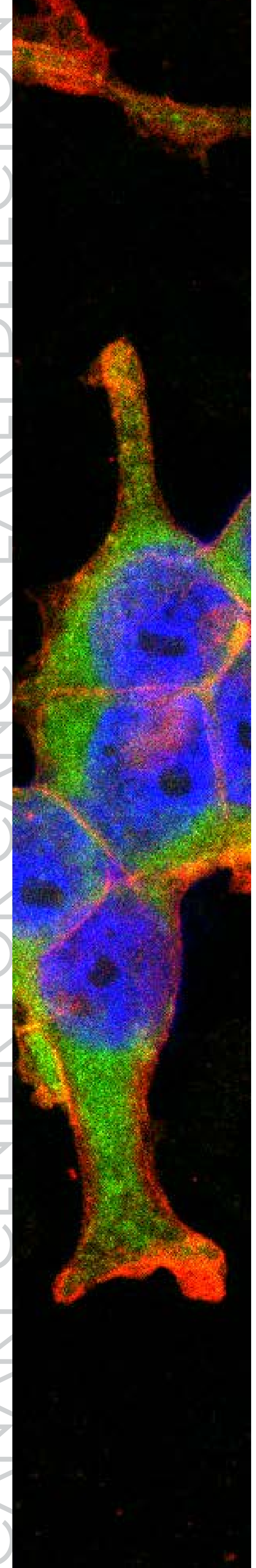
https://med.stanford.edu/stoyanovalab.html

Dr. Stoyanova's research focuses on understanding fundamental molecular mechanisms underlying cancer development. Currently, her group studies signaling cascades which are involved in the early event of prostate cancer initiation and regulation of the transition from indolent to metastatic disease. The long-term goal of Dr. Stoyanova's laboratory is to improve the stratification of indolent from aggressive cancers, and aid the development of better therapeutic strategies for advanced disease.

Additionally, the lab is interested in understanding the molecular mechanisms that govern the self-renewal activity of adult stem cells and cancer stem cells. They use molecular biology techniques, cell culture-based adult stem cell assays, *in vivo* tissue regeneration models of cancer, and genetically engineered mouse models.

- Defined a new therapeutic target for metastatic prostate cancer.
- Awarded Department of Defense, Prostate Cancer Research Program, Idea Development Award; and two Department of Defense, Prostate Cancer Research Program, Early Investigator Awards.
- Identified new driver of neuroendocrine prostate cancer.

CANARY CENTER FOR CANCER EARLY DETECTION



CANARY CENTER SELECTED FUNDING:

The Canary Foundation

Intercept Lung Cancer Through Immune, Imaging & Molecular Evaluation (InTIME). Stand Up To Cancer-Principal Investigators (SU2C Dream Team): SS Gambhir (Stanford Univ.); A Spira (Boston Univ.); S Dubinett (UCLA); J Brahmer (Johns Hopkins Univ.); M Meyerson (Harvard Univ.); C Swanton (Univ. College London)

Glycosylation and Immune Evasion in Urologic Tumors. Alliance of Glycobiologists for Cancer Research: Translational Tumor Glycomics Laboratories. NIH/NCI U01 CA226051 (Pitteri/Bertozzi/Brooks)

Molecular Imaging Methods for the Detection of Pancreatic Ductal Adenocarcinoma. NIH/NCI U01 CA210020 (Iagaru/Park)

Stanford Molecular and Cellular Characterization Laboratory. NIH/NCI U01 CA196387 (Brooks)

Canary Cancer Research Education Summer Training (Canary CREST) Program. NIH/NCI R25 CA21772901 (Soh/Demirci)

Center for Cancer Nanotechnology Excellence for Translational Diagnostics (CCNE-TD). NIH/NCI U54 CA 199075 (Gambhir/Wang)

CANARY CENTER SELECTED PUBLICATIONS:

Aalipour, A, Chuang HY, Murty S, D'Souza AL, Park SM, Gulati GS, Patel CB, Beinat C, Simonetta F, Martinic I, Gowrishankar G, Robinson ER, Aalipour E, Zhian Z, Gambhir SS. Engineered Immune Cells as Highly Sensitive Cancer Diagnostics. *Nature Biotechnology*, 2019 May; 37(5):531-539.

Baday M, Ercal O, Sahan AZ, Sahan A, Ercal B, Inan H, Demirci U. Density Based Characterization of Mechanical Cues on Cancer Cells Using Magnetic Levitation. *Advanced Healthcare Materials*, 2019 May; 8(10):e1801517.

Hyun D, Abou-Elkacem L, Perez VA, Chowdhury SM, Willmann JK, Dahl JJ. Improved Sensitivity in Ultrasound Molecular Imaging with Coherence-Based Beamforming. *IEEE Transactions on Medical Imaging*, 2018 Jan; 37(1):241-250. PMCID: PMC5764183.

Rice MA, Hsu EC, Aslan M, Ghoochani A, Su A, Stoyanova T. Loss of Notch1 Activity Inhibits Prostate Cancer Growth and Metastasis and Sensitizes Prostate Cancer Cells to Antiandrogen Therapies. *Molecular Cancer Therapeutics*, 2019 Jul; 18(7):1230-1242.

Sylman JL, Boyce HB, Mitrugno A, Tormoen GW, Thomas IC, Wagner TH, Lee JS, Leppert JT, McCarty OJT, Mallick P. A Temporal Examination of Platelet Counts as a Predictor of Prognosis in Lung, Prostate, and Colon Cancer Patients. *Scientific Reports*, 2018 Apr; 8(1):6564. PMCID: PMC5920102.

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INTEGRATIVE BIOMEDICAL IMAGING INFORMATICS

DIVISION LEADERSHIP

Sandy Napel, PhD

DIVISION FACULTY:

Curtis Langlotz, MD, PhD

Sylvia Plevritis, PhD

Daniel Rubin, MD, MS

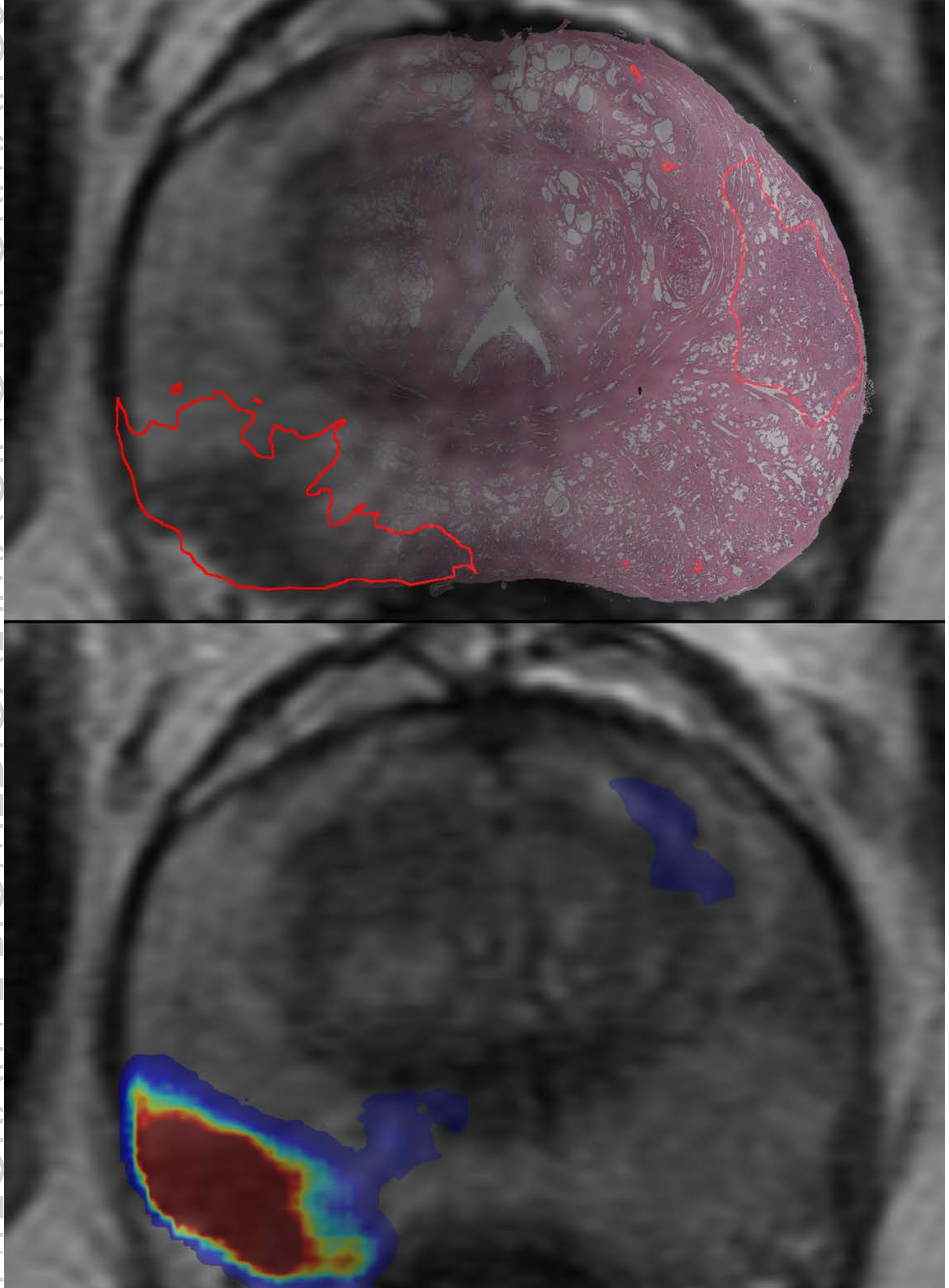
Mirabela Rusu, PhD

3

AIMBE Fellows*
IBIIS

Sandy Napel, PhD
Sylvia Plevritis, PhD
Daniel Rubin, MD, MS

*cumulative



RAPSODI: A platform to fuse prostate MRI and whole-mount histopathology images to map the extent of cancer (red outline, top image) from histology onto pre-surgical MRI. The bottom image is a deep learning prediction of aggressive prostate cancer trained using the labels mapped via RAPSODI; blue indicates a low probability of prostate cancer, with red indicating a high probability.

Integrative Biomedical Imaging Informatics at Stanford (IBIIS)

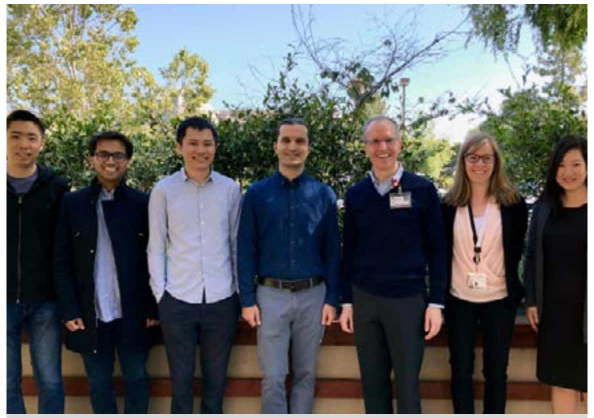
The Integrative Biomedical Imaging Informatics at Stanford (IBIIS) division of the Department of Radiology focuses on pioneering, translating, and disseminating methods using the imaging information sciences to better understand health and disease, and to improve clinical care. Our research activities include: (1) construction of large-scale databases integrating imaging, cellular, and other aspects of the medical record, including clinical outcome, response to therapy, results of other diagnostic tests, and molecular and multi-omic analysis of tissue, development and testing of patient-specific and population-scale algorithms, possibly including wet-lab investigations, (2) automated methods to leverage large-scale image collections, (3) image analysis, federated with other databases if needed, to identify critical findings from imaging examinations in near real-time, (4) automated report generation, (5) fusion of images and clinical data from radiology and pathology for staging and building predictive models, (6) natural language processing to extract discrete data from human interpretations of images, (7) conventional and deep learning analysis of massive data sets containing both images and data collected from imaging examinations, patient monitors, wearable devices, medical records, patient self-reports, and disease-specific early detection tests, (8) imaging-driven clinical decision support, (9) correlation of imaging appearance with molecular profiles of tissue, (10) development of novel imaging-based biomarkers of disease and response to therapy, (11) data-driven models of cancer progression, and (12) development and evaluation of cancer screening programs.

NOTABLE ACHIEVEMENTS

- Developed a community-accessible and -expandable resource for (1) computation of image features (radiomics) from collections of 2D and 3D medical images, and (2) sharing of quantitative imaging software tools.
- Identified partial states of the epithelial to mesenchymal transition in clinical lung cancer samples that confer differential drug sensitivity.
- Showed that pre-training a computer vision algorithm on medical images labeled with information extracted from the radiology report is superior to pre-training on natural scenes.
- Produced novel and clinically-impactful applications (1) to predict disease progression based on computer analysis of retinal images in AMD to enable early preventive intervention (patent awarded, 2019), and (2) to predict survival in cancer to enable shared decision making based on computerized analysis of longitudinal medical records data.
- Developed and validated a framework for registering corresponding histology and MRI slices using traditional registration methods and made it available as a plugin for an open source visualization application.

ibiis.stanford.edu

INTEGRATIVE BIOMEDICAL IMAGING INFORMATICS



L-R: Yuhao Zhang, Nish Khandwala, David Eng, Saeed Seyyedi, Curt Langlotz, Stephanie Bogdan, and Johanna Kim.

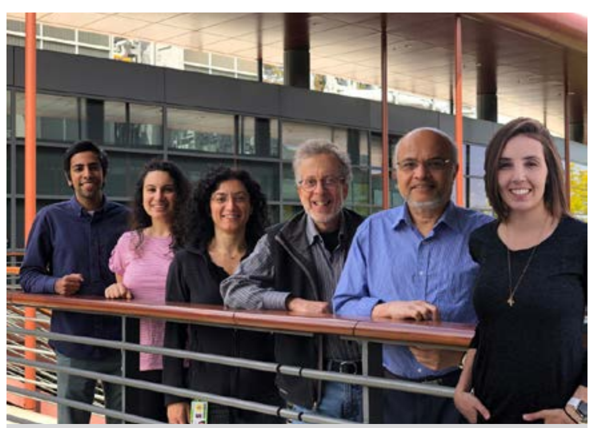
Artificial Intelligence in Medicine and Imaging (AIMI) Lab

Curtis Langlotz, MD, PhD

http://langlotzlab.stanford.edu/

Our laboratory investigates the use of deep neural networks and other machine learning methods to help radiologists detect disease and eliminate diagnostic errors. We use the radiology report as a resource to improve the performance and labeling efficiency of training data for computer vision experiments. We develop natural language processing methods that extract information from radiology reports to label images automatically and improve the performance of computer vision algorithms. We develop methods that accommodate the complexity of clinical images and their relationships to other patient data. When our results show potential, we evaluate their clinical utility and disseminate them as open source or commercial software.

- Developed and published consensus statements for a roadmap for foundational and translational research on artificial intelligence applications in medical imaging.
- Created a method to automatically construct the impression section of a radiology report to summarize the body of the report.
- Created an algorithm to predict the acuity of a radiology report from the report text.
- Developed vector-based encoding of a large radiology report corpus for broad distribution.



L-R: Akshay Jaggi, Shaimaa Bakr, Emel Alkim, Sandy Napel, Dev Gude, Sarah Mattonen

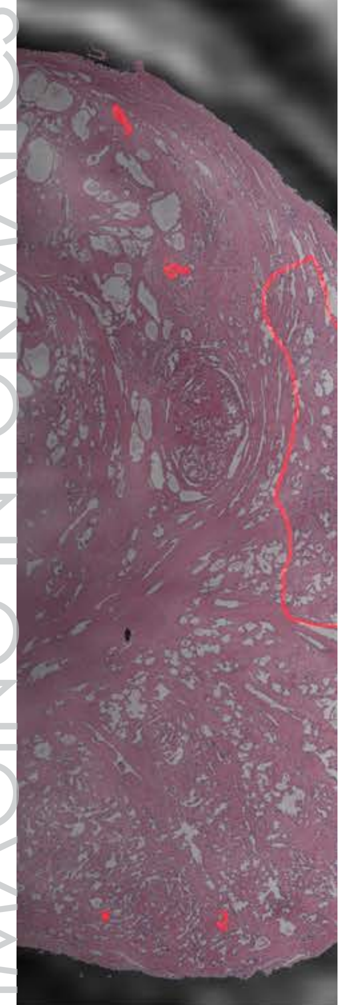
Radiological Image and Information Processing Lab

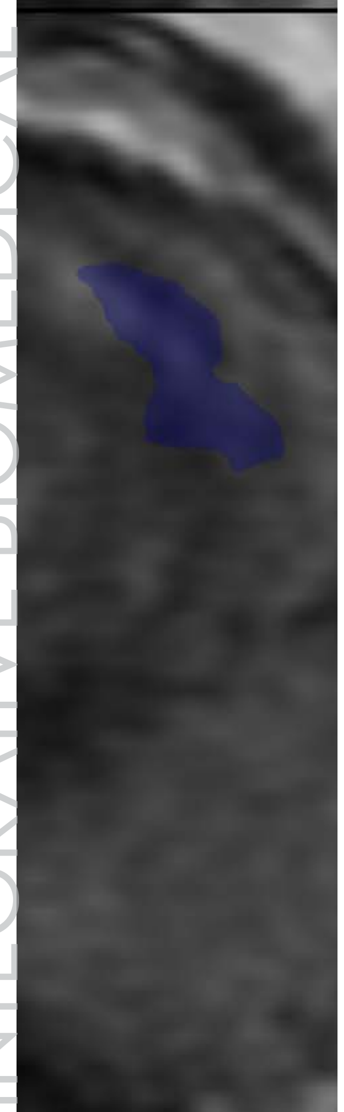
Sandy Napel, PhD

https://med.stanford.edu/riipl.html

Our lab focuses on developing new techniques to determine diagnosis, to predict prognosis, response to treatment, and outcomes from images and other associated data. This involves developing algorithms to make image features (e.g., volumes, lengths, shapes, edge sharpness, curvatures, textures) computer-accessible, building integrated databases combining features of multidimensional radiological images and other clinical data, including molecular assays of biopsies and/or resected tissue, and machine learning algorithms to make inferences from the integrated data. We translate these developments into clinical applications, including content-based medical image retrieval and decision support systems for radiologists. We primarily work with cross-sectional images, including CT, MR, and ultrasound, and specialize in cancer imaging.

- Shared tools and algorithms with international quantitative cancer imaging networks.
- Developed a community-accessible and -expandable resource for computation of image features (radiomics).
- Established and documented the opportunities and challenges of using semantic features for predictive models in lung and liver cancer.
- Developed and shared digital reference objects for calibrating and comparing radiomics tools.





Top row L-R: David Cohn, Thorbjørn Grønbæk, Assaf Hoogi, Alfiia Galimzianova, Khaled Saab, Blaine Rister, Mete Akdogan, Kim Wilder-man, Selen Bozkurt; Bottom row L-R: Hersh Sagreiya, Imon Banerjee, Daniel Rubin, Emel Alkim

Quantitative Imaging and Artificial Intelligence Lab

Daniel Rubin, MD, MS

https://rubinlab.stanford.edu/

Our laboratory develops AI methods and computational tools to realize precision health and enable better care in disease. We translate our discoveries into practice through decision support applications to enable precision medicine, reduce variation in clinical care, and improve patient outcomes. Our work spans from basic science discovery (e.g., of image phenotypes to define disease subtypes and understand their molecular characteristics) to clinical practice through translational research (decision support, disease profiling, treatment response assessment, and personalized treatment selection). Our vision is that computational approaches to mining large collections of integrated molecular, clinical, and image data will drive discovery, help to predict/detect disease, and guide clinical practice.

- Produced novel applications to predict (1) disease progression from computer analysis of retinal images in AMD (awarded U.S. patent, 2019) and (2) survival in cancer from computer analysis of longitudinal medical records data.
- Developed the ePAD semantic image annotation resource and the Quantitative Imaging Feature Pipeline platform enabling large-scale AI application development with images and machine learning to recognize disease subtypes and predict clinical outcomes.
- ePAD won Best Scientific Paper Award, European Congress of Radiology, 2019.
- Developed innovative methods for distributed learning of AI models, enabling for community multi-institutional data leveraging, facilitating data sharing, and more robust healthcare applications.
- Developed novel natural language processing methods to automatically code and summarize narrative radiology reports and clinical text notes.

L-R: Mirabela Rusu, Rewa Sood, Arun Seetharaman, Richard Fan, Makena Sierra Low

Integrative Personalized Medicine Lab

Mirabela Rusu, PhD

https://med.stanford.edu/rusulab.html

Our laboratory focuses on developing analytic methods for biomedical data integration, with a particular interest in radiology-pathology fusion. Such integrative methods may be applied to create comprehensive multi-scale representations of biomedical processes and pathological conditions, thus enabling their in-depth characterization. The radiology-pathology fusion allows the creation of detailed spatial labels that can later on be used as input for advanced machine learning, such as deep learning.

- Trained a generative adversarial network to super-resolve prostate MRI, and reconstruct isotropic volume from anisotropic MRI.
- Trained a holistically-nested edge detection (HED) network to predict prostate cancer using bi-parametric MRI.
- Validated a deep learning-based approach to register corresponding histology and MRI slices.
- As proof-of-concept, registered histology slices and MRI in breast lesions.
- Developed a framework for registering corresponding histology and MRI slices using traditional registration methods.

Back row L-R: Sylvia Plevritis, Mehrad Bastani, Ramzi Totah, Iakovos Toumazis, Loukia Karacosta, Alborz Bejnood, David Knowles, Gina Bouchard, Theresa McCann, Maggie Bos; Front row L-R: Isha Chakraborty, Jessica Johnstone, Melissa Ko, Weiruo Zhang, Alice Yu, Irene Li, Zina Good

Cancer Systems Biology Lab

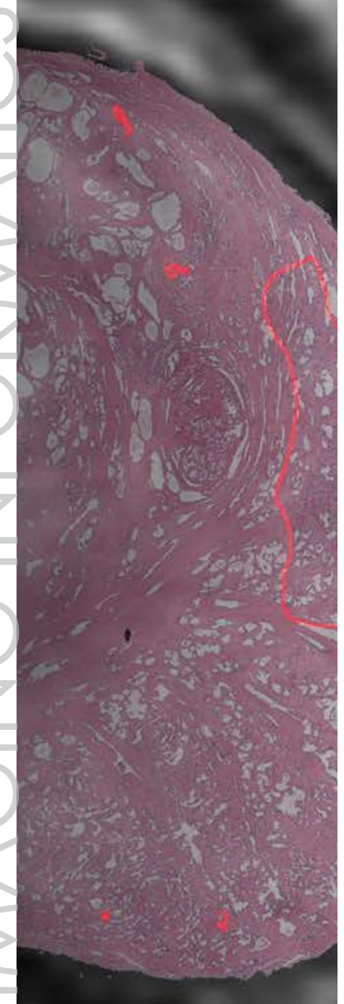
Sylvia Plevritis, PhD

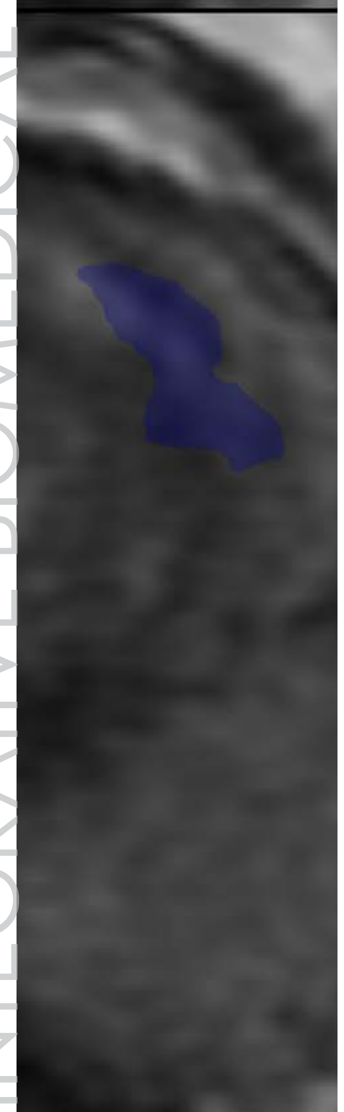
https://med.stanford.edu/plevritis.html

The Cancer Systems Biology Laboratory (CSBL) unravels the molecular mechanisms underlying cancer progression to identify novel approaches to early detection and effective cancer treatment. Our work involves the analysis of cancer as a complex system whose components can be reverse-engineered from multi-omics data. Active research projects include: (1) reconstructing intra- and inter-cellular communication networks of cancer from genomic, proteomic and radiomic data, (2) optimizing combination drug therapy strategies, and (3) quantifying the impact of risk-based screening and molecularly targeted therapeutics on population cancer incidence and mortality rates. Our goal is to develop a multiscale view of cancer progression to improve early detection and treatment strategies for the individual patient. CSBL brings together computer scientists, statisticians, engineers, biological experimentalists and clinical researchers for a multidisciplinary approach to tackle cancer.

