The green/red matrix represents a database of patients (rows) with lung cancer and the expression of a multitude of genes (columns) from their tumors. Artistically rendered together, these images illustrate the idea of building integrated databases of image, clinical outcomes, and advanced tissue analysis data, within which individual patients can be compared to others for decision support, biological discovery, and prediction of outcome in response to therapy.

A volumetric CT reconstruction is provided showing a lung cancer tumor (green) within the lung (brown).
Contents

Message from the Chair 1

Faculty 4
Department Chair and Associate Chairs 6
Section Chiefs 7
New Faculty 8
Faculty 10
Faculty Transitions 12
Emeriti 14
In Memoriam 16

Clinical Education and Training 18
Radiology Residency Program 20
Nuclear Medicine Residency Program 22
Fellowships in Radiology 24
Advanced Residency Training at Stanford 26
Radiology Clerkship 28
Visitors Program 29

Research Education and Training 30
Advanced Techniques for Cancer Imaging and Detection 32
Training in Biomedical Imaging Instrumentation 36
In Vivo Cellular and Molecular Imaging Center at Stanford 37
Stanford Molecular Imaging Scholars 38

Clinical Sections 40
Abdominal Imaging 42
Body MRI 44
Breast Imaging 46
Cardiovascular Imaging 48
Interventional Radiology 50
Musculoskeletal Imaging 52
Neuroradiology 54
Nuclear Medicine and Molecular Imaging 56
Pediatric Imaging 58
Thoracic Imaging 60
Veterans Affairs-Diagnostic Radiology 62
Veterans Affairs-Nuclear Medicine 64

Research Sections 66
Canary Center Overview 68
Multiscale Diagnostics Laboratory (Mallick) 70
Cancer Molecular Diagnostics Laboratory (Pitteri) 71
ISIS Overview 72
Radiology 3D Visualization and Analysis Laboratory (Napel) 74
Imaging Bioinformatics Laboratory (Paik) 75
Cancer Systems Laboratory (Plevritis) 76
Quantitative Imaging Laboratory (Rubin) 78
MIPS Overview 80
Cancer Molecular Imaging Chemistry Lab (Cheng) 82
Multimodality Molecular Imaging Lab (Gambhir) 84
Molecular Imaging of Nociception and Inflammation Laboratory (Biswal) 85
Translational Tumor and Stem Cell MR Imaging Lab (Daldrup-Lipman) 86
Molecular Imaging Instrumentation Lab (Levin) 87
Cellular Pathway Imaging Laboratory (Palmurugan) 88
Cellular and Molecular Imaging Lab (Liu) 90
Cardiovascular Cellular & Molecular Imaging Lab (Wu) 91
Translational Molecular Imaging Lab (Willmann) 92
RSI Overview 94
Bammer Lab (Bammer) 96
MR-guided Focused Ultrasound and Cancer Interventions (Butts Pauly) 97
X-Ray Guidance of Interventional Procedures (Fahrig) 98
Functional Neuroimaging (Glover) 99
Joint and Osteoarthritis Imaging with Novel Techniques (Gold) 100
Body MR Imaging Laboratory (Hargreaves) 101
Inverse Geometry CT and Conventional CT (Pelt) 102
High Field Magnetic Resonance Program (Rutt) 103
Magnetic In Vivo Spectroscopy and Multinuclear Imaging (Spielman) 104
Clinical Center for Advanced Neuroimaging (Zaharchuk/Moseley) 106

Centers and Programs 108
US Guided Interventions 110
Stanford Center for Cancer Systems Biology 112
Center for Cancer Nanotechnology Excelence and Translation 114
In Vivo Cellular and Molecular Imaging Center at Stanford 116
Center for Biomedical Imaging at Stanford 118

Facilities and Services 120
New Research Facilities 122
Stanford Radiology 3D and Quantitative Imaging Laboratory 124
Cyclotron and Radiochemistry Facility 126
Lucas Center MR Systems 128
Lucas Center MR Systems Training 129
Small Animal Imaging Facility 130
Animal Model Management 131

Faculty Honors 132

The People Connection 138

Appendix 144
Sponsored Projects 146
Presentations and Publications 154
Peer-Reviewed Presentations at Scientific Meetings 154
Other Scientific Meeting Presentations 167
Published Papers 179
Books & Book Chapters 197
Collaborators 199
Summary Statistics 200
Canary Challenge 202
It has been a terrific 18 months of learning and personal growth in my new role as Chair of the Department of Radiology. I can hardly believe how much has happened in such a short time - thanks to the hard efforts of so many wonderful faculty colleagues and staff. The Stanford School of Medicine is in a great growth phase and the Department of Radiology is poised for continued growth with multiple new areas of clinical and research expansion.

With a truly outstanding faculty and staff, we continue to push the boundaries of what Radiology as a field will become in the years to come. “Science without borders” will be one of the key themes during my chairmanship. This will be accomplished through creating significant bridges to scientific and clinical activities throughout the medical school, affiliated hospitals, and across the Stanford campus.

Several new departmental cultural changes have been initiated that I hope become traditions in the years ahead. These include: (i) Honoring our retiring faculty and emeriti. We all rest on the shoulders of these great giants; we will continue to honor them in different ways in the years to come. (ii) Honoring promotions and advancements of our existing faculty by recognizing their accomplishments at faculty meetings and other events. (iii) Providing our junior faculty opportunities for formal leadership training and providing them leadership opportunities that yield significant career growth. (iv) Building better bi-directional relationships between faculty and staff by providing proven tools from our business school so that, together, we all succeed. (v) Valuing all aspects of our enterprise including patient care, basic/translational/clinical research, education, and administrative efforts by investing in each area. (vi) Enhancing transparency in all of our activities so that everyone has a chance to weigh in on major decisions within a culture that respects an open process. (vii) Providing faculty with expert advice for their intellectual property and potential startup ventures from consulting faculty with expertise in entrepreneurship. (viii) Building a culture where our residents have a chance for greater interaction with other residents in the Department. Additionally, encouraging residents to do research and providing them with opportunities and funding to do so. (ix) Improving the quality of the care we deliver to our patients by changing the Department culture of quality and safety through greater education and investment. (x) Developing a regular CME grand rounds in order to bring faculty and trainees together on a monthly basis to listen to the best our field has to offer from physicians and scientists around the world. (xi) Investing in research using Departmental funds by allowing a fair and competitive process such as the new “Angel Funds” to seed and nurture innovative pilot research.

With the opening of many new facilities, our growth in space for both clinical and research facilities is tremendous. In clinical space, faculty and staff are working hard on both the pediatric and adult hospital expansions that will open in 2017 and 2018 respectively. We will also open three new imaging facilities in 2014-2015: 1) a south bay radiology facility as part of the Cancer Center expansion, 2) a new Neuroradiology Imaging Center in Hoover 2 to complement the expansion in clinical neurology/neurosurgery, and 3) the Breast Imaging Clinic in the Cancer Center will also undergo
Several faculty searches are currently in progress and include the Chief of Neuroradiology, Chief of VA Palo Alto Radiology Service, Pediatric Radiology, Pediatric Imaging Scientist, Cardiovascular Imaging, and multiple basic and translational science recruitments. A search for an Associate Chair of Quality Assurance (QA) has recently concluded with the recruitment of Dr. David Larson (Associate Professor, Pediatric Radiology, and Associate Chair of Performance Improvement, Department of Radiology), recruited from Cincinnati Children’s Hospital.

We also had major changes in staff leadership with hiring a new DFA (Yun-Ting Yeh) and a new assistant DFA (Lin Ng). We are very fortunate to have them heading our entire administration with their significant prior experience in leading and managing large groups. In addition, we have made multiple staff position changes based on programmatic needs that will lead to continued improvement in administrative efficiency in the Department.

Research has been on a tremendous trajectory as well. We continue to receive new NIH funding and according to the most recent data published by the Academy of Radiology Research in 2011, we are the second highest NIH-funded Radiology Department in the country and the highest NIH-funded per capita of all Radiology Departments in the USA. Industrial collaborations continue to grow with new research funding from Sanofi-Aventis and others. Drs. Zhen Cheng and Fred Chin also recently obtained funding from the Department of Energy for PET based molecular imaging. The NCI training grant (T32) has also been renewed under the leadership of Drs. Sandy Napel and Graham Sommer. Multiple R01s were also renewed in this difficult funding environment. Although the NIH funding environment has become very tough and will likely get even tougher, we are relatively well positioned to be highly competitive and weather the storms ahead.

In addition, through help from several foundations including the Canary Foundation, Ben and Catherine Ivy Foundation, and the Sir Peter Michael Foundation (Laguerre) we have raised in excess of $20 million for research, the highest gift funding in the history of the Department.

We have also been working hard with the Canary Foundation to build bridges with the community and had the Canary bike ride in 2012 and will do so again in September 2013 (see page 202). This activity brings together our entire Department for a great cause and raises research funding for our Department and for the Cancer Center.

It was my honor to serve as Co-chair of the search committee along with Provost John Etchemendy that helped to recruit Dean Lloyd Minor (previously Provost at Johns Hopkins) to become the new Dean of the Stanford School of Medicine. This is an important part of the new growth phase for Stanford Medicine and also a great learning experience for me personally.

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 all of our section chiefs and vice/associate chairs for their tremendous efforts and their continued support. It is my pleasure to learn from them each day and to benefit from their great collective wisdom, enthusiasm and support.

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 all of our section chiefs and vice/associate chairs for their tremendous efforts and their continued support. It is my pleasure to learn from them each day and to benefit from their great collective wisdom, enthusiasm and support.
Faculty
Department Chair and Associate Chairs

Sanjiv Sam Gambhir, MD, PhD
Chair, Department of Radiology

R. Brooke Jeffrey, MD
Vice Chairman
Associate Chair, Academic Affairs

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

Michael Federle, MD
Associate Chair, Education

Garry Gold, MD
Associate Chair, Research

Robert Herfkens, MD
Associate Chair, Clinical Technology

Ann Leung, MD
Associate Chair, Clinical Affairs

Section Chiefs

Richard Barth, MD
Pediatric Imaging

Christopher Beaulieu, MD, PhD
Musculoskeletal Imaging

Payam Massaband, MD
VA Palo Alto

Nancy Fischbein, MD
Neuroradiology

Sandy Napol, PhD
Information Sciences in Imaging
at Stanford

Dominik Fleischmann, MD
Cardiovascular Imaging

Sylvia Plevritis, PhD
Information Sciences in Imaging
at Stanford

Sanjiv Sam Gambhir, MD, PhD
Molecular Imaging Program at Stanford
Canary Center at Stanford for Cancer
Early Detection

Andrew Quon, MD
Nuclear Medicine and
Molecular Imaging

Gary Glover, PhD
Radiological Sciences Laboratory

George Segall, MD
Nuclear Medicine, VA Palo Alto

Lawrence “Rusty” Hofmann, MD
Interventional Radiology

Shreyas Vasanawala, MD, PhD
Body MRI

Andrei Iagaru, MD
Nuclear Medicine and
Molecular Imaging

Juergen Willmann, MD
Abdominal Imaging

Debra Ikeda, MD
Breast Imaging
Frederick Chin, PhD – Molecular Imaging Program at Stanford

Dr. Frederick Chin began his new faculty position as Assistant Professor of Radiology (Research) in the Molecular Imaging Program at Stanford (MIPS) section on February 1, 2013. Dr. Chin received his undergraduate degree in Chemistry with honors from Indiana University in 1991, and his PhD degree in Organic Chemistry with emphasis on PET Radiosynthesis in 2000 from Purdue University. From 2001-2007, he was a postdoctoral research associate in the Department of Chemistry at Purdue University, followed by a visiting postdoctoral fellowship at Lawrence Berkeley National Laboratory at UC Berkeley from 2001-2002. He spent 3 years at the National Institute of Mental Health (NIMH) from 2002-2005 as a postdoctoral research fellow. Dr. Chin was an Instructor in the Radiology department and, since 2005, has been Head of the Cyclotron Radiochemistry group in the Molecular Imaging Program at Stanford (MIPS). Dr. Chin has expertise in radiochemistry and synthetic organic chemistry. His research focus is on development of novel radiotracers for PET with an emphasis of 18F and 11C radiochemistry and an emphasis on neurogligands.

Palmyra Ghanouni, MD, PhD – Body MRI

Dr. Pejman Ghanouni joined the Department as Assistant Professor of Radiology in the Body MRI section on January 1, 2012. Following completion of his undergraduate training at Harvard, Dr. Ghanouni acquired his MD and PhD in the Medical Scientist Training Program (MSTIP) at Stanford in 2005. For his PhD research he used bio-physics and molecular biology to investigate the mechanism of activation of the beta-2 adrenergic receptor, a model G protein-coupled receptor. Dr. Ghanouni served as chief resident while at Stanford, and was awarded a Radiological Society of North America (RSNA) Trainee Prize in 2009 for his research using MRI to monitor the role of macrophages in the development of chronic pain behavior. Also prior to his faculty appointment, Dr. Ghanouni, as a National Cancer Institute (NCI) fellow, studied clinical and preclinical applications of MR-guided focused ultrasound surgery. Dr. Ghanouni is co-Principal Investigator on two human clinical trials using focused ultrasound to palliate painful bone metastases.

Henry Guo, MD, PhD – Thoracic Imaging and Nuclear Medicine Sections

Dr. Henry Guo joined the Department of Radiology as a Clinical Instructor in the Thoracic and Nuclear Medicine sections on July 1, 2012. He completed his undergraduate degree in Molecular Biology at MIT, after which he obtained his PhD in Molecular Pathology (2004) and his MD (2006) at University of Washington. For his PhD thesis, Dr. Guo conducted research on DNA repair mechanisms, mutations in cancer, and directed molecular evolution under the mentorship of Lawrence A. Loeb, MD, PhD. Following completion of his MD and PhD training, Dr. Guo completed an internship in internal medicine, surgery, and pediatrics at the Scripps Mercy Hospital San Diego, CA. He completed his radiology residency training and a one-year fellowship in Nuclear Medicine (general nuclear medicine, therapy, and PET-CT), followed by dedicated training in chest imaging, at Stanford. He is involved in clinical service, teaching, and applying molecular imaging tools to further enhance anatomic imaging, particularly in the chest.

Tarik Massoud, MD, PhD – Neuroradiology and MIPS Sections

Dr. Tarik Massoud joined the Department February 1, 2013, as a Professor of Radiology in the Neuroradiology and MIPS sections. He completed his medical training at the Medical School of the Royal College of Surgeons in Ireland and in Radiology at Oxford (UK), UCLA, and the University of Michigan. He is a Fellow of the Royal College of Radiologists in London and holds a research MD degree in experimental neuroimaging (National University of Ireland) and a PhD in molecular imaging (Cambridge). Dr. Massoud is a member of the Cambridge Cancer Centre and Cambridge Neuroscience, was formerly an Associate Professor of Radiology at UCLA, and has also held visiting Associate Professorships at Columbia and Milwaukee. Dr. Massoud was most recently a University Lecturer and Honorary Consultant in Neuroradiology and Molecular Imaging at the University of Cambridge and Addenbrooke’s Hospital in Cambridge, UK. His current interests include molecular imaging using reporter genes, experimental aspects of neuroimaging, clinical neuroradiology, radiological anatomy, and research education and academic training of radiologists.

Jennifer McNab, PhD – Radiological Sciences Laboratory

Dr. Jennifer A. McNab joined the Department as Assistant Professor of Radiology (Research) in the Radiological Sciences Laboratory (RSL) section on October 11, 2012. She was a Research Fellow at the Martinsos Center for Biomedical Imaging at Harvard Medical School and Massachusetts General Hospital. She received her BS degree from the Department of Physics and Astronomy at the University of British Columbia (Canada) in 2003, her MS degree from Department of Medical Biophysics at University of Western Ontario in 2005, and her PhD degree from Department of Clinical Neurology at University of Oxford (UK) in 2009. Dr. McNab has a strong background in diffusion imaging and pulse sequence development. She has made scientific contributions on complex diffusion imaging projects. Along with Dr. Brian Rutt, Professor of Radiology, she will play an important role in the building of Stanford’s high field MRI program.

Linda Morimoto, MD – Abdominal Imaging Section

Dr. Linda Morimoto joined the Department of Radiology as a Clinical Instructor in the Abdominal Imaging section on July 1, 2012. She completed her BA in Molecular and Cell Biology at the UC Berkeley in 2001 and received her MD from University of Southern California, Keck School of Medicine, in 2006. Dr. Morimoto was Chief Resident from 2009-10 and completed her residency in diagnostic radiology (2011) at Santa Clara Valley Medical Center, and followed up with a fellowship in body imaging at Stanford in June 2012. Dr. Morimoto is providing clinical service in body imaging and teaching radiology residents, fellows, and medical students during clinical service.

David Rex, MD, PhD – Neuroradiology Section

Dr. David Rex joined the Department of Radiology as a Clinical Instructor in the Neuroradiology section on July 1, 2012. He graduated, summa cum laude, from UC Berkeley in 1996 with a bachelor's degree in Computer Science and subsequently entered the Medical Scientist Training Program at UCLA School of Medicine where he received his PhD degree in Neuroscience in 2005 and his MD degree in 2006. He completed his residency in Radiology in 2011 and his fellowship in Neuroradiology in June 2012, both at Stanford. Dr. Rex is providing clinical service in Neuroradiology and involved in case conferences and didactic lectures to trainees. He is also teaching residents and fellows during clinical service.

Geoffrey Riley, MD – Musculoskeletal Section

Dr. Riley joined the Department of Radiology as a Clinical Associate Professor December 1, 2012. He received his BA from UC Santa Barbara and his MD from Creighton University School of Medicine. In 1997, Dr. Riley completed his residency in diagnostic radiology, and in 1998, completed fellowship training in MRI/MSK imaging, both at UC Davis. From 1998 to 2003, he worked at Kaiser in Walnut Creek, holding various associate chief positions. Since 2003, he was the president and partner at Imaging Partners Medical Group, covering three imaging centers in San Ramon, Hayward, and San Francisco. Dr. Riley also held adjunct associate clinical professor positions at UCSF and UC Davis, and is the current president of the San Francisco Bay Radiological Society.
Faculty Transitions

Retirees

Michael Goris, MD, PhD
Nuclear Medicine

Peter Moskowitz, MD
Pediatric Radiology

Faculty Departures

Scott Atlas, MD
Senior Fellow
Hoover Institution

New Administrative Roles

Roland Bammer, PhD
3DQ Lab Technical Director

Payam Massaband, MD
Interim Chief
Radiology Service, VA Palo Alto

Nancy Fischbein, MD
Acting Section Chief
Neuroradiology

Norbert Pelc, ScD
Chair, Department of Bioengineering

Dominik Fleischmann, MD
3DQ Lab Clinical Director

Andrew Quon, MD
Acting Co-Section Chief
Nuclear Medicine and Molecular Imaging

Garry Gold, MD
Associate Chair, Research

Juergen Willmann, MD
Section Chief, Abdominal Imaging

Andrei Iagaru, MD
Acting Co-Section Chief
Nuclear Medicine and Molecular Imaging

Joseph Wu, MD, PhD
Co-Director, Cardiovascular Institute

Peter Moskowitz, MD
Pediatric Radiology

Michael Goris, MD, PhD
Nuclear Medicine
Emeriti

Herbert Abrams, MD
Diagnostic Radiology

Ronald Castellino, MD
Diagnostic Radiology

Gerald Friedland, MD
Abdominal Imaging
Palo Alto VA

David Goodwin, MD
Nuclear Medicine
Palo Alto VA

Michael Goris, MD, PhD
Nuclear Medicine

Barton Lane, MD
Neuroradiology
Palo Alto VA

Albert Macovski, PhD
Radiation Therapy

Bruce Parker, MD
Pediatric Radiology

William Marshall, MD
Neuroradiology

Kendric Smith, PhD
Radiation Physics

I. Ross McDougall, MBCHB, PhD
Nuclear Medicine

Lewis Wexler, MD
Cardiovascular Radiology

Robert Mindelzun, MD
Abdominal Imaging

Leslie Zatz, MD
Neuroradiology

Peter Moskowitz, MD
Pediatric Radiology

F. Frank Zboralske, MD
Diagnostic Radiology

William Northway, MD
Pediatric Radiology
In Memoriam

Gary M. Glazer, MD (1950-2011)

Gary Glazer, MD, was an extraordinary man, a visionary and a pioneer in the field of radiology. Glazer served as chairman of the Department of Radiology at the Stanford University School of Medicine from 1989 until August 2011. He passed away on October 16, 2011, at age 61, after a long battle with prostate cancer.

Dr. Glazer, the Emma Pfeiffer Merner Professor in the Medical Sciences at Stanford, authored more than 155 scientific articles and three books. He was one of 21 radiologists ever to receive Gold Medal awards from both the Radiological Society of North America and the Association of University Radiologists. Among his many other national and international awards, he was given honorary membership in the French, Japanese and German radiological societies.

“Gary was the first of our generation to really hit it big in academic circles,” said William Bradley, Jr, MD, director of radiology at the University of California, San Diego. “He became chair at a young age and did some very innovative things. MRI was Dr. Glazer’s ticket for success”, Dr. Bradley said. The technology provided a financial foundation for growth through the department’s investment in Diasonics, a pioneer MRI scanner manufacturer, whose stock went viral at that time.

Moreover, Dr. Glazer gained the support of the Richard M. Lucas family, that funded the construction of the Richard M. Lucas Center for Magnetic Resonance Spectroscopy and Imaging in 1992, as well as a major addition to that facility in 2005. With aid from other private endowments, Stanford’s medical imaging facilities supported equipment inventory valued at more than $30 million. The university’s first-class infrastructure was a magnet for world-class researchers.

“Gary had an exceptional capacity to see new directions in which our field should go, even when that meant significant departures from the status quo,” Dr. Pelc remembered. “He used his intuition, as well as his ability to judge talent and his solid sense of right and wrong, to transform the department into the international leader it is now.”

Dr. Glazer was strongly dedicated to his family, including his wife Diane, and their two sons, David and Daniel. “Gary loved his family deeply and was tremendously proud of their many accomplishments,” said Radiology Professor and Associate Chair Richard Barth, MD, who has been a friend of Glazer’s since their days as residents at UCSF. “He often began meetings with a highlight about family milestones before diving into the business at hand. He was equally caring to his friends and colleagues, never missing an opportunity to inquire with genuine interest about their personal well-being.”

We are fortunate to have known and worked with Dr. Gary M. Glazer and pleased to call Gary our friend.

Henry H. Jones, MD (1917-2012)

Dr. Henry Jones, with more than 50 years of service to Stanford Radiology (1948-2006), died peacefully at home, Saturday, August 11, 2012 with his wife Peggy and family nearby.

Dr. Jones came to Stanford in 1948. He became the first chief of the radiology service at the Palo Alto Veterans Administration Hospital, and he earned the moniker “Bones Jones” in recognition of his subspecialty regarding the skeletal system. His research focused on the mechanisms governing the growth and modeling of the skeletal system. Dr. Jones left the department with a legacy of more than 2,000 case studies, which are being digitized to make them available to students today and in the future.

Students and faculty praised Jones as a devoted teacher, who won the medical school’s Henry J. Kaiser Award for Excellence in Teaching. His trainees have gone on to become radiologists in private practices and academic medical centers nationwide. As chief of the radiology service at the Palo Alto Veterans Administration Hospital, now the Veterans Affairs Palo Alto Health Care System, he trained many Stanford medical students, interns and residents. Upon assuming emeritus status in 1985, Jones also reported that he had provided pre-med counseling to 847 undergraduates.

“He was a wealth of experience and patient approach to problems was unmatched,” said Christopher Beaulieu, MD, PhD, chief of musculoskeletal imaging in the Department of Radiology. “We were all very lucky to have worked with him.”

Jones is survived by his wife, Peggy, of Stanford, daughter Virginia Jones of Castro Valley, CA, son Henry C. Jones of Eugene, OR, son Keasley Jones and daughter-in-law Autumn Stephens of Berkeley, CA, and two grandchildren. He also leaves many friends, colleagues and former students who retain warm memories of his exuberant spirit, which informed his customary way of ending a conversation: “Happy Day!”

James F. Silverman, MD (1932-2012)

Dr. James F. Silverman came to Stanford in 1969 to begin a two-year Fellowship in Cardiovascular Radiology, after which he accepted a junior faculty position. From the outset, it was clear that Dr. Silverman was a skilled clinical radiologist and a natural teacher. He produced 44 manuscripts, mainly in the fields of cardiac radiology and health policy research. To assist angiographers, primarily cardiologists, he published a book, “Coronary Angiography: An Introduction to Interpretation and Technique,” that included a tear-out 3-D model of the heart. His academic career flourished and he was promoted to full Professor in 1984.

Dr. Silverman's interests in improving the quality of patient care led to his appointment as Clinical Chief of Diagnostic Radiology in 1974. He was the first physician to earn a Master’s degree in Business Management from the prestigious Sloan Program at the Stanford Graduate School of Business. From 1979 to 1986 he served as Chief of Staff of Stanford University Hospital, converting a previously ceremonial post into an active management position. Dr. Silverman instituted policies to expedite quality patient care by crafting strong working relationships between hospital administrators, physicians, hospital personnel and the Dean. During this period he also served as Associate Dean for Clinical Affairs, Stanford University School of Medicine.

Dr. Silverman loved the outdoors: camping and hiking with family and friends, skiing, tennis, running and golf. He was loyal, selfless, compassionate and great company. His devotion to his family was uncompromising and they were a source of constant joy to him. Barbara, his wife and best friend of 50 years, his daughter Susie and son Ben, their spouses and three grandchildren survive him.
Clinical Education and Training

Stanford Radiology offers multiple clinical training opportunities including the Radiology Residency (four years), Advanced Residency Training (ARTS – duration varies), Clinical Fellowships (1-2 years), a Clerkship (duration varies), and a unique Visitors’ Program tailored to each visitor for one-on-one training. In this section, we highlight those programs.
Radiology’s residency program provides four years of clinical training in a rich learning milieu where everyone is on a first-name basis and the faculty is passionate about teaching. The residents learn radiology working side-by-side with internationally acclaimed clinicians. They encounter a breadth of clinical material and gain confidence in their clinical skills through a carefully structured program of graduated responsibility and autonomy. Since our department’s research faculty are among the most productive and creative scientists in the world, the residents will preview -- even help develop -- the imaging of tomorrow while mastering the techniques of today. Please visit our website for more information about radiology residency training at http://xray.stanford.edu/. See next page for a current residents.
The residency training program in Nuclear Medicine and Molecular Imaging provides exceptional education in the basic science related to instrumentation, molecular imaging, and clinical nuclear medicine. The Stanford Nuclear Medicine & Molecular Imaging Clinic combines unique features in order to offer a solid multi-modality training program in both the adult and pediatric settings. The Program has the main rotations at the Stanford University Medical Center (including patients from Lucile Packard Children’s Hospital), as well as at the Palo Alto VA Hospital. Training in conventional Nuclear Medicine, PET/CT and therapeutic procedures is provided. Ample research opportunities are also a unique feature of the program.
The Department offers a number of one or two year postdoctoral clinical fellowships that begin July 1 of each year. Each Section in Radiology interviews and selects fellows specific to their area of clinical interest.

Fellowships in Radiology

Fellowship Directors:
Abdominal Imaging: Brooke Jeffrey, MD and Aya Kamaya, MD
Breast Imaging: Sunita Pal, MD
Cardiovascular Imaging: Frandics Chan, MD, PhD
Interventional Radiology: William Kuo, MD
Musculoskeletal Imaging: Sandip Biswal, MD
Neuroradiology: Huy Do, MD
Neuro/Interventional: Michael Marks, MD
Nuclear Medicine PET/CT: Andrew Quon, MD
Pediatric Radiology: Richard Barth, MD and Erika Rubesova, MD
Thoracic Imaging: Ann Leung, MD
The ARTS Program offers the opportunity to combine clinical training with advanced research training to complete a PhD degree during or upon completion of residency or clinical fellowship. The program begins with one or more years of postgraduate clinical training, followed by research training in a graduate program in Stanford University’s Schools of Medicine, Engineering, or Humanities and Sciences.

Residents/clinical fellows admitted to the program complete clinical training toward board certification in their chosen field. These include internal medicine, its subspecialties (cardiovascular medicine, hematology, immunology and rheumatology, infectious diseases, nephrology, oncology, pulmonary and critical care medicine), surgical disciplines (neurosurgery, obstetrics and gynecology, surgery and urology), or non-surgical disciplines (neurology, pediatrics, psychiatry, radiation oncology and radiology).

The Advanced Residency Training at Stanford (ARTS) Program prepares trainees for today’s competitive clinical/research environment that demands rigorous scientific training for young academicians. The ARTS Program offers a high level of knowledge and intense training to physician-scientists. The program is designed to prepare trainees for a career that combines basic science research with residency or clinical fellowship training. The goal is to foster development of physicians with comprehensive scientific training. Applications for this program are accepted throughout the year. Please see the ARTS program website for further details at http://med.stanford.edu/arts/.

**Current Students**

- **Andrew Beck, MD**
  - Pathology - Resident
  - PhD Program: Biomedical Informatics, 2009-Present
  - Mentor: Daphne Koller, PhD

- **Katherine Fuh, MD**
  - OB/GYN - Gynecology Oncology Clinical Fellow
  - PhD Program: Cancer Biology, 2009-Present
  - Mentor: Amato Giaccia, PhD

- **Elizabeth Choe, MD**
  - Medicine - Cardiovascular Medicine Fellow
  - PhD Program: Cancer Biology, 2010-Present
  - Mentor: James Spudich, PhD

- **Haruka Itakura, MD**
  - OB/GYN - Gynecology Oncology Clinical Fellow
  - PhD Program: Cancer Biology, 2009-Present
  - Mentor: Phil Tsao, PhD

- **Charles Gawad, MD**
  - Pediatrics - Hematology/Oncology Clinical Fellow
  - PhD Program: Cancer Biology, 2011-Present
  - Mentor: Patrick Brown, MD, PhD

- **Eugene Richardson, MD**
  - Medicine - Infectious Diseases and Geographic Medicine Fellow
  - PhD Program: Sociology, 2012-Present
  - Mentor: Andrew Zolopa, MD

- **David Kurtz, MD**
  - Medicine - Resident
  - PhD Program: Bioengineering, 2012-Present
  - Mentor: Sanjiv Sam Gambhir, MD, PhD
Visitors Program

The Department of Radiology is pleased to offer Visiting Fellowships in all subspecialties. Our unique program offers individualized instruction that ensures each participant will receive one-on-one training with some of the leading radiologists in the country. Each personally tailored program offers flexibility to accommodate the schedules of both the visitor and the sponsoring faculty member. Please visit our website to complete an application and specify your clinical focus area: http://radiology.stanford.edu/education/clinical/visitors.html. Also, contact Sofia Gonzales, Visitors’ Program Coordinator at sofias@stanford.edu.