- Evaluated the impact of indeterminant nodules on the effectiveness and cost-effectiveness of lung cancer CT screening.
- Developed a novel algorithm to predict cancer drug sensitivity based on sparse discriminate latent characteristics.
- Estimated trajectories of tumor cell plasticity from single cell time course data of the epithelial to mesenchymal transition.
- Benedict Anchang, PhD (Instructor) and David Knowles, PhD (Postdoctoral Fellow) appointed to tenure-track faculty positions at NIH and NY Genome Center, respectively.
- Sylvia Plevritis, PhD appointed to Chair of of Biomedical Data Science (see page 27) and Program Director of the Biomedical Informatics Graduate Training Program.

INTEGRATIVE BIOMEDICAL IMAGING INFORMATICS





IBIIS SELECTED FUNDING:

Stanford Cancer Imaging Training (SCIT) Program. NIH/NCI T32 CA009695 (Napel)

Computing, Optimizing, and Evaluating Quantitative Cancer Imaging Biomarkers. NIH/NCI U01 CA187947 (Napel/Rubin)

Qualification and Deployment of Imaging Biomarkers of Cancer Treatment Response. NIH/NCI U01 CA190214 (Rubin)

Distributed Learning of Deep Learning Models for Cancer Research. NIH/NCI U01 CA242879 (Rubin)

Modeling the Role of Lymph Node Metastases in Tumor-Mediated Immunosuppression. NIH/NCI U54 CA209971 (Plevritis)

Comparative Modeling: Informing Breast Cancer Control Practice & Policy. NIH/NCI U01 CA199218 (Mandelblatt, Plevritis)

IBIIS SELECTED PUBLICATIONS:

Mattonen SA, Davidzon GA, Bakr S, Echegaray S, Leung ANC, Vasanawala M, Horng G, Napel S, Nair VS. 18F-FDG Positron Emission Tomography (PET) Tumor and Penumbra Imaging Features Predict Recurrence in Non-Small Cell Lung Cancer. *Tomography*, 2019 Mar; 5(1):145-153. PMCID: PMC6403030.

Bakr S, Gevaert O, Echegaray S, Ayers K, Zhou M, Shafiq M, Zheng H, Benson JA, Zhang W, Leung ANC, Kadoch M, Hoang CD, Shrager J, Quon A, Rubin DL, Plevritis SK, Napel S. A Radiogenomic Dataset of Non-Small Cell Lung Cancer. *Scientific Data*, 2018 Oct; 5:180202. PMCID: PMC6190740.

Toumazis I, Tsai E, Erdogan SA, Han SS, Wan W, Leung A, Plevritis SK. Cost-Effectiveness Analysis of Lung Cancer Screening Accounting for the Effect of Indeterminate Findings. *JNCI Cancer Spectrum*, 2019 May; 3(3):pkz035. In Press.

Knowles DA, Bouchard G, Plevritis S. Sparse Discriminative Latent Characteristics for Predicting Cancer Drug Sensitivity from Genomic Features. *PLoS Computational Biology*, 2019 May; 15(5):e1006743. PMCID: PMC6555538.

Langlotz CP, Allen B, Erickson BJ, Kalpathy-Cramer J, Bigelow K, Cook TS, Flanders AE, Lungren MP, Mendelson DS, Rudie JD, Wang G, Kandarpa K. A Roadmap for Foundational Research on Artificial Intelligence in Medical Imaging: From the 2018 NIH/RSNA/ACR/The Academy Workshop. *Radiology*, 2019 Jun; 291(3):781-791. PMCID: PMC6542624.

Percha B, Zhang Y, Bozkurt S, Rubin D, Altman RB, Langlotz CP. Expanding a Radiology Lexicon Using Contextual Patterns in Radiology Reports. *Journal of the American Medical Informatics Association*, 2018 Jun; 25(6):679-685. PMCID: PMC5978019.

Banerjee I, Gensheimer MF, Wood DJ, Henry S, Aggarwal S, Chang DT, Rubin DL. Probabilistic Prognostic Estimates of Survival in Metastatic Cancer Patients (PPES-Met) Utilizing Free-Text Clinical Narratives. *Scientific Reports*, 2018 Jul; 8(1):10037. PMCID: PMC6030075.

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Rusu M, Kunder C, Fan R, Ghanouni P, West R, Sonn G, Brooks J. Framework for the Co-Registration of MRI and Histology Images in Prostate Cancer Patients with Radical Prostatectomy. *SPIE Medical Imaging*, 2019; Proceedings Volume 10949, Medical Imaging 2019: Image Processing; 109491P.

Sood R, Topiwala B, Choutagunta K, Sood R, Rusu M. An Application of Generative Adversarial Networks for Super Resolution Medical Imaging. 2018 Dec; *17th IEEE International Conference on Machine Learning and Applications (ICMLA)*: 326–331.

MOLECULAR IMAGING PROGRAM AT STANFORD

DIVISION LEADERSHIP

Sanjiv Sam Gambhir, MD, PhD
Gunilla Jacobson, PhD

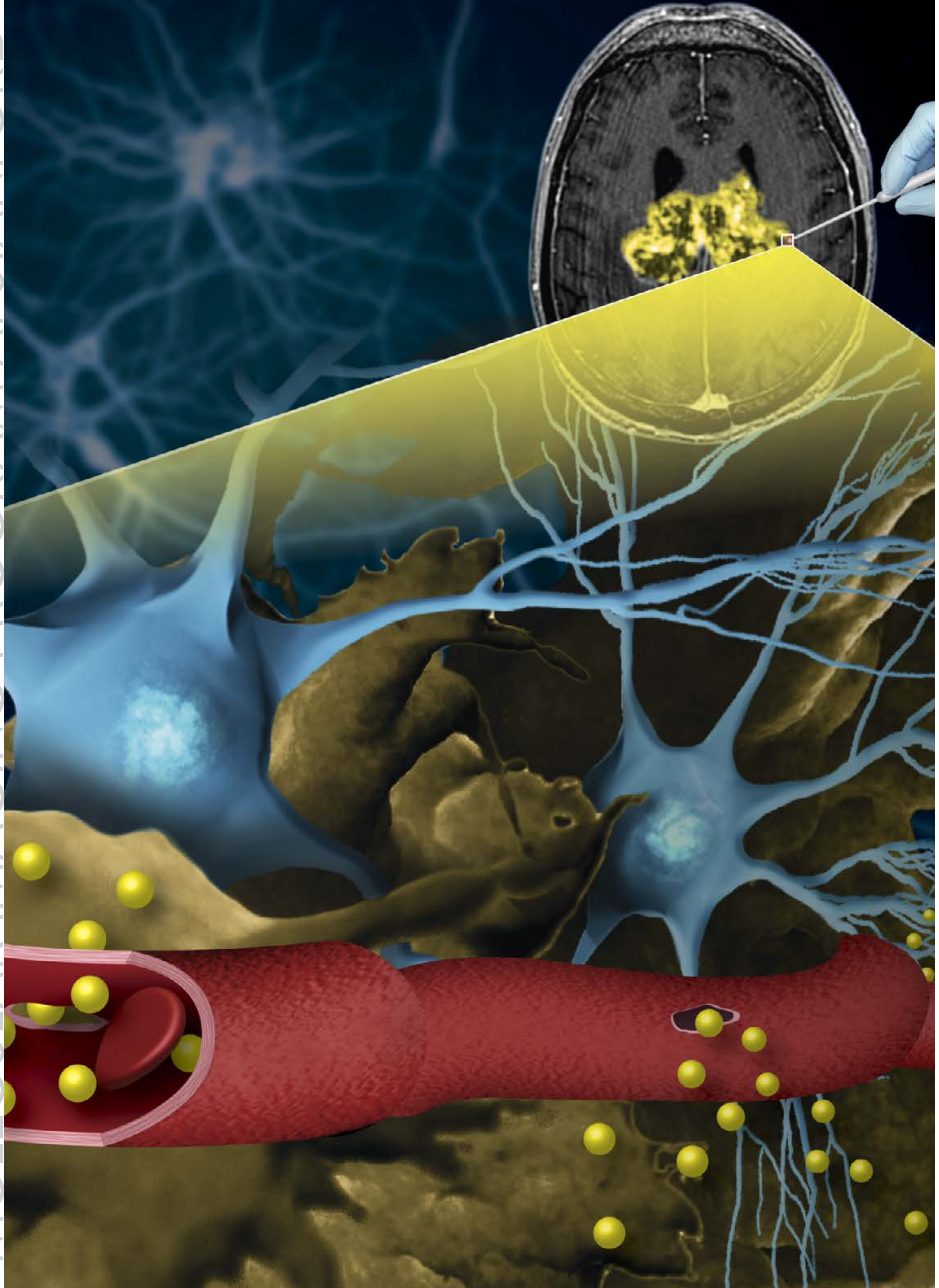
DIVISION FACULTY

Raag Airan, MD, PhD
Corinne Beinat, PhD
Sandip Biswal, MD
Zhen Cheng, PhD
Frederick Chin, PhD
Heike Daldrup-Link, MD
Gozde Durmus, PhD
Katherine Ferrara, PhD
Brett Fite, PhD
Josquin Foiret, PhD
Michelle James, PhD
Shivaani Kummar, MD
Craig Levin, PhD
Andreas Loening, MD, PhD
Sanjay Malhotra, PhD
Tarik Massoud, MD, PhD
Koen Nieman, MD, PhD
Chirag Patel, MD, PhD
Ramasamy Paulmurugan, PhD
Jianghong Rao, PhD
Stephan Rogalla, MD
Eben Rosenthal, MD
Avnesh Thakor, MD, PhD
Katheryne Wilson, PhD
Joseph Wu, MD, PhD

6
AIMBE Fellows*
MIPS

Heike Daldrup-Link, MD
Katherine Ferrara, PhD
Sanjiv Sam Gambhir, MD, PhD
Craig Levin, PhD
Jianghong Rao, PhD
Joseph Wu, MD, PhD

*cumulative



An illustration of a canine clinical trial to delineate nanoparticles' delivery to spontaneous brain tumors. This article, by Radiology MIPS researchers, reported heterogenous delivery of the nanoparticles to these naturally occurring brain tumors (brown color tissue).

Molecular Imaging Program at Stanford (MIPS)

The Molecular Imaging Program at Stanford was established in 2003 as an interdisciplinary program to bring together scientists and physicians who share a common interest in developing and using state-of-the-art imaging technology, and developing molecular imaging assays for studying intact biological systems.

The goals of the program are to fundamentally change how biological research is performed, using cells in their intact environment in living subjects, and to develop new ways to diagnose, treat, and monitor diseases in patients. Areas of active investigation include cancer research, microbiology/immunology, cardiovascular research, early disease detection, stem cell biology, quantitation and visualization, nanobiotechnology, molecular probe development, developmental biology, and pharmacology. A multi-modality approach using imaging technologies such as positron emission tomography (PET), single photon emission computed tomography (SPECT), digital autoradiography, magnetic resonance imaging (MRI), magnetic resonance spectroscopy (MRS), optical bioluminescence, optical fluorescence, Raman spectroscopy, photoacoustic imaging, and ultrasound are all technologies under active development and investigation.

Since its inception, MIPS has followed a clearly defined roadmap toward translating its work into clinical use to benefit patients.

NOTABLE ACHIEVEMENTS

- The MIPS program continues to grow and now includes 32 faculty and their labs, spanning eight different departments on campus.
- A $3.5M investment into the small animal imaging facilities has allowed for numerous new equipment upgrades, such as a PET-CT, an additional 3T MRI, an 11.7T MRI, and numerous optical systems.
- A new MIPS Alumni award was initiated in 2018, and the first recipient was Dr. Gaolin Liang, formerly from Dr. Jianghong Rao's lab.

mips.stanford.edu

MOLECULAR IMAGING PROGRAM AT STANFORD

Back row L-R: Lakshyaa Balakrishnan, Ananya Karthik, Jeffrey Wang, James Bishop, Tommaso Di Ianni, Qian Zhong; Front row L-R: Muna Aryal, Zhenbo Huang, Raag Airan, Brenda Yu, Sunmee Park, Dayna Schiessler; Not Pictured: Niloufar Hosseini Nassab, Doug Martin, Daivik Vyas, Mario Landeros, Andi Park Chaloult, Melissa Daniel, Sarah Smith

Noninvasive Neurointerventions Lab

Raag Airan, MD, PhD

https://airan-lab.stanford.edu/

The Noninvasive Neurointerventions (ni2) Lab is focused on developing novel molecular interventions for interrogating and treating the nervous system, through focused US-mediated targeted drug delivery. We are (1) adapting the use of US-sensitive drug-delivery nanotechnology to deliver neuromodulatory agents to the brain, to enable spatiotemporally-precise and receptor-specific noninvasive neuromodulation; (2) implementing clinical protocols for targeted, safe, and reversible BBB opening to increase delivery of anti-cancer agents to the brain; and (3) exploring methods to use these technologies to modulate cerebral perfusion and the neural immunological response, in addition to oncologic applications.

- Developed nanoparticles enabling noninvasive and targeted ultrasonic drug uncaging so that the delivered drug acts only when and where US is applied.
- Demonstrated that these nanoparticles may generalize to allow delivery of any small molecule hydrophobic drug and do so safely without measurable toxicity.
- Validated aseptic methods to produce these particles at scales relevant for eventual clinical translation and established a regulatory path to enable that translation.
- Developing US hardware for these preclinical and clinical applications, and combining therapeutic US interventions with diagnostic US imaging.

Top row L-R: Yingding Bryan Xu, Mary Ellen Koran, Angela Fast; Bottom row L-R: Sandip Biswal, Peter Cipriano, Daehyun Yoon

Molecular Imaging of Nociception and Inflammation Lab

Sandip Biswal, MD

https://med.stanford.edu/mips/research/minil.html

Current imaging approaches that identify pain generators are inadequate. Our group has been developing clinical molecular imaging methods to objectively pinpoint the site of pain generation using PET agents that specifically seek out pain-related inflammation. We are currently conducting clinical trials using PET-MRI with either FDG or a sigma-1 receptor radioligand. This study has been facilitated through extensive collaboration of many scientists and clinicians from different disciplines including radiochemistry, MR physics, anesthesia/pain, neurosurgery, plastic and orthopedic surgery, and others.

- Successfully recruited 150+ research subjects to date for our clinical trials identifying pain generators using a sigma-1 receptor radioligand or FDG and PET-MRI.
- Delivered two Radiology Grand Rounds (UCSD and Stanford) and a Keynote Address at the NIH/NCI inflammation science workshop discussing our work on imaging pain.
- Sandip Biswal, MD represented radiology on Capitol Hill during MEDTECH 10, an event to help congress learn about the need to continue to support radiology research.
- The Biswal Lab was selected to propose the entrepreneurial idea of imaging pain at two Imaging Shark Tanks (WMIC and RSNA).

Front row L-R: Muru Subbarayan, Bin Shen, Frederick T. Chin, Regie Ledesma, Jessa Castillo, Emily Carmen Azevedo; Middle row L-R: Ning Zhao, Rowaid Kellow, Francis Balmaceda, Ka Ho, Jun Park Hyung ; Back row L-R: Berend Van der Wildt, Alex Romero, Samantha Levine, Kenneth Hettie; Inset L-R: Soujanya Gade, Azhia Harris, Scarlett Guo, George Montoya, Jessica Klockow, Rita Dindral, Rhea Scott

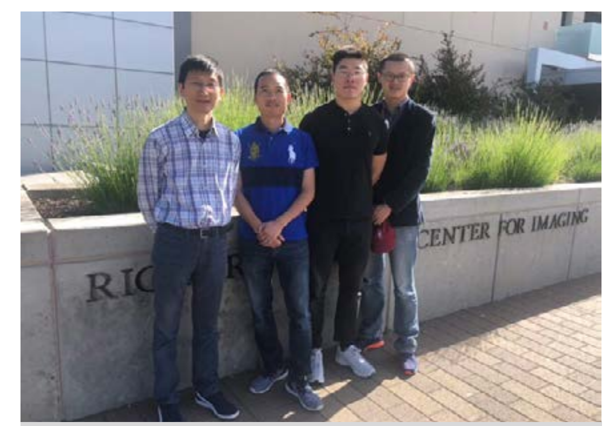
TRACER for Molecular Imaging Lab

Frederick Chin, PhD

https://med.stanford.edu/mips/research/tracer.html

The Translational Radiopharmaceutical Sciences and Chemical Engineering Research (TRACER) for Molecular Imaging laboratory specializes in synthetic chemistry and focuses on advancing radiopharmaceutical sciences for molecular imaging. We design and synthesize novel chemical strategies that bind to various molecular targets related to cancer biology and gene therapy. New radiolabeling techniques and methodologies are created for emerging radiopharmaceutical development and the general radiochemistry community. These approaches are coupled with innovative chemical engineering and in vivo models to investigate new molecular imaging strategies. Successful imaging agents are extended towards clinical applications including disease detection and drug therapy.

- Developed a new class of CSF-1R radioligands for potential monitoring of glioblastoma progression and therapy.
- Evaluated S1R agonists (with [18F]FTC-146 PET imaging) for therapeutic treatment of neurodegenerative diseases.
- Submitted an IND application for [11C]UCB-J to image synapses in the human brain with PET-MR.
- Received NIH R21 funding to study Sigma-1 Receptors: A Novel Clinical Target in Fragile X Syndrome.



L-R: Zhen Cheng, Qiang Liu, Yifan Wu, Baisong Chang

Cancer Molecular Imaging Chemistry Lab

Zhen Cheng, PhD

https://med.stanford.edu/chenglab.html

This laboratory aims to develop novel molecular imaging techniques and theranostic agents for early diagnosis and treatment of severe disease including cancer, as well as neurological and cardiovascular diseases. We have actively explored both new chemistry and platforms for imaging probe preparation and developed new imaging strategies for clinical translation. A multidisciplinary team composed of members with expertise in chemistry, bionanotechnology, molecular biology, and molecular imaging has been built to implement several research projects, all related to molecular imaging.

- Developed a new class of small-molecule-based dyes and rare-earth-doped nanoparticles for in vivo near-infrared window II imaging of a variety of disease models.
- Established Cerenkov luminescence imaging (CLI) as a new approach for bioimaging and further developed Cerenkov luminescence endoscopy for clinical translation.
- Developed new nanoplatforms such as bioinspired melanin dots, gold-tripod nanoparticles, Au-iron oxide heterostructures, perylene-diimide-based nanoparticles for cancer multimodality imaging and theranostics.
- Developed PET probes for cancer, cardiac and neurological disease imaging with three probes having been translated into clinical evaluation.

MOLECULAR IMAGING PROGRAM AT STANFORD

L-R from back to front: Florian Siedek, Laura Pisani, Ramyashree Nyalakonda, Jordi Garcia-Diaz, Anne Muehe, Kimberly Ku, Ashok Theruvath, Louise Kiru, Heike Daldrup-Link, Wei Wu, Hossein Nejadnik (not shown: Crystal Farrel, Anuj Pareek, Hussein Mahmood, Kristina Hawk, Eileen Misquez)

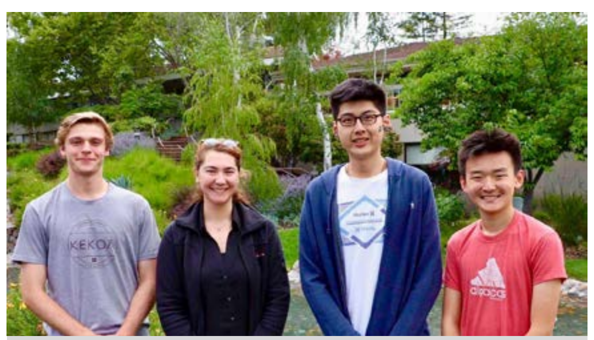
Pediatric Molecular Imaging Lab

Heike Daldrup-Link, MD

http://daldrup-link-lab.stanford.edu/

The vision of our lab is to provide the best medical diagnosis for every child by combining nanotechnology and innovative imaging technologies towards improved detection and treatment monitoring of pediatric cancers. We improve the safety and efficacy of imaging tests by minimizing radiation exposure and designing "one-stop" exams for whole body and local cancer staging. We are also testing new imaging approaches for in vivo tracking of novel stem cell therapies.

- Our work was highlighted on the covers of the journals Clinical Cancer Research (Sept. 2018), and Nanomedicine and Nanobiotechnology (Jul. 2019).
- Our team received two new research grants, an R21 and SPARK. Hossein Nejadnik, MD, PhD (Research Associate) received a 2018 WMIC Travel Award; Suchismita Mohanty, PhD (Research Scientist) received a 2018 Women in Molecular Imaging Scholar Award; and Anne Muehe, MD (Clinical Research Scientist) received a 2018 RSNA Trainee Travel Award.
- Dr. Daldrup-Link was (1) elected as Fellow of AIMBE; and (2) received the 2019 Harry Fischer Lifetime Achievement Award for Excellence in Contrast Media Research; and (3) was selected for the SCARD leadership program with GE Healthcare Women's Imaging Network.



L-R: Colin Grant, Gozde Durmus, Brandon Cai, Elliot Chin

Precision Biosystems Lab

Gozde Durmus, PhD

https://gdurmus.people.stanford.edu/

Dr. Durmus develops and applies translational micro/nanotechnologies to study cellular heterogeneity and complex biological systems for single cell analysis and precision medicine. Her research philosophy is to apply these platforms to fundamentally understand and address the mechanisms of disease, with a specific emphasis on cancer. By bridging the gap between biology, engineering and medicine, the vision of her research is to develop simple, inexpensive, easy-to-use, yet, broadly applicable platforms that will change the way in which medicine is practiced as well as how patients are monitored, diagnosed, and treated for precision medicine.

- Demonstrated magnetic levitation of living cells and developed new tools for cell sorting and diagnostics.
- Technologies are used for broad applications in medicine, such as, label-free detection of circulating tumor cells from blood, high-throughput drug screening, and rapid detection of antibiotic resistance in real-time.
- Dr. Durmus was named a Rising Star in Biomedicine, by Broad Institute of MIT and Harvard, 2018.
- Dr. Durmus was named, for Medical Innovation, as one of Ten Outstanding Young Persons of the World by Junior Chamber International (JCI), 2019.
- Dr. Durmus received the McCormick and Gabilan Faculty Award from Stanford University School of Medicine, 2019.

Inset, L-R: Hua Zhang, Sarah Tam, Craig Patterson, Tali Ilovitsh, Asaf Ilovitsh, Jai Seo; L-R: Xiran Cai, Josquin Foiret, Cheng Liu, Kathy Ferrara, Spencer Tumbale, Elizabeth Ingham, Gwansuk Kang (from the Hwang lab), Hamilton Kakwere, Brett Fite, Azadeh Kheirolomoom, Bo Wu

Ferrara Lab

Katherine Ferrara, PhD

https://ferraralab.stanford.edu/

Our overall objective is to bridge imaging with drug and gene delivery. Our work emphasizes ultrasound imaging and therapy, with additional expertise in PET tracer development and real-time MR imaging. Current activities include: 1) large arrays and 1024 channel real time ultrasound for combined imaging and therapy; 2) strategies for image-guided gene delivery spanning viral and non-viral techniques; 3) protocols for combining focal and immunotherapy based on molecular characterization of their impact; and 4) lipid and polymer nanoparticles for encapsulating drugs and nucleic acids. We apply these techniques in the treatment of cancer, and in neuroscience and regenerative medicine applications.