Radiology Clerkship

Director: Michael Federle, MD

The goal of the basic four-week clerkship (Diagnostic Radiology and Nuclear Medicine Clerkship 301A) is to teach the fundamental principles of interpreting radiographic and nuclear medicine studies. The medical student will learn the value and limitations of such studies in commonly encountered clinical problems. The concept of what constitutes an adequate radiographic study will be examined. Case material will be selected to illustrate both normal and abnormal anatomic and physiologic states. Additionally, an introduction to the principles of radiation protection and the public health implications of diagnostic radiation will also be discussed. Contact Grayling Thompson (grayling@stanford.edu) for additional information regarding this course.

Visitors Program

Program Coordinators: Jackie Walker and Samantha Scott

The Department of Radiology is pleased to offer Visiting Fellowships in all subspecialties. Our unique program offers individualized instruction that ensures each participant will receive one-on-one training with some of the leading radiologists in the country. Each personally tailored program offers flexibility to accommodate the schedules of both the visitor and the sponsoring faculty member. Please visit our website to complete an application and specify your clinical focus area: http://radiology.stanford.edu/education/clinical/visitors.html. Also, contact Sofia Gonzales, Visitors’ Program Coordinator at sofias@stanford.edu.
Research Education and Training
Advanced Techniques for Cancer Imaging and Detection (SCIT)

Directors: Sandy Napel, PhD and Graham Sommer, MD
Program Manager: Sofia Gonzales, MS

http://scitprogram.stanford.edu/

The Department of Radiology at Stanford University offers qualified individuals a unique research opportunity through our Advanced Techniques for Cancer Imaging and Detection Program, which began its 20th year of training on March 1, 2012. Initially designed and directed by Dr. Gary M. Glazer in 1992, the goal of this program is to provide MD and PhD research fellows training in cancer-related imaging research. Fellows have the opportunity to work with our world-renowned faculty who are committed to sharing their knowledge and mentoring future leaders in radiology. Our program allows basic scientists in medical imaging (PhD) and clinical scientists (MD post-residency) to collaborate in an unparalleled environment that combines medical imaging sciences, clinical sciences, a strong cancer focus, and an institutional commitment to training academic radiologists and basic scientists in imaging science. New Program Directors, Drs. Napel and Sommer, renamed the program to “Stanford Cancer Imaging Training (SCIT) Program” and submitted a competing renewal application in January 2012, which was reviewed and given an outstanding score. Our program received news on March 10, 2013, that NIH will continue to fund the SCIT program for another five years or until 2018.

A specific aim of our training program is to position our trainees for a career in academic radiology. To date, we have graduated 34 trainees from our program, 24 of which have taken positions in academia, 3 in industry and 7 are in private practice. Our trainees continue to be extremely productive. We often collaborate with them in their new positions both locally and throughout the country. We are grateful to the National Institutes of Health for its recognition of the strength and success of our training program.

Recent graduates from the SCIT program include Dr. Pejman Ghanouni who ended his fellowship in December 2011 and joined the Department of Radiology as an Assistant Professor. Dr. Dragos Constantin also ended his fellowship in February 2012 and accepted a position as a Research Associate in Dr. Fahrig’s laboratory at Stanford. Assistant Professor. Dr. Dragos Constantin also ended his fellowship in February 2012 and accepted a position as a Research Associate in Dr. Fahrig’s laboratory at Stanford. Initially designed and directed by Dr. Gary M. Glazer in 1992, the goal of this program is to provide MD and PhD research fellows training in cancer-related imaging research. Fellows have the opportunity to work with our world-renowned faculty who are committed to sharing their knowledge and mentoring future leaders in radiology. Our program allows basic scientists in medical imaging (PhD) and clinical scientists (MD post-residency) to collaborate in an unparalleled environment that combines medical imaging sciences, clinical sciences, a strong cancer focus, and an institutional commitment to training academic radiologists and basic scientists in imaging science. New Program Directors, Drs. Napel and Sommer, renamed the program to “Stanford Cancer Imaging Training (SCIT) Program” and submitted a competing renewal application in January 2012, which was reviewed and given an outstanding score. Our program received news on March 10, 2013, that NIH will continue to fund the SCIT program for another five years or until 2018.

The following table lists all graduates from our NIH/NCI funded training program (T32 CA09695):

<table>
<thead>
<tr>
<th>NCI Fellow</th>
<th>Completed</th>
<th>Current Position</th>
<th>Current Institution</th>
<th>Primary Mentor</th>
</tr>
</thead>
<tbody>
<tr>
<td>John String, MD</td>
<td>1995</td>
<td>Assistant Professor</td>
<td>University of Rochester, Rochester, NY</td>
<td>Herfkens</td>
</tr>
<tr>
<td>Ian Chen, MD</td>
<td>1996</td>
<td>Radiologist</td>
<td>Southwest Washington Medical Center, Vancouver, WA</td>
<td>Li</td>
</tr>
<tr>
<td>Susan Lenderman, PhD</td>
<td>1996</td>
<td>Assistant Professor</td>
<td>Diagnostic Imaging, Virginia Commonwealth University, Richmond, VA</td>
<td>Glazer</td>
</tr>
<tr>
<td>Bruce Daniel, MD</td>
<td>1997</td>
<td>Associate Professor</td>
<td>Radiology, Stanford University, Stanford, CA</td>
<td>Herfkens</td>
</tr>
<tr>
<td>Gary Gold, MD</td>
<td>1997</td>
<td>Associate Professor</td>
<td>Radiology, Stanford University, Stanford, CA</td>
<td>Macovski</td>
</tr>
<tr>
<td>Yi-Fan Yan, PhD</td>
<td>1997</td>
<td>Research Scientist</td>
<td>GE Advanced Health Care</td>
<td>Glover</td>
</tr>
<tr>
<td>Esther Yeh, PhD</td>
<td>1998</td>
<td>Clinical Fellow</td>
<td>Radiology (Neuroradiology), UCSF, CA</td>
<td>Li &amp; Napel</td>
</tr>
<tr>
<td>Roger Shitina, MD</td>
<td>1998</td>
<td>Assistant Professor</td>
<td>University of Florida, FL</td>
<td>Pelc &amp; Herfkens</td>
</tr>
<tr>
<td>Steven Heim, MD</td>
<td>1999</td>
<td>Radiologist</td>
<td>Radiology Imaging Associates, Denver, CO</td>
<td>Li</td>
</tr>
<tr>
<td>Martin Bikom, MD</td>
<td>2000</td>
<td>Researcher</td>
<td>PET/Nuclear Medicine, Palo Alto VA, CA</td>
<td>Jeffrey</td>
</tr>
<tr>
<td>Curtis Coulam, MD</td>
<td>2001</td>
<td>Radiologist</td>
<td>Gen State Radiology Group, Boise, ID</td>
<td>Sommer</td>
</tr>
<tr>
<td>Lawrence Chow, MD</td>
<td>2002</td>
<td>Assistant Professor</td>
<td>University of Oregon, Eugene, OR</td>
<td>Sommer</td>
</tr>
<tr>
<td>Samir Gaccevce, PhD</td>
<td>2002</td>
<td>Assistant Professor</td>
<td>Radiology, Stanford University, Stanford, CA</td>
<td>Bednarski</td>
</tr>
<tr>
<td>Vishwanath Yang, PhD</td>
<td>2002</td>
<td>Research Associate</td>
<td>Radiology, Stanford University, Stanford, CA</td>
<td>Bednarski</td>
</tr>
<tr>
<td>Charles Lu, MD</td>
<td>2003</td>
<td>Radiologist</td>
<td>La Jolla Radiology, La Jolla, CA</td>
<td>Herfkens &amp; Sommer</td>
</tr>
<tr>
<td>Karl Vigen, PhD</td>
<td>2003</td>
<td>Research Scientist</td>
<td>University of Wisconsin-Madison, Madison, WI</td>
<td>Butts Pauly</td>
</tr>
<tr>
<td>Susan Hobbes, MD, PhD</td>
<td>2004</td>
<td>Radiologist</td>
<td>CT Section Chief, Kaiser Permanente, Walnut Creek, CA</td>
<td>Bednarski</td>
</tr>
<tr>
<td>John Levin, MD</td>
<td>2004</td>
<td>Radiologist</td>
<td>St. Luke’s Medical Center &amp; Clinic, Minneapolis, MN</td>
<td>Herfkens &amp; Sommer</td>
</tr>
<tr>
<td>Laura Pisani, PhD</td>
<td>2004</td>
<td>Postdoctoral Fellow</td>
<td>Radiology, Stanford University, Stanford, CA</td>
<td>Glover</td>
</tr>
<tr>
<td>Daniel Margolis, MD</td>
<td>2005</td>
<td>Assistant Professor</td>
<td>Dept. of Radiology, UCLA, Los Angeles, CA</td>
<td>Jeffrey</td>
</tr>
<tr>
<td>Daniel Eavis, PhD</td>
<td>2006</td>
<td>Postdoctoral Fellow</td>
<td>University of Washington, Seattle, WA</td>
<td>Pelc</td>
</tr>
<tr>
<td>Anthony Farnnou, MD</td>
<td>2007</td>
<td>Research Scientist</td>
<td>NIH, Washington, DC</td>
<td>Pelc &amp; Hargraves</td>
</tr>
<tr>
<td>Lewis Shin, MD</td>
<td>2007</td>
<td>Assistant Professor</td>
<td>Radiology, Stanford University, Stanford, CA</td>
<td>Herfkens</td>
</tr>
<tr>
<td>Michael McDonald, PhD</td>
<td>2007</td>
<td>Research Scientist</td>
<td>NIH, Washington, DC</td>
<td>Guccione</td>
</tr>
<tr>
<td>Byard Edwards, MD, PhD</td>
<td>2008</td>
<td>Scientific Researcher</td>
<td>Vanderbilt University</td>
<td>Jeffrey</td>
</tr>
<tr>
<td>Cristina Zavodnik, PhD</td>
<td>2008</td>
<td>Scientific Researcher</td>
<td>MIPS, Radiology, Stanford University, Stanford, CA</td>
<td>Gambhir</td>
</tr>
<tr>
<td>Jinhu Park, MD, PhD</td>
<td>2008</td>
<td>Assistant Professor</td>
<td>University of Southern California, Los Angeles, CA</td>
<td>Gambhir</td>
</tr>
<tr>
<td>Stephanie Bailey, PhD</td>
<td>2009</td>
<td>Scientific Researcher</td>
<td>Comprehensive SIDS/UCSD Cancer Center</td>
<td>Pelc</td>
</tr>
<tr>
<td>Moses Darupolu, PhD</td>
<td>2010</td>
<td>Postdoctoral Fellow</td>
<td>Radiation Oncology, Stanford University, Stanford, CA</td>
<td>Spielman</td>
</tr>
<tr>
<td>Rachel Bitton, PhD</td>
<td>2010</td>
<td>Postdoctoral Fellow</td>
<td>UCLA, Stanford University, Stanford, CA</td>
<td>Butts Pauly</td>
</tr>
<tr>
<td>Grace Yee, MD</td>
<td>2011</td>
<td>Radiologist</td>
<td>Alvarado Breast Center, La Jolla, CA</td>
<td>Jeffrey, Napel</td>
</tr>
<tr>
<td>Pejman Ghanouni, MD PhD</td>
<td>2011</td>
<td>Clinical Applications of MR Guided Focused Ultrasound Surgery</td>
<td>Assistant Professor, Stanford University</td>
<td>Butts Pauly</td>
</tr>
<tr>
<td>Dragos E. Constantinescu, MD</td>
<td>2012</td>
<td>MR Real Time Image Guidance in Radiation Therapy</td>
<td>Research Associate, Stanford University</td>
<td>Fabreg</td>
</tr>
</tbody>
</table>
Current NCI T32 Postdoctoral Trainee Research Interests

Catherine Moran, PhD

(2/16/2011 - 2/15/2013) received her PhD degree in Medical Physics in 2009 from the University of Wisconsin under the supervision of Dr. Walter Block. Her thesis work focused on radial MRI acquisition methods for the detection and diagnosis of breast cancer. She is currently a postdoctoral fellow in Dr. Brian Hargreaves’ lab in the RSL and is co-mentored by Dr. Bruce Daniel. Her primary research interest continues to be breast cancer with the goal of improving lesion characterization in breast MRI, with specific application of these techniques to women at a high risk for breast cancer. Training with Drs. Daniel and Hargreaves, her work encompasses both basic science and clinical translational aspects of breast MRI. Prior to beginning graduate school, Dr. Moran spent three years as a management consultant at PricewaterhouseCoopers, LLC, and utilizes this experience in improving business processes to facilitate the translation of research to the clinic.

Sarah Geneser, PhD

(2/16/2011 - 2/15/2013) received a Masters degree in mathematics and a PhD in computer science from the University of Utah in 2002 and 2008, respectively. She is currently a postdoctoral fellow in Dr. Lei Xing’s lab in Radiation Oncology working on improving the accuracy of radiation therapy targeting. Dr. Geneser has developed a novel method for treating lung and liver tumors that improves targeting accuracy while reducing the total time for delivery of radiation therapy. Dr. Geneser is also working with collaborators at UCSF (Pouliot and Kirby) to accurately model the effects of organ motion on radiation dose delivered to tissues to help account for organ motion in the treatment planning process and improve treatment accuracy.

Bhavya Shah, MD

(8/1/2011 - 7/31/2013) completed a double-major in Biologic Systems and Philosophy from Washington University and subsequently completed medical school at University of Missouri-Columbia. He completed a transitional internship at Lutheran General Hospital before completing his radiology residency at Boston University Medical Center. While there, Dr. Shah was involved in research projects investigating applications of quantitative magnetic resonance imaging in body imaging, interventional radiology and neuroradiology. During his residency he also engaged in research at the Massachusetts Institute of Technology in regenerative medicine applications of nanotechnology. He is presently working with Dr. Biswal and Dr. Beaulieu developing a database of quantitative features of radiographs of bone tumors for decision support and discovery applications, and investigating the imaging of pain from bone tumors. He looks forward to a career in academic radiology with a focus on bone tumors for decision support and discovery applications, and investigating the imaging of pain from bone tumors.

Sarah Geneser

Catherine Moran

Steven Sensarn, PhD

(3/1/2012 - 2/28/2014) received his PhD degree in Electrical Engineering in 2010 from Stanford University, is currently a postdoctoral fellow in Dr. Christopher Contag’s lab. Dr. Sensarn has designed and constructed a fluorescence endoscope system to enable wide-field imaging of tumor-targeting molecular biomarkers that were obtained from collaborators here at Stanford (Dr. Bogyo) and at Vanderbilt (Marnett). He has used this system to image colon polyps in rats (transgenic rats modeling human colon cancer). This work has led Dr. Sensarn to explore the link between cancer stages and the expression of target enzymes labeled with fluorescent biomarkers.

Daniel Golden, PhD

(7/1/2012 - 6/30/2013) received his PhD in Electrical Engineering at Stanford University in March 2011. His doctoral work in the field of space physics was performed in the VLF (very low frequency) group in the EE Department. His background and training, which involves the in-depth use of machine learning and statistical analysis, provides skills, which directly translate into the field of biomedical informatics, his particular area of interest. Dr. Golden’s planned research in Dr. Balbo’s lab focuses on the identification of quantitative imaging features derived from dynamic contrast-enhanced MRI (DCE-MRI) that can be used to characterize the heterogeneity of breast cancer lesions. The goal of this work is to provide a input for support in treatment plan decision-making. For Dr. Golden, imaging informatics is a shift in focus and commitment from space physics to the more humanitarian study of health and disease.

Christopher Parham, MD PhD

(7/1/2012 - 6/30/2013) received his MD and PhD in Biomedical Engineering from the University of North Carolina at Chapel Hill in May 2012. His doctoral work was focused on the development of a clinical Diffraction Enhanced Imaging (DEI) system. This novel imaging technique utilizes multiple x-ray interactions to generate high contrast, ultra-low dose images with applications to many areas of radiology. Initially developed using a synchrotron, the challenge has been to design a compact system for clinical use. After completing his doctorate, Dr. Parham co-designed and built a DEI prototype during his engineering post-doc at the UNC Biomedical Research Imaging Center. He then completed a medicine internship at the University of California, San Diego and will complete radiology residency training at UNC Chapel Hill in June 2012. Dr. Parham will be joining the radiology department at Stanford as a body imaging fellow and plans to continue working towards the development of new imaging technologies in Dr. Levin’s lab.

Bhavik Patel, MD

(7/1/2012 - 6/30/2013) received his B.S. in Microbiology from the University of Alabama and subsequently completed medical school at UAB. He completed a surgical internship at Harvard Medical School/Brigham & Women's Hospital before completing his radiology residency back at UAB. While at UAB, Dr. Patel was involved in research projects involving chest radiology, neuroradiology, interventional radiology, and abdominal imaging and was recognized with several awards including the RSNA Research & Education Foundation Roentgen Resident Research Award and the Alabama Academy of Radiology Robert Stanley Outstanding research award. His latest research focused on the Dual Energy CT applications in pancreatic lesions and hepatic steatosis. He has presented his findings at various scientific meetings, published his findings, as well as authored/co-authored two book chapters. At UAB, he served as Chief resident and served on several administrative committees. He is looking forward to continuing his body imaging research in Dr. Sommer’s lab.
Training in Biomedical Imaging Instrumentation (TBI²)

Directors: Norbert Pelc, ScD and Kim Butts Pauly, PhD

http://tbi2.stanford.edu/

In vivo Cellular and Molecular Imaging Center at Stanford (ICMIC)

Director: Sanjiv Sam Gambhir, MD, PhD
Program Manager: Billie Robles, BS

http://mips.stanford.edu/grants/icmic/

Training in Biomedical Imaging Instrumentation (TBI²) is a multidisciplinary pre-doctoral training program at Stanford University in biomedical imaging technology that is entering its third year. Our mission is to train the next generation of researchers in and inventors of biomedical imaging technology. Imaging technology continues to evolve at a rapid pace generating new techniques in research today that will become the standard of care for tomorrow. There is a high need for trained researchers in this field to fill positions in academia, industry, and government. Stanford University has a unique multidisciplinary research effort in biomedical imaging, spanning magnetic resonance, computed tomography and radiography, radionuclide and optical methods for molecular imaging, ultrasound, and hybrid imaging such as Xray/ MR and PET/MR, as well as image processing and analysis for diagnosis, radiation therapy, and science.

Our program attracts students from six different degree granting programs to train in biomedical imaging technology with faculty from 8 different departments and Interdepartmental Programs.

In general, we recruit two new trainees each year and provide each with financial support for 2 years. However, we were able to leverage the funding from NIH and currently have 2 new students (Farah Memon and Nicholas Dwork), and 3 second year trainees (Matt Bieniosek, Arbi Tamrazian and Mihir Pendse).

In vivo Cellular and Molecular Imaging Center (ICMIC)

Dominique van de Sompel, PhD, joined the ICMIC program in 2010. Dr. Van de Sompel completed his PhD training at the University of Oxford in Medical Image Processing prior to coming to Stanford and joining Dr. Sam Gambhir’s research lab in multimodality molecular imaging. Dr. Van de Sompel is particularly interested in algorithm development for quantitative in vivo cancer imaging, and would like to learn more about the underlying molecular biology that prompts the need for research in the first place. His current work is focused on Raman spectroscopy and photoacoustic tomography.

Thillai Sekar Veerapazham, PhD, also joined the ICMIC program in 2010. His interests in nanoscale synthesis and assembly for biomedical applications make him a good fit for the labs of Dr. Jianghong Rao and Dr. Heike Daldrup-Link. Dr. Veerapazham will acquire hands-on experience with cell cultures, collecting image data, small animal handling, as well as strengthening his organic and nanoparticle synthetic skills, as well as gaining experience with clinical work. His clinical interests focus on applying his basic science knowledge and experience in areas of breast cancer research.

The following table lists all graduates from our NIH/NCI funded ICMIC program (P50CA114747):

<table>
<thead>
<tr>
<th>ICMIC Fellow</th>
<th>Completed</th>
<th>Current Position</th>
<th>Current Institution</th>
<th>Primary Mentor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shum-Woo Lee, MD</td>
<td>2005</td>
<td>Assistant Professor</td>
<td>Gachon University Medical School, Incheon, Korea</td>
<td>Bressel</td>
</tr>
<tr>
<td>Gayatri Gowrishankar, PhD</td>
<td>2006</td>
<td>Research Scientist</td>
<td>Stanford University</td>
<td>Rao</td>
</tr>
<tr>
<td>Elmaz Yeni, MD</td>
<td>2007</td>
<td>Research Scientist</td>
<td>Nanox, Inc.</td>
<td>Melosh</td>
</tr>
<tr>
<td>Mitke Schopper, MD</td>
<td>2007</td>
<td>Chief Resident, Nuclear Medicine</td>
<td>Stanford University</td>
<td>Gambhir</td>
</tr>
<tr>
<td>Wuzei Cui, PhD</td>
<td>2007</td>
<td>Assistant Professor</td>
<td>Univ of Wisconsin, Madison, WI</td>
<td>Chen</td>
</tr>
<tr>
<td>Arne Vandenbroucke, PhD</td>
<td>2008</td>
<td>Research Scientist</td>
<td>Ceres BioScience</td>
<td>Levin</td>
</tr>
<tr>
<td>Frank Cochran, PhD</td>
<td>2008</td>
<td>Postdoctoral Fellow</td>
<td>Biomedical Engineering, Stanford Univ</td>
<td>Cochran</td>
</tr>
<tr>
<td>Michael Helms, PhD</td>
<td>2008</td>
<td>Research Scientist</td>
<td>Ceres BioScience</td>
<td>Contag</td>
</tr>
<tr>
<td>Phoebe Tran, MD, PhD</td>
<td>2008</td>
<td>Assistant Professor</td>
<td>Johns Hopkins</td>
<td>Felder</td>
</tr>
<tr>
<td>Jie Li, PhD</td>
<td>2008</td>
<td>Assistant Professor</td>
<td>Univ of Southern California</td>
<td>Chen</td>
</tr>
<tr>
<td>Gang Ren, PhD</td>
<td>2009</td>
<td>Research Scientist</td>
<td>Stanford University</td>
<td>Cheng</td>
</tr>
<tr>
<td>Michael Bemis, PhD</td>
<td>2009</td>
<td>Research Scientist</td>
<td>Stanford University</td>
<td>Marin</td>
</tr>
<tr>
<td>Prithi Balachandran, PhD</td>
<td>2009</td>
<td>Postdoctoral Fellow</td>
<td>Stanford University</td>
<td>Spigman</td>
</tr>
<tr>
<td>Zheng Mao, PhD</td>
<td>2009</td>
<td>Research Scientist</td>
<td>Stanford University</td>
<td>Cheng</td>
</tr>
<tr>
<td>John Renato, PhD</td>
<td>2010</td>
<td>Postdoctoral Fellow</td>
<td>Stanford University</td>
<td>Gamblir/Ratt</td>
</tr>
<tr>
<td>Dominique van de Sompel, PhD</td>
<td>2011</td>
<td>Postdoctoral Fellow</td>
<td>Stanford University</td>
<td>Gamblir</td>
</tr>
<tr>
<td>Pascal Kallai, PhD</td>
<td>2011</td>
<td>Postdoctoral Fellow</td>
<td>Stanford University</td>
<td>Harris</td>
</tr>
<tr>
<td>Thillai Sekar Veerapazham, PhD</td>
<td>2011</td>
<td>Postdoctoral Fellow</td>
<td>Stanford University</td>
<td>Ramasamy</td>
</tr>
<tr>
<td>Yang Liu, PhD</td>
<td>2011</td>
<td>Postdoctoral Fellow</td>
<td>Stanford University</td>
<td>Zhen Cheng</td>
</tr>
</tbody>
</table>
The Stanford Molecular Imaging Scholars Program was previously led by Dr. Sam Gambhir (September 2006 - August 2012) who transferred leadership to Dr. Craig Levin (September 2012). The Program is a cross-disciplinary postdoctoral training program at Stanford University that brings together 45 faculty mentors from 15 departments in the Schools of Medicine, Engineering, and Humanities and Sciences. Faculty mentors provide a diverse training environment spanning biology, physics, mathematics/biocomputation/biomedical informatics, engineering, chemistry, biochemistry, cancer biology, immunology, and medical sciences. The centerpiece of the SMIS program is the opportunity for trainees (PhD or MD with an emphasis on PhD) to conduct innovative molecular imaging research that is co-mentored by faculty in complementary disciplines. SMIS trainees also engage in specialized coursework, seminars, national conferences, clinical rounds, ethics training, and the responsible conduct of research. The three-year program culminates with the preparation and review of a mock grant in support of trainee transition to an independent career in cancer molecular imaging research that is co-mentored by faculty in complementary disciplines. SMIS trainees also engage in specialized coursework, seminars, national conferences, clinical rounds, ethics training, and the responsible conduct of research. The three-year program culminates with the preparation and review of a mock grant in support of trainee transition to an independent career in cancer molecular imaging with the ultimate goal of training them to become leaders in the field. Thus far, 20 trainees have entered the SMIS program and 13 have completed the program.

The following table lists all graduates from our NIH/NCI funded SMIS training program (R25 CA 118681):

<table>
<thead>
<tr>
<th>SMIS Fellow</th>
<th>Completed</th>
<th>Current Position</th>
<th>Current Institution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ted Che, PhD</td>
<td>2008</td>
<td>Research Scientist</td>
<td>Regeneron</td>
</tr>
<tr>
<td>Hans-Ten Jollin, PhD</td>
<td>2009</td>
<td>Consultant</td>
<td>Campbell Alliance</td>
</tr>
<tr>
<td>Keith Hartman, PhD</td>
<td>2009</td>
<td>Senior Analyst</td>
<td>Boston Consulting Group</td>
</tr>
<tr>
<td>Bryan Smith, PhD</td>
<td>2010</td>
<td>Research Scientist</td>
<td>Stanford University (MIPS)</td>
</tr>
<tr>
<td>Henry Haeberle, PhD</td>
<td>2010</td>
<td>Senior Scientific Officer</td>
<td>University of New South Wales, Australia</td>
</tr>
<tr>
<td>Hua Fan-Minogue, MD, PhD</td>
<td>2010</td>
<td>Graduate Student, BMI Program</td>
<td>Stanford University</td>
</tr>
<tr>
<td>Jennifer Prester, PhD</td>
<td>2010</td>
<td>Assistant Professor of Chemistry</td>
<td>University of California, Irvine</td>
</tr>
<tr>
<td>Richard Kimmor, PhD</td>
<td>2010</td>
<td>Senior Research Scientist</td>
<td>Canary Center for Cancer Early Detection</td>
</tr>
<tr>
<td>Marybeth Pyze, PhD</td>
<td>2011</td>
<td>Scientist</td>
<td>Stem CellFyx</td>
</tr>
<tr>
<td>Nicholas Conley</td>
<td>2012</td>
<td>Principal Research Engineer</td>
<td>HGST / Western Digital</td>
</tr>
<tr>
<td>Benjamin Coogrove</td>
<td>2012</td>
<td>Postdoctoral Scholar</td>
<td>Stanford University (Baxter Lab)</td>
</tr>
<tr>
<td>Eric Gonzalez</td>
<td>2012</td>
<td>Self Employed</td>
<td>Stanford University (MIPS)</td>
</tr>
<tr>
<td>Sharon Hori</td>
<td>2012</td>
<td>Postdoctoral Scholar</td>
<td>Stanford University (MIPS)</td>
</tr>
</tbody>
</table>

Moiz Ahmad, PhD, will begin his SMIS fellowship in Dec 2012 after completing his PhD in Medical Physics at The University of Texas Graduate School of Biomedical Science. His primary mentor in the program is Dr. Lei Xing. Moiz will be working on improving x-ray stimulated luminescence tomography, which uses targeted phosphor nanoparticles combined with spatially targeted x-ray stimulation for high-sensitivity molecular imaging.

Michael Angelo, MD, PhD, joined the SMIS program in 2012 after completing his clinical training in Clinical pathology at the University of California San Francisco. He is working with Drs. Garry Nolan and Helen Blau on developing a new methodology for multiplexed immunohistochemical staining for visualizing expression of dozens of proteins within a single tissue section.

Rehan Ali, PhD, joined the SMIS program in 2010 under the joint supervision of Drs. Edward Graves and Ramasamy Paulmurugan, after completing his PhD in Biomedical Image Analysis at the University of Oxford. His research focus is the development of non-invasive in vivo techniques for detecting and predicting tumor resistance to radiation therapy, using a combination of experimental and modeling techniques.

Jesse Jokerst, PhD, joined the SMIS program in 2009 after completing his PhD in Chemistry at University of Texas, Austin. With a background in graduate school that emphasized Raman fluorescent nanoparticles for biomarker measurement in vitro, Dr. Jokerst has found the SMIS program an opportunity to expand his experience in nanotechnology a perfect fit. His primary mentor in the program is Dr. Sam Gambhir.

Timothy Larson, PhD, began his SMIS fellowship in 2012 after completing his PhD in Biomedical Engineering at Duke University. Her primary mentor in the program is Dr. Brian Rutt. Prachi, in collaboration with Dr. Jianghong Rao’s group, is working on developing magnetic resonance imaging based molecular imaging systems to image cancer-specific enzymatic activity of protease in vivo. This work focuses on “smart” Gd-based probes, which upon encountering a specific molecular target aggregate to form nanoparticles, thereby increasing the detection sensitivity of the system.

Katherine Wilson, PhD, began her SMIS fellowship in 2012 after completing her PhD in Biomedical Engineering at The University of Texas at Austin. She is currently working with Dr. Juergen Willmann in the Department of Radiology as her primary mentor to develop molecular imaging contrast agents for combined ultrasound, photoacoustic, and mammographic imaging, three highly complementary modalities. The goal of these agents to aid in early detection of breast cancer in high risk patients with dense tissues, where current methods have poor sensitivity and specificity.
The Abdominal Imaging Section strives for excellence in clinical care, teaching, and research. Our goal is to care for our patients and referring clinicians with the utmost of professionalism and train the next generation of imaging scientists in the field of abdominal imaging.

Clinical Services
Abdominal imaging encompasses CT, ultrasound, MRI and fluoroscopy of the abdomen and pelvis. All of our inpatient and outpatient facilities have state-of-the-art equipment, and all examinations are optimized for maximal diagnostic information, and supervised by highly trained technologists and attending physicians. We strive to develop highly innovative techniques that push the boundaries of the diagnostic capabilities of advanced technologies.

Our Team
Our team at Stanford University Hospital (SHC) includes ten faculty dedicated to the use of conventional (fluoroscopy), cross-sectional (CT, US, MR) and molecular imaging techniques for diagnosing diseases of the abdomen and pelvis. In addition, we maintain strong collaborations with radiology faculty at the Palo Alto VA, which includes Drs. Laufik, Nino-Murcia, Okcott, Shin, and Yao.

Education
Our section is actively involved in the training of medical students, radiology residents, and fellows. Our radiology residents rotate through our CT, ultrasound and fluoroscopy services, and are frequently supervised by abdominal imaging attending radiologists while on the Body MRI service. All of our Abdominal Imaging Section members participate in resident conferences, as well as advanced lectures for our body imaging fellows. In addition to our standard, one-year body imaging fellowship in clinical radiology, there are additional research-focused fellowships in our section that are funded by the National Cancer Institute.

Research
Our section has multiple NIH grants dealing with such diverse areas as ultrasound contrast agents, MRI of the prostate and pancreas, and breast MRI. Numerous members of our faculty do translational clinical research involving such innovative techniques as photoacoustic ultrasound, high-intensity focused ultrasound, and 3-D imaging of the pancreas.
Body MRI
Section Chief: Shreyas Vasanawala, MD, PhD

The body MR section aims to provide outstanding patient care, lead innovations in the practice of body MR, and train the next generation of clinician scientists. The overall direction of the group is development of a tight link between diagnosis and therapy to enable highly personalized care.

Clinical Services

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. Each faculty member is an internationally recognized expert in body MRI, and has experience developing new methods to improve diagnostic precision. Recently we introduced whole body MR exams, MR-HIFU fibroid therapy, and MR elastography to our services.

Education

Recently, we have developed an innovative hands-on weekend intensive course focused on teaching trainees the essentials of body MRI. Core-concept interactive didactics are interlaced with hands-on imaging sessions. Participants are a mix of residents, fellows, technologists, attendings, and MR physicists actively learning to optimize images, troubleshoot, build protocols, time image acquisitions, and handle advanced post-processing.

Research

Body MRI research at Stanford is fostered by close collaborations and friendships between clinicians and research scientists in the Department of Radiology, the University, and throughout the Bay Area. The past year has seen strides in better cancer detection and treatment. We are grateful that these efforts are supported by multiple NIH and Foundation grants.

RESEARCH AREAS

- Breast MRI
- Fast MRI techniques
- Focal pancreatic ablation
- Focal prostate ablation
- Interventional MRI
- MR Angiography
- MR-HIFU of bone metastases and soft tissue tumors
- Novel MRI Hardware
- MR-PET
- Advanced Prostate MRI
- Quantitative Methods
- Sleep MRI
- Small Bowel Motility
- Whole body MRI
Our team is dedicated to improving the health and lives of women by detecting and diagnosing breast cancer at its earliest stage using standard and emerging advanced diagnostic procedures, one woman at a time. We are devoted to providing personalized and comprehensive breast care in a holistic manner, minimizing discomfort and anxiety, using Stanford’s expert physicians, a multidisciplinary approach, integrated healthcare solutions, and state-of-the-art equipment.

Clinical Services
We provide breast imaging services in two Stanford Hospital locations: the Advanced Medicine Women’s Center and the Blake Wilbur Outpatient Clinic, where our patients expect a full range of services dedicated to their individualized care. Our breast imaging centers achieved the Breast Imaging Center of Excellence designation from the American College of Radiology in 2011 due to our expertise in mammography, breast ultrasound, breast biopsy and MRI. We will also soon offer digital breast tomosynthesis, a recently FDA-approved 3D mammographic technique that has been shown in early clinical trials to increase cancer detection and decrease the rate of false positive exams in a screening population.

Our Team
Our team of five faculty are Radiology (ABR) credentialed and certified by the FDA Mammography Quality Standards Act (MQSA) to read mammography and tomosynthesis. Our team also includes seven technologists, a medical assistant and nurse.

Education
Our Breast Imaging Fellowship offers nine months of breast imaging, one month breast MRI, and two months of elective. The fellowship also provides a three-month body imaging (cross-sectional) rotation for individuals interested in this option. Research time is provided during the fellowship for academic projects.

Research
Breast imaging research is fostered by close collaborations among clinicians and research scientists. Our section also has long-standing collaborations with Surgical Oncology, Medical Oncology, Radiation Oncology, and Pathology.

Dr. Ikeda has published on digital breast tomosynthesis compared to full field digital mammography to respond to the need for improving breast cancer detection. She will continue this work with installation of 2 new tomosynthesis units in 2013. Other work includes the study of genetic signatures of breast tumors and surrounding stroma (Dr. Robert West, Pathology) and correlating results with plasma proteomics by mass spectrometry (Dr. Sharon Pitteri, the Canary Center). These data will be compared with their phenotypes on FFDM, US and MRI. Other work focuses on imaging utilization and women’s perceptions of breast density, risk and imaging tests in response to the California SB 1538 Breast Density Law, effective April 1, 2013.

Dr. Lipson’s research focuses on breast cancer risk assessment; mammographic density and cancer risk; early detection with alternative screening modalities including automated whole breast ultrasound and tomosynthesis; cost-effective strategies to assess the likelihood of breast malignancy and extent of disease using contrast-enhanced mammography and tomosynthesis; and the evaluation of novel biomarkers of cancer burden and neoadjuvant chemotherapy response. She received Department of Radiology Angel Funding for a pilot study of correlative imaging, leukocyte telomere length, and circulating telomerase levels of patients with benign and malignant breast lesions (Co-PI: Sharon Pitteri - Canary Center). She is also a co-investigator on an NCI-funded R01: “Genetics of mammographic breast density and breast cancer risk in a Kaiser cohort (PI: Weiva Sieh - Health Research and Policy).”

Drs. Pal, Kao and Schmelzel are 100% dedicated to patient care; their presence in the clinic provides a consistency to our infrastructure that enhances patient care by providing a familiar and comfortable experience for our patients. Our entire team is committed to a patient experience that includes a personal encounter focused entirely on a woman’s needs.
The Cardiovascular Imaging (CVI) section, a radiology subspecialty dedicated to the care of patients suffering from diseases of the heart and blood vessels, was built on the pioneering works of Drs. Herbert Abrams and Lewis Wexler, who developed many early catheter-based angiographic techniques. Following the revolutionary developments of cardiac MRI, cardiac CT and medical image post-processing in the 1990s, there was great interest in applying these technologies to cardiovascular diseases.

Thus, in 2001, Drs. Geoffrey Rubin and Robert Herfkens organized the CVI Section. The goals of the section are to support basic research in promising CVI technologies, to develop new patient imaging protocols, and to investigate innovative image-based treatments and their outcomes, including sophisticated post-processing techniques. CVI advanced imaging enables unprecedented 3- and 4-D visualization of complex cardiovascular anatomy, function, and pathology that facilitate treatment planning for surgical or endovascular procedures.

Clinical Services
The CVI section provides a full spectrum of noninvasive imaging services using MRI and CT for adult and pediatric patients with cardiovascular diseases. This includes diseases of the heart (coronary and valvular diseases, cardiomyopathy, tumors, and congenital heart disease) and diseases of the blood vessels (obstruction, aneurysm, dissection, thrombosis, and vasculitis). Patients are referred from adult cardiology, pediatric cardiology, rheumatology, cardiothoracic surgery, vascular surgery, interventional radiology, as well as the emergency department. Cardiovascular imaging is technically demanding and requires sophisticated image acquisition and contrast injection protocols carried out by experienced CVI faculty, and highly-trained CT and MRI technologists.

Our Team
The CVI faculty consists of renowned experts in non-invasive cardiovascular imaging. Dr. Fleischmann is an expert on CT technology, contrast medium kinetics, imaging post-processing, and aortic diseases. Dr. Chan is an expert in pediatric cardiovascular imaging and a nationally recognized specialist in congenital heart disease. Dr. Herfkens is an expert in cardiac MRI technology and cardiac nuclear medicine.

Education
The CVI Section provides dedicated training in non-invasive cardiovascular imaging for medical students, radiology residents and fellows, and visiting physicians. 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 multi-detector row CT and cardiovascular MR imaging systems. Clinical studies include CT and MR angiography of the aorta, coronary arteries, renal arteries, pulmonary arteries, peripheral arteries, mesenteric arteries, pulmonary and systemic venous structures as well as cardiac CT and MRI in the assessment of congenital heart disease, ischemic heart disease, valvular heart disease, cardiomyopathy, cardiac tumor, and pericardial disease. Fellows in the CVI program study cardiovascular diseases in adults as well as in children. Fellows may also participate in research projects and develop skills for clinical investigations.

Research
CVI section members engage in technical and clinical research programs that are enhanced through close collaboration with scientists and engineers in the Radiological Sciences Lab, and extensive collaborations with clinical and industry partners. Clinical research topics include imaging of the aorta and heart valves, transcatheter aortic valve replacement (TAVR), imaging of acute aortic syndromes. Research in pediatric cardiovascular imaging includes surgical planning for congenital heart disease, MRI 4D-flow visualization and measurements for cardiovascular physiology, radiation dose reduction strategies in pediatric cardiac CT, and sedation-free CT techniques. Technical research includes iterative image reconstruction in cardiovascular CT, contrast optimization for subsecond CT, and the development of image postprocessing technology of vascular diseases.

http://cardiovascularimaging.stanford.edu/
Interventional Radiology

Section Chief: Lawrence “Rusty” Hofmann, MD

The goal of the Interventional Radiology section is to provide outstanding patient care, education, and research while pioneering new interventional endovascular treatments. Our section is one of the most active clinical and research sections in the School of Medicine, with over 20 clinical research studies and an active basic research initiative. Our studies focus on three main areas of interest: Deep Vein Thrombosis (DVT)/Pulmonary Embolism, Venous Stenoses, and Interventional Oncology.

Clinical Services
We lead active clinical trials for the treatment of DVT and Pulmonary Embolisms (PE). Some of these studies are first in human studies to provide better treatments for subjects with DVT/PE. Our studies often bridge clinical and basic research. For example, in a DVT study we identify blood biomarkers linked to imaging characteristics to identify those patients who will develop DVT or PE; preliminary data has successfully identified potential DVT biomarkers for this purpose. Our group has also pioneered the treatment of venous stenoses in patients with May-Thurner Syndrome or in patients with vein blockages, typically due to deep vein thrombosis. We have also demonstrated that women on birth control pills who develop DVT present with a normal variant in venous anatomy (May-Thurner Syndrome) thereby significantly increasing their risk for DVT. We continue to pursue prospective and retrospective clinical trials for further study of the May-Thurner Syndrome.

Our Team
The interventional section includes eight faculty, five clinical fellows, two residents, five nurses, three medical assistants, two clinical trials coordinators, and one practice manager; all contributing to provide high-quality patient evaluation and management in a patient-oriented clinically intensive section that is unusual in the field of interventional radiology.

Education
Our section accepts five fellows annually with two residents rotating through at any one time. The fellowship experience encompasses the entire range of IR including vascular and nonvascular interventions. Fellowship trainees perform a variety of cases, including for example: tumor therapy (chemoembolization, radioembolization, radiofrequency ablation, cryoablation); transplant interventions; angioplasty; IVC filtration; venous reconstruction; vascular ablation and stenting; and aortic stent grafting. Our goal is to provide IR fellows with an extraordinarily high level of appropriate hands-on experience during this intense advanced training. We also ensure our residents of a rich experience that will benefit them in their clinical imaging career.

Research
We lead investigator sponsored and industry-sponsored clinical trials, including a new study utilizing a tumor selective vaccinia virus for the treatment of hepatocellular carcinoma, and a highly successful collaboration using Highly Focused Ultrasound (HIFU) to treat pain due to bone metastasis. Also, working with the Radiology, ISS section, CPMC, and the VA Palo Alto, we examine/describe microvascular invasion in hepatocellular carcinoma (HCC). This new project combines genomic signature from extracted tumors with radiological images to create a building block to help identify microvascular invasion prior to treatment. Study results ensure that individual HCC patients are offered appropriate treatment options.

We also specialize in localized delivery of therapy directly to a tumor using drugs or small radioactive beads. The VIPER project, shown in Figure 1, provides a gene-therapy treatment example using current techniques. We also conduct basic research with animal models to determine the potential off label, catheter based delivery of existing drugs for the treatment of acute pancreatitis.
The musculoskeletal (MSK) section aims to develop and deliver high quality imaging and image-guided procedures for patients with bone, joint, and soft tissue abnormalities.

**Clinical Services in Musculoskeletal Imaging**

The MSK service is one of the busiest and highest profile sections in the Department, serving Stanford Hospital and Clinics (SHUC) as well as part time coverage at the Palo Alto VA Medical Center (PAVAMC). Exam volumes in 2012 surpassed 60,000, including nearly 10,000 MRI studies and over 1,000 injection and interventional procedures. February 2013 marked the fourth anniversary of comprehensive MSK services at the Stanford Medicine Outpatient Center in Redwood City. This center has six diagnostic x-ray rooms, two 3T MRI scanners, a multidetector CT scanner, two radiography and fluoroscopy rooms, and an ultrasound room, all immersed in a beautifully appointed facility staffed with highly talented and committed staff. MSK provides interpretation of skeletal radiographs (x-rays), MRI, CT, and diagnostic US. Using fluoroscopy or US guidance, we inject or aspirate joints, tendon sheaths, and benign soft tissue collections. Recent enhancements to the clinical service include improved methods for MRI in patients with metallic implants, MR neurography, and special injections of biological agents such as platelet rich plasma. We provide all MSK imaging and image-guided therapeutic procedures to Stanford athletics as well as to the San Francisco 49ers Football Club and the Golden State Warriors Basketball Club.

**Our Team**

There are currently five MSK faculty primarily based at Stanford, including Christopher Beaulieu, MD, PhD, Section Chief, Garry Gold, MD, Kathryn Stevens, MD, Sandip Biswal, MD, and Amelie Lutz, MD. At PAVAMC, Payam Massaband MD, and Bao Do MD are the primary MSK radiologists. Vol Van Dalsem MD, director of outpatient imaging at Stanford, is an affiliated section member. Administrative support is provided by Thomas (T.J.) Mims.

**Education**

Each year there are two to three full time MSK clinical fellows. In recent years, nearly 50% of Stanford radiology residents have elected to pursue fellowship training in MSK. All faculty are active in developing lectures and teaching materials for either local use or online teaching.

**Research**

MSK faculty are involved in a number of clinical and basic science projects. Drs. Beaulieu and Do are particularly active in developing biomedical informatics methods for application to MSK and other areas. Dr. Gold, now Associate Chair of Research in the department, is actively involved in development of new MRI pulse sequences and imaging methods for articular cartilage and around metallic implants. Dr. Stevens is heavily involved in the translation of new MRI pulses to clinical utilization, and in clinically-focused MSK projects. Dr. Biswal is developing novel molecular imaging methods to image mechanisms of peripheral pain, primarily based in animal models. Dr. Lutz is also involved in abdominal imaging, and has special expertise in development of molecular imaging methods for early detection of ovarian cancer. In the MSK arena, she is particularly interested in imaging of peripheral nerves.
The Neuroradiology section provides diagnostic and interventional neuroradiological services at Stanford Hospital and Clinics (SHC). Lucille Packard Children’s Hospital (LPCH), and the Palo Alto VA (VAMC). Diagnostic neuroradiology includes imaging of the brain, spine, and head and neck with CT and MR, the diagnostic section also performs fluoroscopically-guided procedures such as lumbar puncture and myelography.

Interventional neuroradiology includes diagnostic angiography of the blood vessels that supply the brain, head and neck, and spinal cord, as well as therapeutic angiographic procedures related to treatment of aneurysms, vascular malformations, and acute stroke. Embolization of tumors, image-guided biopsies, vertebroplasty, and percutaneous sclerotherapy of vascular malformations of the head and neck are also provided.

In the past year, the interventional neuroradiology section introduced two new stent procedures, making Stanford Hospital one of the earliest hospitals in the nation to routinely use them: 1) a new stent retriever to open arteries at the time of acute stroke, and 2) an intravascular flow-diverting stent to occlude large and giant intracranial aneurysms.

Clinical Services and the Diagnostic Neuroradiology Team

The diagnostic neuroradiology service includes nine faculty and seven fellows, with five faculty based at SHC, two at LPCH, and two at the VAMC. Of the SHC-based members, acting section chief, Nancy Fischbein, MD, has particular expertise in head and neck imaging; she manages the head and neck service and collaborates with clinicians and researchers in Otolaryngology and Radiation Oncology; she also works on image post-processing projects with Dr. Roland Bammer’s group (page 96). Greg Zaharchuk, PhD, MD, recognized as a leading authority on non-invasive methods to image brain perfusion, collaborates with faculty in Neurology and Neurosurgery and conducts research to investigate xenon CT, arterial spin label perfusion, and bolus perfusion methods to evaluate cerebral perfusion. Michael Zeineh, MD, PhD, uses diffusion-tensor imaging (DTI) and high-field MRI methods to study epilepsy, Alzheimer disease, and traumatic brain injury; he also collaborates with Dr. Brian Rutt’s group (page 103) and Dr. Roland Bammer’s group (page 96). David Rex, MD, PhD, has expertise in functional neuroradiology and biomedical informatics, while Zina Payman, MD, has expertise in general neuroradiology. At LPCH, fat Barnes, MD, Chief of Pediatric Neuroradiology, is recognized as an expert in child abuse, while Kristen Yeom, MD, studies DTI methods related to the diagnosis and treatment of pediatric brain tumors. At the VA, Bart Lane, MD, performs both diagnostic and interventional neuro procedures and collaborates with the War-Related Injuries Group. Sirisha Komakula, MBBS, practices general diagnostic neuroradiology and collaborates on clinical and research projects with faculty in Spinal Neurosurgery and Otolarngology.

Clinical Services and the Interventional Neuroradiology Team

The interventional neuroradiology group consists of three full time physicians and two fellows. The faculty manage all adult and pediatric neuroradiological procedures performed at Stanford Hospital and LPCH and conduct clinical research studies. Michael Marks, MD, the interventional neuroradiology section chief, has ongoing research projects in ischemic stroke treatment, management of brain AVMs, and the endovascular treatment of intracranial atherosclerotic disease. Huy Do, MD, has research interests in percutaneous spine intervention, traumatic brain injury in athletes, and vascular treatment of oncologic diseases. Robert Dodd, MD, has a joint appointment in Neurosurgery and Radiology and does both endovascular interventions and open surgical procedures. He has research interests in cerebral artery vasospasm and pharmacologic protection strategies for vasospasm.

Education and Training

Resident and fellow training and education are central to the mission of the Neuroradiology section. Our competitive two year fellowship in diagnostic neuroradiology attracts strong candidates who join our group following residency training to develop their clinical and research skills in diagnostic neuroradiology. Many of our graduates are now in faculty positions at major universities across the country. An additional two fellows train in Interventional Neuroradiology each year to develop proficiency in diagnostic catheter angiography, catheter-based intervention, and image-guided procedures.
Nuclear Medicine and Molecular Imaging

Co-Section Chiefs: Andrei Iagaru, MD and Andrew Quon, MD

Nuclear Medicine uses radioactive materials (or tracers) to help diagnose and treat a variety of diseases. We determine the cause of a medical problem based on the function of an organ, tissue or bone. In this way Nuclear Medicine differs from x-ray, ultrasound or any other diagnostic tests that determine the presence of disease based on structural appearance.

Positron Emission Tomography (PET)
PET is a powerful diagnostic test that has a major impact on the diagnosis and treatment of disease. PET can detect and stage many cancers, often before they are evident through other tests. PET can also provide to physicians important information about heart disease and many neurological disorders.

Clinical Services
Our Clinic is an integral part of a busy tertiary referral center. We conduct SPECT/CT, PET/CT and therapies as routine clinical practice, as well as part of clinical translational research. We make every effort to support collaborations across academia, as well as with the industry, with the ultimate goal of advancing patient care. Our patients benefit from the most modern imaging modalities, delivered in a state of the art facility.

Our Team
The Nuclear Medicine and Molecular Imaging Clinic at Stanford includes 4 physicians, 2 scientists (radiochemistry, physics), 10 technologists, 1 nurse, 4 administrative and research support personnel, and 6 trainees.

Education
The Division of Nuclear Medicine and Molecular Imaging offers several programs for medical students, residents and fellows, with a mix of traditional didactics and strong clinical exposure. Our trainees rotate at the VA Palo Alto, Lucile Packard Children’s Hospital, and Stanford University Hospital. There are ample clinical research opportunities at the Stanford University Medical Center and more basic science oriented projects in the Molecular Imaging Program based at the Clark Center (http://nuclear-medicine.stanford.edu/education/).

http://nuclearmedicine.stanford.edu/
The mission for the pediatric radiology section is to improve the health of fetuses and children via high resolution imaging of both anatomy and function for detection and minimally invasive treatment of diseases.

Clinical Services
Pediatric radiologists provide a full compliment of pediatric imaging services including x-ray, fluoroscopy, ultrasound, CT, and MRI at the Lucile Packard Children’s Hospital at Stanford. Pediatric radiology subspecialists in cardiovascular imaging (Drs. Chan, Newman, and Vasanawala), neuroradiology (Drs. Barnes and Yeom), fetal imaging (Drs. Barth and Rubesova), and musculoskeletal imaging (Drs. Vasanawala and Rubesova) are aligned with the centers of excellence at the Lucile Packard and provide state of the art imaging care for children.

Our Team
The Pediatric Radiology section includes fifteen faculty and six clinical fellows. Our team of imaging specialists includes world renown clinicians and scientists and dedicated technologists and support staff. We strive to provide the very best in state-of-the-art imaging for children.

Education
The Pediatric Radiology Fellowship is jointly sponsored by the Lucile Salter Packard Children’s Hospital and Stanford University Hospital. Our clinical fellowship training 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. Pediatric Radiology faculty are devoted to teaching, patient care, and translational research. Fellows are exposed to a wealth of clinical case material in an organized, structured, hands-on educational approach. Fellows rotate through a series of services, including pediatric MRI, pediatric CT, PET/CT, pediatric fluoroscopy, pediatric neuroradiology, nuclear medicine, interventional radiology, and general radiography. Stanford’s program also provides a comprehensive educational curriculum, including didactic lectures pertinent to pediatric radiology, radiology case conferences, and multi-disciplinary imaging conferences in which all of the major pediatric clinical subspecialties participate. In addition, Stanford also offers interested fellows unique exposure to fetal imaging including fetal MRI and cutting-edge pediatric radiology research.

Research
Clinical and basic science research of the section address imaging issues unique to children including motion correction techniques, minimizing radiation exposure and general anesthesia requirements, visualization of anatomically small structures, and early detection of disease. Shreyas Vasanawala, MD, PhD, has developed MRI clinical applications to reduce radiation exposure, reduce effects of motion (Figures 1a-c), as well advanced cardiovascular flow imaging (Figure 1c). Kristine Yeom, MD, introduced fiber tract imaging of the pediatric brain at Lucile Packard Children’s Hospital over the past year to guide neurosurgical procedures and minimize neurologic deficits associated with brain tumor resection (Figure 2). Richard Barth, MD, and Erika Rubesova, MD, have collaborated to develop a fetal MRI program at Stanford to improve outcomes of fetuses with severe anomalies (Figure 3).
The thoracic imaging section provides a range of diagnostic examinations, including chest radiography and inpatient and outpatient computed tomography of the thorax, high-resolution chest CT, and low-dose CT screening for lung cancer.

Clinical Services
Chest section members serve as active consultants who work closely with the subspecialty services of Stanford Hospital and Clinics including infectious disease, pulmonary medicine, thoracic oncology, radiation oncology, thoracic surgery, and pulmonary pathology. Working in concert with pulmonologists and thoracic surgeons, the chest section began offering low-dose CT screening studies in the summer of 2012 for eligible individuals who are at high-risk for lung cancer (images). Current research activities in the section include a collaboration with ISIS in linking imaging and genomic data in patients with non-small cell lung cancer.

Our Team
There are currently three faculty in the section, all based at Stanford Hospital and Clinics. Ann Leung, MD, the section head, has particular expertise in imaging of infiltrative lung disorders and opportunistic pulmonary infections. Anne Chin, MD is a visiting assistant professor from the University of Montreal who will be working in the department for a 1-year period. Henry Guo, MD, PhD is fellowship trained in both chest imaging as well as nuclear medicine and began his appointment as a clinical instructor in July of 2012.

Education
Education on imaging of lung diseases either at the view box or in the form of lectures is provided by section members to medical students, radiology residents, radiology fellows, and pulmonary fellows. The section also offers a 1-year thoracic imaging fellowship with the majority of prior graduates now working in academic radiology departments across North America.

Research
Through on-going research with the ISIS group, the thoracic team collaborates to identify prognostic imaging biomarkers in patients with non-small cell lung cancer (NSCLC) by means of a radiogenomics strategy that integrates gene expression data and medical images by leveraging survival data in public gene expression data sets. These research techniques are currently being translated into clinical use to very soon improve patient care through early detection and monitoring of disease. Please see the cover of this year’s Annual Report for a sample of this work.

60-year-old woman with history of smoking was found on screening CT study (Figure A) to have a new 2mm nodule (arrow). On an 11-month follow-up CT study (Figure B), this nodule had increased in size (double arrows). Subsequent biopsy and staging resulted in diagnosis of an early stage small cell lung cancer that was successfully resected.
The VA Palo Alto is the key VA hospital of the region, consisting of three inpatient facilities and seven outpatient clinics throughout northern California and the Bay Area. The Palo Alto Health Care System is a flagship of the VA for clinical care and maintains one of the top three research programs in the VA. It is a large multispecialty tertiary care center with a 900+ bed system. There are multiple ongoing expansion projects with over $1 billion dollars of capital projects within the next decade, including a new radiology department. The Palo Alto VA serves more than 85,000 veterans including polytrauma, multi-organ system, as well as traumatic brain and spinal cord injury patients.

Clinical Excellence
The VA Department of Radiology helps provide our veterans with outstanding care utilizing state-of-the-art technology. The Department includes 16 radiologists, 47 technologists, 10 nursing and 11 administrative staff.

The Radiology team works to provide truly comprehensive care for our veterans, with faculty taking part in well over 30 interdisciplinary conferences each month and cultivating outstanding rapport with other departments. Our Department provides imaging services in all modalities and sections, including chest, cardiovascular, fluoroscopic, body, neuroradiology, and musculoskeletal imaging, as well as interventional radiology procedures. Recent Department milestones include the addition of numerous outstanding, Stanford-affiliated faculty as well as a planned expansion of the department physical plant. A new second 64 slice dual energy CT, a 3T MR, and two new ultrasound scanners have also been recently added.

Teaching
VA Radiology provides excellent resident teaching in all services, stemming from a strong faculty commitment to education. Residents also benefit from excellent pathology, high volume, and daily teleconferencing from Stanford Medical Center.

Research
We are strongly dedicated to both clinical and non-clinical research, with numerous ongoing studies including for example: 1) algorithms for improved image quality and radiation dose CT, 2) three dimensional image reconstruction, 3) functional neuroimaging - 4) neuroimaging of traumatic brain injury; 5) neuroimaging of degenerative brain diseases, 6) dynamic MRI of the airway during sleep, 7) imaging of complex cholecystitis, 8) MRI of the prostate; Gastrointestinal endoluminal imaging, 9) radiology informatics, 10) Metal artifact reduction in CT, 11) natural language processing, 12) PACS customization for paperless practice, 13) abdominal aortic aneurysm modeling and risk stratification, and 14) cloud based radiology training.

Sagittal high resolution MRI image of the upper airway obtained for obstructive sleep apnea research.
The Nuclear Medicine Service at VA Palo Alto Health Care System is a tertiary referral center in Northern California for veterans requiring PET/CT, myocardial perfusion imaging, and other molecular imaging procedures and radioisotope therapies. Veterans are also referred from Sacramento, San Francisco and Fresno VA medical centers for advanced imaging procedures.

The mission of the Nuclear Medicine Service is to maintain and improve the health of veterans through the use of unsealed radionuclides in diagnosis and therapy; advance the field through medical research in molecular imaging; and provide training for technologists and physicians.

Molecular imaging is an emerging discipline that uses radioisotopes and other imaging technologies to investigate processes at a cellular and molecular level. Molecular imaging performed in conjunction with anatomic based techniques such as CT and MR is known as Hybrid Imaging.

Clinical Services
The department has three SPECT-CT cameras, a PET/64-slice CT scanner, and one bone densitometer at the Palo Alto Division. A second bone densitometer is located at the Livermore Division. Approximately 6,000 procedures are performed annually, including 2,000 PET/CT scans, 2,000 myocardial perfusion studies, 1,000 general nuclear medicine/molecular imaging studies, and 1,000 bone density studies. The department also uses unsealed radioisotopes for therapy of hyperthyroidism and thyroid cancer, as well as palliation of painful skeletal metastases.

Our Team
The department is staffed by two full-time Nuclear Medicine Physicians, Chief Technologist, Nuclear Medicine Technologist Training Program Director, four Nuclear Medicine/CT Technologists, Administrative Officer, and three Program Assistants.

Education
Education and training is provided for nuclear medicine residents, radiology residents, and cardiology fellows. The department also has a Nuclear Medicine technologist training program, which is the only VA-based training program in the United States, and one of two training programs in Northern California. Our graduates have been hired by Stanford, University of California, VA medical centers throughout California, and other major hospitals.

Research
The department collaborates with investigators from Cardiology, Oncology and Neurology to support research in coronary artery disease, cancer, and dementia using molecular imaging.

A study investigating the impact of PET myocardial perfusion imaging (MPI) plus CT coronary arteriography (CTA) on clinical decision making is now closed to enrollment, and the results are being analyzed. PET MPI and CTA are also being used for a second protocol investigating the effect of exercise on severity of coronary artery disease. The department is also participating in a Phase 3 trial of a new F-18 radiopharmaceutical for PET MPI.

The VA/Stanford Aging Center and VA Mental Illness Research and Clinical Center (MIRECC) are participating in the Alzheimer’s Disease Neuroimaging Initiative (ADNI) trials: ADNI-1, ADNI-2, and ADNI-GO. Normal volunteers and patients with Alzheimer’s disease enrolled in these trials have FDG PET/CT brain scans and amyloid PET/CT brain scans. A new study about to begin will use FDG PET/CT brain scans to evaluate the effect of repetitive transcranial magnetic stimulation (rTMS) in subjects with traumatic brain injury.
The Canary Center at Stanford for Cancer Early Detection

Director: Sanjiv S. Gambhir, MD, PhD
Deputy Director: Bree Mitchell, PhD

http://canarycenter.stanford.edu/

The Canary Center at Stanford for Cancer Early Detection will celebrate its fourth anniversary in June 2013. This year we added a new Agilent triple-quadrupole mass spectrometer and an Agilent 400 MHz NMR instrument to our state of the art shared instrument facilities. As we head into the upcoming year, our goals include recruiting several new faculty members, building up the Biorepository Core which will store and organize human samples for research efforts headed by the Canary Center, and pursuing a number of other funding and collaboration opportunities.

The mission of the Canary Center is to lead and foster research programs leading to the development of blood and imaging tests for the early detection of cancer. The Canary Center represents a novel alliance between the Canary Foundation, the Department of Radiology, the Cancer Center, and the School of Medicine. The Canary Center also actively fosters intellectual and programmatic alliances with the Schools of Engineering & Humanities and Sciences.