- Development of pulse sequences for ultrasound contrast agent and molecular imaging.
- Early work on the use of ultrasound radiation force to localize microbubbles and nanoparticles.
- Development of multi-frequency ultrasound arrays.
- Development of methods to radiolabel nanoparticles, dendrimers, and nucleic acids for PET.

L-R: Poorva Jain, Haley Cropper, Isaac Jackson, Michelle James, Katie Lucot, Aisling Chaney, Marc Stevens

Neuroimmune Imaging Research and Discovery Lab

Michelle James, PhD

https://med.stanford.edu/jameslab.html

Our lab focuses on designing and evaluating novel imaging agents to improve the way we diagnose, treat, and understand neurological diseases. Specifically, we are developing new PET radioligands for visualizing different aspects of neuroinflammation in the context of Alzheimer's disease, stroke, and multiple sclerosis. Our goal is to not only shed light on toxic immune responses in the aforementioned diseases, but also to guide therapeutic selection and monitoring for individual patients.

- Dr. James received the (1) 2019 Alavi-Mandell Award, SNMMI, (2) 2019 Basic Science Teacher of the Year Award, Stanford Radiology and (3) 2018 Exceptional Mentor Award, American Medical Women's Association.
- Marc Stevens, PhD won 1st Place in the 2019 Radiopharmaceutical Sciences Young Investigator Symposium, SNMMI.
- Aisling Chaney, PhD received the 2018 SNMMI-ERF Postdoctoral Molecular Imaging Scholar Program Fellowship.
- Received NIH/NINDS R21 grant in 2018, focused on the development of a highly specific PET imaging biomarker of toxic CNS-infiltrating myeloid cells and early treatment response in multiple sclerosis.

Front row L-R: David Huland, Seung-min Park, Edwin Chang, Corinne Beinat, Sanjiv Sam Gambhir, Hadas Frostig, Hui-Yen Chuang, Ivana Martinic, Riley Glick, Sindhuja Ramakrishnan, Brittany Goulart; 2nd row L-R: Mirwais Wardak, Winston Wang, Gayatri Gowrishankar, Aloma D'Souza, Nicole de Jesus, Lingyun Xu, Elise Robinson, Israt Alam, Richard Kimura, Carmel Chan; 3rd row L-R: Jung Ho Yu, Mohammad Namavari, Ataya Sathirachinda, Caroline Young, Maggie Wang, Aimen Zlitni, Hamed Arami, Stefan Harmsen, Amin Aalipour; 4th row: Michael Mandella, Chirag Patel, Tomomi Nobashi, Yuan Yang, Yun-Sheng Chen, Prachi Singh, Zunyu Xiao, Arutselvan Natarajan, Stephan Rogalla, Travis Shaffer; Back row L-R: Sharon Hori, Idan Steinberg, Sarah Hooper, Sebastiaan Joosten, Thomas Haywood, David Anders, Friso Achterberg; Not Pictured: Demir Akin, Weiyu Chen, Fadi El Rami, Moustafa Gabr, Brian Lee, Aaron Mayer, Surya Murty, Martin Schneider, Di Fan, Jeesu Kim, Chulhong Kim, Heekyung Kim, Razieh Khalifehzadeh, Saloni Shah, Daniel Chung

Multimodality Molecular Imaging Laboratory

Sanjiv Sam Gambhir, MD, PhD

https://med.stanford.edu/mips/research/mmil.html

Our lab develops novel technologies and strategies for the early detection of cancer. We believe that combining low-cost blood/urine/stool tests with state-of-the-art molecular imaging can lead to better prognostication. We develop novel strategies for imaging the immune system with PET and other technologies. Examples of some recent technologies include: (1) a new molecular imaging agent to image activated T-cells based on the OX40 cell surface target on T-cells; (2) imaging prostate cancer with a novel transrectal photoacoustic system; and (3) genetically re-engineering immune cells so that they become sensors of disease as they travel throughout your body (immunodiagnostics).

- Research article on immunodiagnostics published in Nature Biotechnology and on the cover of the journal in 2019.
- Research article on delivery of Raman nanoparticles into spontaneous brain tumors in dog models featured on the cover of ACS Nano in 2019.
- Recruitment of the 1,000th participant into Project Baseline for studying precision health.
- Completion of the first-in-human studies of a novel PET tracer that may be useful in detecting early cancer and monitoring interstitial pulmonary fibrosis; accepted into Nature Communications.
- Completion of the first-in-man studies of a novel, transrectal, photoacoustic instrument for imaging prostate cancer; published in Science Translational Medicine.

MOLECULAR IMAGING PROGRAM AT STANFORD

Front row L-R: Tatiana Norman-Brivet, Anna Ajero, Shivaani Kummar, Nam Bui, Alana Pague, Feriel Buchholz; Back row L-R: Jason Paik, Jee Min Lee, Erica Velasco, Nimna Ranatounga

Phase I Clinical Research Program

Shivaani Kummar, MD

https://med.stanford.edu/mips/research/pcrp.html

The Phase I Clinical Research Program specializes in the rapid completion of science driven trials tailored to make early, informed decisions about novel agents for further clinical investigation. Shivaani Kummar, MD, Director of the Program, and other co-investigators focus on designing and conducting pharmacokinetic and pharmacodynamic driven first-in-human trials, and integrating genomics and laboratory correlates into early phase trials.

- A number of early phase trials are currently open for patients with advanced solid tumors, including novel immunotherapies and agents targeting genetic aberrations in cancer.
- The Phase I Clinical Research Program is a member of the California Cancer Consortium (along with USC, City of Hope, and UC Davis Cancer Centers), and part of the National Cancer Institute's Experimental Therapeutics Clinical Trials Network (ETCTN).
- The Phase I Clinical Research Program has collaborative efforts with a number of laboratories on campus to translate their discoveries into the clinic.

Front row L-R: Craig Levin, Diana Jeong, Garry Chinn, Shirin Pourashraf; Middle row L-R: Emily Anaya, Lucas Watkins, Jonathan Fisher, Chen Ming Chang, Min Sun Lee, Derek Innes; Back row L-R: Mina Esmaeelpour, Li Tao, Andrew Groll, Qian Dong, Myungheon Chin, Andrea Gonzalez Montoro, Zhengzhi Liu

Molecular Imaging Instrumentation Lab

Craig Levin, PhD

http://med.stanford.edu/miil.html

The research interests of the molecular imaging instrumentation lab are to (1) create novel instrumentation and computational algorithms for quantitative in vivo imaging of cellular and molecular signatures of disease in living subjects; and (2) incorporate these innovations into practical imaging devices. The ultimate goal is to introduce these new quantitative imaging tools into studies of molecular mechanisms, and treatments of disease in the clinic, or in animal models of disease.

- Published 16 peer-reviewed research articles.
- Awarded four NIH R01 research grants (from NCI and NIBIB), since 2017, including Technologies to Drastically Boost Sensitivity of Brain-dedicated PET Systems, and Dual Modality X-ray Luminescence CT for In vivo Cancer Imaging.
- Awarded two Wallace H. Coulter Foundation Translational Grants to bring new instruments to the clinic for brain and head/neck imaging.
- Awarded a Women's Cancer Innovation Award from the Stanford Cancer Institute to perform breast cancer imaging with a novel 1-millimeter resolution clinical PET system built in the lab.
- Graduated five PhD students from the MIIL during the past year.

L-R: Maxim Moroz, Andreas Loening

Body MR Translational Research Lab

Andreas Loening, MD, PhD

https://med.stanford.edu/mips/research/all.html

The lab focuses on expanding the capability of MR as it relates to applications in body imaging. Clinical research aims include the application of new or improved MR sequences and reconstruction mechanisms to increase the speed, robustness, and diagnostic capability of body MR protocols. Translational research aims include exploring new MR contrast mechanisms, contrast agents, and contrast agent activation methods, for roles such as prostate cancer stratification and evaluation of lymphatic disorders.

- Clinical implementation of dual-agent relaxivity contrast MR lymphangiography protocols.
- Validation of complementary Poisson-disc sampling with compressed sense reconstruction to add robustness to clinical dynamic contrast-enhanced abdominal MRI examinations.
- Demonstrated clinical quality improvement by improving breath-hold techniques for contrast-enhanced abdominal MRI.
- Evaluated ultra-short echo time T1-weighted imaging to improve MR appendix protocols.
- Implementation of variable refocusing flip angles and outer volume suppression techniques into single-shot fast spin-echo imaging to increase speed, image quality, and robustness of body MRI protocols.

L-R: Arpit Dheeraj, Phuong Luong, Jun Kim, Angel Resendez, Sanjay V. Malhotra, Alexander Honkala, Mallesh Pandrala, Dhanir Tailor, Saloni Gupta

Small Molecule Design Lab

Sanjay Malhotra, PhD, FRSC

http://med.stanford.edu/mips/research/all.html

Our laboratory focuses on the design and discovery of synthetic and natural product-inspired small molecules, which can be used as probes to understand biological phenomena, including protein-protein interactions and modulation of signal transduction pathways. We employ the tools of synthetic and medicinal chemistry, molecular modeling, and chemical biology for translational research in drug discovery, development, imaging and radiation. Our current projects include design of new scaffolds/molecules as chemical tools to study various solid tumors, Alzheimer's disease, and markers for screening of hypoxic metabolically active cells.

- Developed a novel small molecule anti-cancer agent against paclitaxel-resistant cancer cells.
- Designed chemical probes to achieve the first structure of a signaling cannabinoid receptor 1-G protein complex.
- Developed a small molecule radiosensitizer of head and neck squamous cell carcinoma (HNSCC).
- Developed a prototype fluorescent saccharide sensor for detection of gastrointestinal cancer.

MOLECULAR IMAGING PROGRAM AT STANFORD

L-R: Sung Bae Kim, Rayhaneh Afjei, Tarik F Massoud, Ramasamy Paulmurugan, Sukumar Uday Kumar

Lab of Experimental and Molecular Neuroimaging

Tarik Massoud, MD, PhD

https://med.stanford.edu/mips/research/lemni.html

Our lab focuses on molecular imaging of the brain, especially in neuro-oncology. We use novel experimental and preclinical translational imaging in theranostic applications against glioblastoma. This includes *in vivo* multimodality imaging of gene expression using reporter assays, and cellular and nano-imaging. Other interests include animal modeling of gliomas, studying the p53 transcriptional network, imaging protein folding and misfolding in cancer, and development of novel nanoparticle-based drug and microRNA formulations for ultra-targeted therapeutic anti-cancer strategy applications.

- Development of a novel molecular biosensor based on split reporter gene technology to image p53 protein folding in cancer, for use in the discovery of new anti-misfolding drugs.
- Development of novel strategies to package therapeutic microRNAs in colloidal and metal nanoparticles delivered to glioblastomas.
- Development of novel approaches for combined microRNA and drug therapies to treat and image glioblastomas via novel routes, e.g., intranasally.
- Research article on targeted nanoparticle delivery of therapeutic antisense microRNAs presensitizing glioblastoma cells to lower effective doses of temozolomide *in vitro* and in a mouse model, featured on the cover of Oncotarget in 2018.

L-R: Koen Nieman, Ayman Jubran, Sujana Balla, Vera Wang

Clinical Application of Advanced Cardiac Imaging

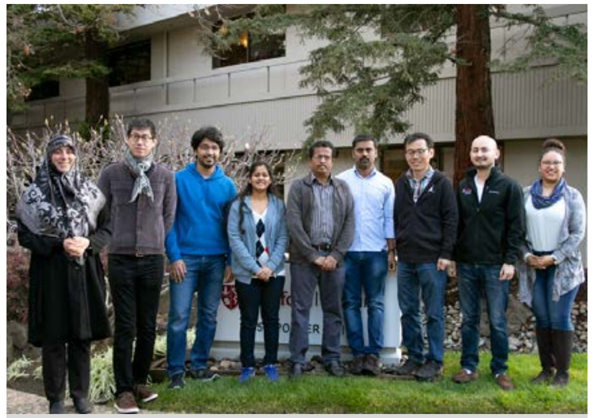
Koen Nieman, MD, PhD

https://med.stanford.edu/mips/research/all.html

The objective of Dr. Nieman's research is the development and clinical validation of new cardiac imaging techniques and diagnostic pathways to improve the management of patients with cardiovascular disease. Ongoing research focuses on the clinical effectiveness of cardiac CT in patients with stable and acute chest pain through randomized trials, CT myocardial perfusion imaging, CTA-derived fractional flow reserve, and atrial mapping.

- In 2017 and 2018, performed the first CT myocardial perfusion scans at Emeryville and the VAPAHCS (both Stanford facilities).
- Completion of the international multicenter SPECIFIC trial to validate dynamic CT myocardial perfusion imaging, in 2019.
- Clinical implementation of CTA-based fractional flow reserve at Stanford; completion of the multicenter ADVANCE registry on the clinical impact of CT-FFR in clinical practice; and started participation in the multicenter PRECISE trial, a randomized trial between CTA with CT-FFR and standard diagnostic testing for patients with stable chest pain.
- NIH R01 grant awarded in 2019 to investigate the use of cardiac CT for guidance of coronary artery bypass graft surgery.

MOLECULAR IMAGING PROGRAM AT STANFORD



L-R: Rayhaneh Afjei, Huaijun Wang, Uday Kumar Sukumar, Vrinda Kulshreshtha, Ramasamy Paulmurugan, JC Bose Rajendran, Sung Bae Kim, Rakesh Bam, Jessica E. Zuniga

Cellular Pathway Imaging Lab

Ramasamy Paulmurugan, PhD

https://med.stanford.edu/mips/research/cpil.html

Our lab mainly focuses on reprogramming cancer cells to improve their response to chemotherapy and overcome drug resistance. We target endogenous microRNAs which are dysregulated in cancers, to achieve this property. We use this strategy for treating drug-resistant breast cancer, glioblastoma and hepatocellular carcinoma. We adopted ultrasound-microbubble mediated targeted delivery of selective microRNAs using cell derived vesicles and PLGA-PEG nanoparticles as nanocarriers for achieving our goal. We are also working on patterning epigenetic methylations in histone proteins, isolated from circulating exosomes, as a blood-based biomarker for early detection of cancers.

- Developing multiplex-imaging assays to quantify methylations to various lysine marks of histone proteins.
- Patterning epigenetic methylations in histone proteins isolated from circulating exosomes as a biomarker for cancer early detection.
- Developing FDA approved polymer nanoparticles, and cell-derived membranes isolated from cancer cells and stem cells to improve cancer chemotherapy.
- Studying the chemotherapy induced stemness of cancer cells for targeting Wnt/β-catenin, NFkB-Nrf2, and p53 signaling to improve cancer chemotherapy without metastasis.

L-R: Antonio Benayas, Jinghang Xie, Ke Jiang, Jianghong Rao, Guosheng Song, Ting Ting Dai, Yunfeng Jerry Cheng, Xianchuang Zheng, Xue Wu, Liyang Sarah Cui, Aiguo Song, Zixin Laura Chen, Min Chen, Susan Singh

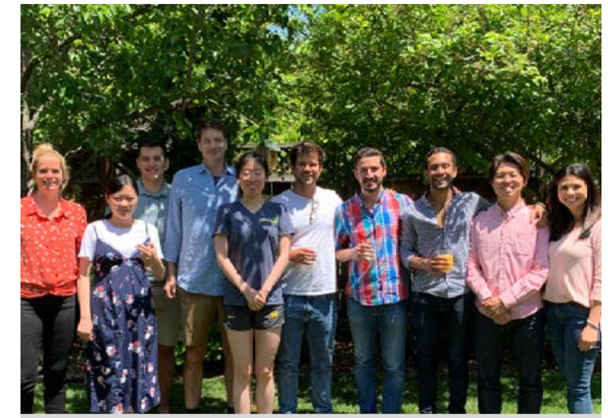
Chemical Biology and Nanomedicine Lab

Jianghong Rao, PhD

https://med.stanford.edu/raolab.html

Our lab designs, synthesizes and evaluates novel molecular probes, smart biosensors, and new strategies for early biomarker detection and targeted biomolecule manipulation. We aim to apply molecular imaging techniques to investigate biological systems for better understanding of the fundamental biology and for improved therapeutic interventions. We are developing tools to image the tumor microenvironment and characterize immune activation after cancer immunotherapy and radiotherapy. We are also working towards the first-in-human clinical trial using our Target-Enabled *in Situ* Ligand Assembly platform for early evaluation of treatment outcome.

- Developed new lactam-trehalose probe for in-macrophage mycobacteria detection, and copper depleting nanomedicine for metabolic switch of breast cancer.
- Dr. Rao elected to the AIMBE College of Fellows (2018).
- Invention disclosure filed by J. Rao, Y. Cheng, M. Chen. Stanford Docket No. S17-356. Caspase-3-Triggered Molecular Self-Assembling PET Probes and Uses Thereof. U.S. Provisional patent application serial number 62/559243.
- First-in-human clinical trial using Caspase-3-Triggered Molecular Self-Assembling PET Probes received FDA approval for human trial (2019).



L-R: Nynke van den Berg, Guolan Lu, Zach Hart, Eben Rosenthal, Quan Zhou, Stan van Keulen, Shayan Fakurnejad, Giri Krishnan, Naoki Nishio, and Heather Restificar. Not pictured: Stefania Chirita, Roan Raymundo, Grace Yi, Crista Horton and Myrthe Engelen

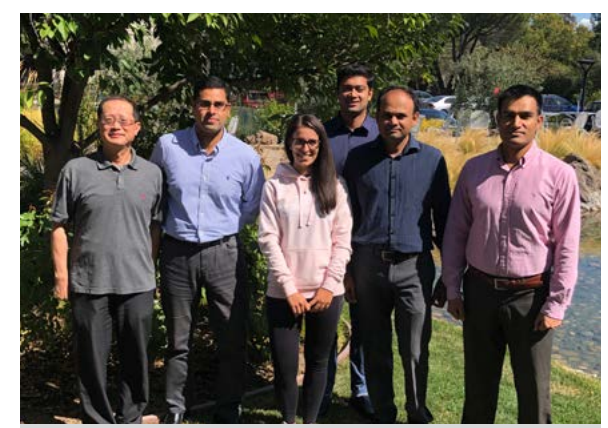
Translation Cancer Imaging Lab

Eben Rosenthal, PhD

https://med.stanford.edu/ohns/research/labs/eben-rosenthal-lab.html

Our lab focuses on the development and clinical translation of novel imaging probes and multimodal imaging strategies to improve cancer detection and treatment. Our research has focused on phase I-II clinical trials evaluating near-infrared and radiolabeled antibodies for surgical and pathological navigation during surgeries of head and neck, brain, lung and pancreatic cancer. We are also studying the role of optical imaging in quantification of antibody delivery to tissue and distribution in the tissue as well as developing non-invasive imaging biomarkers to identify patients amendable to targeted therapy.

- One first-in-human trial to investigate the role of dual-modality imaging in humans (panitumumab-IRDye800 and 89Zr-panitumumab) for the detection of head and neck cancer.
- New NIH R01 grant: *Phase I-II Study of Ad/PNP for head and neck cancer* (Orphan Drug Des, 14-4438).
- Guolan Lu, PhD (Postdoctoral Fellow) received a SMIS-T32 program fellowship (2018-2021).
- Nynke van den Berg, PhD (Postdoctoral Fellow) received a Rubicon Fellowship (NWO-STW).



L-R: Jing Wang, Avnesh Thakor, Rosita Primavera, Ganesh Swaminathan, Bhavesh Kevadiya, Mujib Ullah

Interventional Regenerative Medicine and Imaging Lab

Avnesh Thakor, MD, PhD

https://med.stanford.edu/thakorlab.html

The Thakor Lab investigates minimally invasive ways to deliver cellular therapy for organ regeneration. We focus on the use, optimization, and characterization of mesenchymal stem cells (MSCs) in different animal models. We also use non-invasive technologies like focused ultrasound for MSC homing, permeation and retention. In addition, we are investigating and developing novel nanoplatforms and biomaterials to support pancreatic islets, either in isolation or in combination with MSCs.

- Research article, Adipose tissue-derived mesenchymal stem cells rescue the function of islets transplanted in sub-therapeutic numbers via their angiogenic properties, published in Cell and Tissue Research in 2019.
- Research article, Mesenchymal stem cells confer chemoresistance in breast cancer via a CD9 dependent mechanism, published in Oncotarget in 2019.
- Research article, An oxygen plasma treated poly(dimethylsiloxane) bioscaffold coated with polydopamine for stem cell therapy, published in Journal of Materials Science-Materials in Medicine in 2018.

Back row L-R: Evangeline Tzatzalos, Praveen Shukla, Jared Churko, Kazuki Kodo, Ioannis Karakikes, Arun Sharma, Won Hee Lee, Jaecheol Lee, Raman Nelakanti, Tor Termglinchan, Timon Seeger, Yingxin Li; Middle row L-R: Kolsoum InanlooRahatloo, Haodong Chen, Hyoju Yi, Youngkyun Kim, Mintao Zhao, Ning-Yi Shao, Ian Chen, Johannes Riegler, Sang-Ging Ong, Haodi Wu, Mohamed Ameen; Front row L-R: Adriana Bozzi, Elena Matsa, Rinkal Chaudhary, Chunli Zhao, Yan Zhuge, Nigel Kooreman, Joseph Wu, Priyanka Garg, Justin Vincent, Paul Burridge, Loan Nguyen, Alexandra Holmstroem, Lu Cui, Yu Ma, Ying Zhang, Dan Xiao.

Cardiovascular Stem Cell Lab

Jospeh Wu, MD, PhD

https://med.stanford.edu/wulab.html

Our lab studies the biological mechanisms of adult stem cells, embryonic stem cells, and induced pluripotent stem cells. We use a combination of technologies to better understand stem cell biology in vitro and in vivo. For adult stem cells, we are interested in monitoring stem cell survival, proliferation, and differentiation. For embryonic stem cells, we study their tumorigenicity, immunogenicity, and differentiation. For induced pluripotent stem cells, we are interested in cardiovascular disease modeling, drug screening, and cell therapy. We also develop novel vectors and therapeutic genes for cardiovascular gene therapy applications.

- Elucidated mechanism of lamin cardiomyopathy using iPSCs (Nature).
- Developed a tool to isolate specific subpopulations of cardiovascular cells to provide a model for more precise drug testing (Cell Stem Cell).
- Used iPSC-cardiomyocytes to model diastolic dysfunction (European Heart Journal).
- Performed research to increase understanding of metabolism and maturation of iPSC cardiomyocytes (Circulation Research).