The Canary Center's mission is based on the striking association between early cancer diagnosis and improved survival rates: the chances of survival are far greater when cancer is detected in its earliest stages when it is most treatable. To optimize the detection of cancer at this stage, the Canary Center is taking a two-stage approach to cancer diagnosis pairing blood tests with imaging for cancer early detection. The extraordinary technical challenges associated with this dual strategy include the refinement of molecular imaging agents to specifically detect pre-invasive malignant tumors the size of a small blueberry (< 5 mm). They also include the development of proteomic approaches that can reliably detect minute (< 0.1 ng/ml) quantities of cancer-specific proteins released into the bloodstream by these small lesions. Cost-effective solutions are expected by applying a relatively inexpensive blood test followed by a more expensive imaging study, although in some cases the blood test and the imaging test will be performed concurrently. Having both approaches will also likely lead to a greater overall accuracy.

To accomplish these goals, the Canary Center was specifically designed to house state-of-the-art core facilities and collaborative research programs in molecular imaging, proteomics, chemistry, and bioinformatics. The Proteomics Core facility houses cutting-edge mass spectrometry platforms dedicated to the discovery and validation of blood and tissue protein biomarkers. The Chemistry Core is engaged in the specific design and refinement of molecular imaging agents for early detection, which then undergo preclinical testing using in vivo and ex vivo model systems, including patient blood and tissue samples. The Molecular and Cell Biology Core works closely with both the Proteomics and Chemistry Cores to screen and refine agents that can bind cancer-specific targets in tissues and thus complement the efforts of the Chemistry and Proteomics Cores to develop blood and imaging tests for cancer early detection. A significant effort has been put forward over the past few years to equip the Canary Center cores and laboratories with state-of-the-art instrumentation to promote and facilitate innovative research efforts.

Collaborative research efforts fostered at the Center are made possible by creating a truly multidisciplinary team of faculty members. Current faculty members focus on imaging technologies, chemistry, and disease mechanisms/cell biology. We are currently in the process of recruiting 4 additional faculty for billets committed by the Stanford School of Medicine with the intent to have a total of 8 faculty by 2016. Canary Center research programs are actively interfacing with other facilities and programs on campus, including MIPS and the CCNE, in order to leverage the latest developments in molecular imaging and nanotechnology into the early detection effort. Collectively, these initiatives form a direct pipeline for the translation of early cancer detection into clinical trials and practice.

A specific example of a novel molecular imaging strategy that is expected to help the goal of early cancer detection is ultrasound with targeted microbubbles. These gas filled microbubbles can be chemically coupled to targeting ligands that allow the bubbles to bind to tumor vasculature. This will allow molecular imaging using a conventional anatomical imaging strategy (ultrasound). This is expected to allow detection of tumors in the 3-5 mm range. A specific example of a novel strategy being pursued for blood biomarker detection is based on magnetonanarrays being developed as part of the Stanford CCNE. This novel technology allows the detection of many different biomarkers at levels that are 10 to 100-fold better than the most sensitive ELISA tests currently available.
Research Group Updates

Multi-scale Diagnostics Laboratory
Farag Mallick, PhD
http://canarycenter.stanford.edu/

The Multi-scale Diagnostics Laboratory focuses on developing and applying systems approaches to quantitatively describe organisms’ physiologic states toward the goal of enabling personalized, predictive medicine. As part of this effort we are trying to characterize the diverse states of cells and how signals describing those states are propagated from molecular and cellular length scales to tumor and organismic length scales. In addition, we are developing experimental and computational approaches for quantifying and interpreting cellular and organismic proteomic changes in order to identify robust, mechanistic, diagnostic protein fingerprints. Lastly, we are exploring human clinical application of these fingerprints. As each of these biologic challenges poses significant technical hurdles, we are additionally working to develop novel technologies to overcome these challenges.

Most recently, we have been highly active in developing software tools to accelerate progress in the field of proteomics (the high-throughput study of proteins). This research is part of the ProteoWizard Project that was recently published in *Nature Biotechnology* (Oct 2012). Figure 1 shows a snapshot of an image generated by our software tool. Most recently we have begun developing a comprehensive experimental design and execution framework that will allow researchers to collect data in a manner that is optimized for the biological question they are asking. This research is in collaboration with Agilent Corporation.

Once proteomics data has been collected, it can be complex to interpret. We have been working to integrate multi-omics data using sophisticated models of cellular regulation. We show an example of one such model in Figure 2. In this model, triangles represent transcription factors, and boxes are groups of genes regulated by that transcription factor. Edges represent a regulatory relationship. All these relationships were learned directly from experimental studies.

We have been additionally been active in biomarker validation. As published in *Prostate* (Aug 2012), we have demonstrated that AGR2, a protein we discovered in broadscale proteomics screens, is elevated in metastatic prostate cancer and associated with the particularly aggressive neuroendocrine phenotype.

Beyond our studies in ‘omics’ we have begun studies in the area of biomechanics. Biomechanics is the study of a cell’s mechanical properties. In much the same way that a nerf ball is different from a bowling ball, an aggressive, metastatic cell is different from a benign cell. By using a novel device called a Suspended Microchannel Resonator, we have been able to, for the first time, measure the biomechanical properties of thousands of cells revealing a relationship between cells’ biomechanical properties and metastatic potential. This work has been submitted for publication and is a collaboration with the Manalis Lab at MIT.

Our group is focused on the discovery and validation of blood-based molecular diagnostic markers for cancer early detection. We are interested in defining novel molecular signatures for breast, ovarian, and other epithelial cancers, including sub-types of these diseases. These molecular signatures have potential applications such as molecular indicators of cancer risk, diagnosis, progression, and recurrence.

We are currently exploring different classes of molecules as potential blood-based early indicators of disease. The following are some highlights of our ongoing efforts: 1) Proteins are known to be differentially glycosylated in cancer. We have developed a workflow to quantify glycoproteins directly in blood samples and are currently applying this approach to identify novel glycoproteins as potential cancer biomarkers. 2) Leukocyte telomere length has been shown to be altered in cancer. In collaboration with the Breast Imaging Section in the Radiology Department (pages 46-47), we are investigating the utility of telomere length and circulating telomerase levels in the blood, to differentiate women with benign and malignant breast lesions. 3) In collaboration with the Cancer Prevention Institute of California, we are examining blood-based protein levels in women up to two years before they were diagnosed with breast cancer. 4) MicroRNAs have been shown to be potentially useful indicators of cancer. We are using new technologies to investigate microRNAs, and their modifications, as potential blood-based cancer biomarkers.

Cancer Molecular Diagnostics Laboratory
Sharon Pitteri, PhD
http://canarycenter.stanford.edu/

Left to Right – Parag Mallick, Farag Mallick, and Sharon Pitteri

Left to Right – Majlinda Kullolli, PhD, Sharon Pitteri, PhD, Maria Arampatzidou PhD

Left to Right – Dario Amodei, Farag Mallick, and Sharon Pitteri

Figure 1 – Proteomics view of a drop of blood. Shown is a ‘psuedo-2d gel,’ which illuminates the complexity of a typical proteomics experiment. The X axis is m/z, the Y axis is retention time and the color reflects intensity.

Figure 2 – A small portion of a complex regulatory network comparing two cell types and how they respond to DNA damage. Triangles are transcription factors. Boxes contain sets of genes regulated by a given transcription factor.
The mission of the ISIS (Information Sciences in Imaging at Stanford) section of the Radiology Department is “pioneering, translating, and disseminating methods in the information sciences that integrate imaging, clinical, and molecular data to understand biology and improve clinical care.” This includes deriving new clinical and biological knowledge regarding normal and pathological processes, predicting clinical outcomes such as response to therapy and probability of survival, and translating these advances into practice, such as by creating decision support applications. Researchers within ISIS collectively explore the full spectrum of information-intensive activities in imaging (e.g., image management, storage, retrieval, processing, analysis, understanding, visualization, navigation, interpretation, reporting, and communications) in associated non-imaging domains (e.g., pathology, ophthalmology, oncology, molecular and genetic markers, medical record data, and clinical outcomes). This is done by developing methods to extract computational and semantic features from images and by integrating them with related clinical and molecular data.

The expertise of the ISIS faculty, staff, postdocs, and students spans image acquisition, image quantification, imaging informatics, knowledge engineering, bioinformatics, biocomputation, and systems biology. ISIS is co-led by Drs. Sandy Napel, Professor of Radiology, and Sylvia K. Plevritis, Associate Professor of Radiology, and includes core faculty David S. Paik and Daniel L. Rubin, both Assistant Professors of Radiology. Administrative Program Manager Danae Barnes handles ISIS administrative activities. In addition to pervasive collaboration, the four faculty maintain individual laboratories (described elsewhere in this report): 3D Visualization and Analysis Laboratory (Napel: 4 doctoral students, one scientific staff), Cancer Systems Laboratory (Plevritis: 3 doctoral students, 6 postdoctoral fellows, 3 scientific staff), Laboratory of Imaging Informatics (Rubin: 11 doctoral students, 2 postdoctoral fellows, 2 scientific staff), and Image Analysis, Bioinformatics, and Computational Modeling Laboratory (Paik: 2 doctoral students, one scientific staff). Collectively, we are supported by major funding agencies for projects listed in ISIS Funding (Page 136).

This year, ISIS began its strategic planning process with the help of the Office of Institutional Planning (OIP), with goals to clarify our mission and to identify and prioritize areas for growth. During the summer, OIP staff interviewed 19 thought leaders from around the globe to elicit key strategic strengths, weaknesses, opportunities, threats and priority initiatives. During the afternoon following the retreat, OIP presented their findings to ISIS faculty and staff, and with a similar number of stakeholders from several School of Medicine departments who have synergies with and interests in ISIS’ future. Key findings were that ISIS embodied “world class creative scientists with a great track record covering a broad spectrum of research in a growing field.” They also commented “ISIS cannot, at its current size, significantly impact key areas,” “translating research into clinical applications requires a bigger critical mass,” and “stronger networks would be beneficial.” Over the next several months we will be scrutinizing these findings and meeting again with our stakeholders to define the best way forward for ISIS.

The 2012 ISIS Annual Retreat, a half-day event held on 8/30/2012 in the Clark Center, attracted nearly 40 participants involved or interested in ISIS activities. Goals were to find synergies, motivate additional projects, and to help plan the future of ISIS. Our keynote speaker, Dr. Sandy Anderson, Chair of the Department of Integrative Mathematical Oncology at the Moffitt Cancer Center in Tampa Florida, spoke on the topic of developing 3D cellular automata models of the tumor microenvironment. The keynote was followed by brief lab overviews from the four ISIS faculty, and a “speed dating” session in which all the ISIS students, postdoctoral fellows and staff, each described themselves in terms of general interests and research projects in one minute using 3 slides. Two poster sessions followed, wherein everyone could showcase and discuss their work. We also organized three small “break-out” discussion groups to focus on identifying research themes in ISIS that unify us and distinguish our activities in imaging Keynote Speaker), Wei Lu, Selen Bozkurt, Anita Samanta—Back row, L to R: David Paik, Dr. Alexander Anderson (visiting keynote speaker), Wei Lu, Yelena Burkat, Andrea Sansom—Front row, L to R: Francisco Gimenez, Diego Munoz, Ramonde Nair, Olivier Courbet.

The expertise of the ISIS faculty, staff, postdocs, and students spans image acquisition, image quantification, imaging informatics, knowledge engineering, bioinformatics, biocomputation, and systems biology. ISIS is co-led by Drs. Sandy Napel, Professor of Radiology, and Sylvia K. Plevritis, Associate Professor of Radiology, and includes core faculty David S. Paik and Daniel L. Rubin, both Assistant Professors of Radiology. Administrative Program Manager Danae Barnes handles ISIS administrative activities. In addition to pervasive collaboration, the four faculty maintain individual laboratories (described elsewhere in this report): 3D Visualization and Analysis Laboratory (Napel: 4 doctoral students, one scientific staff), Cancer Systems Laboratory (Plevritis: 3 doctoral students, 6 postdoctoral fellows, 3 scientific staff), Laboratory of Imaging Informatics (Rubin: 11 doctoral students, 2 postdoctoral fellows, 2 scientific staff), and Image Analysis, Bioinformatics, and Computational Modeling Laboratory (Paik: 2 doctoral students, one scientific staff). Collectively, we are supported by major funding agencies for projects listed in ISIS Funding (Page 136).

The 2012 ISIS Annual Retreat, a half-day event held on 8/30/2012 in the Clark Center, attracted nearly 40 participants involved or interested in ISIS activities. Goals were to find synergies, motivate additional projects, and to help plan the future of ISIS. Our keynote speaker, Dr. Sandy Anderson, Chair of the Department of Integrative Mathematical Oncology at the Moffitt Cancer Center in Tampa Florida, spoke on the topic of developing 3D cellular automata models of the tumor microenvironment. The keynote was followed by brief lab overviews from the four ISIS faculty, and a “speed dating” session in which all the ISIS students, postdoctoral fellows and staff, each described themselves in terms of general interests and research projects in one minute using 3 slides. Two poster sessions followed, wherein everyone could showcase and discuss their work. We also organized three small “break-out” discussion groups to focus on identifying research themes in ISIS that unify us and distinguish our activities in imaging Keynote Speaker), Wei Lu, Selen Bozkurt, Anita Samanta—Back row, L to R: David Paik, Dr. Alexander Anderson (visiting keynote speaker), Wei Lu, Yelena Burkat, Andrea Sansom—Front row, L to R: Francisco Gimenez, Diego Munoz, Ramonde Nair, Olivier Courbet.
Our group addresses the field of medical image analysis, focusing on volumetric visualization, structure segmentation, quantitative analysis, computer-aided detection of lesions, and the capture and use of imaging phenotype and integration with other clinical data, including those from high-throughput technologies such as gene arrays, for knowledge discovery and decision support. Advances here have impact in many technical and clinical areas. Examples are automated visualization and quantitation of vascular wall images, virtual colonoscopy, intra-procedural registration of 2D fluoroscopic images of instruments with 3D volume data, automated computation of peak flow velocity using a novel ultrasonic transducer for reproducible determinations of carotid stenosis, automatic generation of curved-planar images through blood vessels, determination of likely neuronal connections of the visual tracts in the brain. Our group is highly collaborative, working with many radiology department investigators (including Chris Bouglieu, Heike Daldup-Link, Nishita Kohbay, David Paik, Sylvia K. Plevritis, and Daniel L. Rubin) as well as many other Stanford (e.g., Pierre Khuri-Yakub, electrical engineering) and non-Stanford (e.g., Geoffrey D. Rubin, Duke University) faculty. This year we have focused on efficient methods for the creation of a visual similarity standard for content-based image retrieval and decision support, automated volumetric segmentation of tumors from cross-sectional images, feature extraction from these segmentations, building integrated databases of image features of lesions and other associated data, and correlation of image features to molecular profiles of excised tissues in lung cancer. Based on our work this past year, 7 new manuscripts are characteristic of different tumor types.

Correlation of gene expression of excised lung tumors (left) with image features in CT scans (right). Smooth, compact lesions (e.g., top right) correlate with down-regulation (green; left), while irregularly shaped lesions (bottom right) correlated with up-regulation (red; left) of specific gene modules.

Correlation of gene expression of excised lung tumors (left) with image features in CT scans (right). Smooth, compact lesions (e.g., top right) correlate with down-regulation (green; left), while irregularly shaped lesions (bottom right) correlated with up-regulation (red; left) of specific gene modules.

Quantitative analysis, computer-aided detection of lesions, and the fusion of imaging-derived information with other types of data such as molecular and/or clinical information. We are particularly interested in applying computational techniques to better understanding of cancer biology. While most computational models and analyses focus on a single source or modality of data, it is becoming increasingly clear that models must integrate across a wide variety of data types as well as spatial and temporal scales. Our focus is on developing and validating these types of models.

Molecular imaging is a key technology in producing breakthrough biological results where better quantitation and mathematical modeling will lead to a more detailed understanding of specific biological mechanisms. We are working on a variety of projects to improve and standardize the quantitative measurements from molecular imaging. Examples include statistical analysis of ROI methods, knowledge representations of quantitative imaging, and improving software for quantitative imaging (Fig. 3). In collaboration with MIPS, we are performing qualitative analyses of pre-clinical imaging to develop and validate methods for high-throughput imaging of mouse subjects so that studies can use more subjects to produce higher confidence results. As a part of the ICMC center, we are collaborating with the lab of Dean Felsher to develop and validate a model of how oncogenes affect the response of tumors to directed therapies and in particular, how the immune system is a key player (Fig. 2a). We hope to demonstrate how this modeling will allow us to develop new combination therapies that will produce improved outcomes for cancer patients. We are also working on methods for representing the vast data and knowledge using quantitative imaging biomarkers in clinical trials and other research to deal with the onslaught of new information being produced (Fig. 2b).

Our long-term goal is to tackle the problem of information extraction and information flow from medical/molecular imaging to be on par with that of genomic and proteomic profiling technologies so that these very different types of information may be treated as equals. Our philosophy is that for an integrative approach to imaging and non-imaging information to come to fruition, a major pre-requisite is that models must integrate across a wide variety of data types as well as spatial and temporal scales.

Agreement Between Truth and Algorithm on Prediction of Number of Tumors

Simulations of agreement between observers on the reality of tumors in cross-sectional images revolved, how many models’ ratings of similarity must be averaged in order to have good agreement with truth as a function of uncertainty intervals.

Precision of edge, one of many features we extract from lung tumors. Perpendicular lines (lower shown in a) to tangent edge are computed, and gray value along perpendiculars are fit to sigmoid function (b). Different distributions of fit parameters (variances, width) around edge are characteristics of different tumor types.

Research Group Updates

Radiology 3D Visualization and Analysis Laboratory

Sandy Napel, PhD

http://med.stanford.edu/profiles/radiology/researcher/Sandy_Napel/

Imaging Bioinformatics Laboratory

David Paik, PhD

http://www.stanford.edu/people/david.paik

Figure 1. High-throughput imaging using a multiple mouse holder in PET scanner with 3D imaging.

Figure 2. Mathematical model of oncogene-dependent tumor growth kinetics in mouse model. Right: Knowledge model of quantitative imaging biomarkers.

From L to R: Danielle Rasooly, David Paik, Tiffany Lia, Kosnife Kado, Chinyere Nwabugwu, Rahul Agreavle, Frezghi Habte
Cancer Systems Laboratory (CSL)

Sylvia K. Plevritis, PhD
http://plevritis.stanford.edu/

The Plevritis’ Cancer Systems Laboratory (CSL) takes a multidisciplinary approach to identify drivers and rates of cancer progression in order to improve clinical strategies for early detection and treatment. CSL research draws from the domains of bio-computation, engineering, genomics/proteomics, imaging, and population sciences. Four key components of CSL are depicted in Figure 1, namely: (1) the Stanford Cancer Systems Biology Program (CCSB, ccsb.stanford.edu) (2) Information Sciences in Imaging at Stanford (ISI, isi.stanford.edu (3) the NCI Cancer Intervention and Surveillance Modeling Network (CISNET) and (4) the System Biology Laboratory (SBL) which is a new component of CSL and established to experimentally validate computationally-derived biological findings in in-vitro and in-vivo model systems. To demonstrate the breadth and depth of CSL, below is a summary of its current funded research programs.

A. Understanding Cancer Cellular Hierarchy by Reconstructing Regulatory Networks: Within the NCI-funded U54 Center for Cancer Systems Biology (CCSB), for which Dr. Plevritis is the Principal Investigator; CSL has been identifying a cellular hierarchy of cancer. Most recently, the lab has begun testing the hypothesis that the evolution of any given tumor is encoded in the tumor itself, and is accessible through single-cell analysis. To reconstruct a likely hierarchical relationship among distinct subsets of malignant cells that are potentially related through varying states of differentiation, CSL postdoctoral fellow Dr. Benedict Anchang developed a novel computational approach to identify and gate the cellular heterogeneity of cancer from flow cytometry data. CSL’s graduate student Aravind Babu has developed an approach to identify the likely cell-of-origin of cancer and assess the degree of normal differentiation underlying cancer heterogeneity. Senior research associate Dr. Monica Nicolau has also developed an approach to determine the likely cell-of-origin of cancer and assess the degree of normal differentiation underlying cancer heterogeneity. Senior research associate Dr. Andrew Gentles, in close collaboration with Prof. Ash Alizadeh, has expanded a gene-centric survival analysis of the majority of publicly available cancer datasets. Dr. Gentles, together with CSL’s analyst Dr. Ramesh Nair, has developed a computational pipeline for next gen sequencing data analysis. CSL’s Anita Samantary is developing an approach to identify drivers and rates of cancer progression in order to improve clinical strategies for early detection and treatment. CSL’s senior research associate Dr. Andrew Gentles is working together with data scientist Dr. Ramesh Nair, to establish RNAseq analysis of the sorted cell populations. CSL’s postdoctoral fellow Dr. Xia Zhou is developing new analytical approaches to infer the cellular communication between the malignant cells and its microenvironment.

B. Inferring the Plasticity of Cancer: CSL has established a Systems Biology “wet-lab” in LUCAS P169 to experimentally validate our computationally-derived findings. With this new experimental laboratory, CSL is expanding its molecular-network-based research to the analysis of solid tumors, specifically the microenvironment of breast cancer. CSL postdoctoral fellow Dr. Mary Do is analyzing the natural history of breast cancer into a decision support tool for BRCA1/2 mutation carriers. In addition, CSL has been identifying a cellular hierarchy of cancer. Most recently, the lab has begun testing the hypothesis that the evolution of any given tumor is encoded in the tumor itself, and is accessible through single-cell analysis. To reconstruct a likely hierarchical relationship among distinct subsets of malignant cells that are potentially related through varying states of differentiation, CSL postdoctoral fellow Dr. Benedict Anchang developed a novel computational approach to identify and gate the cellular heterogeneity of cancer from flow cytometry data. CSL’s graduate student Aravind Babu has developed an approach to identify the likely cell-of-origin of cancer and assess the degree of normal differentiation underlying cancer heterogeneity. Senior research associate Dr. Andrew Gentles, in close collaboration with Prof. Ash Alizadeh, has expanded a gene-centric survival analysis of the majority of publicly available cancer datasets. Dr. Gentles, together with CSL’s analyst Dr. Ramesh Nair, has developed a computational pipeline for next gen sequencing data analysis. CSL’s Anita Samantary is developing an approach to identify drivers and rates of cancer progression in order to improve clinical strategies for early detection and treatment. CSL’s senior research associate Dr. Andrew Gentles is working together with data scientist Dr. Ramesh Nair, to establish RNAseq analysis of the sorted cell populations. CSL’s postdoctoral fellow Dr. Xia Zhou is developing new analytical approaches to infer the cellular communication between the malignant cells and its microenvironment.

C. Unraveling the Tumor Microenvironment by Inferring an Intercellular Interactome: With a newly funded five-year NCI grant, Dr. Plevritis is Principal Investigator, together with Prof. Clarke, and collaborators Prof. Dinh and Prof. Chou, on a project to reconstruct a regulatory network of the tumor microenvironment of human non-small cell lung cancer (NSCLC). This work involves flow sorting cellular sub-compartments of human NSCLC (i.e. malignant cells, infiltrating immune cells, fibroblasts, and endothelial cells), genomically profiling each sub-compartment, then reconstructing a gene regulatory network that captures intercellular and intra-cellular interactions. The main goal of this program is to identify mediators that represent promising drug targets for disrupting the interaction between lung cancer cells and their microenvironment to improve survival outcomes for lung cancer patients. CSL’s senior research associate Dr. Andrew Gentles is working together with data scientist Dr. Ramesh Nair, to establish RNAseq analysis of the sorted cell populations. CSL’s postdoctoral fellow Dr. Xia Zhou is developing new analytical approaches to infer the cellular communication between the malignant cells and its microenvironment.

D. Decoding Tumor Heterogeneity by Integrating Genomic, Imaging and Clinical Data: With a funded five-year NCI grant, Dr. Plevritis is a Principal Investigator, together with Dr. Napel, on a project to correlate CT and PET information with gene expression microarray data of human NSCLC in order to better understand the molecular heterogeneity of the disease from imaging studies. Initial analyses led by CSL postdoctoral fellows Dr. Olivier Govaert and Dr. Vish Nair showed the genes up-regulated with the activation of extracellular matrix remodeling, cell migration and NF Kappa-Beta signaling were associated with CT and PET features. In this work, CSL developed a novel approach that leverages the public cancer gene expression microarray databases that contain clinical outcomes across thousands of patients to identify candidate prognostic and predictive image biomarkers from clinical studies with limited clinical follow-up.

E. Reconstructing the Natural History of Cancer by Simulating Clinical Trials and Population Cancer Trends: With renewed 5-year funding from the NCI CISNET, CSL is expanding a previously funded 10-year program in population level studies focused on modeling the natural history of breast and lung cancer in order to estimate the impact of risk-stratified screening and medically-targeted therapeutics on current and future cancer incidence and mortality US trends. This modeling work is based on Monte Carlo simulation of cancer progression and clinical outcomes. In the area of breast cancer, CSL’s graduate student Deigo Munoz, working together with Assistant Professor Allison Kurian, translated its work on the natural history of breast cancer into a decision support tool for BRCA1/2 mutation carriers to manage their heightened breast and ovarian cancer risk (brca tool.stanford.edu). In addition, Diego Munoz is evaluating the impact of new biomarker-specific breast cancer therapeutics on clinical outcomes and evaluating the effect of hormone replacement therapy on breast cancer trends, together with recently graduated PhD student Yihan Guan. In the area of lung cancer screening, CSL’s postdoctoral fellow Dr. Ayca Erdogan and medical scholar Weishuai Wan are working to extend the results of the National Lung Screening Trial of CT to the population-level setting by characterizing the effect of screening on indolent versus aggressive disease subtypes. Recently, CSL expanded its effort in population level modeling with the recruitment of NH-trained statistician Dr. Summer Han who is focusing on the parameter estimation algorithms.

In summary, CSL brings together biocomputational modelers, engineers, statisticians, molecular biologists and clinical researchers to improve our understanding of cancer by producing insights that are biologically and clinically relevant and have potential for clinical translation.
Our research group develops computational methods and tools to leverage "Big Data" in medical imaging to discover imaging biomarkers of disease that enable precision medicine. We translate our discoveries into practice through decision support applications to reduce variation in clinical care and to improve patient outcomes. Our work spans a broad gamut from basic science discovery (using image phenotypes to define subtypes of diseases and to 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 Big Data related to imaging will guide clinical practice and drive scientific discovery. Our ultimate goal is to bring cutting-edge radiological data and knowledge into practice to guide precision care of individual patients.

Basic science activities: We are developing computational methods to extract quantitative and semantic content from images ("image biomarkers") and to use them in conjunction with clinical, pathology, and molecular data to discover image-based predictors of disease and treatment response. Our ultimate goal is to discover disease subtypes and to "profile" patients based on image-based characteristics to clinical practice through translational research (using image phenotypes to define subtypes of cancers, and these subtypes drive scientific discovery. Our ultimate goal is to bring cutting-edge radiology into practice to guide precision care of individual patients.

Figure 1. We are developing a Web-based image viewing platform and can display a broad variety of medical images (lower left). The radiologist has measured lesions on a CT scan that were measured previously. The PIP tool raises the patient's historical imaging studies to locate the same lesions seen on other studies and summarizes them with their measurements, helping physicians to quickly and accurately detect change in the disease status of the patient.

Figure 2. We have developed quantitative imaging methods to characterize breast cancer. Our methods analyze the raw MRI perfusion image of the breast (upper left) and we derive quantitative features from the images with the use of image enhancement, heterogeneity, and the rate of change in enhancement over time (upper middle and right). From the quantitative information, we create maps of the quantitative parameters (lower right) which we can relate quantitative analysis of the corresponding pathology images (lower middle). We also utilize statistical models to create the image features to the pathology images using a modeling technique. A mathematical model predicts the change in disease status based on analysis of the quantitative features, which can provide decision support to the physician treating the patient (lower right).

Figure 3. We have developed a framework to integrate and relate molecular data and imaging data. The image data—which provides phenotypic characterization of cancer—derives from the molecular features, since the latter give rise to processes and pathways that ultimately produce changes in tissue that are visible on images. The molecular data are being used to deliver subtypes of cancer, and these subtypes drive scientific discovery. Our ultimate goal is to bring cutting-edge radiology into practice to guide precision care of individual patients. The other hand, obtaining molecular characterization is invasive, requiring biopsy and it is not practical to expect such treatment to monitor for biological change in cancer during treatment. Our hypothesis is that we can predict the molecular changes based on quantitative analysis of the imaging features—since the latter ultimately derive from the former. We are linking the imaging features to the molecular features by incorporating them into a formal model of the biological processes and pathways that are informative of the underlying biology of lesions (Figure 2); (4) methods to integrate molecular and imaging data to identify disease subtypes in brain cancer and other malignancies (Figure 3); and (5) a large database of annotated quantitative imaging cancer studies as a resource for discovering new biomarkers that will improve the sensitivity of detecting cancer treatment response (in collaboration with the Cancer Center). We recently began a new program in quantitative evaluation of breast cancer with the Body Imaging (pages 38-39) and Breast Imaging sections (pages 46-47) (Figure 2).

Translational and clinical activities: Projects include (1) content-based image retrieval to improve radiologist diagnostic accuracy (a collaboration with the Body, pages 42-43, and MSK, pages 52-53, sections); (2) automated segmentation of lesions in serial imaging studies, enabling physicians to objectively and reproducibly assess lesions in images and to monitor the response to treatment; (3) quantitative image analysis of retinal images to detect and monitor progression of eye diseases (a new collaboration with Dept. of Ophthalmology) (Figure 4), (4) natural language techniques to enable uniform indexing, searching, and retrieval of radiology information resources such as radiology reports (a new collaboration with the Radiology Service at the VA, pages 62-63); and (5) decision support applications integrated into the reporting workflow to improve diagnosis and reporting clarity and completeness.
The Molecular Imaging Program at Stanford (MIPS) (http://mips.stanford.edu) continues to experience significant growth. The participation of many faculty members and trainees within the Department of Radiology and from other departments contributes to building and growing the program. MIPS now has 58 faculty members with 26 full members and 32 associate members, representing more than 25 different disciplines. In addition, MIPS includes five instructors, 35 research associates and scientists, and more than 150 postdoctoral fellows, graduate and undergraduate students. The number of graduate students, MSTP students, post-doctoral fellows, research scientists, technicians, and administrative staff continues to grow and is currently approximately 250. Although we have experienced a significant increase in personnel with the Canary Center for Cancer Early Detection, we anticipate that number of MIPS faculty and staff to continue increasing.

Our program continues to benefit from support of two highly productive NCI-funded programs, the In vivo Cellular Molecular Imaging Center (ICMIC) P50 grant and the Center for Cancer Nanotechnology Excellence (CCNE) U54, through which we have advanced projects in the Radiology Department, the School of Medicine, the School of Engineering, across the Stanford campus, nationwide at a number of academic centers, as well as in the medical imaging industry. In 2012, the Stanford Molecular Imaging Scholars (SMIS, R25T) NIH training program, which is now being led by Dr. Craig Levin, was renewed and is now in its eighth year of training the next generation of cancer molecular imaging post-doctoral scholars. More than 90% of SMIS graduates have gone on to seed imaging programs at other academic and industrial centers. We also participate in an NIH post-doctoral training grant (T32) for cardiovascular molecular imaging, which is in its fourth year. In addition, all labs continue to grow with new students, post-doctoral fellows, and outstanding research staff joining the program. Many scientists from around the world visit our program to learn more about molecular imaging.

Through the Canary Foundation’s efforts to develop the Canary Center at Stanford for Cancer Early Detection (http://canarycenter.stanford.edu/), we continue to build bridges with many investigators on campus. Our off-campus space on California Avenue facilitates our cancer early detection efforts. We are convinced that more investments are needed in the earlier detection of all disease. Detecting disease earlier allows a much better potential for cure. The Canary Center works on novel in vitro diagnostics (e.g., using patient blood samples) as well as new imaging strategies with high sensitivity to detect very low burden cancer signatures. It is hoped that in the next three to five years, Stanford will become a world leader in the important field of early cancer detection.

We continue to have several seminar series on campus to help educate scientists about molecular imaging. The Molecular Imaging seminar series (http://mips.stanford.edu/public/mi_seminar.adp) is now in its sixth year and has a large collection of videos available on-line of speakers from the last few years. Students from different MIPS labs now routinely present as well. The Nanobiotechnology seminar series (http://mips.stanford.edu/public/nanobiotech_seminar.adp), which focuses on new applications of nanotechnology to cancer, continues to draw attendance from faculty from all over the Stanford campus as well as surrounding academic, medical, and industry centers. Several speakers from around the country have presented in the series; all lectures are available on-line. We also host a year-long graduate course entitled: “Multi-modality molecular imaging of living subjects” directed by Dr. Craig Levin, which covers the science and technology of molecular imaging.

Our Molecular Imaging/Nuclear Medicine clinic is an advanced facility with spectacular design and state-of-the-art equipment that consolidates all of the PET-CT, and SPECT-CT, and SPECT imaging systems and related equipment in one location, including a new radiocardiometry facility. Newer cardiac and optical imaging equipment will also be placed in this new clinic. And for our advanced pre-clinical research, we have designed the clinic so that large animal imaging experiments can be performed there. Research trials that combine state-of-art imaging with in vitro diagnostics (e.g., blood proteomics) are also now possible in this new facility.

An important link in the MIPS research chain focuses on industrial partnerships with key leaders in the molecular imaging community. Several projects to develop new imaging agents, methods, and instrumentation are underway with General Electric Global Research, General Electric Healthcare, Bracco Diagnostics, Siemens Healthcare, Philips Healthcare, Schering-Plough, Bayer-Schering, Sanofi-Aventis, Millennium Pharmaceuticals, and GlaxoSmithKline. It is likely that additional industrial partners will enter into long-term collaborative research relationships over the next several years. These relationships support and strengthen our goals to translate discoveries at Stanford to the patient bedside. Several faculty are also involved in new startup-company efforts with intellectual property from their laboratories at Stanford. These include new instrumentation, methods, and assays in diagnostics, small animal imaging and clinical imaging.

For a complete summary of MIPS funding led by Radiology faculty, please see pages 148-149.
The main research of the Cancer Molecular Imaging Chemistry Laboratory (CMICL) is to develop novel multimodality imaging probes and techniques for cancer early detection. Our multidisciplinary team is composed of members with expertise in organic chemistry, radiochemistry, bionanotechnology, biochemistry, molecular and cell biology, radiological science, medicine and molecular imaging. Currently, we are actively studying several important problems in the molecular imaging field as described below in detail.

I. Molecular Probe Development Based on Novel Protein Scaffolds

Our research group is interested in studying whether the protein scaffold based approach could become a generalizable strategy to facilitate molecular probe development. We have focused our work on studying two new emerging protein scaffolds for their diagnostic applications: Affibody and Cystine knot miniproteins (knottins). Affibody molecules are engineered to form a protein scaffold with 58-amino acid residues and have a three-helix bundle scaffold structure (Figure 1). Cystine knot proteins are small constrained polypeptides that share a common disulfide-bonded framework and a triple-stranded β-sheet fold. We have synthesized and evaluated a variety of radiolabeled (18F, 68Ga, 64Cu, 111In, etc) or optical dye labeled Affibody (3-helix and 2-helix) and Cystine knot miniproteins. These imaging agents could be used to image several important tumor targets such as human epidermal growth factor receptor type 2 (HER2), epidermal growth factor receptor (EGFR), tumor angiogenesis target integrin receptor αvβ3. Overall, our studies have clearly demonstrated that Affibody and Cystine knot based scaffolds can be used as excellent platforms for molecular probes development. Those Affibody and Cystine knot based probes are worthy of further evaluation and optimization for the development of positron emission tomography (PET) probes for clinical HER2, EGFR and αvβ3 imaging.

II. Melanoma Early Detection

Cutaneous malignant melanoma is one of the most lethal cancers. The most important approach for improvement of survival of melanoma patients still remains early diagnosis, along with accurate staging of disease. Positron emission tomography (PET) is a very promising technology for non-invasively imaging tumor micro-metastases. Though 18F-fluorodeoxyglucose (18F-FDG) PET has been widely used clinically for melanoma imaging, other approaches to specifically identify, characterize, monitor and guide therapeutics for malignant melanoma are still needed. Our research has focused on developing novel peptides and small molecules based PET probes targeting melanoma associated specific targets such as melanocortin receptor 1 (MC1R), melanin, etc. For example, we have successfully developed novel benzamide analogs based PET probes, such as 18F-N-[2-(diethylamino)ethyl]-4-fluoro-Benamide (18F-FBZA) for melanoma imaging (Figure 2). We are currently optimizing the probe and will move one of its analogs with best in vivo properties into clinical evaluation very soon.

III. Cerenkov Luminescence Imaging

Recently, we and others have found that a variety of radioactive materials (β+ and β- emitters) could be detected using optical imaging techniques (Figure 3). This is mainly attributed to the ability of radioactive materials to produce low energy visible photons (0.2-3.1 eV, 400-1000nm) associated with Cerenkov radiation. Optical imaging of Cerenkov radiation has thus emerged as an important and promising strategy for molecular imaging research that nicely bridges nuclear imaging and optical imaging. This technique could be particularly useful in preclinical research such as radiopharmaceutical development and drug screening. It may also find applications in clinical cancer diagnosis. Moreover, we also demonstrated that the radioactive luminescent light at visible and NIR window could serve as an internal source for illumination of many different fluorophores such as QDs, and the resulting fluorescent emissions could then be used for optical imaging in living subjects. We are actively exploring the applications of Cerenkov Luminescence Imaging in biomedical imaging and clinical translation.

Our research is supported by National Institutes of Health, Department of Defense, Department of Energy, Melanoma Research Alliance and the Radiology Department at Stanford. Trainee fellowships are supported by China Scholarship Council.
The Gambhir Group develops imaging assays to monitor fundamental cellular processes in living subjects. To complete these studies, we use a host of molecular imaging modalities including micro positron emission tomography, bioluminescence and fluorescence, micro-computerized axial tomography, ultrasound, photoacoustics, intravital microscopy, magnetic resonance imaging (MRI), and Raman spectroscopy. Our ultimate goal is to marry new insights in cell and molecular biology with those in biomedical engineering to advance the field of molecular imaging. In particular, we focus on cancer biology and have developed several reporter genes to study cell trafficking models, gene therapy models, transgenic models, and other oncogenic processes in vivo. Imaging of biologic therapies with engineered proteins for cancer cell surface targets are another focus. Assays to interrogate cells for mRNA levels, cell surface antigens, protein-protein interactions, protein phosphorylation, and intramolecular folding are also under active development. We also have a large focus on nanotechnology-enhanced molecular imaging and have created novel nanoparticle imaging probes for photoacoustic, Raman, ultrasound, and multimodality imaging strategies. In these and other examples, we characterize our imaging agents in cell cultures and small animal models of human disease before progressing to larger animals and human clinical trials. Of particular interest is the combination of in vivo imaging data with measurements of serum protein levels for even greater insight into disease state. We actively collaborate with many other academic research teams including faculty in the Departments of Electrical Engineering, Chemical Engineering, Chemistry, Materials Science, Pediatrics, Urology, Gastroenterology, and many others.

The Multimodality Molecular Imaging Lab (MMIL) is interested in using multimodality molecular imaging techniques to study nociception and neuronal inflammation as a means of improving objective, image-guided diagnosis and treatment of chronic pain generators. Deepak Behera, DNB continues to admirably lead and manage the lab, juggling a number of projects, collaborations and students. He has been able to garner a number of publications and awards for the lab during this past year. Our recently graduated medical student, Eric Davalos, MD, continued our collaborations with Garry Gold, MD and Brian Hargreaves, PhD, to help develop improved isotropic MR approaches for MR Neurography. We also welcomed Radiology Resident, Andreas Loening, MD, PhD, to our lab; he has been instrumental in developing diffusion tensor imaging (DTI) of the peripheral nervous system. We continue our exciting collaborations with Justin Du Bois, PhD, William Parsons, BS, John Mulcahy, PMD, Frederick Chin, PhD, Aileen Hoehne, PhD, Bin Shen, PhD, Michelle James, PhD and David Yeomans, PhD, studying the role of voltage-gated sodium channels in neuropathic pain using PET-MRI and radiolabeled guanidinium toxins. Important collaborations with the Stuart Goodman Lab continue to thrive as we continue to examine the role of mesenchymal stem cells and macrophages in the prosthetic-induced osteolysis and in fracture models. Another collaboration with Bin Shen, PhD, Michelle James, PhD, and Frederick Chin, PhD, has led to interesting results with the use of a sigma-1 receptor radioligand in neuropathic pain models. We are hopeful that our research will advance to clinical trials with FDA-approved and novel tracers in the coming year.

Radiology Annual Report

Figure 1: MIP image of a CUBE data set showing the lumbar plexus in a human subject. Nerve roots, dorsal root ganglia and peripheral nerves can be easily identified using this isotropic MR imaging approach.

Figure 2: [18F]FTC-146 PET-MR transverse image through the thigh of a rat model of nerve injury and neuropathic pain. Increased [18F]FTC-146 uptake is identified in the sciatic neuroma (white arrow) compared to the contralateral normal sciatic nerve. This approach will be helpful in identifying nerve injury and potential sources of pain.

Lab Members (left to right): Dr. Sandip Biswal, Dr. Deepak Behera, Dr. Eric Davalos, Dr. Andreas Loening.
We develop non-invasive imaging techniques that can generate detailed information about specific cells in the body. We focus on applications for imaging stem cells, immune cells and various cell types in cancers. Our goal is to improve tumor detection, diagnose tumor characteristics linked to poor prognosis, monitor tumor cell-targeted therapies and stem cell therapies for tissue regeneration.

**Stem Cell Imaging:** We have developed several novel and immediately clinically translatable approaches for MR imaging of stem cells transplants (Radiology 2012, Nanomedicine 2012, PLOS one 2012). We are also evaluating an immune rejection of stem cell transplants via intravenous injection of an FDA-approved iron supplement, in vivo labeling of RES macrophages and tracking of the migration of iron labeled macrophages into failed or rejected stem cell transplants with MR imaging (Fig. 1). We have initiated a team research project in collaboration with the pediatric nephrology lab, the kidney transplant team, the Moseley lab and the Nishimura lab, to develop novel MR imaging approaches for detection of macrophage infiltrations in kidney transplants that may indicate rejection.

**Initiated a clinical trial to evaluate nanoparticle-enhanced MR imaging approaches for in vivo assessment of transplant rejection. In collaboration with the pediatric nephrology lab, the Gambhir, Napel, Paulmurugan, Rao, and Rubin labs to integrate a panel of immune cell imaging tests for non-invasive assessment of transplant rejection.**

**Nanophotonic MR Imaging:** We have initiated a team research project in collaboration with the Gambhir, Napel, Paulmurugan, Rao, and Rubin labs to integrate a panel of immune cell imaging tests for non-invasive assessment of transplant rejection. In collaboration with the pediatric nephrology lab, the kidney transplant team, the Moseley lab and the Nishimura lab, to initiate a clinical trial to evaluate nanoparticle-enhanced MR imaging approaches for detection of macrophage infiltrations in kidney transplants that may indicate rejection.

**Tumor Imaging:** We are developing the novel iron oxide nanoparticle compound GEH121333 in collaboration with GE Global Research for tumor MR imaging, specifically for detection of tumor necrosis and tumor associated macrophages (TAM), which are linked to poor prognosis. In collaboration with the Courns lab (NHSU), we are evaluating new approaches to improve the delivery of nanoparticles and other macromolecules to tumors via inhibition of the type I TGF receptor Alk5 (expressed in vascular tissue), which leads to enhanced tumor microvascular permeability. Via an investigational new drug application and a collaboration with the Moseley lab and the pediatric oncology team, we have started clinical evaluations of the iron supplement ferumoxytol (Feraheme) as an alternative MR contrast agent to gadolinium chelates for pediatric oncology team, we have started clinical evaluations of the iron supplement ferumoxytol (Feraheme) as an alternative MR contrast agent to gadolinium chelates for pediatric oncology treatment transport, and imaging system, and to provide the best available reconstructed image quality and quantitative accuracy. The work involves computer modeling, position sensitive sensors, readout electronics, data acquisition, image formation, signal/image processing, and data/image analysis algorithms, and incorporating these innovations into practical imaging devices. The ultimate goal is to introduce these new imaging tools into studies of molecular mechanisms and treatments of disease within living subjects in the clinic and in preclinical research.

**Dr. Levin’s laboratory is interested in the development of advanced instrumentation and software algorithms for in vivo imaging of molecular signatures of disease in the clinic and in small laboratory animal research. The goals of the instrumentation projects are to advance the sensitivity and spatial, spectral, and/or temporal resolutions as far as physically possible. The algorithm goals are to understand and model the physical system comprising the subject tissues, radiotransport, and imaging system, and to provide the best available reconstructed image quality and quantitative accuracy. The work involves computer modeling, position sensitive sensors, readout electronics, data acquisition, image formation, signal/image processing, and data/image analysis algorithms, and incorporating these innovations into practical imaging devices. The ultimate goal is to introduce these new imaging tools into studies of molecular mechanisms and treatments of disease within living subjects in the clinic and in preclinical research.**
The main focuses of our lab are 1) to develop new molecularly targeted therapies for various sub types of breast cancers (triple negative (TNBC) and receptor positive tamoxifen resistant phenotypes), 2) to understand the molecular mechanism of tamoxifen resistance in breast cancer, 3) to develop non-invasive molecular imaging assays to measure histone methylations in cells at different cellular diseases, 4) to study Nrf2-Keap1 interaction to monitor antioxidant chemoresistance in breast cancer chemo- and radio- therapies and, 5) to develop ultrasound-microbubbles mediated targeted delivery of microRNAs for advanced cancer therapy.

Breast cancer is a highly heterogeneous disease, and there is a growing body of evidence that this heterogeneity occurs at both genetic and phenotypic levels. Although breast cancer research has improved the efficacy of therapies, especially for the treatment of a sub-type of breast cancer that is estrogen receptor positive (endocrine and antibody based immunotherapies), the increase in the incidence of the receptor negative phenotype and the development of receptor positive tamoxifen resistant phenotype keep the mortality rate very high. Our lab mainly focuses on developing strategies to improve breast cancer therapy while understanding the molecular mechanism of drug resistance to circumvent the problem and to improve the therapeutic efficacy.

We are mainly interested in studying the pathways regulated by estrogen receptors (ERα and ERβ) and Nrf2 (Nuclear factor (erythroid-derived 2)-like 2) to develop our therapeutic interventions.

MicroRNAs are small regulatory RNAs expressed by cells to control gene expression. MicroRNA expression is completely dysregulated in cancer. Inhibition or restoration of microRNA functions have been reported to play significant roles in cancer-related events in cells, thus potentially heralding a powerful approach to create a new generation of molecularly targeted anti-cancer therapies. The functions of endogenous microRNAs can be successfully blocked by delivering antisense oligonucleotides, which are complementary to endogenous microRNAs (AntagomiRs). MicroRNAs such as microRNA-21, microRNA-335, and microRNA-10b play crucial roles in breast cancer, either by acting as tumor suppressors (microRNA-335) or as oncogenes (microRNA-21 and microRNA-10b). The finding that individual microRNAs target several hundred genes, regulate associated pathways involved in cellular pathogenesis, and target microRNAs for the functional maintenance of cellular genes, further underscores the emerging importance of microRNA-mediated regulation in breast cancer. Ultrasound (US) can be used for image-guided delivery of drugs with microRNAs for therapeutic interventions in cancers. Our lab is developing microRNA mediated targeted therapy specifically for breast cancers, which has no therapy available currently.

The epigenetic mechanisms, including DNA-methylation, histone acetylation, and histone methylation, are important for cellular development, differentiation, proliferation, and apoptosis. In addition to their roles in normal cellular processes, epigenetic mechanisms are believed to be capable of responding to different chemical and physical agents, possibly leading to altered biological pathways associated with cellular diseases. Recent developments demonstrating the importance of epigenetic processes as cellular targets, and the development of small molecule modulators with therapeutic efficiency, have further highlighted the need to develop advanced molecular imaging strategies capable of imaging different epigenetic processes in living animals. We are currently working on developing molecular imaging assays to image histone methylation by employing split reporter proteins complementation strategy, and evaluating small molecule therapeutic agents that modulate histone methylation in living animals.
The focus of our research is on the development of novel medical imaging probes to monitor specific biological events such as progression of cancer, and bacterial or viral infection. Using chemical, biological, physical, and engineering tools, we are making advances in the field of diagnostic imaging via optical, MRI, PET and photoacoustic modalities. We also employ our imaging strategies for point-of-care applications. In general, our projects fit into one or more of the following major interconnected lines:

**Imaging enzyme activity in vivo.** We are employing both small molecule probes and nanoparticle-based nanosensors to image the activity of proteases such as matrix metalloproteinases (MMPs), caspases, and furins, as well as poly (ADP-ribose) polymerase 1 (PARP-1), in cancer cells. Using a biocompatible reaction between cysteine and cyanobenzothiazole developed in our lab (Nature Chem. 2010, Angew. Chem. Int. Ed. 2011), we have created a versatile platform that allows formation of self-assembled nanoparticles or polymers upon activation by target enzyme. This strategy has led us to the development of activatable fluorescence and photoacoustic imaging probes to detect activity in vivo (in collaboration with the Gambhir lab). We are currently developing caspase-activatable fluorescence imaging probe, MRI imaging probe (in collaboration with the Rutll lab and Daldrup-Link lab) and PET imaging probe (in collaboration with the Chin lab and Fesik lab) which can be translated to clinical applications to monitor cancer patients’ responses to chemotherapy.

**Near-infrared (NIR) nanoparticles for in vivo imaging.** We have developed self-luminescing nanoparticles using fluorescent semiconductor quantum dots (Nature Biotech. 2006). In an alternative approach, we have achieved our second generation of self-luminescing nanoparticles using organic polymer-based particles, which are highly stable in mouse serum and exhibit strong luminescent NIR emission without external excitation (Nature Comm. 2012, accepted). This novel design of nanoparticle can be useful in optical in vitro diagnostics and in vivo imaging. We have used the nanoparticles for lymph node mapping and imaging of glioblastoma tumors in mice. We have also developed a NIR nanoparticle-based probe for imaging of reactive oxygen and nitrogen species (ROS), termed NanosORONE, in vivo. This imaging probe allows in situ and real-time detection of ROS that are associated with bacterial infection, inflammation and tumor therapy.

**Development of point-of-care strategies for infectious diseases.** We have recently developed rapid diagnostic tests that are important in the fight against tuberculosis and can be applied in resource-limited settings. A fluorogenic probe can be specifically activated by BlaC, an enzyme secreted by tubercle bacilli (TB), enabling detection of live pathogen in unprocessed human sputum in less than 10 min using a smart phone (Nature Chem. 2012). Currently, we are extending the strategy to chromogenic imaging as a platform for translational research in cellular and gene therapies for ischemic heart disease in the 21st century.

**Protein Engineering and Aptamer Selection.** Using in vitro evolution (SELEX), we have selected a protein chaperone-like RNA molecule that can recover the fluorescence of genetically engineered “dark” superfolder green fluorescent protein (sGFP) in living cells by the stabilization of protein folding during translation. The chaperone-like RNA aptamer and its development could be a useful strategy for various purposes in the bio-technology field, such as RNA imaging.
The Willmann laboratory is a group of scientists with backgrounds that span from cell and molecular biology, chemistry, pharmacology, electrical engineering, nuclear medicine, to radiology (Figure 1). Our goal is to develop and test novel molecular imaging strategies for improved detection and monitoring of cancer and inflammatory diseases. Also, we design and optimize novel image-guided therapeutic approaches for spatially controlled treatment of diseases with minimal side effects. We focus on new techniques with high potential for rapid clinical translation. The following is a summary of three research projects in the Willmann lab.

Early Detection of Breast and Pancreatic Cancer with Ultrasound Molecular Imaging

Ultrasound already fulfills many criteria as an ideal non-invasive imaging modality for early cancer detection: 1) it is widely available at modest cost, 2) it does not expose patients to ionizing radiation, and 3) it has a very high spatial and temporal resolution. In the Willmann lab, we develop novel molecularly targeted ultrasound contrast agents to molecular targets that are differentially expressed in cancer such as pancreatic and breast cancer compared to benign disease or normal tissues (Figure 2).

Non-invasive Monitoring of Inflammation with Molecular Imaging

Chronic inflammatory diseases such as inflammatory bowel diseases (IBD) require regular and accurate monitoring for appropriate clinical patient management. While clinical scores often poorly correlate with the disease’s activity, novel IBD drugs such as immunosuppressants and immunomodulators with potential substantial side effects have further increased the need for techniques to accurately quantify disease activity. In addition, since multiple follow-up exams are needed, often over many years, monitoring should be non-invasive and, above all, patient-friendly. A simple technique that meets all these requirements is not yet available. In the Willmann lab, we develop novel non-invasive imaging strategies for accurate and objective quantification and monitoring of inflammation at the molecular level (Figure 3).

Improved Drug Delivery using Image Guidance

Through a process termed “sonoporation,” selective insonation of tissue with ultrasound actuates local formation of transient cell membrane microperforations, enhancing blood vessel wall permeability and facilitating the ingress of therapeutic agents into cells. The putative primary mechanism for sonoporation is acoustic cavitation, whereby gas bodies oscillate and eventually collapse, releasing the energy necessary to induce transient cell membrane permeabilization. Ultrasound-mediated drug delivery has shown to be markedly enhanced in the presence of microbubbles, which serve as exogenous cavitation nuclei and reduce the ultrasound energy threshold for sonoporation to occur. In the Willmann lab, we develop and optimize ultrasound equipment, microbubble and nanoparticle design to generate a clinically translatable platform for image-guided drug delivery (Figure 4).

Translational Molecular Imaging Lab (TMIL)

Jürgen Willmann, MD

http://mips.stanford.edu/research/tmil.html
The Lucas Center has been home to the Radiological Sciences Laboratory (RSL), a section of the Radiology Department since the building’s dedication in 1992, and in conjunction with the Electrical Engineering Department has hosted the Center for Advanced MR Technology, an NIH-funded National Research Resource since 1995. The Center also houses a cyclotron and radiochemistry labs as well as other wet labs for the Molecular Imaging Program led by Dr. Sanjiv Gambhir. The Center’s state of the art imaging facilities support research of the RSL and others in the Radiology department as well as hundreds of on-campus and extramural researchers as a core facility. The Center has always been, and remains an exciting and lively nexus for fundamental imaging research.

The Radiological Sciences Laboratory

With the very recent arrival of Dr. Jennifer McNab, the RSL now comprises 10 faculty, approximately 45 graduate and postdoctoral students, approximately 30 scientific staff and 5 administrative assistants, as well as the Lucas Center/RSL Administrative Services Director, Donna Cronister. These numbers represent a small increase in trainees over 2011.

The faculty serve in a wide variety of advisory roles to government and foundation agencies as well as to train students and others in MRI. Over the years that goal has remained, as research projects have been introduced, matured and been replaced with new developments and opportunities. The grant is now in its 18th year of continuous funding. During it’s last 5 year renewal review in 2010 it received a perfect score (10) from the study section.

Outstanding progress has been made in all five of the core technology development areas that include RF pulse design, reconstruction methods (John Pauly, EE Department, core director), hardware (Brian Rutt, core director), body MRI techniques (Brian Hargreaves), neuro MRI (Gary Glover, with Mike Moseley and Roland Bammer contributing), and spectroscopic imaging development (Dan Spielman).

RSL Overview

Radiological Sciences Laboratory
Director: Gary H. Glover, PhD

http://rsl.stanford.edu/

Achievements of 2012

Kim Butts Pauly:
- Named to the Council of Distinguished Investigators of the Academy of Radiology Research.
- Serves on the board of ISTU (International Society for Therapeutic Ultrasound).
- Member of the Academy of Radiology Research.
- Member, editorial board of Journal of Therapeutic Ultrasound, in addition to boards for JMRI and MRM.
- Rachelle Bitton received Magna Cum Laude Merit Award for the 20th Annual ISMRM.
- Mike Marx – Outstanding TA award.

Rebecca Faring:
- Named to the Council of Distinguished Investigators of the Academy of Radiology Research.
- Student MiHyer Shin’s abstract is a finalist in the Young Investigators competition of the ASME Applied Mechanics Division and she has also received the Haithornthwaite Foundation Travel Award to attend the conference.
- She is now a Charter Member of NIH review panel BMIT-A.

Jennifer McNab:
- Jennifer joined the RSL faculty in October 2012, coming from a postdoc position at MGH. Her research interests are in imaging of tissue microstructure using diffusion and structural imaging, with particular emphasis on high-field applications.
- We are excited by the added breadth that she will bring to the RSL, and look forward to working with her on many projects.

Norbert Pelc:
- Elected to National Academy of Engineering.
- Selected as chair of Bioengineering.
- Yuan Yao did an internship at CEHC CT.
- Adam Wang defended and graduated, and is now a postdoc at John Hopkins.
- Paper: Wang AS and Pelc NJ. Synthetic CT: Simulating, Med Phys 38, 5551-62, 2011 was highlighted as an Editor’s Pick.

Gary Glover:
- Research Associate Priti Balchandani concluded her K99/R00 NIH fellowship and accepted a faculty position at Mount Sinai Hospital in New York.
- She will build a new research program based on their 7T magnet, and will have an adjunct position with our lab.
- Ranked number 73 (out of 3,926,582 entries) in academic research, microsoft.com’s listing of “top authors in medicine”, based on the H-index of citations.
The general research focus of the Bammer lab is to develop novel MRI acquisition and reconstruction methods for clinical neuroimaging. Currently, our research program is primarily concentrated around improving pediatric neuroimaging as well as various studies on the adult side. We also provide support for Lucas Center users who are interested in advanced diffusion imaging, perfusion imaging or angiographic MRI applications. A major goal in our laboratory is to reduce motion- and distortion-sensitivity of MRI by development of various sophisticated methods, such as stereo-vision and RF tracking in concert with real-time MRI. Motion correction can improve the diagnostic quality of MR images, reduce the number of repeat studies, and decrease or eliminate the need for sedation/anaesthesia.

The Bammer lab also maintains a major focus on the development of high-resolution MRI methods for diffusion-weighted and susceptibility-weighted imaging of the brain and spine. These methods are highly valued for their utility in the diagnostic work-up of traumatic, oncologic, psychiatric, developmental, or neurovascular abnormalities.

Our lab also continues to develop MR imaging sequences and analysis tools to study vasculature on the macroscopic (angiography) and microscopic (perfusion) level. For example, with our collaborators from the Stanford Stroke Center, we have developed software tools that can identify, based on CT perfusion or MR perfusion/diffusion image patterns, those patients who might benefit from reperfusion stroke therapy. With our collaborators from the Stanford Stroke Center, we have developed software tools that can identify, based on CT perfusion or MR perfusion/diffusion image patterns, those patients who might benefit from reperfusion stroke therapy. With our collaborators from the Stanford Stroke Center, we have developed software tools that can identify, based on CT perfusion or MR perfusion/diffusion image patterns, those patients who might benefit from reperfusion stroke therapy.

Thanks mostly to generous support from NIH, the Bammer Lab continues to grow; allowing us to attract and retain, extraordinary talent. This year Drs. Eric Aboussouan (Barrow Neurological Institute), Alexander Brost (Erlangen University), Natalie Han (Vanderbilt University), and Eric Peterson (Marseille) joined our group. Dr. Julian Maclaren, an international authority on real-time motion correction, joined us also this year as a research associate (University of Freiburg). For most of this year, we also had two extremely talented, young visiting researchers in our lab: Christoph Seeger (Erlangen University) and Speed Vos (University of Utrecht). During the summer break we had a star high school student, Colin Man, from the highly competitive Stanford Institute of Medicine Summer Research (SIMR) Program working with us. Out of approximately 2,000 junior and senior high school applicants, only 50 are admitted to this program.

Two of our female colleagues, Anh Van Tu and Arryani Tipirneni, left our lab this year. Arryani is currently taking care of her parents after a tragic car accident, and Anh got married and followed her sweetheart to Munich.

We also had two very junior additions to our lab. Arda Aksoy is Murat and Didem Aksoy’s first son, and Rafael is Rafael O’Halloran and Erin Girard’s first son. Congrats!
Our group conducts research with the broad goal of improving the x-ray guidance of minimally invasive procedures, including guidance of radiation therapy. The zeego@Stanford Lab houses a new state-of-the-art robotic clinical C-arm fluoroscopy system (Siemens zeego®), official launch October 2012, which was purchased with American Recovery and Reinvestment Act (ARRA) funding through an NIH Shared Instrumentation Program. The previous C-arm CT system (Siemens Artis d’A, Axiom Lab) has been used for a number of in vivo investigations outlined below. The Advanced X-ray Imaging Lab is used for hardware and software development including table-top digital x-ray imaging, conebeam CT, new detector development and MR-compatible x-ray tubes.

Software investigations have the primary goal of improving the image quality of C-arm CT reconstructions. In the past year, our flexible, open-source framework for C-arm CT reconstruction has been used to reconstruct images of human in vivo knees in standing position (collaboration with Dr. A. Maser, U. Erlangen-Nürnberg). This new approach may provide a more sensitive measure of early osteoarthritis progression. The challenge is to obtain high-resolution images of cartilage deformation under realistic use conditions. The same software framework will enable testing of new, ultra-high-resolution detector hardware for C-arm CT on the zeego@Stanford.

Clinical imaging protocols developed in the Axiom lab have focused on liver blood volume and liver perfusion, with new results showing excellent agreement with measurements obtained on a clinical CT system (collaboration with Dr. N. Kothary). Earlier work demonstrating accurate quantitative cerebral blood flow in a swine model is now in clinical evaluation (collaboration with Dr. Michael Marks). These projects were also in collaboration with Siemens AX.

In hardware developments, design and optimization of an MR-compatible rotating anode x-ray tube continue, as do our simulations of new designs for an MR-compatible linear accelerator. The Stanford-Varian collaboration is in its third year; this project has anode x-ray tube continue, as do our simulations of new designs for an MR-compatible x-ray tubes.