MIPS SELECTED FUNDING:

Stanford Molecular Imaging Scholars (SMIS). NIH/NCI T32 CA118681 (Levin)

Technologies to drastically boost photon sensitivity for brain-dedicated PET. NIH/NIBIB R01 EB025125 (Levin)

Cross-Species Multi-Modal Neuroimaging to Investigate GABA Physiology in Fragile X Syndrome. NIH/NICHD R01 HD084214 (Chin)

Beta-lactamase fluorescent probes for bacterial detection. NIH/NIAID R01 AI125286 (Rao)

Cancer-Translational Nanotechnology Training Program (Cancer-TNT). NIH/NCI T32 CA196585 (Rao/Felsher)

Insonation of ultrasound microbubbles at low frequency to enhance image-guided therapy. NIH/NCI R01 CA112356 (Ferrara)

Optimized ultrasound-enhanced immunotherapy. NIH/NCI R01 CA199658 (Ferrara)

An 18F PET/NIRF Smart Probe for Identifying, Grading, and Visualizing Astrocytic Gliomas. NIH/NCI F32 CA213620 (Hettie)

Tracking the invaders in multiple sclerosis: Highly specific TREM1-targeted PET imaging of toxic infiltrating myeloid cells and early treatment response. NIH/NINDS 5R21 NS109783 (James)

Levitating Rare Biological Materials to Decode the Fundamentals. Burroughs Wellcome Fund (Durmus)

MOLECULAR IMAGING PROGRAM AT STANFORD

Therapeutic miRNA Modulation of Hepatocellular Carcinoma Using Ultrasound Guided Drug Delivery. NIH/NCI R01 CA209888 (Paulmurugan)

A Novel Positron Emission Tomography Strategy for Early Detection and Treatment Monitoring of Graft-versus-host Disease. NIH/NCI R01 CA201719 (Gambhir)

Center for Cancer Nanotechnology Excellence for Translational Diagnostics. (CCNE-TD) NIH/NCI U54 CA199075 (Gambhir)

Nanoparticle-based Triple Modality Imaging and Photothermal Therapy of Brain Tumors. NIH 5R01CA19965604 (Gambhir)

Changes in [18F]DASA-23 PET uptake, a measure of pyruvate kinase M2, from pre- to post-therapy in recurrent glioblastoma: effects on survival. Stanford ChEM-H (Gambhir)

A New Strategy to Image Tumor Metabolism in GBM Patients to Help Optimize Anti-Tumor Therapies. The Ben & Catherine Ivy Foundation (Gambhir)

A Modeling-Based Personalized Screening Strategy Combining Circulating Biomarker and Imaging Data for Breast Cancer Early Detection. United States Army Medical Research Acquisition Activity (USAMRAA) W81XWH1810342 (Hori)

MIPS SELECTED PUBLICATIONS:

Aalipour A, Chuang HY, Murty S, D'Souza AL, Park SM, Gulati GS, Patel CB, Beinat C, Simonetta F, Martinić I, Gowrishankar G, Robinson ER, Aalipour E, Zhian Z, Gambhir SS. Engineered Immune Cells as Highly Sensitive Cancer Diagnostics. *Nature Biotechnology*, 2019 May; 37(5):531–539.

Aghighi M, Theruvath AJ, Pareek A, Pisani LL, Alford R, Muehe AM, Sethi TK, Holdsworth SJ, Hazard FK, Gratzinger D, Luna-Fineman S, Advani R, Spunt SL, Daldrup-Link HE. Magnetic Resonance Imaging of Tumor-Associated Macrophages: Clinical Translation. *Clinical Cancer Research*, 2018 Sept; 24(17):4110-4118. PMCID: PMC6125171.

Cheng Y, Xie J, Lee KH, Gaur RL, Song A, Dai T, Ren H, Wu J, Sun Z, Banaei N, Akin D, Rao J. Rapid and Specific Labeling of Single Live Mycobacterium Tuberculosis with a Dual-Targeting Fluorogenic Probe. *Science Translational Medicine*, 2018 Aug; 10(454):eaar4470. PMCID: PMC6314683.

Vermesh O, Aalipour A, Ge TJ, Saenz Y, Guo Y, Alam IS, Park SM, Adelson CN, Mitsutake Y, Vilches-Moure J, Godoy E, Bachmann MH, Ooi CC, Lyons JK, Mueller K, Arami H, Green A, Solomon EI, Wang SX, Gambhir SS. An Intravascular Magnetic Wire for the High-Throughput Retrieval of Circulating Tumour Cells in Vivo. *Nature Biomedical Engineering*, 2018 Sep; 2(9):696-705. PMCID: PMC6261517.

Sagiv-Barfi I, Czerwinski DK, Levy S, Alam IS, Mayer AT, Gambhir SS, Levy R. Eradication of Spontaneous Malignancy by Local Immunotherapy. *Science Translational Medicine*, 2018 Jan; 10(426):eaan4488. PMCID: PMC5997264.

Shou K, Tang Y, Chen H, Chen S, Zhang L, Zhang A, Fan Q, Yu A, Cheng Z. Diketopyrrolopyrrole-Based Semiconducting Polymer Nanoparticles for In Vivo Second Near-Infrared Window Imaging and Image-Guided Tumor Surgery. *Chemical Science*, 2018 Feb; 9(12):3105-3110. PMCID: PMC5914543.

DIVISION LEADERSHIP

Sanjiv Sam Gambhir, MD, PhD

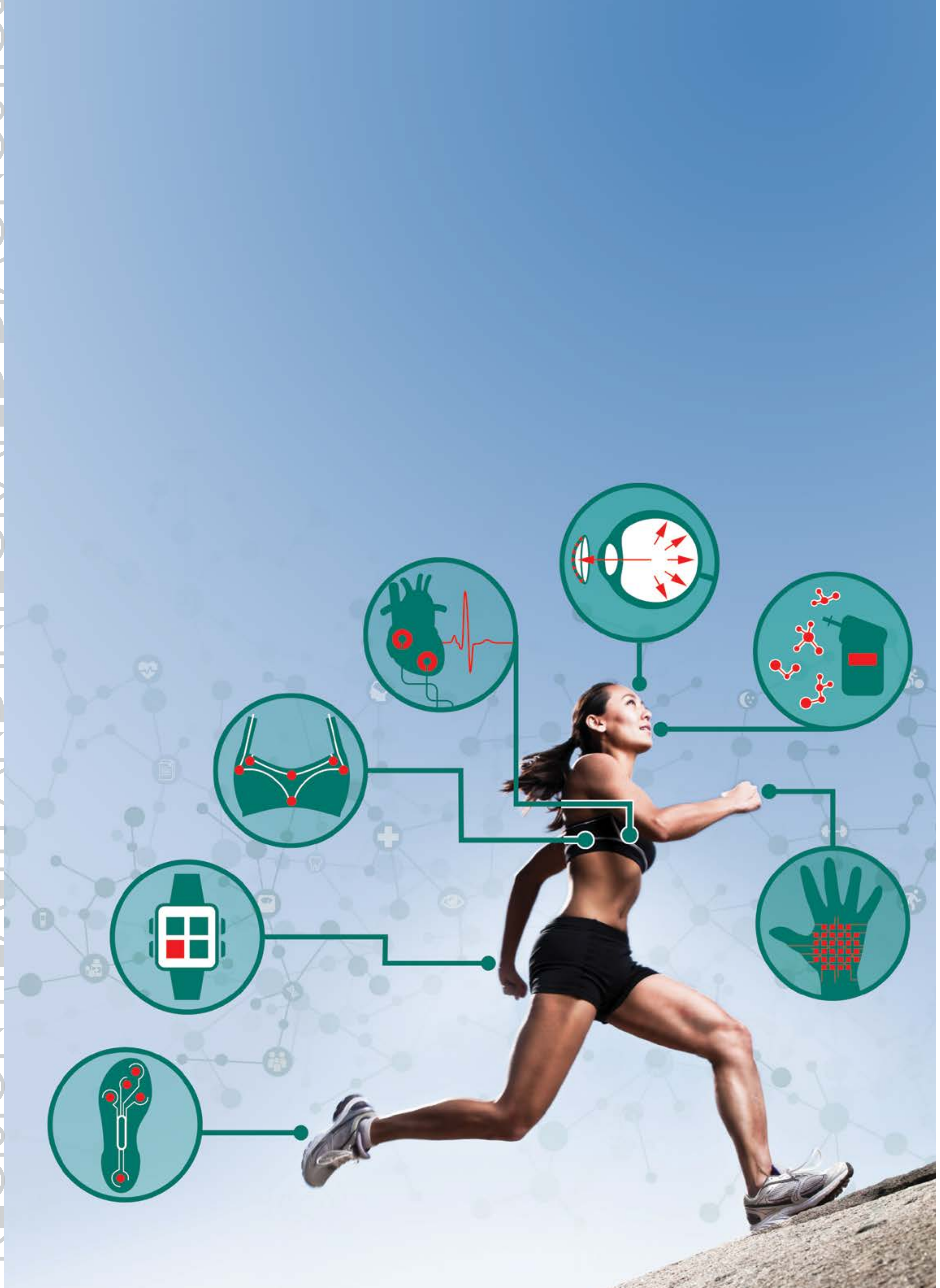
Ryan Spitler, PhD

DIVISION FACULTY

Pablo Paredes, PhD

Sindy Tang, PhD

PRECISION HEALTH AND INTEGRATED DIAGNOSTICS



A selection of wearable and implantable devices is shown to demonstrate the variety of physiological and molecular parameters that can be measured using these devices.

Precision Health and Integrated Diagnostics (PHIND) Center at Stanford

The Precision Health and Integrated Diagnostics (PHIND) Center is the first center in the world focused on precision health and integrated diagnostics. Whereas precision medicine is focused on the treatment after the manifestation of disease, precision health is focused on early prediction and prevention of disease onset. The goal of the PHIND Center is to advance this new vision of healthcare, and spans the following healthcare research topics: wearable/implantable technologies, data analytics and computational tools including clinical decision making, (molecular) imaging strategies, cancer models, and fundamental studies on the biology of disease formation, biomarker research, and health economics. This center is developing, testing, and disseminating the next generation of healthcare mechanisms for precision health, with a focus on the detection of disease at its earliest, most curable stage. Stanford has a significant opportunity to lead the world in this bold new direction.

The PHIND Center envisions revolutionizing healthcare leading to healthier and more productive lives for individuals by integrating several key areas including:

- Risk analytics to predict risk of specific disease(s) for a given individual.
- Fundamental studies of the biology of disease initiation/progression to understand the earliest transitions from healthy humans, organs, and cells to the disease state.
- Biomarker research to study the molecules that indicate healthy states and early signs of disease.
- Diagnostic technology and information to accurately monitor and detect health changes early, such as collecting and analyzing information from multiple sources on the body and in the home, office, or wider community.
- Health economic analyses for precision health strategies to show savings to the health care system for pursuing various precision health efforts.

med.stanford.edu/phind

PHIND

The PHIND Center is unique within the Department of Radiology in that it comprises Associate faculty members from across multiple schools and departments at Stanford. To realize the promise of precision health, the center provides two mechanisms of seed funding opportunities which include the formation of "Dream Teams" that bring together researchers from various disciplines to form synergistic teams, and also individual seed grants providing pilot funding for individual Stanford investigators. Collectively, the PHIND seed program is making significant advances on three fronts: (1) data analytics for risk assessment, (2) identifying biomarkers for the transition from health to disease, and (3) developing wearable monitoring devices. Members of these teams include Stanford faculty and trainees who will benefit from a highly multidisciplinary experience, and who will become well equipped to establish independent, multidisciplinary research programs. Each of these projects serve to grow the existing PHIND program in exciting new areas.

PHIND by the Numbers

34	94	48	10
Seed Projects	Associate Faculty Members	Departments Across Campus	New Stanford Faculty Hires to Come

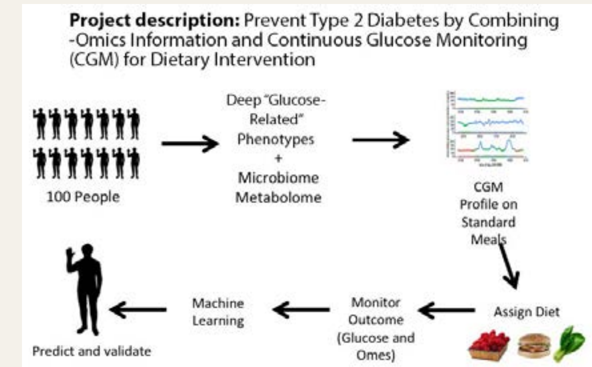
Pervasive Wellbeing Technology Lab

Pablo Paredes, PhD

Pablo Paredes, PhD, PHIND Instructor, is taking on the challenge of engineering precision health approaches in mundane environments by leveraging concepts from affective and embedded computing, behavioral economics, and human-centered design. His group is developing digital technologies and interventions (i.e., chat bots, subliminal cues, and gentle physical/digital nudges) for the places we frequent the most—the office, car, and home. His technology tracks, among other parameters, different combinations of breathing rate, heart rate, and cortisol levels to gauge how well the interventions dampen stress and promote mental health upkeep. Some of his flagship projects on stress management include repurposing existing devices into "sensorless" stress sensors, and minimal transformation of car and office furniture to regulate breathing. His group is working on engineering precision health approaches where affordable design and machine learning can drive long-term behavior change.

PRECISION HEALTH AND INTEGRATED DIAGNOSTICS

2017–2018 DREAM TEAM AWARDS

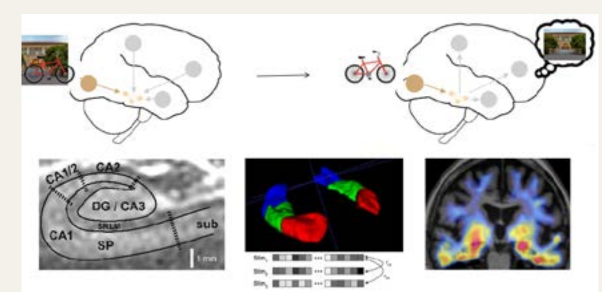


Precision Diets for Diabetes Prevention

The aim of this project was to prevent Type 2 Diabetes by combining -omics information and continuous glucose monitoring (CGM) for dietary intervention. The approach includes: (1) -omics strategies to identify early stages of disease and to categorize different subsets of prediabetes that may benefit from different treatments; and (2) use of wearable CGM technology, for early diagnostics via capture of glucose concentrations every five minutes throughout the day. The latter opens the door to not only novel and improved capacity to see responses to diet previously unavailable to scientists, but also to linking these to -omics biomarkers that have yet to be properly harnessed and utilized for prevention of diabetes.

PROJECT LEADERS:

Michael Snyder, PhD, Professor, Genetics
Tracey McLaughlin, MD, MS, Associate Professor, Medicine
Justin Sonnenberg, PhD, Associate Professor, Microbiology
Manisha Desai, PhD, Professor, Medicine
Christopher Gardner, PhD, Professor, Medicine



Predicting Healthy vs. Pathological Aging: Multimodal Biomarkers of Age-Related Memory Change and Risk for Alzheimer's Disease

The Predicting Health in Aging (PHIA) project addressed two major health goals: (1) to use multimodal neuroimaging for longitudinal monitoring of focal age-related brain changes, and (2) to establish patterns of changes that are highly predictive of pathological aging and risk of future clinical impairment. The study leveraged a deeply characterized cohort of 200 healthy older individuals from whom baseline measures were collected of brain structure, brain function, genetics, and cerebral spinal fluid (CSF) biomarkers of risk for Alzheimer's Disease.

PROJECT LEADERS:

Anthony Wagner, PhD, Professor, Psychology
Elizabeth Mormino, PhD, Assistant Professor, Neurology & Neurological Science
Brian Rutt, PhD, Professor, Radiology
Carolyn Fredericks, MD, Clinical Assistant Professor, Neurology & Neurological Science
Jennifer McNab, PhD, Assistant Professor, Radiology
Frederick T. Chin, PhD, Assistant Professor, Radiology

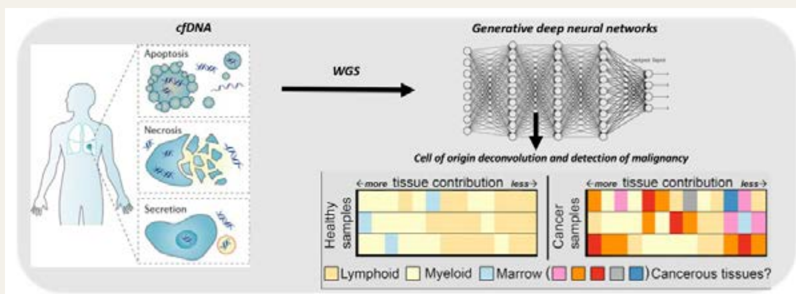
PRECISION HEALTH AND INTEGRATED DIAGNOSTICS

Enabling Early Cancer Detection with Lower Costs and Improved Sensitivity from Noninvasive Genome-wide Liquid Biopsy Tests through Novel Deep Learning Analytics and Improved Chemistry

The goal of this project was to develop a novel circulating free DNA (cfDNA) sequencing technology and deep learning analytical framework that achieves state-of-the-art accuracy in distinguishing normal versus pathological states and tissue-of-origin from clinical samples.

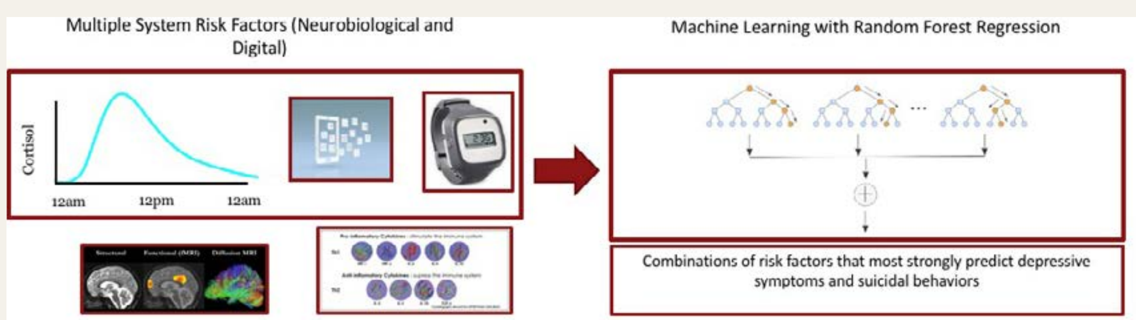
PROJECT LEADERS:

Christina Curtis, PhD, MSc, MS, Assistant Professor, Oncology & Genetics
Anshul Kundaje, PhD, Assistant Professor, Computer Science & Genetics
Allison Kurian, MD, Associate Professor, Oncology & Health Research and Policy
George Sledge, MD, Professor, Oncology
Irene Wapnir, MD, Professor, Surgery
Robert West, MD, PhD, Professor, Pathology



Multidimensional Predictors of Major Depressive Disorder and Suicidal Behaviors in High-Risk Adolescents

This longitudinal study aimed to leverage a well-characterized sample of healthy adolescents who experienced early life stress in order to integrate multisystem neurobiological and digital phenotypes (real-time measures of effect and social behavior obtained with a mobile app). Machine learning algorithms will be used to identify risk factors and mechanistic targets involved in the onset of depression and engagement in suicidal behaviors.



PROJECT LEADERS:

Ian H. Gotlib, PhD, Professor, Psychology
Holden Maecker, PhD, Professor, Microbiology & Immunology
Rachel Manber, PhD, Professor, Psychiatry & Behavioral Sciences
Trevor Hastie, PhD, Professor, Statistics
Dennis Wall, PhD, Associate Professor, Pediatrics

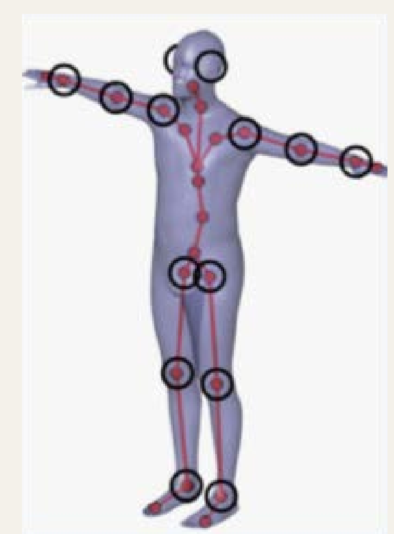
2018–2020 DREAM TEAM AWARDS

Wearable Wireless Sleep Monitoring System for Precision Health

This project aims at developing a miniaturized, skin-friendly sleep monitoring system where small wireless patches will be distributed on a few locations on a body to fully monitor sleep conditions. These patches will record electroencephalography, respiration, and body actigraphy. The goal is to create a wearable, wireless, nonintrusive, and minimalist at-home sleep monitoring system with associated analytics that can monitor and detect changes in sleep pattern with accuracy on par with or better than the complex and bulky clinical polysomnography (PSG) system currently in use.

PROJECT LEADERS:

Ada Poon, PhD, Associate Professor, Electrical Engineering
Zhenan Bao, PhD, Professor, Chemical Engineering
Emmanuel Mignot, MD, PhD, Professor, Psychiatry and Behavioral Sciences

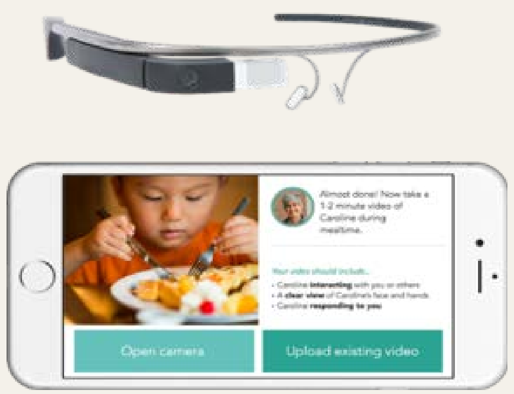


Assessment of Early Knee Osteoarthritis Using a Low-Cost, Rapid, and Multimodal Imaging and Biomechanics Approach

The team is developing a true 5-minute bilateral knee MRI measurement method for generating quantitative and semi-quantitative biomarkers for osteoarthritis. This method is coupled with deep learning approaches to provide fully-automated quantitative analysis, particularly looking at between-knee asymmetries. The goal of the study is to establish a pipeline for imaging acquisition and analysis in a rapid and low-cost manner, to combine with mobile gait measurement. Subjects exhibiting symptoms of osteoarthritis will be studied in order to identify potential responders to early interventions with the goal of reducing symptoms and the likelihood of progression.

PROJECT LEADERS:

Brian Hargreaves, PhD, Professor, Radiology
Scott Delp, PhD, Professor, Bioengineering, and Mechanical Engineering, and, by courtesy, Orthopaedic Surgery
Garry Gold, MD, Professor, Radiology
Akshay Chaudhari, PhD, Postdoctoral Research Fellow, Radiology



Detection and Prevention of Autism Through Wearable Artificial Intelligence and Multimodal Data Integration

This project aims to create a mobile-AI core for autism care. This is accomplished by (1) building an app to screen for autism via home videos, (2) developing AI that can track features of autism through videos reliably, and (3) testing the potential of our Google Glass system to act as a mobile therapeutic intervention. The team is collecting data (video, behavioral questionnaires, genomic, and microbiome data) from 100 family participants, and using a cloud-based computing environment to analyze results from this population in need of care.

PROJECT LEADERS:

Dennis Wall, PhD, Associate Professor, Biomedical Data Science, and Pediatrics
James Landay, PhD, Professor, Computer Science
Trevor Hastie, PhD, Professor, Statistics
Thomas Robinson, MD, MPH, Professor, Pediatrics
Pablo Paredes, PhD, Instructor, Radiology
Michael Snyder, PhD, Professor, Genetics

INDUSTRY AFFILIATE PROGRAM

The PHIND & Canary Center Industry Affiliate Program combines precision health and early cancer detection approaches. While the PHIND center studies the transition from health to disease in broad terms, the Canary Center focuses on the early detection of cancer, with both centers capitalizing on the substantial initiative-driven synergies between them. It is the first program of its kind at Stanford to combine the efforts of two centers. The program provides the opportunity for corporate collaboration, strengthening the academic-industrial relationship and enhancing research and education in precision health. Companies have the opportunity to actively participate in groundbreaking science and technology development through working with faculty and students in specific areas of interest. Additional information is available at https://med.stanford.edu/phind/industry-affiliates.html.

PRECISION HEALTH AND INTEGRATED DIAGNOSTICS

PHIND SELECTED FUNDING:

Automated Detection of Cerebral Ischemia to Reduce Disability and Mortality. Coulter Foundation (Yock)

A Decision-Analytic Framework for Economic Evaluation of Current Precision Health Approaches and Prioritization of their Future Research and Development. NIH Supplement R01 CA 221870 02 (Goldhaber-Fiebert/Phillips)

Biomarkers and Biological Processes Associated with Future Cancer Development and Exposure to Food-Based Carcinogens. NIH/NCI 1 R21 CA 238971 01 (Gentles)

PHIND SELECTED PUBLICATIONS:

Gambhir SS, Ge TJ, Vermesh O, Spitler R. Toward achieving precision health. *Sci Transl Med*, 2018 Feb 28;10(430). pii: eaao3612. doi: 10.1126/scitranslmed.aao3612. Review.

Fitzpatrick MB, Thakor AS. Advances in Precision Health and Emerging Diagnostics for Women. *Journal of Clinical Medicine*, 2019 Sept 23; 8(10):1525.

Chaudhari AS, Stevens KJ, Wood JP, Chakraborty AK, Gibbons EK, Fang Z, Desai AD, Lee JH, Gold GE, Hargreaves BA. Utility of Deep Learning Super-Resolution in the Context of Osteoarthritis MRI Biomarkers. *Journal of Magnetic Resonance Imaging*, 2019 Jul 16; doi: 10.1002/jmri.26872.

Voss C, Schwartz J, Daniels J, Kline A, Haber N, Washington P, Tariq Q, Robinson TN, Desai M, Phillips JM, Feinstein C, Winograd T, Wall DP. Effect of Wearable Digital Intervention for Improving Socialization in Children with Autism Spectrum Disorder: A Randomized Clinical Trial. *JAMA Pediatrics*, 2019 May 1; 173(5):446-454. PMCID: PMC6503634.

Kasman AM, Li S, Luke B, Sutcliffe AG, Pacey AA, Eisenberg ML. Male Infertility and Future Cardiometabolic Health: Does the Association Vary by Sociodemographic Factors? *Urology*, 2019 Aug 1; pii: S0090-4295(19)30697-1.

Ata R, Gandhi N, Rasmussen H, El-Gabalawy O, Gutierrez S, Ahmad A, Suresh S, Ravi R, Rothenberg K, Aalami O. Clinical Validation of Smartphone-Based Activity Tracking in Peripheral Artery Disease Patients. *NPJ Digital Medicine*, 2018 Dec 11; 1(66). doi: 10.1038/s41746-018-0073-x. PMCID: PMC6550212.

Hall H, Perelman D, Breschi A, Limcaoco P, Kellogg R, McLaughlin T, Snyder M. Glucotypes Reveal New Patterns of Glucose Dysregulation. *PLoS Biology*, 2018 Jul 24; 16(7):e2005143. PMCID: PMC6057684.

Manczak EM, Miller JG, Gotlib IH. Water Contaminant Levels Interact with Parenting Environment to Predict Development of Depressive Symptoms in Adolescents. *Developmental Science*, 2019 Apr 22; e12838.

RADIOLOGICAL SCIENCES LABORATORY

DIVISION LEADERSHIP

Kim Butts Pauly, PhD

Carl Herickhoff, PhD

DIVISION FACULTY

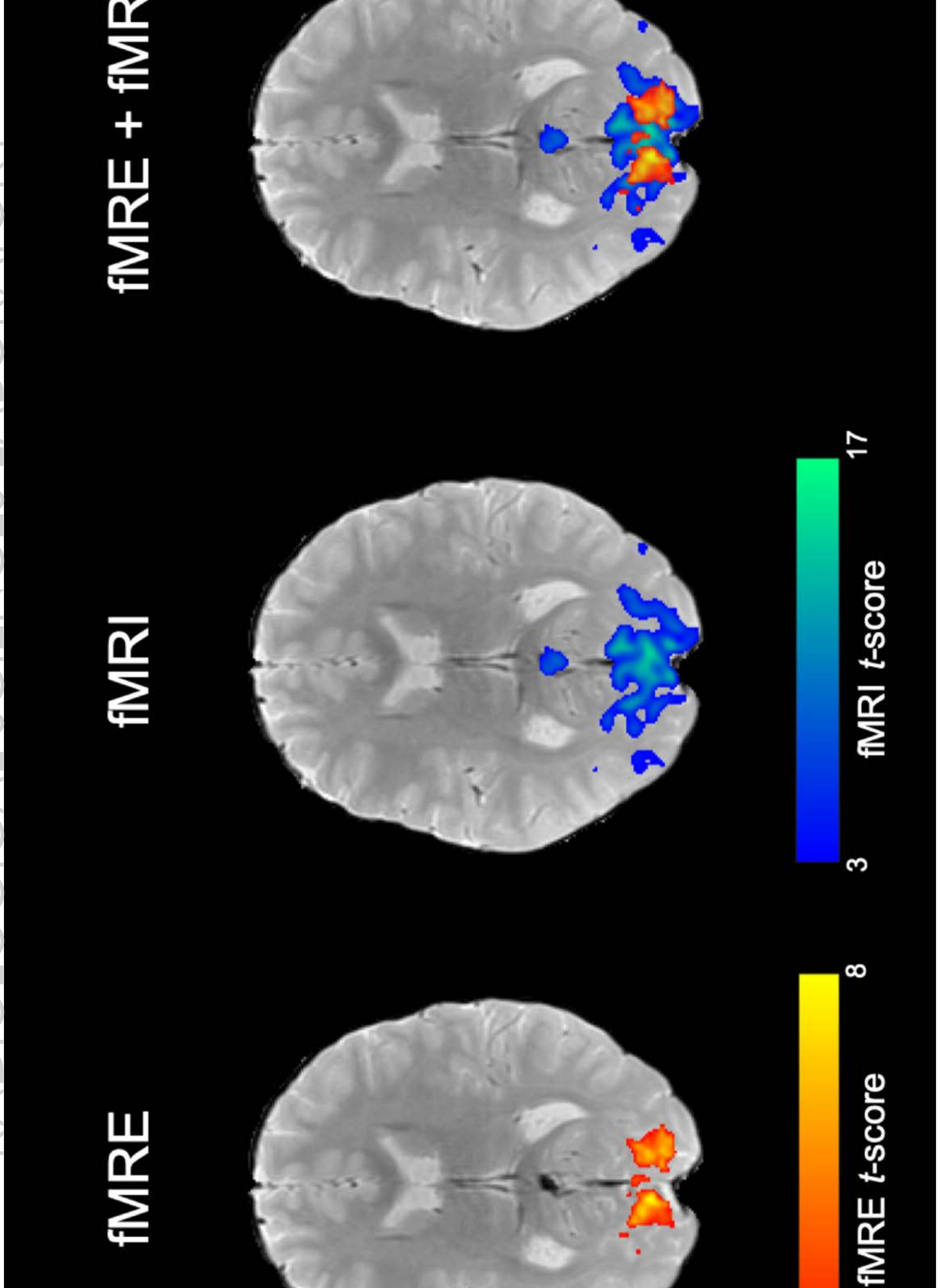
Jeremy Dahl, PhD
Daniel Ennis, PhD
Gary Glover, PhD
Garry Gold, MD
Brian Hargreaves, PhD
Feliks Kogan, PhD
Jennifer McNab, PhD
Michael Moseley, PhD
Norbert Pelc, ScD
Brian Rutt, PhD
Daniel Spielman, PhD
Adam Wang, PhD
Gregory Zaharchuk, MD, PhD

8

AIMBE Fellows*
RSL

Gary Glover, PhD
Garry Gold, MD
Brian Hargreaves, PhD
Kim Butts Pauly, PhD
Norbert Pelc, ScD
Brian Rutt, PhD
Daniel Spielman, PhD
Gregory Zaharchuk, MD, PhD

*cumulative



Functional magnetic resonance elastography (fMRE) is emerging as a new tool for studying viscoelastic, or stiffness, changes in the brain due to functional processes. Our novel simultaneous fMRI-fMRE method allows us to probe brain function using both conventional functional MR and viscoelastic contrast. The above figure depicts fMRE activation (orange-yellow), fMRI activation (blue-green), and both fMRE and fMRI activation maps overlaid resulting from a visual task (adapted from P.S. Lan, et al., Neuroimage, under review, Glover Lab).

Radiological Sciences Laboratory (RSL)

The Radiological Sciences Laboratory division presently comprises 22 faculty and approximately 60 graduate and postdoctoral trainees, research staff, and others devoted to advancing imaging technology for diagnostic, basic science, and therapeutic applications within the department and in collaborations across campus and beyond. Our research foci include the imaging modalities of MRI, X-ray/CT, PET, ultrasound imaging, and MR image-guided focused ultrasound therapy. In addition to exceptional research and collaboration, the RSL's efforts include training the next generation of scientists and engineers, who derive from many departments within the schools of engineering, medicine, and humanities and sciences. Our faculty teach a variety of biomedical imaging courses that include didactic classes, lab work, and seminars as well.

ACHIEVEMENTS

• Developed MR Elastography method to observe functional activation in the brain with contrast dependent on viscoelastic changes in brain tissue (Glover).

• Developed a dynamic piecewise-linear beam attenuator as part of an NIH-funded project for dose efficient CT (Pelc).

• Developed new methodology based on PET and MRI imaging to detect early breakdown of joint function in areas that look normal on conventional MRI (Kogan).

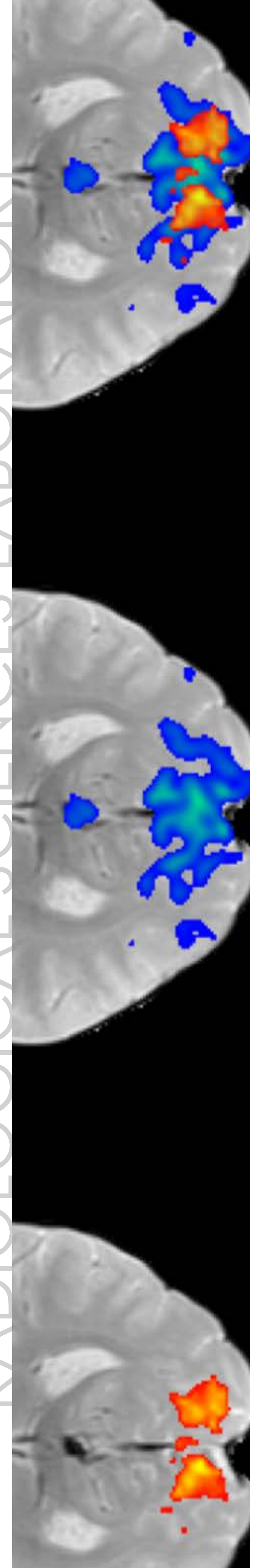
• Demonstrated histologic safety of neuromodulation and MR-ARFI, suppression of evoked potentials by neuromodulation, and modulation of glial cells by blood-brain barrier opening (Pauly).

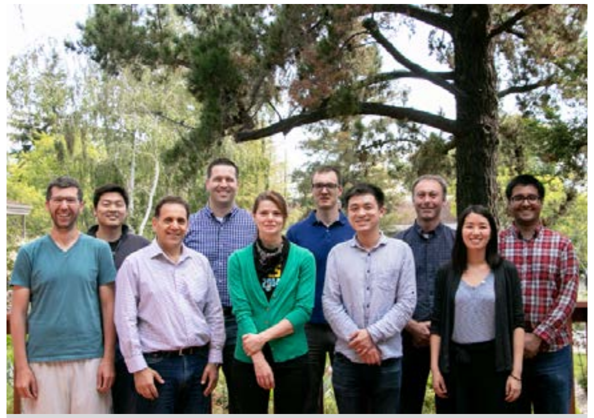
• Developed a generalized spectrum MRI framework and a diffusion tractography technique for improved neural mapping and targeting of brain treatment (McNab).

• Postdoctoral fellow Akshay Chaudari, PhD received the 2019 ISMRM W.S. Moore Young Investigator Award for his project, *5-Minute DESS with Separated Echoes for Comprehensive Whole-Joint Knee MRI Assessment with and without a PD-Weighted Sequence* (Hargreaves).

rsl.stanford.edu

RADIOLOGICAL SCIENCES LABORATORY





L-R: Marko Jakovljevic, Dongwoon Hyun, Fuad Nijim, Carl Herickhoff, Leandra Brickson, Arsenii Telichko, You "Leo" Li, Jeremy Dahl, Jasmine Shu, and Rehman Ali

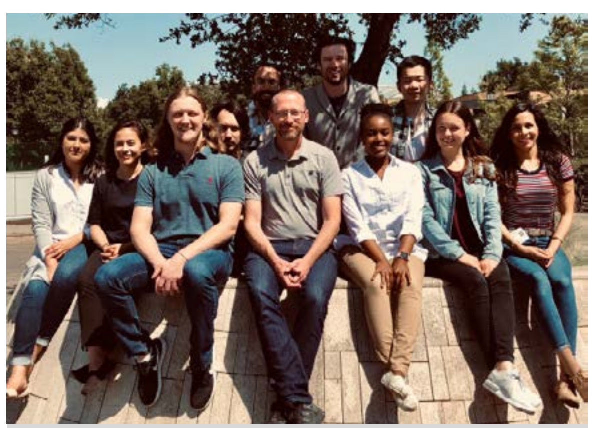
Ultrasound Imaging Research Lab

Jeremy Dahl, PhD

https://med.stanford.edu/ultrasound.html

Our laboratory develops ultrasonic beamforming and imaging modalities, and ultrasound imaging systems and devices, that primarily focus on generating high-quality images in the difficult-to-image patient population. These methods include B-mode and Doppler beamforming techniques that utilize coherence information from the ultrasonic wavefields, speed-of-sound estimation for fat quantification and image correction, molecular imaging for early cancer detection, specialized ultrasound imaging systems for non-traditional applications, and intravascular transducer development for shear wave imaging of atherosclerosis.

- Patent Granted: *Y. Li and J. J. Dahl. Method of Coherent Flow Imaging Using Synthetic Transmit Focusing and Acoustic Reciprocity*. U.S. Patent 10,111,644 (2018).
- Developed and published a method for sound speed estimation using pulse-echo ultrasound that can be used as a potential biomarker for fat quantification.
- Published an in vivo study in 15 stress-echocardiography patients with high BMI showing that harmonic spatial coherence beamforming yielded higher endocardial border detection than conventional echocardiography.
- Developed and published the first neural-network beamformer for ultrasound speckle reduction.



Front row L-R: Jaqueline Velazquez, Amanda Tun, Tyler Cork, Daniel Ennis, Nyasha Maforo, Judith Zimmermann, Jessica Martinez; Back row L-R: Kevin Moulin, Ilya Verzhbinsky, Michael Loecher, Zhanqiu Liu; Not pictured: Matthew Middione, Patrick Magrath, Alexander Wilson, Seraina Dual, Fikunwa Kolawole, Julio Oscanoa, Taghi Rostami, Tabitha Bandy-Vizcaino.

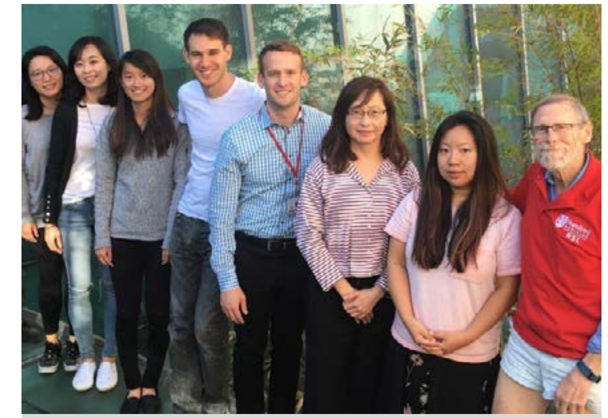
Cardiac MRI Research Group

Daniel B. Ennis, PhD

https://med.stanford.edu/cmrgroup.html

The CMR group develops translational cardiac MRI techniques to improve clinical diagnosis. Current translational projects focus on: (1) characterizing cardiac MRI biomarkers that detect the earliest signs of cardiomyopathy in boys with Duchenne Muscular Dystrophy; and (2) developing MRI methods to estimate changes in passive ventricular stiffness in patients with heart failure with preserved ejection fraction (HFpEF). More generally, the group develops MRI methods that measure structure, function, flow, and remodeling with particular emphasis on time-optimal gradient waveform design.

- Daniel Ennis serves as Deputy Editor, Magnetic Resonance in Medicine.
- Judith Zimmermann received a DAAD fellowship to study aortic aneurysms with MRI.
- Michael Locher released his open source gradient optimization (GrOpt) toolbox for MRI.
- Nyasha Maforo was awarded an NSF Graduate Research Opportunities Worldwide (GROW) fellowship.
- The Ennis group received two awards: (1) an AHA Innovative Project Award, *The Cardiac Connectome for Understanding the Electromechanics of Heart Failure*; and (2) an NIH/NHLBI Research Project Grant, *A New Framework for Understanding the Mechanisms of Diastolic Dysfunction*.



L-R: Annie Jwa, Seul Lee, Patricia Lan, Jonathan Goodman, Kenneth Weber, Christine Law, Allie Lee, Gary. Not pictured: Allyson Rosen

fMRI 'r Us

Gary Glover, PhD

http://rsl.stanford.edu/glover/

Our lab focuses on developing innovative techniques for imaging brain function based on MRI, but often including other imaging technologies such as PET, EEG, and NIRS. Concurrent acquisition utilizing multimodal imaging can provide complementary information unavailable singly. We also use fMRI in conjunction with neuromodulation methods, including TMS, tDCS/tACS and TENS. Neuromodulation can provide causal (as opposed to merely correlative) inferences on mechanisms and pathways that affect or define specific neural circuits.

- Demonstrated fMRI methods for precisely targeting thalamic nucleus responsible for hyperactive motor behavior in essential tremor with greater accuracy than atlas-based methods in current use.
- Developed MR Elastography method to observe functional activation in the brain with contrast dependent on viscoelastic changes in brain tissue (Magna Cum Laude oral presentation by Patricia Lan (Graduate Student) at ISMRM, Montreal 2019).
- Developed phase contrast methods to map current paths in the brain during tDCS stimulation, demonstrating disparity with widely assumed models, and explaining conflicting reports of tDCS efficacy (Power Pitch oral presentation by Annie Jwa (Doctor of Laws Student) at ISMRM, Montreal 2019).

Front row L-R: Laurel Hales, Frank Chavez, Valentina Mazzoli, Elka Rubin, Marianne Black, Lauren Watkins, Kate Young. Back row L-R: Brian Hargreaves, Feliks Kogan, Mary Hall, Marco Barbieri, Akshay Chaudhari, Garry Gold, Daehyun Yoon. Not pictured: Hollis Crowder, Jeslyn Rumbold, Arjun Desai

Joint and Osteoarthritis Imaging with Novel Technology Lab

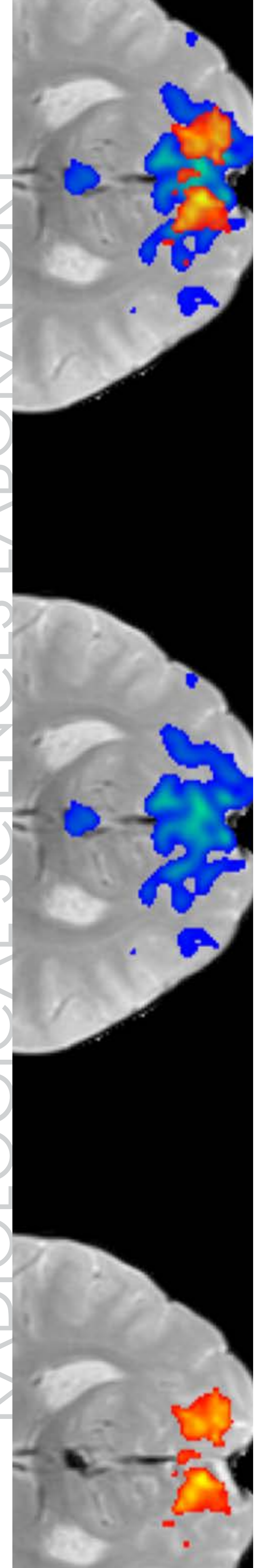
Garry Gold, PhD

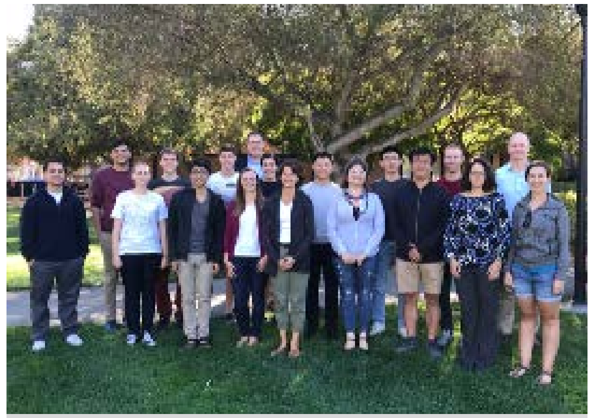
https://med.stanford.edu/jointgroup.html

The JOINT lab's research focuses on improving the diagnosis of musculoskeletal diseases in the lower extremities, including osteoarthritis. To this aim, we have developed and tested several advanced MRI-based techniques to image joints, bone, and muscle. Current projects include the evaluation of knee osteoarthritis with combined PET-MR, automatic segmentation and analysis of knee MR data using deep learning, quantitative imaging of skeletal muscles, and assessment of gait retraining as a conservative treatment for knee osteoarthritis.

- Akshay Chaudhari, PhD (Research Scientist) won the 2019 W.S. Moore Young Investigator Award at the ISMRM annual meeting for his work on rapid and quantitative knee MR.
- The JOINT lab developed DOSMA, a deep learning fully automated open-source software for musculoskeletal MRI analysis.
- Valentina Mazzoli, PhD received a Rubicon postdoctoral fellowship from the Dutch Organization for Research (NWO) to support her work on skeletal muscle MRI.

RADIOLOGICAL SCIENCES LABORATORY





Front row L-R: Frank Chavez, Lauren Watkins, Philip Lee, Laurel Hales, Kate Young, Valentina Mazzoli, Daehyun Yoon, Kitty Moran, Marianne Black; Back row L-R: Akshay Chaudhari, Alex Toews, Marco Barbieri, Garry Gold, Steffi Perkins, Jianmin Yuan, Yuxin Hu, Feliks Kogan, Brian Hargreaves

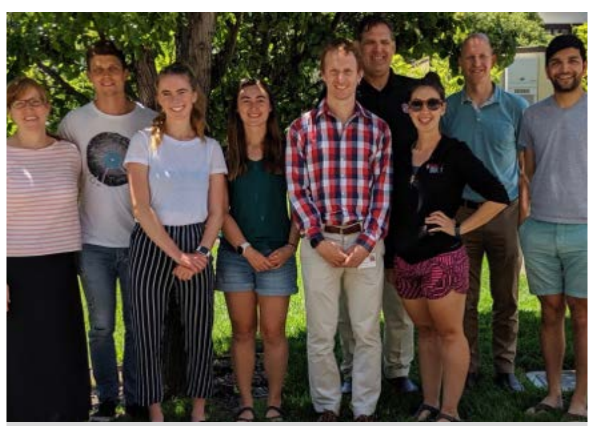
Body MRI Research Group

Brian Hargreaves, PhD

https://med.stanford.edu/bmrgroup.html

Our research links basic science with clinical practice to broadly impact patient care in the following applications: (1) 3D quantitative MRI to enable widespread study of osteoarthritis in a five-minute scan, comparable to X-ray (2) MRI exams to enable better breast cancer screening exams without the use of contrast injection (3) MRI in the presence of metal to evaluate painful conditions following total joint replacement or spinal fixation (4) fast enactment of pediatric and adult abdominal MRI and (5) mixed reality visualization for medical procedures.

- Akshay Chaudhari, PhD (Research Scientist) received the 2019 W.S. Moore Young Investigator Award from the ISMRM annual meeting for his work on rapid and quantitative knee MR.
- PHIND Dream-Team grant awarded to group for *Assessment of Early Knee Osteoarthritis Using a Low Cost, Rapid, and Multi-Modal Imaging and Biomechanics Approach.*
- Graduate students Arjun Desai and Alex Toews awarded NSF and NSERC graduate fellowships, respectively.
- Brian Hargreaves, PhD elected Fellow of AIMBE.



L-R: Jeslyn Rumbold, Marco Barbieri, Joanna Langner, Lauren Watkins, Feliks Kogan, Garry Gold, Marianne Black, Brian Hargreaves, Akshay Chaudhari

Imaging of Musculoskeletal Function Group

Feliks Kogan, PhD

https://med.stanford.edu/imfgroup.html

Our lab develops and clinically translates novel imaging technologies geared toward studying musculoskeletal function and detecting musculoskeletal disease at the earliest stage. We are developing novel PET and MRI methods to study early and reversible tissue changes at the cellular and molecular levels; functional imaging methods to study important relationships between mechanics, physiology, and tissue microstructure; and rapid, comprehensive and quantitative MRI methods for early, low-cost, and precise detection of musculoskeletal disease.