The challenge is to obtain high-resolution images of cartilage deformation under realistic use conditions. The same software framework will enable testing of new, ultra-high-resolution detector hardware for C-arm CT on the zeego@Stanford.

Clinical imaging protocols developed in the Axiom lab have focused on liver blood volume and liver perfusion, with new results showing excellent agreement with measurements obtained on a clinical CT system (collaboration with Dr. N. Kothary). Earlier work demonstrating accurate quantitative cerebral blood flow in a swine model is now in clinical evaluation (collaboration with Dr. Michael Marks). These projects were also in collaboration with Siemens AX.

In hardware developments, design and optimization of an MR-compatible rotating anode x-ray tube continue, as do our simulations of new designs for an MR-compatible linear accelerator. The Stanford-Varian collaboration is in its third year; this project has anode x-ray tube continue, as do our simulations of new designs for an MR-compatible x-ray tubes.

Software investigations have the primary goal of improving the image quality of C-arm CT reconstructions. In the past year, our flexible, open-source framework for C-arm CT reconstruction has been used to reconstruct images of human in vivo knees in standing position (collaboration with Dr. A. Maser, U. Erlangen-Nürnberg). This new approach may provide a more sensitive measure of early osteoarthritis progression. The challenge is to obtain high-resolution images of cartilage deformation under realistic use conditions. The same software framework will enable testing of new, ultra-high-resolution detector hardware for C-arm CT on the zeego@Stanford.

Clinical imaging protocols developed in the Axiom lab have focused on liver blood volume and liver perfusion, with new results showing excellent agreement with measurements obtained on a clinical CT system (collaboration with Dr. N. Kothary). Earlier work demonstrating accurate quantitative cerebral blood flow in a swine model is now in clinical evaluation (collaboration with Dr. Michael Marks). These projects were also in collaboration with Siemens AX.

In hardware developments, design and optimization of an MR-compatible rotating anode x-ray tube continue, as do our simulations of new designs for an MR-compatible linear accelerator. The Stanford-Varian collaboration is in its third year; this project has anode x-ray tube continue, as do our simulations of new designs for an MR-compatible x-ray tubes.

Software investigations have the primary goal of improving the image quality of C-arm CT reconstructions. In the past year, our flexible, open-source framework for C-arm CT reconstruction has been used to reconstruct images of human in vivo knees in standing position (collaboration with Dr. A. Maser, U. Erlangen-Nürnberg). This new approach may provide a more sensitive measure of early osteoarthritis progression. The challenge is to obtain high-resolution images of cartilage deformation under realistic use conditions. The same software framework will enable testing of new, ultra-high-resolution detector hardware for C-arm CT on the zeego@Stanford.

Clinical imaging protocols developed in the Axiom lab have focused on liver blood volume and liver perfusion, with new results showing excellent agreement with measurements obtained on a clinical CT system (collaboration with Dr. N. Kothary). Earlier work demonstrating accurate quantitative cerebral blood flow in a swine model is now in clinical evaluation (collaboration with Dr. Michael Marks). These projects were also in collaboration with Siemens AX.

In hardware developments, design and optimization of an MR-compatible rotating anode x-ray tube continue, as do our simulations of new designs for an MR-compatible linear accelerator. The Stanford-Varian collaboration is in its third year; this project has anode x-ray tube continue, as do our simulations of new designs for an MR-compatible x-ray tubes.

Software investigations have the primary goal of improving the image quality of C-arm CT reconstructions. In the past year, our flexible, open-source framework for C-arm CT reconstruction has been used to reconstruct images of human in vivo knees in standing position (collaboration with Dr. A. Maser, U. Erlangen-Nürnberg). This new approach may provide a more sensitive measure of early osteoarthritis progression. The challenge is to obtain high-resolution images of cartilage deformation under realistic use conditions. The same software framework will enable testing of new, ultra-high-resolution detector hardware for C-arm CT on the zeego@Stanford.

Clinical imaging protocols developed in the Axiom lab have focused on liver blood volume and liver perfusion, with new results showing excellent agreement with measurements obtained on a clinical CT system (collaboration with Dr. N. Kothary). Earlier work demonstrating accurate quantitative cerebral blood flow in a swine model is now in clinical evaluation (collaboration with Dr. Michael Marks). These projects were also in collaboration with Siemens AX.

In hardware developments, design and optimization of an MR-compatible rotating anode x-ray tube continue, as do our simulations of new designs for an MR-compatible linear accelerator. The Stanford-Varian collaboration is in its third year; this project has anode x-ray tube continue, as do our simulations of new designs for an MR-compatible x-ray tubes.

Software investigations have the primary goal of improving the image quality of C-arm CT reconstructions. In the past year, our flexible, open-source framework for C-arm CT reconstruction has been used to reconstruct images of human in vivo knees in standing position (collaboration with Dr. A. Maser, U. Erlangen-Nürnberg). This new approach may provide a more sensitive measure of early osteoarthritis progression. The challenge is to obtain high-resolution images of cartilage deformation under realistic use conditions. The same software framework will enable testing of new, ultra-high-resolution detector hardware for C-arm CT on the zeego@Stanford.

Clinical imaging protocols developed in the Axiom lab have focused on liver blood volume and liver perfusion, with new results showing excellent agreement with measurements obtained on a clinical CT system (collaboration with Dr. N. Kothary). Earlier work demonstrating accurate quantitative cerebral blood flow in a swine model is now in clinical evaluation (collaboration with Dr. Michael Marks). These projects were also in collaboration with Siemens AX.

In hardware developments, design and optimization of an MR-compatible rotating anode x-ray tube continue, as do our simulations of new designs for an MR-compatible linear accelerator. The Stanford-Varian collaboration is in its third year; this project has anode x-ray tube continue, as do our simulations of new designs for an MR-compatible x-ray tubes.

Software investigations have the primary goal of improving the image quality of C-arm CT reconstructions. In the past year, our flexible, open-source framework for C-arm CT reconstruction has been used to reconstruct images of human in vivo knees in standing position (collaboration with Dr. A. Maser, U. Erlangen-Nürnberg). This new approach may provide a more sensitive measure of early osteoarthritis progression. The challenge is to obtain high-resolution images of cartilage deformation under realistic use conditions. The same software framework will enable testing of new, ultra-high-resolution detector hardware for C-arm CT on the zeego@Stanford.

Clinical imaging protocols developed in the Axiom lab have focused on liver blood volume and liver perfusion, with new results showing excellent agreement with measurements obtained on a clinical CT system (collaboration with Dr. N. Kothary). Earlier work demonstrating accurate quantitative cerebral blood flow in a swine model is now in clinical evaluation (collaboration with Dr. Michael Marks). These projects were also in collaboration with Siemens AX.

In hardware developments, design and optimization of an MR-compatible rotating anode x-ray tube continue, as do our simulations of new designs for an MR-compatible linear accelerator. The Stanford-Varian collaboration is in its third year; this project has anode x-ray tube continue, as do our simulations of new designs for an MR-compatible x-ray tubes.

Software investigations have the primary goal of improving the image quality of C-arm CT reconstructions. In the past year, our flexible, open-source framework for C-arm CT reconstruction has been used to reconstruct images of human in vivo knees in standing position (collaboration with Dr. A. Maser, U. Erlangen-Nürnberg). This new approach may provide a more sensitive measure of early osteoarthritis progression. The challenge is to obtain high-resolution images of cartilage deformation under realistic use conditions. The same software framework will enable testing of new, ultra-high-resolution detector hardware for C-arm CT on the zeego@Stanford.

Clinical imaging protocols developed in the Axiom lab have focused on liver blood volume and liver perfusion, with new results showing excellent agreement with measurements obtained on a clinical CT system (collaboration with Dr. N. Kothary). Earlier work demonstrating accurate quantitative cerebral blood flow in a swine model is now in clinical evaluation (collaboration with Dr. Michael Marks). These projects were also in collaboration with Siemens AX.
The JOINT Group
Joint and Osteoarthritis Imaging with Novel Techniques

Garry Gold, MD
http://radiology.stanford.edu/patient/clinical_sections/musculoskeletal/

T he body MR imaging group works with clinicians at Stanford Hospital and scientists at GE Healthcare and in Electrical engineering to apply MRI to abdominal imaging, musculoskeletal imaging, breast imaging, and cardiovascular imaging. More information is at http://bmr.stanford.edu.

This year we celebrated two PhD degrees earned by Dr. Ernesto Staroswiecki and Dr. Anderson Nnewihe, both of whom are now working in industry. We said farewell to Drs. Kyung Sung and Pauline Worters, both research scientists who had tremendous impact on both research and clinical scanning, and wish them well at UCLA and GE Healthcare. Graduate student Brady Quist was awarded a prestigious NSF Fellowship, as well as an ISMRM student award. Bragi Svistovens was given an RSL award for Outstanding Student Service to RSL. Our major R01 grant on High-Resolution Whole-Breast MRI scored well and will successfully be renewed through 2016. Work on this grant has dramatically improved the reliability and resolution of our clinical breast MRI protocol. Finally, our group was also awarded a grant to work with GE Healthcare to continue to advance clinical MRI near metallic implants.

We welcome graduate students Evan Levine and Limit Yoruk, both in Electrical Engineering. Evan is working on compressed sensing techniques for accelerated imaging in the body, while Limit is working on MRI assessment of regional renal function. Most recently, Dr. Daehyun Yoon has also joined our group as a Post-doctoral fellow after graduating from University of Michigan where he worked on RF pulse design for parallel imaging, amongst other areas.

MRI normally assumes a narrow band of resonance frequencies. Near metal implants, the varied frequencies lead to failed fat suppression, signal loss, and distortion. Sampling an extra dimension allows reduction of artifacts, but takes more time. However, compressed sensing methods can enable reduced scan times with excellent artifact correction, as demonstrated in the spine.

D CE equivalent 8 Ch coil

Novel breast coil images (top) show better morphological detail because of reduced coil images (bottom), including lesions, shape, borders and heterogeneity.
Our research is directed toward the development of technology and applications of computed tomography (CT). The long-term aim of this work is to push the limits of CT performance, to improve dose efficiency, and to aid in the development of new applications. Intrinsically in these goals is the need to understand the basic limitations in current systems and, when physically possible, to develop solutions to effectively address them.

For many years we have been working on a project to develop a CT system with an “inverse geometry”, using a wide array of sources rather than a single point source, in collaboration with GE Global Research. This year, thanks to NIH funding from the American Recovery and Reinvestment Act, we completed construction of an experimental system with 32 sources arranged in two rows. Jongduk Baek is analyzing the initial data from this unique system.

The main disadvantage of inverse geometry is the complexity of the source array. One of the potential benefits of the use of multiple sources is reduction of radiation dose from the ability to control the illumination beam. Scott Hsieh came up with an ingenious way to achieve comparable control of the x-ray beam in a conventional CT design by using a much simpler mechanical approach. We have demonstrated the potential of this approach using computer simulations and, with the help of Mark Peng, have now built a test unit to further explore this opportunity (Fig. 2). Scott is also conducting research to improve the image quality of CT when the object is wider than the x-ray fan beam (Fig. 2).

Yuan Yao continued his work on x-ray filtration in dual energy CT. He also conducted a comparison of the dose efficiency of “blended” dual energy images vs. single energy CT for liver imaging (Fig. 3). This is the first step in his longer-term work toward modeling CT imaging of liver tumors.

Adam Wang completed his dissertation research on information extraction in CT, especially in spectral CT. One technology with significant potential to improve CT performance is photon-counting detectors, which process individual photons rather than the combined contributions from thousands of them. However, their response is imperfect, especially when the count rate is high. Adam Wang studied the impact of different types of performance limitations of these detectors and showed that further improvements are needed before system benefits would be obtained. Paurakh Rajbhandary is continuing work in this field, researching the best way to process the spectral data.

On a personal note, Jongduk Baek is now an Assistant Professor at Hanyang University in his native Seoul, Korea. We also said farewell to Adam Wang this year. He is now a post-doctoral fellow at Johns Hopkins University. We wish them both well.

Intrinsic in these goals is the need to understand the basic limitations in current systems and, when physically possible, to develop solutions to effectively address them.

For many years we have been working on a project to develop a CT system with an “inverse geometry”, using a wide array of sources rather than a single point source, in collaboration with GE Global Research. This year, thanks to NIH funding from the American Recovery and Reinvestment Act, we completed construction of an experimental system with 32 sources arranged in two rows. Jongduk Baek is analyzing the initial data from this unique system.

The main disadvantage of inverse geometry is the complexity of the source array. One of the potential benefits of the use of multiple sources is reduction of radiation dose from the ability to control the illumination beam. Scott Hsieh came up with an ingenious way to achieve comparable control of the x-ray beam in a conventional CT design by using a much simpler mechanical approach. We have demonstrated the potential of this approach using computer simulations and, with the help of Mark Peng, have now built a test unit to further explore this opportunity (Fig. 2). Scott is also conducting research to improve the image quality of CT when the object is wider than the x-ray fan beam (Fig. 2).

Yuan Yao continued his work on x-ray filtration in dual energy CT. He also conducted a comparison of the dose efficiency of “blended” dual energy images vs. single energy CT for liver imaging (Fig. 3). This is the first step in his longer-term work toward modeling CT imaging of liver tumors.

Adam Wang completed his dissertation research on information extraction in CT, especially in spectral CT. One technology with significant potential to improve CT performance is photon-counting detectors, which process individual photons rather than the combined contributions from thousands of them. However, their response is imperfect, especially when the count rate is high. Adam Wang studied the impact of different types of performance limitations of these detectors and showed that further improvements are needed before system benefits would be obtained. Paurakh Rajbhandary is continuing work in this field, researching the best way to process the spectral data.

On a personal note, Jongduk Baek is now an Assistant Professor at Hanyang University in his native Seoul, Korea. We also said farewell to Adam Wang this year. He is now a post-doctoral fellow at Johns Hopkins University. We wish them both well.

The main disadvantage of inverse geometry is the complexity of the source array. One of the potential benefits of the use of multiple sources is reduction of radiation dose from the ability to control the illumination beam. Scott Hsieh came up with an ingenious way to achieve comparable control of the x-ray beam in a conventional CT design by using a much simpler mechanical approach. We have demonstrated the potential of this approach using computer simulations and, with the help of Mark Peng, have now built a test unit to further explore this opportunity (Fig. 2). Scott is also conducting research to improve the image quality of CT when the object is wider than the x-ray fan beam (Fig. 2).

Yuan Yao continued his work on x-ray filtration in dual energy CT. He also conducted a comparison of the dose efficiency of “blended” dual energy images vs. single energy CT for liver imaging (Fig. 3). This is the first step in his longer-term work toward modeling CT imaging of liver tumors.

Adam Wang completed his dissertation research on information extraction in CT, especially in spectral CT. One technology with significant potential to improve CT performance is photon-counting detectors, which process individual photons rather than the combined contributions from thousands of them. However, their response is imperfect, especially when the count rate is high. Adam Wang studied the impact of different types of performance limitations of these detectors and showed that further improvements are needed before system benefits would be obtained. Paurakh Rajbhandary is continuing work in this field, researching the best way to process the spectral data.

On a personal note, Jongduk Baek is now an Assistant Professor at Hanyang University in his native Seoul, Korea. We also said farewell to Adam Wang this year. He is now a post-doctoral fellow at Johns Hopkins University. We wish them both well.
Research Group Updates

The focus of our laboratory is the development of novel magnetic resonance imaging (MRI) and spectroscopy (MRS) methods for the improved measurement of metabolism in vivo in order to better understand tissue and organ function in both health and disease. The primary applications are in disease detection, treatment monitoring, and drug development. During the past year, our research has been in three distinct directions.

First, the technical development of ultrahigh field (7T) proton imaging and spectroscopy of the brain continues to focus on the design and evaluation of novel adiabatic RF excitation pulses for addressing the magnetic field inhomogeneities encountered at 7T and the development of new pulse sequences to exploit novel contrast mechanisms. Highlights of this work include an innovative adiabatic B1 shimming algorithm for multiple channel transmit, the development and testing of a self-referenced adiabatic pulse for 7T spin echo imaging, an improved adiabatic pulse design yielding robust slice-select combination with fat (or water) suppression while maintaining a short overall pulse duration. Dr. Priti Balchandani, working under her NIH K99/R00 grant entitled "High Resolution Magnetic Resonance Imaging and Spectroscopy of Epilepsy at 7T", has been leading these efforts; she has recently accepted a faculty position at Mt. Sinai Medical Center in NY. While we will certainly miss Priti at the lab and around the Lucas Center, we wish for her the very best in this important step forward in her career.

Second, under an ongoing program in the development of volumetric 1H MRS at 1.5 T and 3.0 T, funded through an NIBIB Bioengineering Partnership grant (EB000822), we have under-taken a multi-site evaluation of a volumetric echo-planar 1H spectroscopic imaging sequence and associated automated data reconstruction software, developed several new short echo time spectroscopic imaging pulse sequences for significantly improved sensitivity, and are currently initiating a clinical study, in collaboration with Dr. Michael Zeineh, using this sequence to evaluate patients with traumatic brain injury.

Finally, we have received an outstanding score on a NIH Shared Instrument Grant "Hyperpolarizer for 13C MR Metabolic Imaging of Human Subjects and Animal Models" for the purchase of the next generation polarizer. If funded, we hope to site the new polarizer during the upcoming year at the Lucas Center on the 3T scanner also slated to become Stanford’s first MR/PET imaging laboratory.

Third, our efforts in the area of hyperpolarized 13C MRS and MRSI continue to move rapidly forward. Hyperpolarized 13C is a promising new technology capable of directly probing key metabolic pathways by providing unprecedented increases in signal-to-noise ratio for these in vivo measurements. Over the past year we have successfully developed several novel MRSI pulse sequences and associated metabolic modeling tools including the use of hyperpolarized [1-13C]pyruvate for the study of liver, heart, and brain metabolism in the normal rat and in a C6 rat glioma model, hyperpolarized [2-13C]pyruvate for the investigation of mitochondrial acetyl-CoA trafficking, and investigations into the feasibility of using 13C-labeled di-ethyl-succinate for the measurement of oxidative phosphorylation. The hyperpolarized 13C MRS work is funded under NIH grants R01EB019670 “Dynamic Metabolic Imaging of Hyperpolarized Substrates”, RO1AI03681 “Metabolic Imaging of the Cardioprotective Effects of Alcohol and ALDH2 Activators”, P41EB013591 “Center for Advanced Magnetic Resonance Technology at Stanford”, a Department of Defense award “In Vivo Imaging of Branched Chain Amino Acid Metabolism in Prostate Cancer”, and most recently a Stanford BioX Defense award "In Vivo Imaging of Branched Chain Amino Acid Metabolism in Prostate Cancer" , and most recently a Stanford BioX Defense award "In Vivo Imaging of Branched Chain Amino Acid Metabolism in Prostate Cancer" , and most recently a Stanford BioX Defense award "In Vivo Imaging of Branched Chain Amino Acid Metabolism in Prostate Cancer" , and most recently a Stanford BioX Defense award "In Vivo Imaging of Branched Chain Amino Acid Metabolism in Prostate Cancer" , and most recently a Stanford BioX Defense award "In Vivo Imaging of Branched Chain Amino Acid Metabolism in Prostate Cancer" .

The downstream metabolic products of [5-13C]glutamate, [1-13C]acetylcarnitine (ALCAR), and [1-13C]citrate are all detectable. The fate of acetyl-CoA brain was further investigated by infusing dichloroacetate, which upregulates pyruvate flux to acetyl-CoA. We believe of the hyperpolarized 13C glutamate will yield the best measure of oxidative phosphorylation. The hyperpolarized 13C MRS work is funded under NIH grants R01EB019670 “Dynamic Metabolic Imaging of Hyperpolarized Substrates”, RO1AI03681 “Metabolic Imaging of the Cardioprotective Effects of Alcohol and ALDH2 Activators”, P41EB013591 “Center for Advanced Magnetic Resonance Technology at Stanford”, a Department of Defense award “In Vivo Imaging of Branched Chain Amino Acid Metabolism in Prostate Cancer”, and most recently a Stanford BioX Defense award "In Vivo Imaging of Branched Chain Amino Acid Metabolism in Prostate Cancer" , and most recently a Stanford BioX Defense award "In Vivo Imaging of Branched Chain Amino Acid Metabolism in Prostate Cancer" , and most recently a Stanford BioX Defense award "In Vivo Imaging of Branched Chain Amino Acid Metabolism in Prostate Cancer" .

Finally, we have received an outstanding score on a NIH Shared Instrument Grant "Hyperpolarizer for 13C MR Metabolic Imaging of Human Subjects and Animal Models" for the purchase of the next generation polarizer. If funded, we hope to site the new polarizer during the upcoming year at the Lucas Center on the 3T scanner also slated to become Stanford’s first MR/PET system, thus establishing a new state-of-the-art metabolic imaging laboratory.
Clinical Center for Advanced Neuro Imaging (CFAN)

Greg Zaharchuk, MD, PhD and Michael Moseley, PhD
http://radiology.stanford.edu/research/labs.html

Our advanced neuroimaging MR routinely map and measure brain form, flow, and function. Our expertise in advanced imaging in a large number of diseases in patients, the Clinical Center For Advanced Neuro Imaging (CFAN) is built upon a large framework of funded NIH grants from the RSL, Lucas Center, and Stanford Stroke Center faculty dedicated to bringing the best MRI techniques into everyday clinical use. Based within the Lucas Center in the Radiological Sciences Laboratory, we drive key clinical areas of neuroimaging focusing on disease processes in stroke, brain tumors, and cerebrovascular diseases using diffusion MRI (DWI), tissue perfusion mapping (PWI), as well as the new field of mapping the brain connectivity, DTI, and susceptibility-weighted MRI (SWI). CFAN also develops and uses high-resolution quantitative diffusion tensors and perfusion maps to explore and map complex brain structure and function in active mental tasking to reveal new key findings in the developing and aging brain function for blood flow, tissue integrity, and for cognition.

Under the CFAN umbrella, researchers from the Stanford Stroke Center, Departments of Neurology Neurosurgery, Psychiatry and Psychology, Duke University, Lucille Packard Children’s Hospital, Palo Alto VA Medical Center and many collaborators work together in adapting cutting-edge imaging for neurocognition’s toughest problems. Drs. Zaharchuk, Moseley, Christen, Qiu, and Zun lead an active team adapt novel methods for breakthrough protocols for quantitating collateral blood flow in cerebrovascular disease; altered CNS blood flow in MS, Moyamoya, TIA, stroke, and cerebral vascular diseases of the pediatric to aging brain. We provide our international research and clinical colleagues with new ways to approach the brain’s most complex problems.

Figure 1. Multi-parametric quantitation of cerebral blood volume (CBV), cerebral blood flow (CBF), MR tissue oxygen saturation (max 100% brain oxygen) and the corresponding vascular oxygenation patterns (background).

Figure 2. CFAN Osirix-developed application plug-in for rapid analysis and visualization of white matter structure and integrity. This is used together with our High-Order Tensor (HOT) quantitation models.

Figure 3. Quantitative Susceptibility Mapping for rapid assessment of brain form (aluminum composition), flow (vascular iron), and function (tissue oxygenation) from a single exam.

Image this page provided by Dr. Michael Zeineh. Tractography parameter optimization. In one subject, tracts are depicted with anisotropy thresholds of 0.02, 0.05, and 0.1 and minimum tract length of 10 and 20 mm, all utilizing a curvature threshold of 40°.
Centers and Programs
MR-guided Cancer Interventions

Director: Kim Butts Pauly, PhD

This project, initially funded by the National Cancer Institute (NCI) in 2011, develops and tests controlled minimally invasive thermal ablation techniques for the treatment of cancers that are attributed to a quarter of cancer deaths. Our overall goal in this project is to provide precise imaging, feedback, and control of the shape and size of thermal lesions to improve treatment options for these patients. Built upon the foundation of the Stanford Schools of Medicine and Engineering, the Stanford Cancer Center, and collaborators from UCSF and HeartVista, this program brings together five projects: 1) MR-guided HIFU of soft tissue tumors, 2) Minimally Invasive MRI-Guided Management of Prostate Disease, 3) MR-Guided Precision Thermal Therapy of Retroperitoneal Tumors, 4) MRI Methods for Guiding Focused Ultrasound in the Brain, and 5) MR-guided RF Ablation. The five projects have many common requirements for programmatic and infrastructure support, which have been consolidated into cores. An engineering core will support Projects 2-5 with control hardware and software, as well as improved device visualization. An Imaging Assessment and Histopathology Core will assist all of the projects with post ablation assessment imaging, correlation with histology, and statistical support. The outcomes of this PPG will be 1) improved minimally-invasive treatment options, 2) an increase in the basic science understanding of tissue response to thermal treatments, and 3) advances in engineering, both hardware and software, specifically for treatment of these cancers.

In addition to Dr. Kim Butts Pauly as the overall PI of this P01, other project and core leaders include:

Project 1, MR-guided HIFU of Soft Tissue Tumors, which is co-lead by Garry Gold, MD, Professor of Radiology and Raffi S. Avedian, Assistant Professor of Orthopedic Surgery. In this project, we are developing techniques to use MR-guided high intensity focused ultrasound (MRHIFU) to treat soft tissue tumors of the extremities.

Project 2, Management of Prostate Disease, lead by Bruce Daniel, MD, Professor of Radiology. In project 2, we will develop MRI-compatible methods that marry micro-robotic technology with realtime 3T MRI to provide unprecedented control, haptics, guidance and monitoring for trans-perineal minimally invasive biopsy and cryoablation of focal, clinically significant prostate tumors.

Project 3, Thermal Therapy of Pancreatic Cancer, lead by F. Graham Sommer, MD, Professor of Radiology. In project 3, we will design and evaluate inserted ultrasound applicators and external transducer arrays for treating retroperitoneal tumors including pancreatic cancer.

Project 4, MRI Methods for Guiding FUS in the Brain, lead by Kim Butts Pauly, PhD, Professor of Radiology. In project 4, we will improve and evaluate MR imaging for focused ultrasound (FUS) treatments in the brain. This includes improved temperature imaging, calculation imaging, adaptive focusing algorithms to correct for phase aberrations from the skull, and assessment after thermal ablation.

Project 5, MR-guided RF Ablation of the Liver, lead by John Pauly, PhD, Professor of Electrical Engineering. In project 5, we will use MRI’s intrinsic ability to map electromagnetic fields to visualize RF ablation and use feedback to control RF ablation.

Core A, Imaging Assessment and Histopathology Core, directed by Donna Bouley, DVM, PhD, Professor of Comparative Medicine.

Core B, Hardware Engineering Core, directed by Greig Scott, PhD, Senior Research Engineer, Electrical Engineering.

Core C, Software Engineering Core, directed by Andrew Holbrook, PhD, Research Associate, Radiology.

Figure 2. Project 4 highlights: a) MR-ARFI displacement phase images for an aberrated (middle), aberrated, and corrected case are shown. The hybrid simulation MR-ARFI technique used the aberrated image for estimating the corrections. The estimated corrections were subtracted from the applied distortions and used to acquire the corrected image. b) Profiles through the focal spots are shown from the ideal (left), aberrated (middle), and corrected (right) images. c) The maximal focal improvements are shown for the ideal (left), aberrated (middle), and corrected (right) cases, with the standard deviations plotted using error bars.
Increasing evidence indicates that many cancers mimic like normal tissue by creating underlying cancer progression that are driven by impaired cellular differentiation. The Stanford CCSB aims to discover molecular mechanisms of differentiation, and maintain it in a nonlethal state. Toward this aim, we believe that a network-based and multiscale viewpoint is necessary to identify molecular therapeutic targets and strategies to eradicate this disease, or to maintain it in a nonlethal state.

The Stanford Center for Cancer Systems Biology (CCSB) is one of twelve NCI centers funded by the NCI's Integrative Cancer Biology Program to promote the integration of experimentation and biocomputation in the study of the molecular biology of cancer. The Stanford CCSB aims to discover molecular mechanisms underlying cancer progression that are driven by impaired cellular differentiation. Increasing evidence indicates that many cancers mimic like normal tissue by creating a hierarchy of cells at different stages of differentiation, and that the disease is maintained by a self-renewing cellular subpopulation. Our overarching goal is to provide a better understanding of the self-renewing properties of cancer that will enable us to identify molecular therapeutic targets and strategies to eradicate this disease, or to maintain it in a nonlethal state.

Our CCSB research program is organized around three distinct but related biological projects that are informed by novel biocomputational analytical core (Figure 1). The biological projects are designed to identify causal factors underlying impaired differentiation as a driver of cancer progression in several hematologic malignancies. Toward this aim, we believe that a network-based and multiscale viewpoint is needed. Increasingly, diseases such as cancer are recognized as resulting from disruption in the coordinated processes of a complex biological system. This systems biology viewpoint necessitates the incorporation of high throughput, high dimensional data, and development of computational methods specifically designed to its analysis. For computational analysis, we are developing three interlocking approaches. First, we are developing methods to infer molecular regulatory networks that drive phenotypic processes such as differentiation. Second, we are developing new computational tools that identify and isolate underlying patterns of progression in cancer, which can then be related to underlying regulatory networks.

Finally, we are developing executable models are desirable so that it is possible to pose hypothetical “what if” questions to predict how, for example, a targeted intervention might affect the subsequent course of disease. These computational approaches are applied to the study of differentiation in a range of hematological malignancies. In fact, our Research Plan is divided among 4 research projects (see Figure 1). Project 1 is dedicated to developing novel computational methods, whose applications are deeply integrated into our three complementary experimental projects in AML (Project 2), FL (Project 3), and T-ALL (Project 4). Taken as a whole, the four projects provide a systems-level, network-focused view of the role of differentiation in cancer. Our integrative approach enable us to ascertain differences between these hematologic malignancies, and commonalities, which may generalize to other cancers.

The Stanford CCSB faculty brings clinical and basic cancer researchers together with researchers from mathematics, engineering, imaging sciences, and computer science to work on key questions in cancer biology. The CCSB core faculty include: PI Sylvia K. Plevritis, PhD, Associate Professor of Radiology; co-PI Garry Nolan, PhD, Professor of Microbiology & Immunology; Daphne Koller, PhD, Professor of Computer Science; David Dill, PhD, Professor of Computer Science; Ronald Levy, MD, Professor of Medicine (Oncology); Ravindra Majeti, MD, PhD, Associate Professor of Hematology; Dean Felsner, MD, PhD, Professor of Medicine (Oncology) & Pathology.