- Developed new methodology based on PET and MR imaging to detect early breakdown of joint function in areas that look normal on conventional MRI.
- Demonstrated the potential to decrease knee MRI exams by 3-6 fold.
- Implemented simultaneous bilateral knee scanning on both MRI and PET-MRI systems.
- Dr. Kogan named to CECI² by the Academy for Radiology & Biomedical Imaging Research.

L-R: Daniel Barbosa, Christoph Leuze, Erpeng Dai, Grant Yang, Sabir Saluja, Jennifer McNab, Fiene Kuijper, Supriya Sathyanarayana, Mackenzie Carlson, Manuela Vasquez

Magnetic Resonance Imaging of Human Brain Microstructure

Jennifer McNab, PhD

https://med.stanford.edu/mcnablab.html

Our lab develops MRI techniques that probe human brain tissue microstructure. This requires new MRI contrast mechanisms, strategic encoding and reconstruction schemes, brain tissue modeling, and comparisons with histology. Application areas of these methods include neuronavigation, neurosurgical planning, and the development of improved biomarkers for brain development, degeneration, disease, and injury.

- Developed augmented reality neuronavigation system to guide TMS treatments. Patent granted for this work.
- Developed a constrained optimization framework for eddy current nulled isotropic diffusion encoding waveforms.
- Developed a generalized diffusion spectrum MRI framework for model-free reconstruction of diffusion patterns in brain tissue.
- Developed analysis tools for extracting orientational features of brain tissue microstructure from histological images of intact 3D human brain tissue cuboids.

L-R: Fanrui Fu, Mihyun Choi, Ningrui Li, Steve Leung, Pooja Gaur, Morteza Mohammadjavadi, Aurea Pascal-Tenorio, Gerald Popelka, Kim Butts Pauly, Kasra Naftchi-Ardebili; Not pictured: Patrick Ye, Taylor Webb, Pooja Gaur

Focused Ultrasound Lab

Kim Butts Pauly, PhD

https://med.stanford.edu/kbplab.html

Ultrasound can be focused deep in the body to be used as a therapeutic modality through ablation, BBB opening, or neuromodulation. Our lab is developing methods for guiding these procedures including improved skull imaging and modeling, imaging of the focal spot with acoustic radiation force imaging, and MR thermometry. Further, we are studying the effects of these procedures including modulation of immune response in the case of BBB opening, and modulation of evoked potentials in the case of neuromodulation.

- Ningrui Li (Graduate Student) was awarded an NSF Graduate Fellowship award. Pooja Gaur (Postdoctoral Research Fellow) received the FUS symposium 2018 Young Investigator Award.
- Studies on skull acoustic parameters, the accuracy of transcranial ultrasound simulations, and neuromodulation were all published last year.
- Suppression of evoked potentials by neuromodulation, histologic safety of neuromodulation and MR-ARFI, and modulation of glial cells by BBB opening were all demonstrated and presented at major conferences.

RADIOLOGICAL SCIENCES LABORATORY

L-R: Linxi Shi, Jongduk Baek, Elias Eulig, Sarah Divel, Adam Wang, Norbert Pelc, Angelica Castellanos, Phillip DiGiacomo

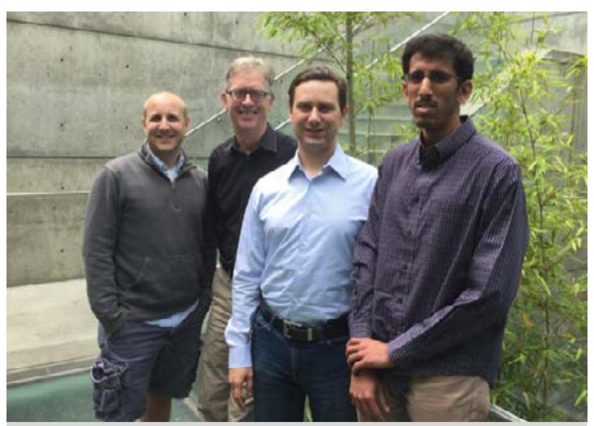
Computed Tomography Lab

Norbert Pelc, ScD

https://med.stanford.edu/pelclab.html

The Pelc group works on technologies that promise to significantly advance diagnostic CT. One core area of our work relates to improving the dose efficiency of CT (i.e., reducing the dose while maintaining or improving the information content) through optimization of X-ray illumination, photon counting detectors, and advanced reconstruction methods. We are also working on new applications of CT, especially for evaluating brain perfusion.

- Developed new theories for detective quantum efficiency of energy discriminating detectors.
- Delivered a dynamic piecewise-linear beam attenuator as part of our major NIH funded project for dose efficient CT.
- Demonstrated a fast and accurate method to simulate realistic noise in CT images.



L-R: Matt Marzelli, Brian Rutt, Josh De Bever, Mihir Pendse. Not pictured: Jason Su, Eun Young Choi, Augustin Lecler, Koray Ertan

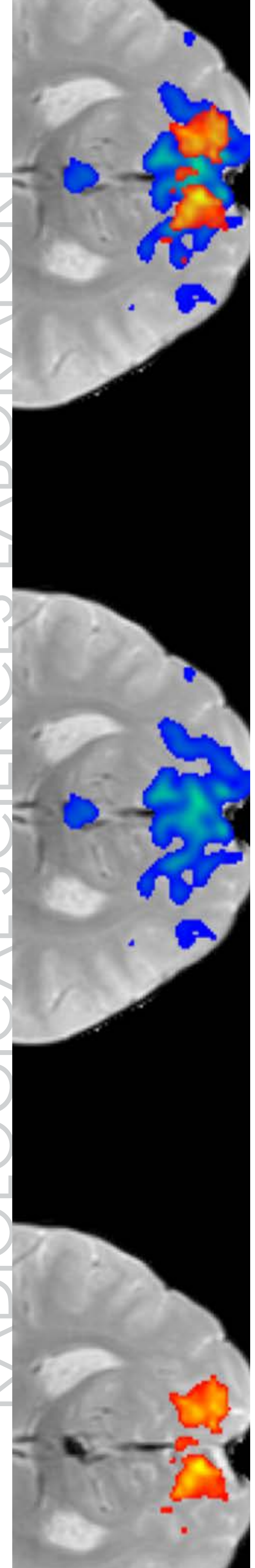
Ultra-High-Field MRI Lab

Brian Rutt, PhD

https://med.stanford.edu/mips/research/cmmril.html

The Rutt Lab aims to develop, optimize, and exploit ultra-high-field (7T) whole-body MRI in a variety of research applications, in the broad area of neuroimaging but progressing to other anatomical regions and applications. Group objectives include conceiving, implementing and applying novel strategies that solve technical challenges associated with using 7T MRI in humans, and developing methods to enable routine high-quality 7T MR imaging. Our long-term aim is to employ these technical developments to study fundamental structural, physiological, metabolic, and functional changes associated with important human diseases of the brain and eventually other anatomical regions.

- Designed, analyzed, and built high-performance head gradient technology.
- Developed new parallel transmit MRI methods for 7T MRI.
- Developed new “focused RF” methodology for targeted hyperthermia.
- Developed new sequences and post-processing methods that delineate thalamic nuclei and characterize T1 relaxation.



L-R: Lawrence Recht, Daniel Spielman, Mette Lauritzen, Taichang Jang, Shie-Chau Liu, Meng Gu, Ron Watkins, Milton Merchant, and Keshav Datta. Not pictured: Ralph Hurd.

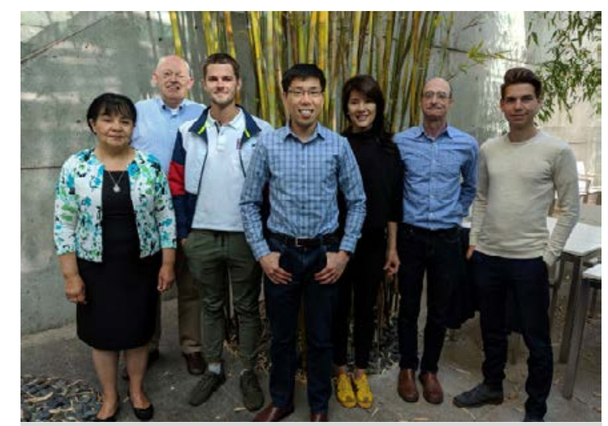
The Spielman Laboratory: In Vivo MR Spectroscopy and Multinuclear Imaging

Daniel Spielman, PhD

https://med.stanford.edu/spielmangroup.html

MRI and MRS provide a wealth of information spanning spatial scales ranging from gross anatomy to biochemical processes. The Spielman Lab research focuses on the acquisition of MR data providing a noninvasive window into in vivo metabolism for use in both preclinical and clinical studies. Current projects include 13C MRS of hyperpolarized substrates for the assessment of glycolysis and oxidative phosphorylation, mapping of 1H metabolite distributions throughout the body, and multimodal PET-MRI imaging.

- Published in 2019 a pilot in vivo proton MRS study on the effects of acute N-acetylcysteine challenge on cortical glutathione and glutamate in schizophrenia.
- Published in 2019 a first experience in a canine prostate cancer model of multimodality hyperpolarized 13C MRS/PET/Multiparametric MR imaging for detection and image-guided biopsy of prostate cancer.
- Published in 2018 a study on metabolic markers, regional adiposity, and adipose cell size and their relationship to insulin resistance in African-American as compared with Caucasian women.



L-R: Manuela Vasquez, Waldo Hinshaw, Max Rohleder, Adam Wang, Linxi Shi, Robert Bennett, Elias Eulig

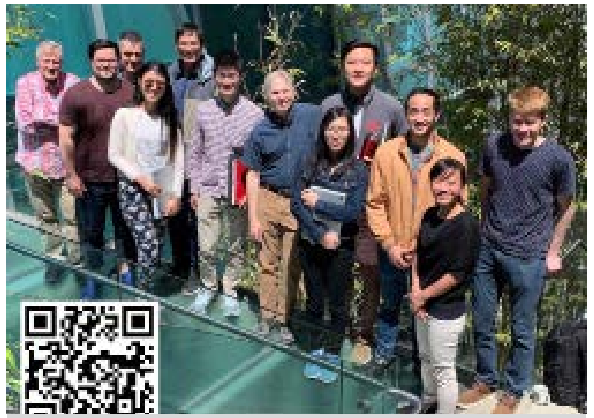
Advanced X-Ray and CT Imaging Lab

Adam Wang, PhD

https://med.stanford.edu/wanggroup.html

The Wang Lab develops new systems and methods for X-ray and CT imaging, for application in image-guided interventions and diagnostic imaging. We use our Tabletop X-ray Lab for prototyping and engineering work, and our Zeego Lab for pre-clinical imaging and translation of ideas to clinical practice. We also model X-ray physics to understand and improve system designs, including new X-ray detectors. The lab has a growing interest in applying artificial intelligence to X-ray/CT acquisition, reconstruction, and analysis.

- Collaborating within radiology to explore applications of AI, dual energy, and cone-beam CT; and with radiation oncology, mechanical engineering, and bioengineering to explore other applications of X-ray and CT.
- Evaluating new dual-layer detector, in collaboration with Varex Imaging.
- Linxi Shi (SCIT Postdoctoral Fellow) won the Helena Anna Henzl-Gabor, and Women in Imaging travel awards to present her work at the 2019 SPIE Medical Imaging and Fully 3D conferences, respectively.



L-R: Michael Moseley, Tobias Faize, Olivier Keunen, Yannan Yu, David Chen, Gregory Zaharchuk, Jiahong Ouyang, Yuan Xie, Antonio Recto Tan-Torres III, Audrey Fan, Todd MacDonald.

Center for Advanced Functional Neuroimaging

Gregory Zaharchuk, MD, PhD and
Michael Moseley, PhD

https://med.stanford.edu/cafn.html

The CAFN group develops new MRI and PET techniques to improve understanding of human brain function and neurovascular diseases, with a focus on contrast MR, diffusion, perfusion, PET-MR, oxygenation imaging and rapid functional BOLD fMRI for dynamic studies. These applications are all immediately amenable to a wide range of novel and compelling deep learning and AI enhancements poised to dramatically increase our imaging and diagnostic powers. Our expertise ranges from design of the latest deep learning neural networks to classic old-school MRI.

- Audrey Fan, PhD (Instructor) received an NIH K99/R00 Pathway to Independence award in 2019.
- Kevin Chen (Graduate Student) was highlighted on Aunt Minnie for his presentation at the 2019 ISMRM annual meeting, AI can generate synthetic contrast-enhanced MRI.
- Gregory Zaharchuk, MD, PhD organized the first AI workshop at the 2019 ASNR meeting.
- Michael Moseley, PhD awarded honorary membership to JSRT at the 2019 Yokohama annual meeting.
- GAN predicts low-dose amyloid PET, featured in June, 2019 RSNA Spotlight Course: Radiology in the Age of AI, by Gregory Zaharchuk, MD, PhD; San Francisco.

RSL SELECTED FUNDING:

Clutter Suppression in Echocardiography Using Short-Lag Spatial Coherence Imaging, NIH/NIBIB, 5R01-EB013661-07 (Dahl)

High dose efficiency CT System, NIH/NIBIB, U01-EB017140 (Pelc)

Accessing the Neuronal Scale: Designing the Next Generation of Compact Ultra High Field MRI Technology, NIH/NIBIB, 1R01-EB025131-01 (Rutt)

Cerebrovascular Reserve Imaging with Simultaneous PET/MRI Using Arterial Spin Labeling and Deep Learning, NIH/NIBIB, 5R01-EB025220-02 (Zaharchuk)

Validating Cardiac MRI Biomarkers and Genotype-Phenotype Correlations for DMD, NIH/NHLBI, R01-HL131975 (Ennis)

Development of Sodium Fluoride PET-MRI for Quantitative Assessment of Knee Osteoarthritis, NIH/NIAMS, 1R01-AR074492-01A1 (Gold)

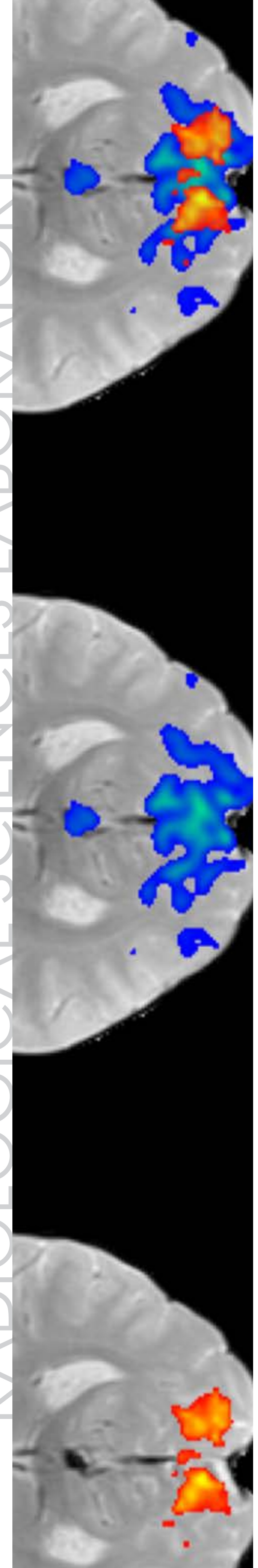
Mixed Reality Neuronavgiation for Transcranial Magnetic Stimulation Treatment of Depression, NIH/NIBIB, R21-MH116484 (McNab)

The Cardiac Connectome for Understanding the Electromechanics of Heart Failure, AHA Innovative Project Award, 19IPLOI34760294 (Ennis)

Weight-Bearing Imaging of the Knee Using C-Arm CT, NIH/NIAMS, 1R01-AR065248-01A1 (Gold)

Quantitative Evaluation of Whole Joint Disease with MRI, NIH/NIBIB, 5R01-EB002524-13 (Gold)

RADIOLOGICAL SCIENCES LABORATORY



RSL SELECTED PUBLICATIONS:

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Hyun D, Brickson LL, Looby KT, and Dahl JJ. Beamforming and speckle reduction using neural networks. *IEEE Transactions on Ultrasonics, Ferroelectrics and Frequency Control*, 66(5):898–910, 2019.

Gu M, Hurd R, Noeske R, Baltusis L, Hancock R, Sacchet MD, Gotlib IH, Chin FT, Spielman DM. GABA editing with macromolecule suppression using an improved MEGA-SPECIAL sequence. *Magn Reson Med*. 2018 Jan;79(1):41-47. doi: 10.1002/mrm.26691.

Pendse M, Stara R, Mehdi Khalighi M, Rutt B. IMPULSE: A scalable algorithm for design of minimum specific absorption rate parallel transmit RF pulses. *Magn Reson Med*. 2019 Apr; 81(4):2808-2822.

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Persson M, Rajbhandary PL and Pelc NJ: A framework for performance characterization of energy-resolving photon-counting detectors, *Med Phys* 2018 Sep 6. doi: 10.1002/mp.13172, PMID: 30191571, 2018.

Santoro JD, Forkert ND, Yang QZ, Pavitt S, MacEachern SJ, Moseley ME, Yeom KW. Brain Diffusion Abnormalities in Children with Tension-Type and Migraine-Type Headaches. *AJNR Am J Neuroradiol*. 2018 May;39(5):935-941. PMCID: 29545251.

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Terem I, Ni WW, Goubran M, Rahimi MS, Zaharchuk G, Yeom KW, Moseley ME, Kurt M, Holdsworth SJ. Revealing sub-voxel motions of brain tissue using phase-based amplified MRI (aMRI). *Magn Reson Med*. 2018 Dec;80(6):2549-2559. PMCID: PMC6269230.

Chen KT, Gong E, de Carvalho Macruz FB, Xu J, Boumis A, Khalighi M, Poston KL, Sha SJ, Greicius MD, Mormino E, Pauly JM. Ultra–Low-Dose 18F-Florbetaben Amyloid PET Imaging Using Deep Learning with Multi-Contrast MRI Inputs. *Radiology*. 2018 Dec 11;290(3):649-56.

Aliotta E, Nourzadeh H, Sanders J, Muller D, Ennis DB. Highly accelerated, model-free diffusion tensor MRI reconstruction using neural networks. *Med Phys*. 2019 Apr; 46(4):1581-1591.

Willemink, MJ, Persson, M, Pourmorteza, A, Pelc, NJ and Fleischmann, D: Photon-counting CT: Technical Principles and Clinical Prospects. *Radiology*, PMID: 30179101, 2018.

Yang G, McNab JA, Eddy current nulled constrained optimization of isotropic diffusion encoding gradient waveforms, *Magnetic Resonance in Medicine*, 81(3):1818-1832, 2018.

Shunhavanich P, Bennett NR, Hsieh SS, and Pelc NJ: Implementation of a Piecewise-linear Dynamic Attenuator. *J. Med. Imag*. 6, 023502, 2019.

Active Sponsored Research

FY19

NIH

Aalipour, Amin	F30	Synthetic Gene Circuits for Monitoring T-Cell Exhaustion
Airan, Raag	RF1	Noninvasive Neuromodulation via Focused Ultrasonic Drug Uncaging
Airan, Raag	UG3-UH3	Clinical Translation of Ultrasonic Ketamine Uncaging for Non-Opioid Therapy of Chronic Pain
Airan, Raag	UG3-UH3	Clinical Translation of Targeted and Noninvasive Ultrasonic Propofol Uncaging
Bishop, James	F32	Defining the Neuromolecular Signature of TMS-Augmented Hypnotic Analgesia in Fibromyalgia Syndrome
Chin, Frederick	R01	Cross-Species Multi-Modal Neuroimaging to Investigate GABA Physiology in Fragile X Syndrome
Chin, Frederick	R21	A New Class of CSF-1R Radioligands for Monitoring Glioblastoma Progression and Therapy
Chin, Frederick	R21	Sigma-1 Receptors: A Novel Clinical Target in Fragile X Syndrome
Coskun, Ahmet	K25	Spatial Epigenomic Profiling of Immune Cell Signatures at Subcellular Resolution in Health and Disease
Dahl, Jeremy	R01	Clutter Suppression in Echocardiography Using Short-Lag Spatial Coherence Imaging
Dahl, Jeremy	R01	High Sensitivity Flow Imaging of the Human Placenta with Coherence-Based Doppler Ultrasound
Dahl, Jeremy	R21	High Sensitivity Molecular Ultrasound Imaging in Pancreatic Cancer
Dahl/Daniel/DeMartini	R01 (MPI)	Automated Volumetric Molecular Ultrasound for Breast Cancer Imaging
Daldrup-Link, Heike	R01	Monitoring of Stem Cell Engraftment in Arthritic Joints with MR Imaging
Daldrup-Link, Heike	R01	Personalized Whole Body Staging for Children with Cancer: A Solution to the Conundrum of Long-Term Side Effects from CT and PET-CT Scans
Daldrup-Link, Heike	R21	Instant Stem Cell Labeling with a New Microfluidic Device
Demirci, Utkan	R01	Platform Technology for Detection of Cancer-Associated Viruses in HIV Patients
Demirci, Utkan	R01	Portable Nanostructured Photonic Crystal Device for HIV-1 Viral Load
Ennis, Daniel	R01	Validating Cardiac MRI Biomarkers and Genotype-Phenotype Correlations for DMD
Fan, Audrey	K99	Quantitative PET-MRI of Brain Oxygenation in Cerebrovascular Disease
Ferrara, Katherine	R01	Image-guided Ultrasound Therapy and Drug Delivery in Pancreatic Cancer

Ferrara, Katherine	R01	In vivo PET imaging of novel engineered AAVs informs capsid design
Ferrara, Katherine	R01	Optimized Ultrasound-Enhanced Immunotherapy
Ferrara/Foiret	R01 (MPI)	Insonation of Ultrasound Microbubbles at Low Frequency to Enhance Image-Guided Therapy
Ferrara/Trahey/Zhou	R01 (MPI)	Large Aperture and Wideband Modular Ultrasound Arrays for the Diagnosis of Liver Cancer
Gambhir, Sanjiv Sam	R01	A Novel Positron Emission Tomography Strategy for Early Detection and Treatment Monitoring of Graft-versus-host Disease
Gambhir, Sanjiv Sam	R01	Nanoparticle-Based Triple Modality Imaging and Photothermal Therapy of Brain Tumors
Gambhir, Sanjiv Sam	R01	Optimization of an Activatable Photoacoustic Agent to Image Thyroid Cancer
Gambhir, Sanjiv Sam	R01	Reporter Gene Technologies for Integrated Cancer Diagnostics
Gambhir, Sanjiv Sam	U54	Center for Cancer Nanotechnology Excellence for Translational Diagnostics (CCNE-TD)
Gambhir/Felsher	U01	Modeling and Predicting Therapeutic Resistance of Cancer
Gambhir/Unger	R44 (MPI)	Pancreatic Ductal Adenocarcinoma Targeted Ultrasound Contrast Agent Development
Glover, Gary	P41	Center for Advanced Magnetic Resonance Technology at Stanford
Glover/Mackey	R01 (MPI)	Characterization of Central Pain Mechanisms Using Simultaneous Spinal Cord-Brain Functional Imaging
Gold, Garry	K24	Advanced MR Imaging of Early Osteoarthritis
Gold, Garry	R01	Development of Sodium Fluoride PET-MRI for Quantitative Assessment of Knee Osteoarthritis
Gold, Garry	R01	Weight-Bearing Imaging of the Knee Using C-Arm CT
Gold, Garry	R01*	Osteoarthritis: Quantitative Evaluation of Whole Joint Disease with MRI
Hargreaves, Brian	R01	Comprehensive MRI near Total Joint Replacements
Hargreaves, Brian	R01	Quantitative 3D Diffusion and Relaxometry MRI of the Knee
Hettie, Kenneth	F32	An 18F PET/NIRF Smart Probe for Identifying, Grading, and Visualizing Astrocytic Gliomas
Iagaru, Andrei	R01	Evaluation of Patients with Low-Risk and Intermediate-Risk Prostate Cancer Scheduled for Hi-Dose Rate Brachytherapy Using 68GA-RM2 PET, 68GA-PSMA-11 PET and Multiparametric MRI
Iagaru, Andrei	U01	Molecular Imaging Methods for the Detection of Pancreatic Ductal Adenocarcinoma
James/Andreasson/Massoud	R21 (MPI)	Tracking the Invaders in Multiple Sclerosis: Highly Specific TREM1-Targeted PET Imaging of Toxic Infiltrating Myeloid Cells and Early Treatment Response
Kamaya, Aya	R01	3D Dynamic Contrast-Enhanced US for Monitoring Chemotherapy of Liver Metastasis
Kogan, Feliks	R00	Quantitative Assessment of Early Metabolic and Biochemical Changes in Osteoarthritis
Levin, Craig	R01	A New Direction to Achieve Ultra-Fast Timing for Positron Emission Tomography
Levin, Craig	R01	Technologies to Drastically Boost Photon Sensitivity for Brain-Dedicated PET
Levin, Craig	R01*	Exploring a Promising Design for the Next Generation Time-of-Flight PET Detector