Our CCSB also maintains a Core for Data Integration, which is lead by Andrew Gentles, PhD, CCSB Scientific Program Manager and includes Rob Tibshirani, PhD, Professor of Health Research and Policy (Biostatistics) and Ramesh Nair, PhD. The purpose of this core is to facilitate interactions between computational projects and experimental projects, and promote timely dissemination of resources. This core also provides initial processing of complex data sets, and dissemination of results and computational tools. Several of our projects produce array-based data such as gene expression of bulk tissue and sorted cells. We perform consistent normalization for these datasets across projects. We also assist with access to public data repositories such as GEO and ArrayExpress, again providing consistent data normalization and processing for analysis. Three recent activities of our Core are listed below:

- We developed a computational pipeline for Next Generation Sequencing. We are developing computational pipelines for processing raw NGS data from CCSB experimental projects, including initial quality control and alignments, through to final variant (single nucleotide, structural, etc) calling for DNA sequencing and expression levels for RNA-seq.
- We developed a Data Portal based on the open-source Labkey system (http://www.labkey.org). In order to facilitate data dissemination between CCSB projects and to the wider scientific community, our Data Portal provides project-oriented views of existing and “in-progress” datasets.
- We maintain a large resource of public cancer datasets, which have genomic profiles and associated clinical outcomes such as survival times. This resource, PRECOG (PREDiction of Clinical Outcomes from Genomics) comprises ~28000 patient samples across 40 malignancies and is utilized by all our experimental groups.

Our CCSB operations are led by Anita Samantaray, MPH, Program Manager, who also coordinates our outreach and education efforts. The Stanford CCSB produces education and outreach programs for students at all levels. Public outreach activities and research experiences enhance CCSB’s impact in the bay area. We continue to offer annual symposia and monthly seminar series on campus to help educate scientists about cancer systems biology. The CCSB seminar series (http://ccsb.stanford.edu/events/seminars.html) is now in its second year and its Video Gallery can be viewed online (http://ccsb.stanford.edu/events/video_galery.html). Our first workshop on next generation sequencing workshop was a success with over 100 in attendance, for more information, please see: (http://ccsb.stanford.edu/education/ngs.html).

In conjunction with the Stanford Cancer Biology PhD program, the Stanford CCSB is pleased to announce a new track focused on Cancer Systems Biology. A new course entitled, Principles of Cancer Systems Biology, will be offered this Spring (CBIO 243, 3 units). Our objective is to train a new generation of researchers in cancer biology who are adept at computational analysis of complex molecular data of cancer. With the emergence of high throughput (HTP) technologies that probe global DNA, RNA and protein expression as well as cellular state, we believe researchers need to consider a systems approach to cancer biology research that integrates experimental and computational methods in the synthesis and testing of new biological hypotheses. Our new program in Cancer Systems Biology will emphasize these principles. Students will learn new how to apply computational approaches to HTP data analysis to enable the discovery of molecular drivers and networks critical to cancer initiation, progression and treatment, and the discovery of novel methods for developing diagnostics and therapies. Students will work with researchers that investigate and develop mathematical formulations of known or conjectured signaling pathways that enable computer simulation of cellular and molecular dynamics. Students will be expected to derive biologically relevant computational predictions that are subsequently experimentally validated. Students with either a background in statistics, mathematics, engineering, computer science, a related quantitative field, or who have a primary background in biology and would like to acquire such quantitative skills and who desire to apply these skills to answering pressing questions in cancer biology are encouraged to apply.
carrier to deliver drugs and report its location. Furthermore, these nanoparticles are of great interest to the molecular imaging community due to their excellent tumor targeting, reporter, and therapeutic properties. Our data demonstrate that this exquisite specificity can be used for many applications in the imaging and therapy of cancers.

Integrated intravital microscopy, electron microscopy, and mathematical modeling uncover surprising differences in extravasation between quantum dots and nanotubes in murine tumor models (Gambhir et al.) - Extravasation is the only passive delivery method by which nanoparticles (NPs) may reach tumor interstitium for cancer imaging and therapy. Understanding this mechanism is critical to enable NPs to reach tumor cells and perform their function(s). The nano-molecular imaging field remains in its infancy and has had minimal mathematical support to guide it. Here we integrate experiments - intravital microscopy (IVM) of living mice and detailed electron microscopy (EM) of tumor vascular pore properties - with sophisticated fluid mechanics models to describe NP extravasation from vessels into tumor interstitium. We employ IVM to visualize how NPs extravasate and models to understand why. The models have the flexibility to model NPs of any shape/sizes in vasculature of any geometry. This will aid in NP design for optimal tumor uptake for imaging/therapy. This work also reveals the importance of combining experimentation with mathematical modeling to drive/optimize the field of NP use in living subjects.

Visualization of lymphoma progression in a murine model using a novel lymph node internal window chamber (LNIWC) strategy (Gambhir Lab) - Non-Hodgkin's Lymphoma is a heterogeneous and malignant form of lymphoma and mechanisms of tumor progression and metastases are poorly understood. Elucidation of this information may lead to better early detection and lymphoma patient management strategies. We reasoned that a multi-modal intravital fluorescence and bioluminescence imaging approach could be used to assess lymphoma progression in mouse models and successfully developed such a system. Our data indicate that imaging lymphoma progression using our newly developed approach is a powerful tool for elucidating lymphoma development in unprecedented detail and is already leading to new biological insights.

Fabrication and Characterization of a Raman-Based Endoscopic Imaging Probe for Cancer Detection (Profs. C. Contag and S.S. Gambhir et al.) - Endoscopic imaging is the standard of care and has been instrumental in decreasing the incidence of gastrointestinal cancers as an early detection procedure and screening method. However, with traditional white-light endoscopic tools, physicians still cannot efficiently and accurately distinguish between precancerous and benign lesions without biopsy and subsequent histopathology. We have developed a Raman-endoscopic probe that can be inserted into a conventional endoscope and has the potential to detect and quantify the presence of a multiplexed panel of 10 tumor-targeting surface-enhanced-Raman-scattering (SERS) nanoparticles. This approach would enable endoscopists to use molecular markers to distinguish between normal and cancerous tissues and to identify the otherwise hard-to-detect flat lesions that are easily missed during conventional endoscopy.

Better visualization of brain tumors and tumor borders during surgery using nanoparticles that have triple modality imaging capabilities (Prof. S.S. Gambhir et al.) - The difficulty in delineating brain tumor margins is a major obstacle for better outcomes for patients with brain tumors. Current imaging methods are limited in sensitivity, spatiotemporal and spatial resolution. We have recently shown that a unique triple-modality magnetic resonance imaging-photoacoustic imaging-Raman imaging nanoparticle can accurately delineate the margins of brain tumors in living mice both preoperatively and intraoperatively.
In Vivo Cellular and Molecular Imaging Center at Stanford (ICMIC)

Director: Sanjiv Sam Gambhir, MD, PhD

The In Vivo Cellular and Molecular Imaging Center at Stanford (ICMIC@Stanford) is directed by Dr. Sanjiv Sam Gambhir, Professor of Radiology and Division Chief of the Nuclear Medicine Division, and co-directed by Dr. Chris Contag, Professor of Pediatrics and Director of Stanford Center for Innovation in vivo Imaging (SCI3). Together, Drs. Gambhir and Contag form a highly unique leadership team that spans the diversity of disciplines involved in the field of multimodality molecular imaging. Drs. Gambhir and Contag also co-lead the Molecular Imaging Program at Stanford (MIPS), which currently has 26 full members (including Drs. Contag and Gambhir) from 8 different departments and 31 associate members from 17 different departments. All ICMIC faculty are all full members of the MIPS program. The ICMIC@Stanford provides a solid foundation for the Molecular Imaging Program at Stanford (MIPS).

While our early ICMIC efforts focused primarily on linking pre-clinical models of cancer with the clinical management of cancer, our overall vision today emphasizes the application and extension of molecular imaging to translational research and clinical applications. We will continue to exploit molecular imaging in the extraction of basic information from animal models and from pre-clinical studies; provide new information on tumor diagnosis, initiation, progression, and responses to therapy in these models; and develop new imaging technologies. Our Developmental Fund projects include projects from outstanding basic science cancer researchers who are newly integrating molecular imaging techniques into their programs. Our major goal for the ICMIC@Stanford in this five-year cycle has been to provide a foundation that allows and encourages the integration of molecular imaging into translational studies and into clinical cancer applications. Therefore, our research projects and developmental fund projects continue to be selected based on their ability to promote the interactions of basic cancer/molecular imaging researchers with clinical researchers in the translation of studies from animal models on cancer initiation, progression, diagnosis, staging, and response to therapy into clinical applications. In our research projects, we have assembled numerous physicians working in concert with molecular imaging scientists in order to further bridge our clinical and scientific community. This blending of individuals with expertise in treating patients and those with expertise in the research laboratory allows us to continue to accomplish our long-term vision of translating molecular imaging strategies into the clinic. We also form important scientific links to our NCI Funded CCNE U54 and NTR U54 programs through use of in vitro nanosensors and intraoperative microscopy, respectively. These links further accelerate our ability to bring important state-of-the-art solutions to cancer research and cancer patient care.

Our mission continues to focus on the growth of multimodality in vivo cellular and molecular imaging to study neoplastic disease and to forge stronger links between pre-clinical models and clinical cancer management through advances in multimodality molecular imaging. In addition to addressing key issues in cancer research from the level of oncogenesis to using imaging for optimizing anti-cancer therapies in pre-clinical models and in cancer patients, the ICMIC also maintains a dedicated interest in training future scientists and clinicians in the field. Overall, the ICMIC@Stanford is charged to accomplish the following aims:

- Maximize interaction among multidisciplinary investigators for a coordinated effort in molecular and cellular imaging of cancer
- Coordinate and manage the multidisciplinary programmatic cores and collaborative research efforts, and integrate these into the specialized research activities of the University for an effective research endeavor that pushes the envelope of scientific discovery
- Understand basic biological mechanisms of cancer that will lead to intervention strategies that will aid in the design and testing of innovative therapies that strike at the molecular foundation of oncogenesis and the minimal disease states that lead to relapse
- Maximize the use of the specialized resources and program strengths with integrated projects that aim to advance novel imaging approaches in oncology
- Provide training opportunities for students and scientists at all career levels to advance the field of in vivo cellular and molecular imaging, nationally and internationally.
The Center for Biomedical Imaging at Stanford, led by Dr. Kim Butts Pauly, PhD, continues to focus on its primary mission of education within the Stanford imaging community. The CBIS education goals are met through an Annual Symposium and a Seminar Series that includes local and invited speakers. Along with Dr. Butts Pauly, CBIS leadership includes an advisory board of the following Stanford faculty: Donna Bouley, DVM, PhD, Comparative Medicine; Sam Gambhir, MD, PhD, Radiology; Pierre Khuri-Yakub, PhD, Electrical Engineering; Michael McConnell, MD, MSEE, Cardiovascular Medicine; Norbert Pelc, PhD, Bioengineering and Radiology; Stephen Smith, PhD, Molecular and Cellular Physiology; and Anthony Wagner, PhD, Psychology.

The CBIS Annual Symposium attracts attendees across the campus and from neighboring institutions. CBIS also manages a Seed Grant funding program through which approximately five awards are made each year. Please visit the CBIS website for added information about our Advisory Board members, the Seminar Series, and further details of Seed Grant recipients' research (http://cbis.stanford.edu/).

2012 Annual Symposium:
A Two Day Symposium presented jointly with SCIEN (April 5-6, 2012)
Keynote Speaker: William Ralph Brody, MD, PhD, Uncommon Sense or Common Nonsense: Ideas That Will Never Work

2013 Annual Symposium:
The Power of Pixels (April 11, 2013 – 8am – 5pm)
Keynote Speaker: Mark Cohen, PhD, A unified theory of images?
Facilities and Services
New Research Facilities
Technology and Innovation Park (TnI)

In Summer 2013, Stanford Radiology will be expanding with 50,000 square feet of new space in the Technology and Innovation (TnI) Park on Porter Drive in Palo Alto, just 3.5 miles from the Stanford School of Medicine. Comprised of four SOM buildings and three Stanford University administrative buildings, housing more than 2,000 people, Porter Drive will represent a true Stanford community in this off-campus location.

The opportunity to grow new programs in an academic research environment is dependent upon space. Facilities for people, specialized labs, along with custom tools and equipment is essential for new research. With the commitment of these new buildings comes the prospect of significant research growth for radiology. Porter Drive will become a focal point for Stanford with its high quality campus environment conducive to collaborative research, intellectual pursuits and recruitment. It also offers great flexibility to accommodate our evolving programs and SOM strategic vision.

SOM Departments to be housed in Porter Drive TnI Park include: Genomics, Sleep Center, and Radiology. Radiology will have space in three adjacent buildings, which will allow for the largest growth in the history of our Department. Two hundred seventy faculty, staff and students will be housed in the first two buildings which will include faculty from all of our research sections: MIPS, Canary Center at Stanford, ISIS and BSL.

Resources include state-of-the-art biology, chemistry and radiochemistry facilities, physics and engineering laboratory, and a small animal imaging facility. The Canary Center at Stanford is currently located at 1501 California Ave. It will be vacating these facilities and moving to Porter Drive in June 2013.

Along with Radiology, the new campus will include the Center for Genomics and Personalized Medicine and Stanford Genome Technology Center. Co-location of Genetics and Imaging will foster multidisciplinary collaboration and help us to fulfill our Department vision of facilitating the merging of genomics and imaging.

Radiology Construction and Expansion

In 2012 the Department of Radiology completed several major construction projects. The Lucas Center was extensively renovated to allow for the siting of two new 3T magnets and the upgrade of our 7T MRI. The construction included remodeling of magnet suites, control rooms, equipment, viewing and patient preparation rooms, and part of the lobby. Additionally we renovated a section of the second floor to create new offices and cubes, and remodeled our animal surgery suite and an adjacent office. These renovations will provide space for approximately 17 people and the upgraded facilities will allow us to continue to fulfill our research and education mission with cutting edge equipment.

In the Grant Building we remodeled the Fahrig Lab to install a new C-Arm fluoro/CT system which was acquired via a NIH instrumentation grant. The renovated lab opening was celebrated in October 2012 with a symposium on new C-arm imaging technology and an open lab. Merging and updating two rooms to a single dry lab, we also renovated space for our 3DQ Lab, which now houses six technologists. Our 3DQ Lab is housed in two locations on campus, the Clark Center and now the Grant building. The lab had been in the Lucas Center since its inception in 1996. Moving the lab to Grant allows for closer collaboration with the clinicians and also frees up much needed student desks in the Lucas Center.

In 2013 we have many new plans for construction and expansion beyond just Porter Drive. We are moving forward with renovations of space in the hospital for the Chairman's office and several faculty offices, and will be updating three to four areas of the Grant Basement to create new offices and student desks to support our growing faculty.
The Stanford Radiology 3D and Quantitative Imaging Laboratory (3DQ) is guided by the mission of developing and applying innovative techniques for efficient display and quantitative analysis of medical imaging data. Since 1996, our clinical goal has been to deliver clinically-relevant alternative visualizations and measurements to radiologists and referring physicians in the Stanford and surrounding communities as rapidly as possible for the swift and accurate diagnosis, tracking, and treatment of disease; our educational goal is to disseminate knowledge so as to replicate our services at other institutions; and our research arm continues to support the use of the MEDIS QMass® and QFlow® analysis software, Vital Images), who site their hardware and software in the 3DQ lab in anticipation of the major blood vessels of the lower extremity.

infrastructure

The last 12 months have been a time of transition for the Lab. While we maintained operations in the James H. Clark Center, we left our original space at the Lucas Center to begin operations in a new space created just for us in the Grant Building. This new location has proven to be an asset to the lab as it allows us to work in closer proximity to our radiologists in a space more compatible with teaching and training. In the Clark Center, a central area table invites professional collaboration, and student desks with moveable workstations provide areas for independent research. The lab equipment consists of workstations and servers that are used for research and devesent bent for image and data storage. The lab also has remote PACS workstations that provide access to all Stanford medical imaging and reporting. During this past year the lab successfully moved away from individual workstations to a server/thin client model, enabling us to expedite the processing and sharing of data throughout the lab. These upgrades have allowed for flexible workspaces utilizing generic PC workstations, while providing access to all 3D and quantitative applications from these centrally located servers. During this evolution, we continue our excellent relationships with corporate developers of 3D workstations/servers (e.g., C&K Healthcare, TerraRecon, and Vital Images), who site their hardware and software in the 3DQ lab in anticipation of our feedback. These relationships continue to ensure that we maintain the most advanced multi-dimensional analytical technologies available. In addition, the lab continues to support the use of the MEDIS QMass® and QFlow® analysis software, which allow for enterprise collaboration when measuring cardiac output and analyzing muscle mass. We also continue to use Angiovis software in the lab for both accurate and quick bone removal while generating curved planar reformations through the major blood vessels of the lower extremity.

Conclusion

The 3DQ Laboratory continues to function as an international leader in clinical care, teaching, and research in medical imaging analysis and quantification. The confluence of talented medical and engineering expertise with the most up-to-date equipment has been a consistent source of innovation in diagnostic, monitoring, and treatment planning approaches. During the coming year we plan to generate an influx of ideas from seasoned technologists and new leadership to position the 3DQ Lab for improved and continued contribution to the care of our patients.
T

he Cyclotron and Radiochemistry Facility (CRF) develops and offers radiotracers for early detection and thera
cpic monitoring of disease in both preclinical and clinical imaging settings. Our radiochemistry personnel (fac
ty, staff, and postdoc) continue to number around 30 people including the recent facility hiring of Natasha Arksey,
M.S. and Stephanie Chen, B.S. in the past year. Additional instruments and upgrades were installed in 2011-2012
including a second FASTlab module (GE), two Multichannel Analyzers upgrades (Canberra), Medsmart System
upgrade (Rotem) and ten desktop PC upgrades (Dell) that control a variety of equipment in the CRF. Although the
new Nuclear Medicine and Molecular Imaging Clinic at the Stanford Hospital opened in October 2010, the clinical
radiochemistry lab, opening this year. This extra lab space will provide clinical-grade radiopharmaceuticals to meet
essential clinical radiochemistry demands while abiding to current regulatory policies.

However, the existing CRF will continue to provide routine clinical tracers for use at Stanford Hospital. Fluorine-18
labeled fluorodextrose (\(\text{\[^{18F}\text{FDG}\]}\)) is still produced daily (5-days/week) and can also be made using either of our
two \(\text{\[^{18F}\text{FDG}\]}\)-labeled \(\text{\[^{18F}\text{FDG}\]}\) GE TRACERlab modules are the workhorses in the lab and perform the syntheses of our \(\text{\[^{18F}\text{FDG}\]}\)
tracer families. The following table summarizes an updated list of radiolabeled compounds that are made in the CRF, excluding research compounds protected under confidentiality
Agreements (Bolded tracers = preclinical and clinical use; * = eIND or IND under preparation for clinical use).

<table>
<thead>
<tr>
<th>Tracer</th>
<th>Use</th>
<th>Application</th>
</tr>
</thead>
<tbody>
<tr>
<td>(\text{[^{18F}\text{FDG}]})</td>
<td>Imaging tumor metabolism</td>
<td>Imaging tumors</td>
</tr>
<tr>
<td>(\text{[^{18F}\text{FDG}]})</td>
<td>Imaging tumor metabolism</td>
<td>Imaging tumors</td>
</tr>
<tr>
<td>(\text{[^{64Cu}\text{DOTA}]})</td>
<td>Imaging agent</td>
<td>Imaging gene therapies targeting cancer</td>
</tr>
</tbody>
</table>

The following facilities and services are available in the CRF:

- \(\text{\[^{18F}\text{FDG}\]}\) - Imaging tumor metabolism
- \(\text{\[^{18F}\text{FDG}\]}\) - Imaging tumor metabolism
- \(\text{\[^{64Cu}\text{DOTA}\]}\) - Imaging agent for gene therapies targeting cancer

The facilities and services listed above are designed to support the clinical and preclinical needs of the Stanford Hospital and beyond. These facilities are equipped to perform a variety of imaging and therapeutic procedures, including Positron Emission Tomography (PET) and single-photon emission computed tomography (SPECT) scans. The facilities include state-of-the-art imaging systems and advanced analytical equipment to ensure the highest quality of research and clinical imaging.

### Cyclotron & Radiochemistry Facility

**Director:** Frederick Chin, PhD

**Facilities and Services**

- **\(\text{\[^{18F}\text{FDG}\]}\) - Imaging tumor metabolism**
- **\(\text{\[^{18F}\text{FDG}\]}\) - Imaging tumor metabolism**
- **\(\text{\[^{64Cu}\text{DOTA}\]}\) - Imaging agent for gene therapies targeting cancer**

The facilities and services listed above are designed to support the clinical and preclinical needs of the Stanford Hospital and beyond. These facilities are equipped to perform a variety of imaging and therapeutic procedures, including Positron Emission Tomography (PET) and single-photon emission computed tomography (SPECT) scans. The facilities include state-of-the-art imaging systems and advanced analytical equipment to ensure the highest quality of research and clinical imaging.

**Radiology Annual Report**

126

127
Lucas Center MR Systems: 3T1, 3T2, 3T3, and 7T Whole Body Magnets

Manager: Anne Marie Sawyer, BS, RT(R)(MR), FSMRT

During 2012, the 3 Tesla #1 MRI system was replaced with a GE Healthcare 3 Tesla Discovery 750W MRI system and is currently operating at 23.x software (Figure 1). This MRI system operates with 32 RF receiver channels, a maximum gradient slew rate of 120 milliTesla per meter per millisecond, and a maximum gradient amplitude of 33 milliTesla per meter (3.3 G/cm). This 750W MRI includes the GEM RF coils in the patient table allowing for much lighter coils for the anterior portion of the body and the ability to use multiple coils required in whole body imaging (Figure 2). This wide bore system (70 cm) is currently planned for a PET-MR insert.

During the last half of 2011, the GE Healthcare 1.5 Tesla MRI system was replaced with a GE Healthcare 3 Tesla Discovery 750 MRI system. The 3 Tesla #2 and #3 GE Healthcare Discovery 750 MRI systems are currently operating at 22.x software (Figures 3 and 4) with a planned upgrade to 23.x software later in 2012. The Insightec Focused Ultrasound System is installed at the 3T3 and being used to treat human subjects and animal models. The systems operate at a maximum gradient slew rate of 150 milliTesla per meter and a maximum gradient amplitude of 33 milliTesla per meter (3.3 G/cm). This 750W MRI includes the GEM RF coils in the patient table under the coil allowing prepare for a study at 3T1 with a 23.x software (Figures 3 and 4). The software tracks due dates for completion and reminds users through automatic emails. This ensures that all users and assistants are qualified to operate the MRI systems and satisfies Lucas Center and University requirements for safety. New users to the center receive MRI system software and coil instruction. MRI systems and safety support is provided to the researchers 7 days a week, 24 hours a day to ensure that research endeavors are successful, generate valuable data, and, above all, are safe for the researchers, the human subjects, and the MRI systems and components. MRI safety is an on-going concern as the MRI environment can be a potentially lethal setting without continuing education and persevering support.

The research environment generates many new yet prototype designs in RF imaging coils, imaging accessories, monitoring and response devices such as button boxes, eye trackers, and electroencephalogram (EEG) recorders, and sensory devices. Evaluation of these new devices is on-going to ensure that neither the image data, the safety of the human subject, nor the integrity of the MRI systems are compromised by the presence of these devices in the magnet room, in the bore of the magnet, or in the presence of an RF coil (Figure 3).

Lucas Center MR Systems Training: 3T1, 3T2, 3T3, and 7T Whole Body Magnets

Manager: Anne Marie Sawyer, BS, RT(R)(MR), FSMRT

MRI safety training and system instruction have been provided to 297 new researchers including scientists and clinicians conducting experimental MRI studies at the Lucas Center over the last twelve months (Figure 1). Initial MRI safety training and the annual refresher course are required for all researchers assisting or conducting studies on any of the MRI systems at the Lucas Center. The annual MRI safety refresher course is required as an on-line tutorial and has provided renewal instruction to 305 researchers (Figure 2). The software tracks due dates for completion and reminds users through automatic emails. This ensures that all users and assistants are qualified to operate the MRI systems and satisfies Lucas Center and University requirements for safety. New users to the center receive MRI system software and coil instruction. MRI system and safety support is provided to the researchers 7 days a week, 24 hours a day to ensure that research endeavors are successful, generate valuable data, and, above all, are safe for the researchers, the human subjects, and the MRI systems and components. MRI safety is an on-going concern as the MRI environment can be a potentially lethal setting without continuing education and persevering support.

The research environment generates many new yet prototype designs in RF imaging coils, imaging accessories, monitoring and response devices such as button boxes, eye trackers, and electroencephalogram (EEG) recorders, and sensory devices. Evaluation of these new devices is on-going to ensure that neither the image data, the safety of the human subject, nor the integrity of the MRI systems are compromised by the presence of these devices in the magnet room, in the bore of the magnet, or in the presence of an RF coil (Figure 3).
Small Animal Imaging Facility

Director: Tim Doyle, PhD

Image Above: Optical and PET-CT imaging of mice. Endoluminal core samples (a) showed similar distribution to the Cerenkov emission (b). A similar system is shown in the bladder and brain, which shows 18F-FDG activity located in tumour cells on the back of a mouse (c). Full scale Cerenkov image (d) shows 18F fluorodeoxyglucose (FDG) activity. The Cerenkov image clearly shows activity distribution that the Cerenkov image does not (d) and PET only (e). Note 13C is clearly apparent from PET-CT in the bladder and brain, which is clearly apparent from PET-CT in the bladder and brain, which shows 18F-FDG activity located in tumour cells on the back of a mouse (c).

In our continuing efforts to provide support to the Radiology investigative staff, we are entrusted with the responsibility of overseeing all animal model protocols within Radiology, and for all other departments conducting research studies at the Lucas Center and the Grant building Axiom lab. Two research professionals, including a California Licensed Veterinary Nurse (RVT) and a California Licensed Veterinary Technician (VT), with over 50 years of combined experience in animal research, support all animal model studies and ensure the health and welfare of the animal is always a top priority. Diligent care is taken during all procedures involving animal subjects; they are treated with the utmost respect, compassion, and professional care. Animal studies at the Lucas Center advance imaging and image-guided therapy procedures for human studies, and are treated with equal compassion in all research and medical imaging examinations.

We realize that living subjects are needed to advance our knowledge, and to that end we ensure that proper respect for life is part of all research studies whether human or animal studies. Research conducted at the Lucas Center improves and aids in the development of new invasive and non-invasive procedures that utilize magnetic resonance imaging (MRI), high-intensity focused ultrasound (HIFU), computed tomography (CT), CT/fluoroscopy, and positron emission tomography (PET). Clinical studies currently conducted at the Lucas Center include the study of cardiac and liver Radio Frequency (RF) ablation, myocardial infarction, liver and prostate cancers, neuroendoscopic imaging with ultrasound, and structural neuroimaging of the brain. The techniques currently being explored at the Lucas Center contribute to more efficient and effective medical treatment for human illness and disease.

As part of the recent renovation of the Lucas Center and Axiom research facilities, our new surgical suite provides a state of the art facility including the technology for a surgical lighting system equipped with a precision High Definition camera and multi display flat screen panel. This will allow our investigators to conduct real time teaching with in vivo and anatomic models.
Faculty Honors
<table>
<thead>
<tr>
<th>Name</th>
<th>Position</th>
<th>Honors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Roland Bammer, PhD</td>
<td>Associate Professor</td>
<td>Academy of Radiology Research Distinguished Investigator Award, 2012</td>
</tr>
<tr>
<td>Kim Butts Pauly, PhD</td>
<td>Professor</td>
<td>Academy of Radiology Research Distinguished Investigator Award, 2012</td>
</tr>
<tr>
<td>Andrei Iagaru, MD</td>
<td>Assistant Professor</td>
<td>Elected to the American College of Nuclear Medicine as a Fellow, 2013</td>
</tr>
<tr>
<td>Ann Leung, MD</td>
<td>Professor and Associate Chair, Clinical Affairs</td>
<td>Named Department of Radiology Faculty of the Year, 2012</td>
</tr>
<tr>
<td>Heike Daldrup-Link, MD</td>
<td>Associate Professor</td>
<td>Academy of Radiology Research Distinguished Investigator Award, 2012</td>
</tr>
<tr>
<td>Bruce Daniel, MD</td>
<td>Professor</td>
<td>Academy of Radiology Research Distinguished Investigator Award, 2012</td>
</tr>
<tr>
<td>Craig Levin, PhD</td>
<td>Professor</td>
<td>Academy of Radiology Research Distinguished Investigator Award, 2012</td>
</tr>
<tr>
<td>Sandy Napel, PhD</td>
<td>Professor and Co-Director of ISIS</td>
<td>Academy of Radiology Research Distinguished Investigator Award, 2012</td>
</tr>
<tr>
<td>Rebecca Fahrig, PhD</td>
<td>Associate Professor</td>
<td>Academy of Radiology Research Distinguished Investigator Award, 2012</td>
</tr>
<tr>
<td>Sanjiv Sam Gambhir, MD, PhD</td>
<td>Professor and Chair of the Department of Radiology Director of MIPS</td>
<td>Academy of Radiology Research Distinguished Investigator Award, 2012</td>
</tr>
<tr>
<td>Norbert Pelc, ScD</td>
<td>Professor and Chair of Bioengineering RSL</td>
<td>National Academy of Engineering (NAE), 2012; Dr. Pelc elected for his role in developing algorithms and technologies for MRI, CT, and hybrid X-ray/MRI imaging. Named Chair, Department of Bioengineering, Stanford University, 2012</td>
</tr>
<tr>
<td>Sylvia Plevritis, PhD</td>
<td>Associate Professor and Co-Director of ISIS</td>
<td>Academy of Radiology Research Distinguished Investigator Award, 2012</td>
</tr>
<tr>
<td>Garry Gold, MD</td>
<td>Professor and Associate Chair for Research</td>
<td>Named Associate Chair for Research, 2012; Academy of Radiology Research Distinguished Investigator Award, 2012</td>
</tr>
<tr>
<td>Robert Herfkens, MD</td>
<td>Professor and Associate Chair, Clinical Technology Cardiovascular Imaging</td>
<td>Academy of Radiology Research Distinguished Investigator Award, 2012</td>
</tr>
<tr>
<td>Jianghong Rao, PhD</td>
<td>Associate Professor</td>
<td>Academy of Radiology Research Distinguished Investigator Award, 2012</td>
</tr>
<tr>
<td>Daniel Rubin, MD</td>
<td>Assistant Professor</td>
<td>Elected to the American College of Medical Informatics (ACMI), 2012; Received “Most Awesome Advisor Award” from his students and trainees</td>
</tr>
<tr>
<td>Ann Leung, MD</td>
<td>Professor and Associate Chair, Clinical Affairs</td>
<td>Named Department of Radiology Faculty of the Year, 2012</td>
</tr>
</tbody>
</table>

**Additional Honors:**
- Academy of Radiology Research (ARR) Distinguished Investigator Recognition Award, 2013
- Elected to the American Institute for Medical and Biological Engineering (AIMBE)
- Academy of Radiology Research (ARR) Distinguished Investigator Recognition Award, 2013
- Elected to the American College of Medical Informatics (ACMI), 2012
- Received “Most Awesome Advisor Award” from his students and trainees
- Academy of Radiology Research Distinguished Investigator Award, 2012
### Faculty Honors

- **Daniel Spielman, PhD**
  - Professor
  - RSL
  - Academy of Radiology Research Distinguished Investigator Award, 2012

- **Joseph Wu, MD, PhD**
  - Associate Professor
  - Radiology and Cardiovascular Medicine
  - MIPS
  - Elected to American Society Clinical Investigators, ASCI, 2013

### Faculty Books

<table>
<thead>
<tr>
<th>Title</th>
<th>Author(s)</th>
<th>Publisher</th>
</tr>
</thead>
<tbody>
<tr>
<td>Breast Imaging: The Requisites</td>
<td>Ikeda D.</td>
<td>Mosby, St. Louis, MO, 2011</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Title</th>
<th>Author(s)</th>
<th>Publisher</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kinderradiologie: Bildgebende Verfahren in der Paediatrise (the German Translation of the book: Essentials of Pediatric Radiology)</td>
<td>Daldrup-Link HE, Gooding C (Co-Editors)</td>
<td>Hans Huber Verlag, in press</td>
</tr>
<tr>
<td>Radiology and Cardiovascular Medicine</td>
<td>MIPS</td>
<td></td>
</tr>
</tbody>
</table>
The People Connection
Did you know that our very own Dr. Chris Beaulieu is the team radiologist for the 49ers? He has performed special image-guided procedures for the club since 1996, and for the last 7 years has overseen Candlestick Park x-ray operations as well as most other imaging studies. Earlier this year, Dr. Beaulieu traveled to New Orleans during the Super Bowl to provide medical imaging and support to the team. In addition to the 49ers, Dr. Beaulieu, his MSK colleagues, and the excellent Stanford Hospital support staff provide imaging expertise to the Golden State Warriors as well as to all Stanford teams and innumerable community athletes. Thanks to the MSK section for their critical service to the football operations as well as most other imaging modalities. Our MSK Team on the Field

Dr. Garry Gold and Sandy Biondi on the sidelines of every one of Stanford Football’s home games along with the technologists and sports med team.