**indicates projects that include a supplement*

Levin, Craig	R01*	RF-penetrable PET ring for acquiring simultaneous time-of-flight PET and MRI data
Levin, Craig	T32	Stanford Molecular Imaging Scholars (SMIS)
Loening, Andreas	R21	PSMA Activatable MRI Contrast Agents to Improve the Detection of Prostate Cancer
Lungren, Matthew	R01	Deep Learning for Pulmonary Embolism Imaging Decision Support: A Multi-institutional Collaboration
Lutz, Amelie	R01	Molecularly-Targeted Ultrasound in Ovarian Cancer
Mallick/Gil	R01 (MPI)	A Discovery Engine For Reproducible and Comparable Multi-Omic Analysis
McNab, Jennifer	R01	Integration of Diffusion MRI Fiber Tracking and CLARITY 3D Histology for Improved Neurosurgical Targeting
McNab, Jennifer	R21	Mixed-Reality Neuronavigation for Transcranial Magnetic Stimulation Treatment of Depression
Napel/Daniel	T32 (MPI)	Stanford Cancer Imaging Training (SCIT) Program
Napel/Rubin	U01 (MPI)	Computing, Optimizing, and Evaluating Quantitative Cancer Imaging Biomarkers
Paulmurugan/Dahl	R01 (MPI)	Therapeutic miRNA Modulation of Hepatocellular Carcinoma Using Ultrasound Guided Drug Delivery
Pauly, Kim Butts	R01	MR-guided Focused Ultrasound Neuromodulation of Deep Brain Structures
Pauly, Kim Butts	R01	The Impact of FUS-Mediated Brain Cancer Therapy on BBB Transport, Cytokines, and Immunocyte Trafficking
Pauly, Kim Butts	RF1	What are we Stimulating with Transcranial Ultrasound in Mice?
Pauly, Kim Butts	T32	Predoctoral Training in Biomedical Imaging at Stanford University
Pelc/Edic/Wang	U01 (MPI)	High Dose Efficiency CT System
Pitteri / Bertozzi	U01 (MPI)*	Making Glycoproteomics via Mass Spectrometry more Accessbile to the Greater Scientific Community
Pitteri/Bertozzi/Brooks	U01 (MPI)	Glycosylation and Immune Evasion in Urologic Tumors
Plevritis, Sylvia	T15	Biomedical Informatics Training at Stanford
Plevritis, Sylvia	T32	Biomedical Data Science Graduate Training at Stanford
Plevritis, Sylvia	U54	Modeling the Role of Lymph Node Metastases in Tumor-Mediated Immunosuppression
Plevritis/Mandelblatt/Berry/DeKoning/Lee/Schechter/Trentham-Dietz	U01 (MPI)	Comparative Modeling Informing Breast Cancer Control Practice and Policy
Plevritis/Meza/Dekoning/Holford/Kong/Levy	U01 (MPI)	Comparative Modeling of Lung Cancer Prevention and Control Policies
Rao/Chu	R01 (MPI)	Noninvasive Deep-Tissue Single-Cell Imaging and Nanoprobe Development
Rao/Felsher	T32 (MPI)	Cancer-Translational Nanotechnology Training Program (Cancer-TNT)
Rao, Jianghong	R01	Beta-lactamase fluorescent probes for bacterial detection
Rao, Jianghong	R01	Copper Depleting Nanotheranostics for Treating Triple Negative Breast Cancer
Reiter, Johannes	R00	Inferring the roots of metastases and their effects on patient survival
Rubin, Daniel	U01	Qualification and Deployment of Imaging Biomarkers of Cancer Treatment Response
Rutt, Brian	R01	Accessing the Neuronal Scale: Designing the Next Generation of Compact Ultra High Field MRI Technology for Order-of-Magnitude Sensitivity Increase in Non-Invasive Human Brain Mapping
Soh/Demirci	R25 (MPI)	Canary Cancer Research Education Summer Training (Canary Crest) Program
Soh, H. Tom	OT2	Real-time biosensor for mapping the function of the pancreas
Soh, H. Tom	R01	Integrated Instrument for Non-Natural Aptamer Generation
Spielman/Recht	R01 (MPI)	Metabolic Therapy of GBM Guided by MRS of Hyperpolarized 13C-Pyruvate
Spielman, Daniel	R01	Imaging Brain Metabolism Using MRS of Hyperpolarized 13C-Pyruvate
Spielman, Daniel	R01	Robust 1H MRSI of GABA, Glutamate, Glutamine, and Glutathione
Stoyanova, Tanya	R03	Elucidating Novel Mechanisms Underlying Prostate Cancer Development
Thakor, Avnesh	R01	A novel approach for treating diabetes using pulsed focused ultrasound and intraarterial delivery of mesenchymal stem cell based therapies directly into the pancreas
Vasanawala/Lustig	R01 (MPI)	Rapid Robust Pediatric MRI
Vasanawala, Shreyas	R01	Development and Validation of Radiation-Free Pediatric Renal Function Quantification
Vasanawala/Larson/Peder/Zufall/Johnson	R01 (MPI)	MRI Methods for High Resolution Imaging of the Lung
Vasanawala/Pauly	R01 (MPI)	Development and Translation of High Performance Receive Arrays for Pediatric MRI
Wilson, Katheryne	K99	Spectroscopic Photoacoustic Molecular Imaging for Breast Lesion Characterization
Wintermark, Max	R01	MR-Guided Focused Ultrasound Combined with Immunotherapy to Treat Malignant Brain Tumors
Zaharchuk, Gregory	R01	Cerebrovascular Reserve Imaging with Simultaneous PET-MRI Using Arterial Spin Labeling and Deep Learning
Zaharchuk, Gregory	R01	Imaging Collaterals in Acute Stroke (iCAS)
Zeineh, Michael	R01	Iron as an Imaging Biomarker for Inflammation in AD

NIH SUBCONTRACT AWARDS

Airan, Raag	Vanderbilt University Medical Center	Prototyping an Ultrasound System for Localized Delivery of Neuromodulatory Agents and Functional Imaging in Awake Primates
Demirci, Utkan	University of California, San Francisco	Single Cell Characterization of Latent HIV-1 Reservoirs

*indicates projects that include a supplement

Ennis, Daniel	Palo Alto Veterans Institute for Research	A New Framework for Understanding the Mechanisms of Diastolic Dysfunction
Ferrara, Katherine	Cedars-Sinai Medical Center	Ultrasound-Guided DNA Delivery for Regenerative Medicine
Gambhir, Sanjiv Sam	Memorial Sloan Kettering Cancer Center	Ultrabright Theranostic SERRS Nanoparticles for Gastrointestinal Endoscopy
Gambhir, Sanjiv Sam	NuvOx Pharma LLC	Pancreatic Ductal Adenocarcinoma Targeted Ultrasound Contrast Agent Development
Kamaya, Aya	Thomas Jefferson University	Contrast-Enhanced Ultrasound Evaluation of Focal Liver Lesions in Patients with Cirrhosis or Other Risk Factors for Developing HCC
McNab, Jennifer	University of California, Berkeley	Foundations of MRI Cartography for Mesoscale Organization and Neuronal Circuitry
Napel, Sandy	Massachusetts General Hospital	Informatics Tools For Optimized Imaging Biomarkers For Cancer Research & Discovery
Paulmurugan, Ramasamy	Mayo Clinic	Imaging of mitochondrial function of progenitor cells transplanted to the ischemic myocardium
Plevritis, Sylvia	Georgetown University	Comparative Modeling: Informing Breast Cancer Control Practice and Policy
Plevritis, Sylvia	University of Michigan	Comparative Modeling of Lung Cancer Prevention and Control Policies
Rutt, Brian	University of Minnesota	Neuronal Ensembles to Networks: Ultrahigh Resolution Imaging of Human Brain Function and Connectivity
Spielman, Daniel	University of Maryland	Metabolic Imaging of Nonalcoholic Fatty Liver Disease
Spielman, Daniel	Palo Alto Veterans Institute for Research	Establishing a Task-Evoked Magnetic Resonance Spectroscopy Approach for Testing the GABA Deficit Hypothesis in Schizophrenia
Vasanawala, Shreyas	University of California, San Francisco	MRI Methods for High Resolution Imaging of the Lung
Vasanawala, Shreyas	Indiana University	Magnetic Resonance Imaging as a Non-Invasive Method for Assessment of Pancreatic Fibrosis (MINIMAP): A Pilot Study
Vasanawala, Shreyas	University of Wisconsin-Madison	MRI-based Quantitative Susceptibility Mapping of Hepatic Iron Overload
Wang, Adam	Marquette University	Software Tool for Routine, Rapid, Patient-Specific CT Organ Dose Estimation
Wintermark, Max	University of Cincinnati	NINDS Efficacy Clinical Trials: National Clinical Coordinating Center (NCC) Renewal
Wintermark, Max	Medical University of South Carolina	NIH StrokeNet National Data Management Center (NDMC)
Wintermark, Max	University of Cincinnati	Multi-Arm Optimization of Stroke Thrombolysis (MOST) Stroke Trial
Wintermark, Max	University of California, San Francisco	The Vascular Effects of Infection in Pediatric Stroke (VIPS II) Study
Wintermark, Max	Magnetic Insight, Inc.	Phase II: Commercialization of a Preclinical Magnetic Particle Imaging System with Sub-Millimeter Resolution, Nano-Molar Sensitivity, and Integrated CT
Wintermark, Max	Virginia Tech	Perinatal Arterial Stroke: A Multi-site RCT of Intensive Infant Rehabilitation (I-ACQUIRE)
Wintermark, Max	Magnetic Insight, Inc.	Phase II: Development of a Neurovascular Magnetic Particle Imaging System with Sub-Millimeter Resolution and Real Time Speed for Non-Radiative 3D Perfusion Angiography

OTHER GOVERNMENT FUNDED PROJECTS

Cui, Liyang	DoD	Targeting Metastatic Breast Cancer with Copper Trap Assembled in Situ
Demirci, Utkan	U.S. Army	Biofidelic 3-Dimensional Brain Surrogate Models of mTBI-Induced Alzheimer's Disease Pathology
Demirci, Utkan	Natl Inst of Justice	A Confirmatory Test for Sperm in Sexual Assault Samples using a Microfluidic-Integrated Cell Phone Imaging System
Ghoochani, Ali	DoD	Ferroptosis induction is a novel therapeutic strategy for advanced prostate cancer
Hori, Sharon	US Army	A Modeling-Based Personalized Screening Strategy Combining Circulating Biomarker and Imaging Data for Breast Cancer Early Detection
Iagaru, Andrei	DoD	Ga-68 Bombesin PET-MRI in Patients with Biochemically Recurrent Prostate Cancer and Non-Contributory Conventional Imaging
Mallick, Parag	DARPA	Using Knowledge of Diffusion Processes to Constrain Learning from Biomedical Image Data
Mallick, Parag	U.S. Dept. of Interior	Accelerating Knowledge Extraction from Large-Scale Multi-Data Sources by Incorporating Prior Knowledge with Deep Learning
Pitteri, Sharon	U.S. Army	Distinguishing Benign from Malignant Breast Lesions: Does Breast Interstitial Fluid Hold the Answers?
Rice, Meghan	U.S. Army	Defining the Role and Therapeutic Potential of Notch Signaling in Aggressive Prostate Cancer
Soh, H. Tom	DARPA	Binder-Finder through Machine-Learning (BFML)
Stoyanova, Tanya	U.S. Army	Trop2 as a Novel Driver and Therapeutic Target for Castration-Resistant Prostate Cancer
Zeineh, Michael	Palo Alto VA	Efficacy of Repetitive Transcranial Magnetic Stimulation for Improvement of Memory in Older Adults with TBI Problems in Complex TBI

INDUSTRY FUNDED PROJECTS

Barth, Richard	Philips Ultrasound Inc.	Liver Fat Quantification Data Collection
Barth, Richard	Siemens Medical Solutions USA, Inc.	Ultrasound Quantative Elastography Assessment of Pediatric Hepatic Fibrosis
Barth, Richard	Siemens Medical Solutions USA, Inc.	Shear Wave Sono-elastography: A Potential Non-invasive Method for Diagnosing Biliary Atresia in Newborns and Infants with Persistent Jaundice
Cheng, Zhen	Infinitus	Molecular Imaging of Lipopolysaccharide on Immune Balance
Daniel, Bruce	General Electric Healthcare	Augmented Reality Visualization of Medical Imaging Data
Demirci, Utkan	Philips Healthcare	Philips Healthcare Fellowship Training Awards
Demirci, Utkan	Philips Healthcare	Advancing Precision Health: Enabling Personalized Diagnostics and Treatment Delivery
Fleischmann, Dominik	Siemens Medical Solutions USA, Inc.	Siemens CT Project - Optimization of Injection Protocols
Gambhir, Sanjiv Sam	Baseline Study LLC	The Baseline Study
Gambhir, Sanjiv Sam	Novocure, Inc.	Investigating Impact of TTFields on Chemotherapies and on Hypoxic Phenotypes
Gambhir, Sanjiv Sam	Pliant Therapeutics, Inc.	Detection of Integrin $\alpha v \beta 6$ in Pancreatic Cancer and Idiopathic Pulmonary Fibrosis with [18F]FP-R01MG-F2: A First in Human Study
Ghanouni, Pejman	InSightec	A Pivotal Study to Evaluate the Effectiveness and Safety of ExAblate Transcranial MRgFUS Thalamotomy Treatment of Medication Refractory Essential Tremor Subjects
Ghanouni, Pejman	InSightec	A Continued Access Study to Evaluate the Effectiveness and Safety of ExAblate Transcranial MRgFUS Thalamotomy Treatment of Medication Refractory Essential Tremor Subjects
Ghanouni, Pejman	InSightec	Post-ExAblate Pregnancy Outcomes Study: ExAblate Tratement of Symptomatic Uterine Fibroids
Ghanouni, Pejman	InSightec	Global Registry: ExAblate 4000 Transcranial MR Guided Focused Ultrasound (TcMRgFUS) of Neurological Disorders
Gold, Garry	General Electric Healthcare	PET-MRI Advanced Research and Development Project
Gold, Garry	General Electric Healthcare	Knee and Patellofemoral Overload and Articular Cartilage Injuries: The Advanced Imaging Protocol Study
Hargreaves, Brian	General Electric Medical Systems	Advanced MR Applications Development - Tiger Team Years 9 and 10
Iagaru, Andrei	Advanced Accelerator Applications USA, Inc.	A Phase 1/2 Open-label, Multi-center, Dose-escalation Study of Safety, Tolerability, Pharmacokinetics, Dosimetry, and Response to Repeat Dosing of 177Lu-PSMA-R2 Radio-ligand Therapy in Patients with Prostate Specific Membrane Antigen (PSMA) Positive (68Ga-PSMA-R2) Progressive Metastatic Castration-resistant Prostate Cancer, Following Previous Systemic Treatment
Iagaru, Andrei	General Electric Healthcare	Advanced Research for Digital PET-CT
Iagaru, Andrei	Progenics Pharmaceuticals, Inc.	A Phase 3, Multi-Center, Open-Label Study to Assess the DiagNostic Performance and Clinical Impact of 18F-DCFPyL PET/CT Imaging Results in Men with Suspected Recurrence of PrOstate CanceR (CONDOR)
Kamaya, Aya	Philips Electronics North America Corp.	Liver Fat Quantification Data Collection
Kothary, Nishita	EchoPixel, Inc.	3D Virtual Reality for Endovascular Procedures
Kothary, Nishita	NZ Technologies, Inc.	The Use of TIPSO to Ergonomically Access and Navigate Images Obtained During CT and Cathlab Based Procedures
Larson, David	Siemens Corporation, Corporate Technology	Siemens QI Project - Implementing a QI program to facilitate the use of Siemens' teamplay product as a part of the Digital Ecosystem.
Lungren, Matthew	General Electric Healthcare	Deep Learning in Whole Body FDG PET-CT Characterization for Clinical Decision Support
Patel, Bhavik	General Electric Healthcare	Machine Learning for Evaluation of CT Image Quality, Task Performance, and Automated Parameter Optimization from Projection and Image Data
Paulmurugan, Ramasamy	Bracco Diagnostic, Inc.	Optimization of Formulations for Gene Loading and Ultrasound-Microbubble Mediated Gene Delivery Efficiency Using Different Nanocarriers
Pelc, Norbert	General Electric Healthcare	Advanced Computed Tomography (CT) Systems and Algorithms
Rubin, Daniel	General Electric Healthcare	Quantitative Imaging for Cancer Risk Assessment of Thyroid Nodules
Rubin, Daniel	General Electric Healthcare	Automated Annotation of Radiology Images for Deep Learning Through Unsupervised Text Analytics
Rubin, Daniel	Verizon Media	Deep Learning for Analyzing Ultrasound Movie Images
Sze, Daniel	Biocompatibles UK Ltd.	A TheraSphere® Advanced Dosimetry Retrospective Global Study Evaluation in Hepatocellular Carcinoma Treatment
Sze, Daniel	Biocompatibles UK Ltd.	RadioEmbolization for the ADvancement of READY90 Glass Microspheres Registry
Sze, Daniel	BioSphere Medical, Inc.	Phase 3 Prospective Randomized Blinded and Controlled Investigation of Hepasphere/Quadrasphere Microspheres for Delivery of Doxorubicin for the Treatment of Hepatocellular Cancer
Vasanawala, Shreyas	General Electric Healthcare	Smart Imaging: High-Value High-Throughput Diagnostic Using MRI with Machine Learning
Wang, David	SillaJen Biotherapeutics, Inc.	A Phase 3 Randomized, Open-Label Study Comparing Pexa-Vec (Vaccinia GM-CSF / Thymidine Kinase-Deactivated Virus) Followed by Sorafenib Versus Sorafenib in Patients with Advanced Hepatocellular Carcinoma (HCC) Without Prior Systemic Therapy
Wang, David	Teclison Ltd.	Tate versus Tace, An Open-label Randomized Study Comparing Transarterial Tirapazamine Embolization versus Transarterial Chemoembolization in Intermediate Stage Hepatocellular Carcinoma
Wintermark, Max	Magnetic Insight, Inc.	Phase II: Commercialization of a Preclinical Magnetic Particle Imaging System with Sub-millimeter Resolution, Nano-molar Sensitivity, and Integrated CT

Wintermark, Max	Magnetic Insight, Inc.	Phase II: Development of a Neurovascular Magnetic Particle Imaging System with Sub-millimeter Resolution and Real Time Speed for Non-radiative 3D Perfusion Angiography
Zaharchuk, Gregory	Bayer Healthcare Pharmaceuticals, Inc.	Reduced Contrast Dose Imaging Using Deep Learning

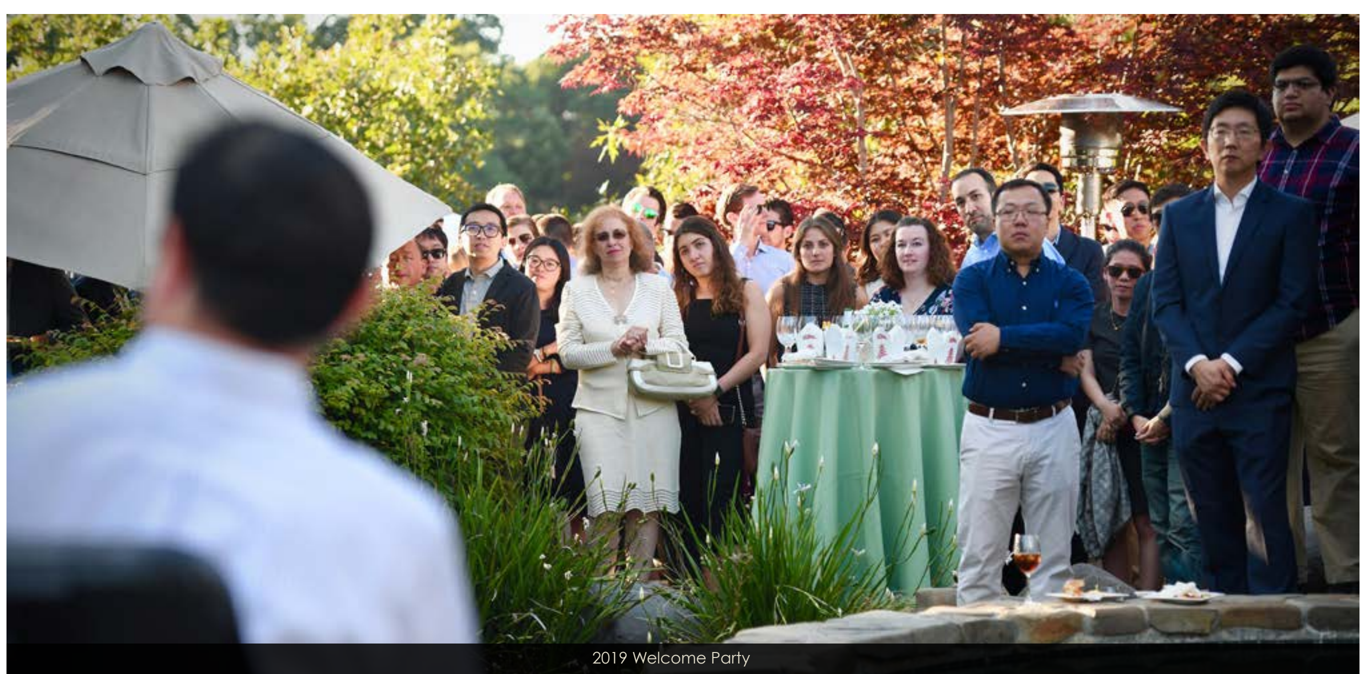
FOUNDATION AND PROFESSIONAL SOCIETY AWARDS

Airan, Raag	The Charles A. Dana Foundation	Towards Clinical Translation of Noninvasive Neuromodulation via Focused Ultrasonic Drug Uncaging
Airan, Raag	Focused Ultrasound Surgery Foundation	The Needle-less Nerve Block: Targeted Non-Invasive Analgesia with Ultrasonic Uncaging of Local Anesthetics
Chaney, Aisling	Society of Nuclear Medicine Education and Research Foundation	Imaging the Invaders in Multiple Sclerosis: Highly-Specific PET Imaging of Myeloid Cells to Identify Early Toxic Inflammation and Monitor Treatment Response
Chen, Kevin	Foundation of the American Society of Neuroradiology	A Generalizable Deep Learning Network for Imaging Neuropathology with Ultra-low-dose PET-MRI
Durmus, Gozde	The Burroughs Wellcome Fund	Levitating Rare Biological Materials to Decode the Fundamentals
Ennis, Daniel	Palo Alto Veterans Institute for Research	A New Framework for Understanding the Mechanisms of Diastolic Dysfunction
Gambhir, Sanjiv Sam	Canary Foundation	Center of Excellence in Early Detection of Cancer
Gambhir, Sanjiv Sam	The Ben & Catherine Ivy Foundation	Glioma Imaging
Gambhir, Sanjiv Sam	The Ben & Catherine Ivy Foundation	A New Strategy to Image Tumor Metabolism in GBM Patients to Help Optimize Anti-Tumor Therapies
Ghanouni, Pejman	Focused Ultrasound Surgery Foundation	Focused Ultrasound Foundation Center of Excellence
Groll, Andrew	The Ford Foundation	CZT Semiconductor Imaging System
Hahn, Lewis	Radiological Society of North America	Quantitative Extraction of Morphologic Risk Factors in Type B Aortic Dissections using Machine Learning
Heit, Jeremy	Semmes Murphey Foundation	Ruptured Aneurysms Treated with Hydrogel Coils - RAGE
Larson, David	Intermountain Healthcare	Intermountain - Stanford Grant Program
McNab, Jennifer	The Charles A. Dana Foundation	Localization of Deep Brain Stimulation Targets Using Diffusion MRI Fiber Tracking Validated Against CLARITY 3D Histology
Patel, Chirag	American Brain Tumor Association	Hypoxia Inducible Factor-1alpa and Sirtuin Inhibition in Glioblastoma in Conjunction with Tumor Treating Fields
Paulmurugan, Ramasamy	Focused Ultrasound Surgery Foundation	A Novel Genetic Reprogramming Therapy for Hepatocellular Carcinoma Using Focused Ultrasound-Guided Delivery of MicroRNA
Rubin, Daniel	American College of Radiology	Evaluating AI Applications in Clinical Practice
Thakor, Avnesh	Society of Interventional Radiology Foundation	A Novel Strategy for Regenerating the Pancreas Using Mesenchymal Stem Cells and Pulsed Focused Ultrasound
Tong, Elizabeth	Radiological Society of North America	Design and Validate an Imaging-based Clinical Assessment Tool for Acute Ischemic Stroke - Functional-MRI Stroke Scale (FMRISS)
Wentland, Andrew	Radiological Society of North America	An Artificial Intelligence Approach to Improve the Differentiation of Surgical from Non-surgical Cystic Renal Lesions
Willemink, Martin	American Heart Association	Improving Individual Risk Assessment in Patients with Aortic Dissection
Wolman, Dylan	Radiological Society of North America	Prospective Utilization of Dual-Energy CT for the Detection and Aging of Vertebral Compression Fractures in Trauma
Yeom, Kristen	Foundation of the American Society of Neuroradiology	Radiogenomic Approaches to Non-Invasive Molecular Subtyping of Pediatric Posterior Fossa Ependymomas
Yeom, Kristen	American Brain Tumor Association	Radiogenomic Prediction of Pediatric Medulloblastoma Molecular Subtypes
Zeineh, Michael	The Charles A. Dana Foundation	The Role of Iron in Alzheimer's Disease
Zeineh, Michael	Foundation of the American Society of Neuroradiology	The Role of Iron and Inflammation in Alzheimer's Disease: From Ex Vivo to In Vivo

STANFORD INTERNAL AND OTHER FUNDING

Airan, Raag	Coulter Endowment Program	Towards Clinical Translation of Noninvasive Neuromodulation via Focused Ultrasonic Drug Uncaging
Beinat, Corrine	Stanford ChEM-H	Development of Novel Molecular Imaging Agents for Visualization of Cytotoxic T-cells and Evaluation of CAR-T Cell Therapy in Preclinical Models of Glioblastoma
Daniel, Bruce	Bio-X	Technologies for Mixed-Reality Breast Surgery
Demirci, Utkan	Stanford Cancer Institute	Decoding Exosomes for the Early Detection and Monitoring of Pancreatic Cancer
Gambhir, Sanjiv Sam	Boston University & American Association for Cancer Research	Intercept Lung Cancer Through Immune, Imaging and Molecular Evaluation-InTIME
Gambhir, Sanjiv Sam	UT MD Anderson Cancer Center	Biospecimen Banking and Biomarker Validation for Lung Cancer Early Detection in Cohort Receiving Low Dose Helical Computed Tomography Screening

Gambhir, Sanjiv Sam	Stanford ChEM-H	Changes in [18F]DASA-23 PET Uptake, A Measure of Pyruvate Kinase M2, from Pre- to Post-therapy in Recurrent Glioblastoma: Effects on Survival
Karacosta, Loukia	UC Tobacco-Related Disease Research Program (TRDRP)	Constructing a Lung Cancer Map of Drug Resistance States with Single-Cell Analysis
Kothary, Nishita	University of Pennsylvania and Guerbet Group	A Phase 2 Randomized Multicenter Trial to Compare Hepatic Progression-Free Survival Following Bland Embolization, Lipiodol Chemoembolization, and Drug-Eluting Bead Chemoembolization of Neuroendocrine Liver Metastases
Kuo, William	UCLA and Angiodynamics, Inc.	Registry of Angiovac Procedures In Detail Outcomes Database
Mazzoli, Valentina	Netherlands Organization for Scientific Research	Non-invasive Sarcomere Imaging Using Advanced MRI Methods
Pejman Ghanouni	UCSF and Focused Ultrasound Surgery Foundation	MRgFUS vs. CTgRFA for Ablation of Osteoid Osteomas
Rubin, Daniel	Bio-X	A Machine Learning Approach to Automated Detection and Characterization of Dendritic Spines in the Mammalian Brain
Soh, H. Tom	Wu Tsai Neurosciences Institute	Real-time Biosensors for Measuring Multiple Neuromodulators in the Brain
Sze, Daniel	Vanderbilt University	Radiation-Emitting SIR-Spheres in Non-resectable (RESiN) Liver Tumor Registry
Wintermark, Max	UCSF and Pediatric Epilepsy Research Foundation	Seizures in Pediatric Stroke (SIPS) II
Zaharchuk, Gregory	Stanford Artificial Intelligence Lab	Using Deep Learning for Imaging Alzheimer's Disease with Simultaneous Ultra-low-dose PET-MRI


2019 Welcome Party

Funded Projects Summary

92 NIH Funded Projects $33.8M

41 Industry Funded Projects $15.6M

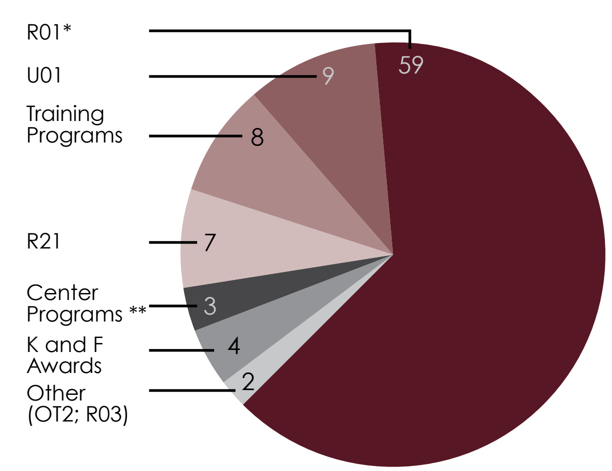
27 Non-Profit Funded Projects $4.6M

12 Other Government Funded Projects $2.3M

26 NIH Subcontracts Funded Projects $3.0M

8 Stanford Internal Funded Projects $0.2M

NIH Award Types

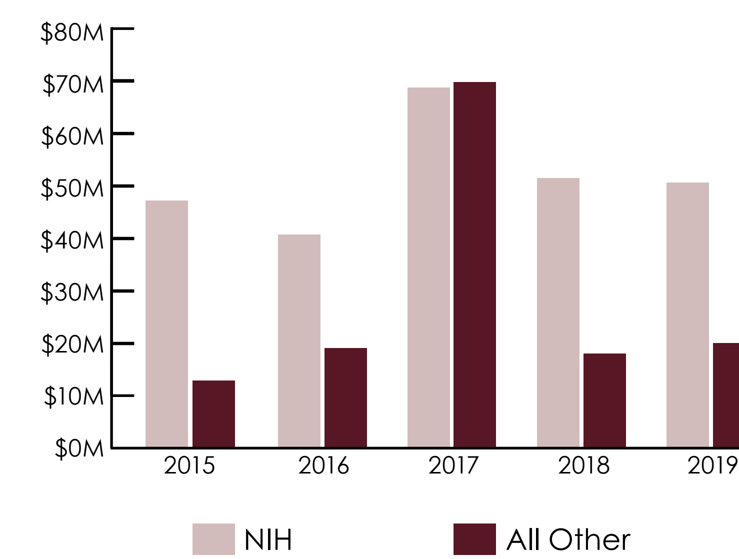


*R01 includes R00, RF1

**Center includes P41 and U54

New Awards (FY 2015–2019)

Total new dollars/year—all years of award



Radiology Snapshot

247
Radiology Faculty
All Inclusive

Top 10
Residency Training
US News & World Report 2015–17

#2
NIH Rank
Academy of Radiology Research FY18

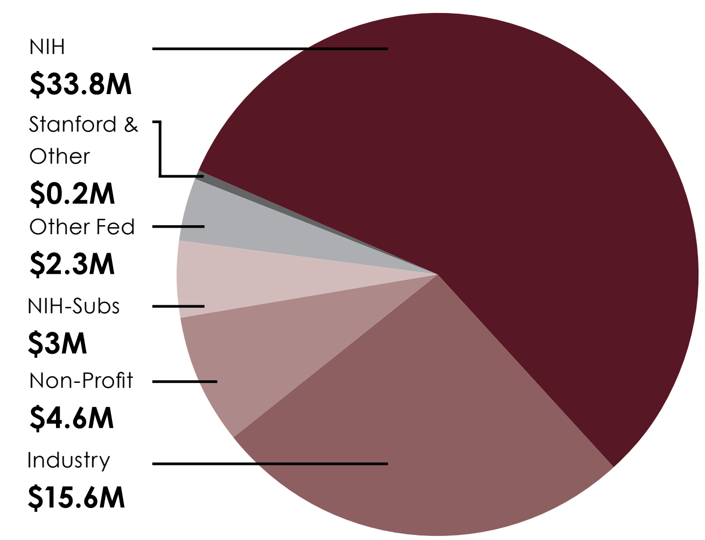
292
Radiology Trainees
(Fellows, Residents, Postdocs, Students, Visitors)

215
Sponsored Projects
Total Number of Active Sponsored Projects FY19

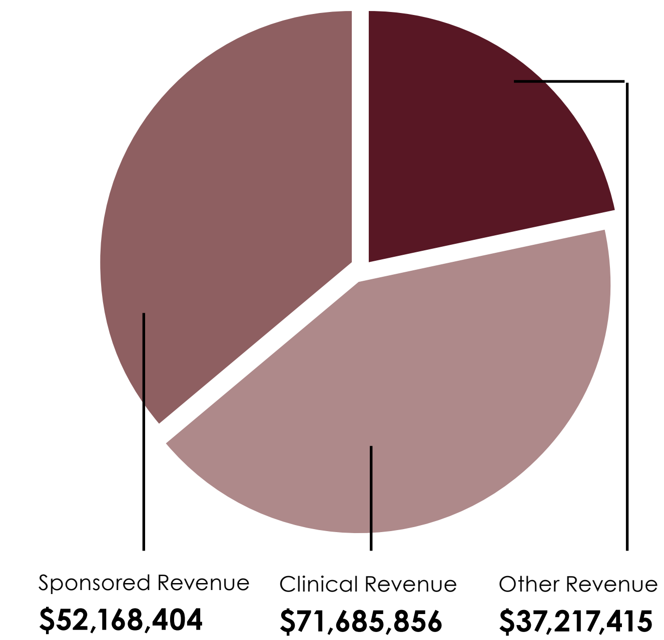
25
Distinguished Investigators
Academy of Radiology Research FY12–FY19

New Stanford Hospital

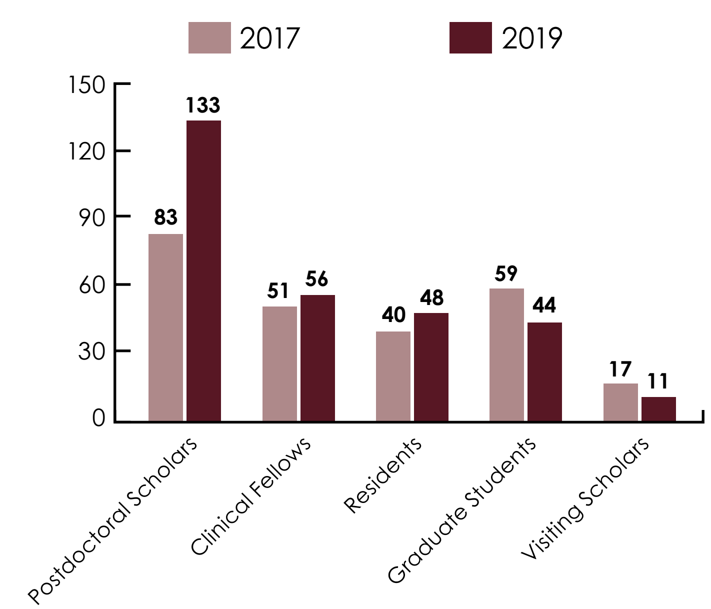
Research Funding FY19
$59,518,636 (total dollars)



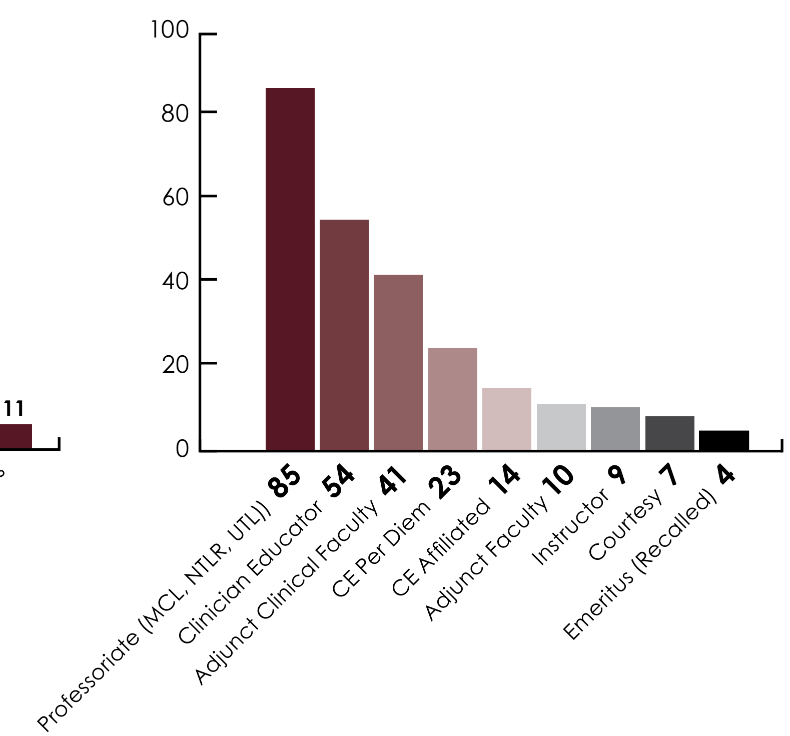
Budgeted Revenue FY19
$161,071,675



Trainees: 292



Faculty: 247

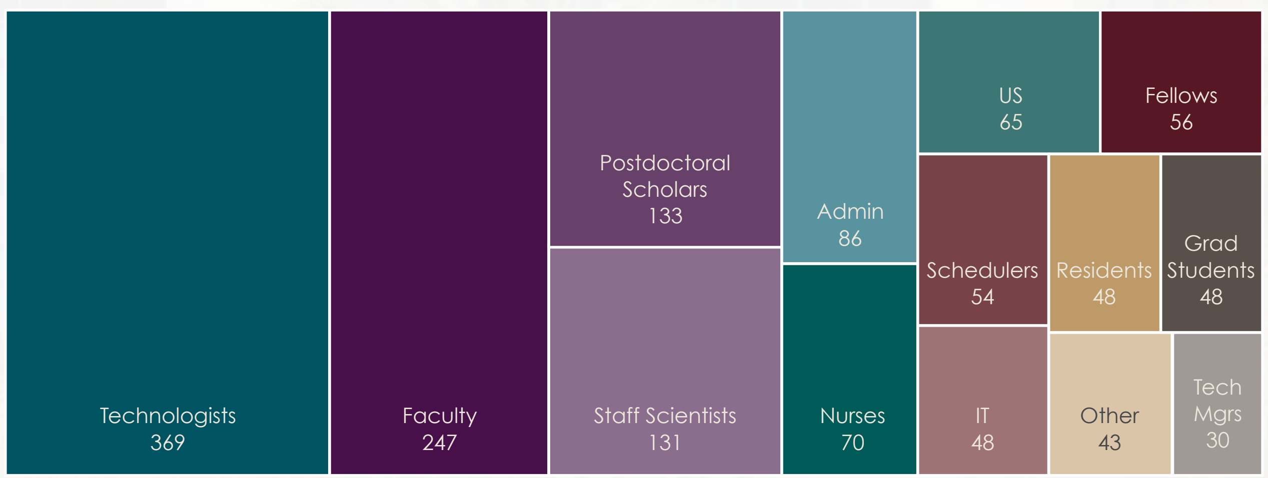


We are the Radiology Family

It takes all 1,425 talented and dedicated individuals to keep a busy department running. Each of you contributes a critical piece that makes a big difference.

Thank you all for your efforts to create the most outstanding team possible.

Sanjiv Sam Gambhir MD, PhD
Virginia and D. K. Ludwig Professor of Cancer Research
Chair, Department of Radiology



247 Total Faculty

783 Total Clinical

395 Total Research

1,425 Radiology Family


Al Macovski's 90th Birthday Celebration


2018 Alumni Dinner


2018 Winter Party


2018 MIPS Retreat


2018 Alumni Dinner


2017 RSNA


2017 RSNA


2018 RSNA


2018 Winter Party


2018 Winter Party

Thank you Stanford Leadership and Colleagues

We are sincerely grateful for your continued support and the ongoing support from all basic science and clinical chairs throughout the School of Medicine.

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Stanford Department of Radiology thanks the following foundations for their generous support of our research in the imaging sciences including technology development and solutions for the early detection, monitoring, and treatment of disease.

We also thank our generous industry partners for their ongoing support.

Academy for Radiology and Biomedical Imaging Research

American Association for Cancer Research

American Brain Tumor Association

Association of University Radiologists

Ben and Catherine Ivy Foundation

Burroughs Wellcome Fund

Canary Foundation

Coulter Foundation

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Etta Kalin Moskowitz Fund

Focused Ultrasound Surgery Foundation

Ford Foundation

Foundation of the American Society of Neuroradiology

General Electric Healthcare

Intermountain Healthcare

Philips Healthcare

Pliant Therapeutics, Inc.

Radiological Society of North America (RSNA)

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Siemens Medical Solutions, Inc.

Society of Interventional Radiology Foundation

Society of Nuclear Medicine Education and Research Foundation

Stanford Bio-X

Wu Tsai Neurosciences Institute

Supporting the Stanford University Department of Radiology

If you would like to learn more about ways to support any area of research or training in the Stanford Department of Radiology, please feel free to contact any of the following members of the department.

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CANARY CHALLENGE

The annual Canary Challenge cycling event and 5K walk/run has been hosted by the Canary Foundation since 2011 to increase awareness and raise funds for the Canary Center at Stanford for Cancer Early Detection. Founded in 2004, the Canary Foundation is the world's first non-profit organization dedicated solely to the funding, discovery, and development of tests for early detection of cancer and has helped catalyze the field by supporting young researchers and innovative ideas. Each year in September, an amazing community of cyclists, volunteers, and sponsors have come together to support the vision of the Canary Foundation. The 2018 Canary Challenge had more than 800 participants, 59 teams, and raised over $750,000. Over the past eight years, more than 2,500 riders and walkers have raised more than $7 million dollars for cancer early detection research. Unfortunately, the Foundation announced that the 2018 Canary Challenge would be the last event of this eight-year successful initiative.

The Canary Foundation, however, invites everyone to continue to "ride along" and work with them towards a shared vision to continue advancing programs in prostate, ovarian, breast, lung, and pancreatic cancers. Members of the community can learn more by receiving "The Challenge" newsletter, a short quarterly summary of the Foundation's initiatives (www.canaryfoundation.org). The Canary Center is currently exploring possibilities with other partners to continue the promise of this annual event.

www.canarychallenge.org


2019 Welcome Party


2018 RSNA


2018 RSNA


2019 Welcome Party


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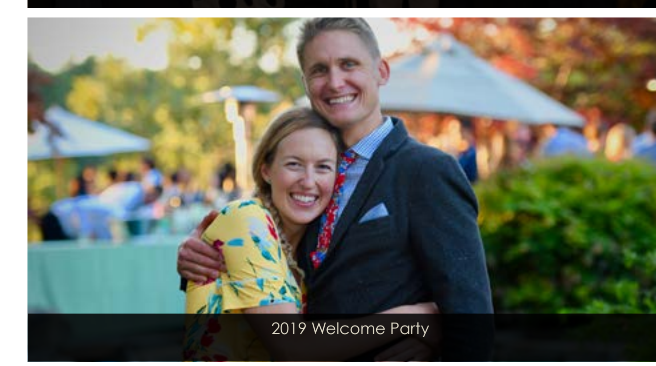
2017 RSNA


2018 RSNA


2019 Welcome Party


2019 Welcome Party


2018 RSNA

Terms Listed

3D, 3-Dimensional

ABNM, American Board of Nuclear Medicine

ABR, American Board of Radiology

ACGME, Accreditation Council for Graduate Medical Education

ACR, American College of Radiology

ADNI, Alzheimer's Disease Neuroimaging Initiative

AI, Artificial Intelligence

AIMBE, American Institute for Medical and Biological Engineering

AIMI, Artificial Intelligence in Medicine & Imaging

AMD, Age-Related Macular Degeneration

ASNR, American Society of Neuroradiology

AUR, Association of University Radiologists

BBB, Blood-Brain Barrier

BMI, Body Mass Index

BOLD, Blood-Oxygen-Level-Dependent

CAD, Computer-Aided Detection

CECI2, Council of Early Career Investigators in Imaging

CT, Computed Tomography

CTA, Computed Tomography Angiography

CT-FFR, Computed Tomography-Fractional Flow Reserve

DARPA, Defense Advanced Research Projects Agency

DoD, Department of Defense

DOSMA, Deep-Learning, Open-Source framework for Musculoskeletal MRI Analysis

EEG, Electroencephalogram

FDA, Food and Drug Administration

fMRE, Functional Magnetic Resonance Elastography

fMRI, Functional Magnetic Resonance Imaging

FUS, Focused Ultrasound

GAN, Generative Adversarial Network

IR, Interventional Radiology

IRB, Institutional Review Board

ISMRM, International Society for Magnetic Resonance in Medicine

IVC, Inferior Vena Cava

JSRT, Japanese Society of Radiological Technology

LPCH, Lucile Packard Children's Hospital

MR-ARFI, Magnetic Resonance-Acoustic Radiation Force Imaging

MR, Magnetic Resonance

MRgFUS, Magnetic Resonance-guided Focused Ultrasound

MRI, Magnetic Resonance Imaging

MRS, Magnetic Resonance Spectroscopy

MSC, Mesenchymal Stem Cells

NCI, National Cancer Institute

NIBIB, National Institute of Biomedical Imaging and Bioengineering

NIH, National Institutes of Health

NIRF, Near-Infrared Fluorescence

NIRS, Near-Infrared Spectroscopy

PAI, Physics of Artificial Intelligence

PET-CT, Positron Emission Tomography-Computed Tomography

PET-MR or PET-MRI, Positron Emission Tomography-Magnetic Resonance Imaging

PET, Positron Emission Tomography

RF, Radio Frequency

RSNA, Radiological Society of North America

SCARD, Society of Chairs of Academic Radiology Departments

SCIT, Stanford Cancer Imaging Training

SHC, Stanford Health Care

SNMMI, Society of Nuclear Medicine and Molecular Imaging

SNMMI-ERF, Society of Nuclear Medicine and Molecular Imaging-The Education and Research Foundation

SPECT, Single Photon Emission Computed Tomography

tDCS/tACS, Transcranial Direct Current Stimulation/Transcranial Alternating Current Stimulation

TENS, Transcutaneous Electrical Nerve Stimulation

TIPS, Transjugular Intrahepatic Portosystemic Shunt

TMS, Transcranial Magnetic Stimulation

UC, University of California

US, Ultrasound

USC, University of Southern California

VAPAHCS, Veterans Affairs Palo Alto Health Care System

WMIC, World Molecular Imaging Congress