Dr. Chris Beaulieu with 49ers quarterback Alex Smith in New Orleans before Super Bowl XLVII.

Dr. Chris Beaulieu with San Francisco Giants baseball pitcher Sergio Romo during a visit to the 49ers locker room after a recent game.

Dr. Erika Rubesova, faculty in Pediatric Radiology, and Dr. Benjamin Johnson, second year radiology resident, spend their after-hours focusing on innovative methods to evaluate ultrasound training and utilization in the United States and other countries. They are on a mission to improve resident ultrasound education and training by building collaborative partnerships with other countries where ultrasound is more broadly utilized, such as in Europe. In the U.S, the Radiologist’s role in ultrasound acquisition has diminished over the past decade to the point that resident training is inadequate and more often bordering on nonexistent. Ultrasound diagnostic fidelity is very much dependent on the operator’s level of expertise. The resulting variability in image quality, when combined with the increasingly higher resolution of CT and MRI, has led to increasing utilization of the latter modalities, with decreasing emphasis on maintaining ultrasound competence in current radiology trainees. As a result, other medical specialties such as obstetrics, surgery, and emergency medicine have begun to fill the void left by the radiological de-emphasis, with more and more trainees in these fields learning point of care ultrasound acquisition and interpretation as part of their resident education. Drs. Rubesova and Johnson believe it is important for radiologists to remain the experts of this modality, and guide research to introduce new ultrasound technology and applications into clinical use in the context of calls to reduce radiation exposure and lower medical costs.

Drs. Rubesova and Johnson are working toward offering a more comprehensive ultrasound training program for Stanford Radiology residents and promoting nationwide training awareness as their program expands. Complementary to their goal of providing residents with diverse and comprehensive training in ultrasound technique and interpretation, they are working to develop an elective rotation in East Africa where residents can apply their ultrasound skillset to improve health care in the developing world. Building imaging infrastructure in resource-poor regions is something that Dr. Johnson is passionate about and an area in which he has been working actively since medical school.

What are the Odds...

...that three radiology residents from the same North Dakota high school would match for the same radiology residency class, the same year, and at the same academic institution? Three Fargo South graduates are members of a select group of nine residents at Stanford School of Medicine at the same time. Sarah Garaas, 1998, Marnie Kremer, 1996, and Jonathan Williams, 1997 are again ‘classmates’. They had not been in contact for years and were unaware that they were all in medical school until they ran into each other while interviewing for residency. The residency match process is somewhat like a lottery. On the day they received their acceptance letters, it was quite a shock not only for the three of them, but also for our Department to learn that all three Fargo South graduates were going to be in the same program.

According to Terry Desser, MD, Residency Program Director, “There are 980 residency positions in Radiology offered nationwide. There are about 1380 radiology residency applicants. What are the chances that 1/3 of our residency class—let alone the SAME residency class—would be filled by graduates of the same Fargo North Dakota high school? You can do the arithmetic, but I would guess they are on par with the probability of winning the lottery.”

Improving Resident Training in Ultrasound to Improve Healthcare in Resource Poor Regions of the World

Our MSK Team on the Field

Pediatric Team Encourages Ultrasound at Home and Internationally

The People Connection

Dr. Garry Gold with Kent Words (Olympic Gold Medal, Volleyball) on the sidelines at a Stanford Football game.

Dr. Chris Beaulieu with Alex Smith in New Orleans before Super Bowl XLVII.

Dr. Garry Gold with Kent Words (Olympic Gold Medal, Volleyball) on the sidelines at a Stanford Football game.

Dr. Chris Beaulieu with San Francisco Giants baseball pitcher Sergio Romo during a visit to the 49ers locker room after a recent game.

Dr. Erika Rubesova, faculty in Pediatric Radiology, and Dr. Benjamin Johnson, second year radiology resident, spend their after-hours focusing on innovative methods to evaluate ultrasound training and utilization in the United States and other countries. They are on a mission to improve resident ultrasound education and training by building collaborative partnerships with other countries where ultrasound is more broadly utilized, such as in Europe. In the U.S, the Radiologist’s role in ultrasound acquisition has diminished over the past decade to the point that resident training is inadequate and more often bordering on nonexistent. Ultrasound diagnostic fidelity is very much dependent on the operator’s level of expertise. The resulting variability in image quality, when combined with the increasingly higher resolution of CT and MRI, has led to increasing utilization of the latter modalities, with decreasing emphasis on maintaining ultrasound competence in current radiology trainees. As a result, other medical specialties such as obstetrics, surgery, and emergency medicine have begun to fill the void left by the radiological de-emphasis, with more and more trainees in these fields learning point of care ultrasound acquisition and interpretation as part of their resident education. Drs. Rubesova and Johnson believe it is important for radiologists to remain the experts of this modality, and guide research to introduce new ultrasound technology and applications into clinical use in the context of calls to reduce radiation exposure and lower medical costs.

Drs. Rubesova and Johnson are working toward offering a more comprehensive ultrasound training program for Stanford Radiology residents and promoting nationwide training awareness as their program expands. Complementary to their goal of providing residents with diverse and comprehensive training in ultrasound technique and interpretation, they are working to develop an elective rotation in East Africa where residents can apply their ultrasound skillset to improve health care in the developing world. Building imaging infrastructure in resource-poor regions is something that Dr. Johnson is passionate about and an area in which he has been working actively since medical school.

What are the Odds...

...that three radiology residents from the same North Dakota high school would match for the same radiology residency class, the same year, and at the same academic institution? Three Fargo South graduates are members of a select group of nine residents at Stanford School of Medicine at the same time. Sarah Garaas, 1998, Marnie Kremer, 1996, and Jonathan Williams, 1997 are again ‘classmates’. They had not been in contact for years and were unaware that they were all in medical school until they ran into each other while interviewing for residency. The residency match process is somewhat like a lottery. On the day they received their acceptance letters, it was quite a shock not only for the three of them, but also for our Department to learn that all three Fargo South graduates were going to be in the same program.

According to Terry Desser, MD, Residency Program Director, “There are 980 residency positions in Radiology offered nationwide. There are about 1380 radiology residency applicants. What are the chances that 1/3 of our residency class—let alone the SAME residency class—would be filled by graduates of the same Fargo North Dakota high school? You can do the arithmetic, but I would guess they are on par with the probability of winning the lottery.”

Improving Resident Training in Ultrasound to Improve Healthcare in Resource Poor Regions of the World

Our MSK Team on the Field

Pediatric Team Encourages Ultrasound at Home and Internationally

The People Connection

Dr. Garry Gold with Kent Words (Olympic Gold Medal, Volleyball) on the sidelines at a Stanford Football game.

Dr. Chris Beaulieu with Alex Smith in New Orleans before Super Bowl XLVII.

Dr. Garry Gold with Kent Words (Olympic Gold Medal, Volleyball) on the sidelines at a Stanford Football game.

Dr. Chris Beaulieu with San Francisco Giants baseball pitcher Sergio Romo during a visit to the 49ers locker room after a recent game.

Dr. Erika Rubesova, faculty in Pediatric Radiology, and Dr. Benjamin Johnson, second year radiology resident, spend their after-hours focusing on innovative methods to evaluate ultrasound training and utilization in the United States and other countries. They are on a mission to improve resident ultrasound education and training by building collaborative partnerships with other countries where ultrasound is more broadly utilized, such as in Europe. In the U.S, the Radiologist’s role in ultrasound acquisition has diminished over the past decade to the point that resident training is inadequate and more often bordering on nonexistent. Ultrasound diagnostic fidelity is very much dependent on the operator’s level of expertise. The resulting variability in image quality, when combined with the increasingly higher resolution of CT and MRI, has led to increasing utilization of the latter modalities, with decreasing emphasis on maintaining ultrasound competence in current radiology trainees. As a result, other medical specialties such as obstetrics, surgery, and emergency medicine have begun to fill the void left by the radiological de-emphasis, with more and more trainees in these fields learning point of care ultrasound acquisition and interpretation as part of their resident education. Drs. Rubesova and Johnson believe it is important for radiologists to remain the experts of this modality, and guide research to introduce new ultrasound technology and applications into clinical use in the context of calls to reduce radiation exposure and lower medical costs.

Drs. Rubesova and Johnson are working toward offering a more comprehensive ultrasound training program for Stanford Radiology residents and promoting nationwide training awareness as their program expands. Complementary to their goal of providing residents with diverse and comprehensive training in ultrasound technique and interpretation, they are working to develop an elective rotation in East Africa where residents can apply their ultrasound skillset to improve health care in the developing world. Building imaging infrastructure in resource-poor regions is something that Dr. Johnson is passionate about and an area in which he has been working actively since medical school.

What are the Odds...

...that three radiology residents from the same North Dakota high school would match for the same radiology residency class, the same year, and at the same academic institution? Three Fargo South graduates are members of a select group of nine residents at Stanford School of Medicine at the same time. Sarah Garaas, 1998, Marnie Kremer, 1996, and Jonathan Williams, 1997 are again ‘classmates’. They had not been in contact for years and were unaware that they were all in medical school until they ran into each other while interviewing for residency. The residency match process is somewhat like a lottery. On the day they received their acceptance letters, it was quite a shock not only for the three of them, but also for our Department to learn that all three Fargo South graduates were going to be in the same program.

According to Terry Desser, MD, Residency Program Director, “There are 980 residency positions in Radiology offered nationwide. There are about 1380 radiology residency applicants. What are the chances that 1/3 of our residency class—let alone the SAME residency class—would be filled by graduates of the same Fargo North Dakota high school? You can do the arithmetic, but I would guess they are on par with the probability of winning the lottery.”

Improving Resident Training in Ultrasound to Improve Healthcare in Resource Poor Regions of the World

Our MSK Team on the Field

Pediatric Team Encourages Ultrasound at Home and Internationally

The People Connection
Ana Reshma (far right), from Bangalore, India, joins our family in 2012.

A boy and his father. Brandon Milo Yi. Noemy with her 15 month old twins, Isabella and Sophia.

Gray Hargreaves-July 2012, Newest member of the Body MRI Research Group

Proud parents with Saum Gideon, having fun on a swing.

Pejman Ghanouni, MD, PhD
Assistant Professor, Body MRI

Jackie’s granddaughter, Vivia, born March 6.

Suzanne Roosevelt
Quality Improvement Manager, SHC Radiology

Jackie Walker
Financial Analyst

The Roosevelts go to the beach with baby James (left). Jackie’s granddaughter, Vivia, born March 6.

Suzanne Roosevelt
Quality Improvement Manager, SHC Radiology

Jackie Walker
Financial Analyst

Gordon Shattock
CT and Department Technologist, SHC Radiology

Gray Hargreaves-July 2012, Newest member of the Body MRI Research Group

Pejman Ghanouni, MD, PhD
Assistant Professor, Body MRI

A boy and his father. Brandon Milo Yi.

Kendall Yi, MA
Faculty Affairs

Noemy with her 15 month old twins, Isabella and Sophia.

Noemy Quiroz
Administrative Assistant, SHC Radiology

Brian Hargreaves, PhD
Associate Professor, RSL
Angel Funding

The Department of Radiology and the Angel Funding Review Committee is pleased to announce 2012 Angel Funding for the following projects that include new partnerships within the Department, high risk projects, and first-in-man studies. Congratulations and wish you great success in your work and your newly established collaborations.

<table>
<thead>
<tr>
<th>PI</th>
<th>Co-I</th>
<th>Project Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sandip Biswal, MD</td>
<td>Matthew Smuck, MD</td>
<td>Focused magnetic nanoparticle theranostics for chronic pain</td>
</tr>
<tr>
<td>Michael Moseley, PhD</td>
<td>Duqiang Qiu, PhD</td>
<td></td>
</tr>
<tr>
<td>Pejman Ghanouni, MD</td>
<td>Pejman Ghanouni, MD</td>
<td>A feasibility study to evaluate the safety and initial effectiveness of MR-guided focused ultrasound surgery in the treatment of facetogenic lumbar back pain</td>
</tr>
<tr>
<td>George Segall, MD</td>
<td>Pejman Ghanouni, MD</td>
<td></td>
</tr>
<tr>
<td>Matthew Smuck, MD</td>
<td>Pejman Ghanouni, MD</td>
<td></td>
</tr>
<tr>
<td>Deqiang Qiu, PhD</td>
<td>Pejman Ghanouni, MD</td>
<td></td>
</tr>
<tr>
<td>Deepak Behera, DNB</td>
<td>Pejman Ghanouni, MD</td>
<td></td>
</tr>
<tr>
<td>Matthew Smuck, MD</td>
<td>Pejman Ghanouni, MD</td>
<td></td>
</tr>
<tr>
<td>Pejman Ghanouni, MD</td>
<td>Pejman Ghanouni, MD</td>
<td></td>
</tr>
<tr>
<td>Deepak Behera, DNB</td>
<td>Pejman Ghanouni, MD</td>
<td></td>
</tr>
<tr>
<td>Matthew Smuck, MD</td>
<td>Pejman Ghanouni, MD</td>
<td></td>
</tr>
<tr>
<td>Pejman Ghanouni, MD</td>
<td>Pejman Ghanouni, MD</td>
<td></td>
</tr>
<tr>
<td>Deepak Behera, DNB</td>
<td>Pejman Ghanouni, MD</td>
<td></td>
</tr>
<tr>
<td>Matthew Smuck, MD</td>
<td>Pejman Ghanouni, MD</td>
<td></td>
</tr>
<tr>
<td>Pejman Ghanouni, MD</td>
<td>Pejman Ghanouni, MD</td>
<td></td>
</tr>
<tr>
<td>Deepak Behera, DNB</td>
<td>Pejman Ghanouni, MD</td>
<td></td>
</tr>
</tbody>
</table>

Canary Funding

<table>
<thead>
<tr>
<th>Sponsor</th>
<th>PI</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dept of Defense</td>
<td>Chang, Zhen</td>
<td>Peptid-Based PET Probes for Prostate Cancer Imaging</td>
</tr>
<tr>
<td>NIH</td>
<td>Chang, Zhen</td>
<td>VEGFR-2 Targeted Imaging</td>
</tr>
<tr>
<td>NIH</td>
<td>Paulmurugan, R.</td>
<td>Molecular Sensors for Imaging Histone Methylation in Living animals</td>
</tr>
<tr>
<td>Amer Soc for Mass Spect</td>
<td>Pittiri, Sharon</td>
<td>Mass Spectrometry-Based Identification, Quantitation, and Characterization Methods of microRNAs for Ovarian Cancer Early Detection</td>
</tr>
<tr>
<td>Labcyte, Inc.</td>
<td>Stosowiec, Mark L</td>
<td>High Throughput Biomarker Verification by MALDI-MS</td>
</tr>
</tbody>
</table>

ISIS Funding

<table>
<thead>
<tr>
<th>Sponsor</th>
<th>PI</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>SOMS</td>
<td>Faruque, Jessica</td>
<td>Developing a Scalable Similarity Reference Standard for a Content-Based Image Retrieval</td>
</tr>
<tr>
<td>NIH</td>
<td>Plevritis, Sylvia</td>
<td>Tools for Linking and Mining Image and Genomic Data in Non-Small Cell Lung Cancer</td>
</tr>
<tr>
<td>NIH</td>
<td>Plevritis, Sylvia</td>
<td>Advanced Techniques for Cancer Imaging and Detection</td>
</tr>
<tr>
<td>Georgetown</td>
<td>Plevritis, Sylvia</td>
<td>Comparative Modeling: Informing Breast Cancer Control Practice &amp; Policy</td>
</tr>
<tr>
<td>MGH</td>
<td>Plevritis, Sylvia</td>
<td>Comparative Modeling of Lung Cancer Control Policies</td>
</tr>
<tr>
<td>NIH</td>
<td>Plevritis, Sylvia</td>
<td>Modeling the Role of Differentiation in Cancer Progress</td>
</tr>
<tr>
<td>NIH</td>
<td>Plevritis, Sylvia</td>
<td>Clinically-Relevant Regulatory Networks in the Lung Tumor Microenvironment</td>
</tr>
<tr>
<td>ACR</td>
<td>Rubin, Daniel L</td>
<td>Informatics Committee Chair</td>
</tr>
<tr>
<td>Beth Israel</td>
<td>Rubin, Daniel L</td>
<td>Small Imaging Informatics Pilot Project</td>
</tr>
<tr>
<td>Brigham &amp; Women’s</td>
<td>Rubin, Daniel L</td>
<td>Neuroimaging Analysis Center (NAC)</td>
</tr>
<tr>
<td>Emory U</td>
<td>Rubin, Daniel L</td>
<td>In Silico Research Center</td>
</tr>
<tr>
<td>GE Medical Systems</td>
<td>Rubin, Daniel L</td>
<td>Next-Generation PACS 2.0: Content-Based Image Retrieval in Contraceptivity System</td>
</tr>
<tr>
<td>General Electric</td>
<td>Rubin, Daniel L</td>
<td>Annotation and Image Markup (AIM) Phase II - Integration with RA1000</td>
</tr>
<tr>
<td>General Electric</td>
<td>Rubin, Daniel L</td>
<td>Pathology Integration Investigator Initiated Study Agreement replaces Work Statement A-56.</td>
</tr>
<tr>
<td>NIH</td>
<td>Rubin, Daniel L</td>
<td>Computerized Quantitative Imaging Assessment of Tumor Burden</td>
</tr>
<tr>
<td>Northwestern U</td>
<td>Rubin, Daniel L</td>
<td>Annotations and Image Markup Project - Phase I and II</td>
</tr>
<tr>
<td>RSNA</td>
<td>Rubin, Daniel L</td>
<td>Enriching the RadLex Ontology to Enable Biomedical Imaging Research in Neuroimaging</td>
</tr>
<tr>
<td>RSNA</td>
<td>Rubin, Daniel L</td>
<td>NIBIB-DOD IAA RadLex Playbook &quot;Expanded Development of Radiology Lexicon&quot;</td>
</tr>
<tr>
<td>RSNA</td>
<td>Rubin, Daniel L</td>
<td>RSNA Imaging Sharing Project</td>
</tr>
<tr>
<td>RSNA</td>
<td>Rubin, Daniel L</td>
<td>RadLex NLP Project</td>
</tr>
<tr>
<td>Siemens</td>
<td>Rubin, Daniel L</td>
<td>Evaluation of radiology reporting concepts</td>
</tr>
<tr>
<td>UCSF</td>
<td>Rubin, Daniel L</td>
<td>Ontology-Based Integration of Human Studies Data</td>
</tr>
<tr>
<td>Vanderbilt</td>
<td>Rubin, Daniel L</td>
<td>Tool Support for Radiologist-Oncologist Workflow in Using Quantitative Methods to Assess Disease Response</td>
</tr>
<tr>
<td>Siemens</td>
<td>Rubin, Daniel L</td>
<td>Evaluation of radiology reporting concepts</td>
</tr>
</tbody>
</table>

Radiology Annual Report 146 147
# Clinical Faculty Funding

<table>
<thead>
<tr>
<th>Sponsor</th>
<th>PI</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>GE Healthcare</td>
<td>Barth, Richard A</td>
<td>Profile Evaluation</td>
</tr>
<tr>
<td>GE Healthcare</td>
<td>Barth, Richard A</td>
<td>EDI User Interface</td>
</tr>
<tr>
<td>General Electric</td>
<td>Benevides, Christopher</td>
<td>Multi-Media Radiology Report</td>
</tr>
<tr>
<td>Sib Tech Inc</td>
<td>Blankenberg, Francis</td>
<td>Temporal delivery of Le-177 to tumor vessels</td>
</tr>
<tr>
<td>GE Global Research</td>
<td>Dallding-Link, Heike</td>
<td>Tumor Enhancement with GEH2121335: Optimization for the Clinic (phase 2)</td>
</tr>
<tr>
<td>NDB</td>
<td>Dallding-Link, Heke</td>
<td>Improved Drug Delivery to Tumors Using Novel Tissue Perfusion Approaches</td>
</tr>
<tr>
<td>NBD</td>
<td>Dallding-Link, Heke</td>
<td>Stem Cell Tracking in Articular Joint: Clinical Translation</td>
</tr>
<tr>
<td>NBD</td>
<td>Dallding-Link, Heke</td>
<td>Novel Imaging Approach to monitor chondrocyte differentiation of joint cells</td>
</tr>
<tr>
<td>NBD</td>
<td>Dallding-Link, Heke</td>
<td>Imaging of Tumor-associated macrophages with Ferrumoxystrol</td>
</tr>
<tr>
<td>Thrombol Chem Fund</td>
<td>Dallding-Link, Heke</td>
<td>Development of a Radiation Free Whole Body MR Imaging Technique for Saging Children with Cancer</td>
</tr>
<tr>
<td>UCSF</td>
<td>Dallding-Link, Heke</td>
<td>Improved Drug Delivery to Tumors Using Novel Tissue Perfusion Approaches</td>
</tr>
<tr>
<td>NBD</td>
<td>Daniel, Bruce Lewis</td>
<td>High Resolution 3D diffusion-weighted brain MRI</td>
</tr>
<tr>
<td>SNIS</td>
<td>Du, Beryl M</td>
<td>Society of Neurorsurgical Surgery (SNIS) Fellowship Grant</td>
</tr>
<tr>
<td>Soc Pediatric Radiology</td>
<td>Gawanke, Rabie</td>
<td>Whole Body Diffusion-weighted MR Scans for Cancer Saging in Pediatric Patients: A Radiation Free Alternative to FDG-PET</td>
</tr>
<tr>
<td>Arthritis Fd</td>
<td>Gold, Gary Evans</td>
<td>Sodium MRI of Post-traumatic Arthritis</td>
</tr>
<tr>
<td>General Electric</td>
<td>Gold, Gary Evans</td>
<td>Advanced MR Applications Development - Tiger Team Year 5</td>
</tr>
<tr>
<td>NBD</td>
<td>Gold, Gary Evans</td>
<td>MRE for Early Detection of Osteosarcoma</td>
</tr>
<tr>
<td>NBD</td>
<td>Gold, Gary Evans</td>
<td>Advanced MR Imaging of Early Osteosarcoma</td>
</tr>
<tr>
<td>Harflano, Robert J</td>
<td>Harflano, Robert J</td>
<td>PET-MRI, Disease Based Patient Workflow and System Requirements</td>
</tr>
<tr>
<td>General Electric</td>
<td>Harflano, Robert J</td>
<td>GE PACS System</td>
</tr>
<tr>
<td>Genetech, Inc.</td>
<td>Hofmann, Rusty</td>
<td>ATTRACT: Industry滋润</td>
</tr>
<tr>
<td>Wash Univ</td>
<td>Hofmann, Rusty</td>
<td>Pharmacomechanical Catheter-Directed Thrombolysis for Acnt DVT-Abinet Trial</td>
</tr>
<tr>
<td>WL Gore &amp; Assoc.</td>
<td>Hofmann, Rusty</td>
<td>Evaluation of GORE VIABAHN Endoprossthes with Hepatic Bioactive Surface for the Treatment of Venous Occlusion and Stenoses</td>
</tr>
<tr>
<td>Infiright</td>
<td>Hoersvag, David</td>
<td>A feasibility study to evaluate the safety and Initial Effectiveness of Exhahbl MRE Guided Focused Ultrasound Surgery in the Treatment of Pain Resulting from Metastatic Bone Tumors with the Exahbl 2100</td>
</tr>
<tr>
<td>Infiright-Telemedicine</td>
<td>Hoersvag, David</td>
<td>A proof-of-concept study to evaluate the effectiveness and safety of Exahbl MRE-guided MDUS Bone Tumors in Patients who are not Candidates for Radiotherapy Therapy</td>
</tr>
<tr>
<td>Gridlab USA, Inc</td>
<td>Hwang, Glicka</td>
<td>Alpha-1 Antitrypsin Therapy for Acute Experimental Pancreatitis</td>
</tr>
<tr>
<td>Bayer Healthcare</td>
<td>Ingrao, Andrea</td>
<td>Radiation-225 Thallium (Alphaphase) in Chemoradiation-Resistant (Hormone-Resistant) Prostate Cancer Patients with Bone Metastases</td>
</tr>
<tr>
<td>ART, Inc</td>
<td>Balsa, Dutra M</td>
<td>SSG-111: Adjunctive Efficacy Study of the SoftScan Optical Breast Imaging System</td>
</tr>
<tr>
<td>Soc of GI Radiologists</td>
<td>Kamaya, Aya</td>
<td>Prognostic Value of Early Perfusion CT changes in colorectal cancer treated with irinotecan based chemotherapy study</td>
</tr>
<tr>
<td>Soc of Uroradiology</td>
<td>Kamaya, Aya</td>
<td>Photodynamic Imaging of Bladder Cancer</td>
</tr>
<tr>
<td>Soc of Uroradiology</td>
<td>Kamaya, Aya</td>
<td>Photodynamic Imaging of Bladder Cancer</td>
</tr>
</tbody>
</table>

## Appendix

<table>
<thead>
<tr>
<th>Sponsor</th>
<th>PI</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amneon, Inc</td>
<td>Kothary, Nitika N.</td>
<td>A Phase 2B Randomized Single-Arm Trial of ES-994 (Vaccine GM-CSF + TK-Derivatized Virus) Plus Best Supportive Care Plus Placebo Plus Best Supportive Care in Patients with Advanced Hepatocellular Carcinoma (HCCs) Who Have Failed Sorafenib Treatment</td>
</tr>
<tr>
<td>Siemens</td>
<td>Kothary, Nitika N.</td>
<td>Advanced Applications in Interventional Radiology: Addendum ID: SUMC-2010-AX-01</td>
</tr>
<tr>
<td>EKOS Corp</td>
<td>Kuo, William</td>
<td>Subtractive and Massive Pulmonary Embolization Embolus with Ultrasound Activated Thrombolysis Therapy: A Prospective, Single-Arm, Multi-center Trial of Ethykkeri Endovascular System and Activase for Acute Pulmonary Embolism</td>
</tr>
<tr>
<td>ev3 Neurovascular</td>
<td>Marks, Michael P</td>
<td>SWIFT-vollute VR with the Intention for Thoracoabdominal Surgery</td>
</tr>
<tr>
<td>Micro Endovascular</td>
<td>Marks, Michael P</td>
<td>Project: Clinical Evaluation of Virtual Stent - Software for Stent Planning of Intracranial Anomalies</td>
</tr>
<tr>
<td>Micro Endovascular</td>
<td>Marks, Michael P</td>
<td>VIVIST: Visceral Intracranial Stent Study for Ischemic Therapy</td>
</tr>
<tr>
<td>Siemens</td>
<td>Marks, Michael P</td>
<td>C-arm CT Perfusion Imaging in Acute Stroke</td>
</tr>
<tr>
<td>Celgene</td>
<td>Quon, Andrew</td>
<td>E2408 PET Scan Review</td>
</tr>
<tr>
<td>Millennium Pharma, Inc.</td>
<td>Quon, Andrew</td>
<td>E2408 PET Scan Review</td>
</tr>
<tr>
<td>NCCN</td>
<td>Quon, Andrew</td>
<td>Evaluating Sunitinib Therapy in Renal Cell Carcinomas</td>
</tr>
<tr>
<td>NIH</td>
<td>Quon, Andrew</td>
<td>PEL-PET/CT for Therapy Monitoring of DLBCL</td>
</tr>
<tr>
<td>RSNA</td>
<td>Shin, Lewis K</td>
<td>RSNA Research Seed Grant</td>
</tr>
<tr>
<td>NBD</td>
<td>Sommers, F Graham</td>
<td>Precise MRI-Directed Sonic Ablation of Prostate Cancer</td>
</tr>
<tr>
<td>NBD</td>
<td>Sommers, F Graham</td>
<td>MRI-Guided Ultrasound Ablation of Prostatic Cancer</td>
</tr>
<tr>
<td>BioPharma Medical, Inc.</td>
<td>Sos, Daniel</td>
<td>PHASE 3: Prospective Randomized, Blinded and Controlled Investigation of Ruxolimus/Qudrasphere Microspheres for Delivery of Deoxyhemoglobin in the Treatment of Hepatocellular Cancer</td>
</tr>
<tr>
<td>WL Gore &amp; Assoc.</td>
<td>Sos, Daniel</td>
<td>Evaluation of the GORE TAG Thoracic Endoprossthes - 45 mm for the Primary Treatment of Aneurysms of the Descending Thoracic Aorta</td>
</tr>
<tr>
<td>WL Gore &amp; Assoc.</td>
<td>Sos, Daniel</td>
<td>An Evaluation of the GORE Conf ormable TAG Thoracic Endoprossthes for the Primary Treatment of Aneurysms of the Descending Thoracic Aorta</td>
</tr>
<tr>
<td>WL Gore &amp; Assoc.</td>
<td>Sos, Daniel</td>
<td>The GORE VIATRER® TIPS Endoprossthes versus Large-Volume Parenchymal for the Treatment of Aneurysms in Patients with Paren Hemorrhage (Early TPA for Aneurysm Study)</td>
</tr>
<tr>
<td>GE Healthcare</td>
<td>Vossounova, Shoyyas</td>
<td>MR Imaging for Pediatric Populations- Pediatric Positioner Pad</td>
</tr>
<tr>
<td>GE Medical Systems</td>
<td>Vossounova, Shoyyas</td>
<td>Wireless Receiver Coil Transponders for MRI</td>
</tr>
<tr>
<td>NIH</td>
<td>Vossounova, Shoyyas</td>
<td>Rapid Rotator Pediatric MRI</td>
</tr>
<tr>
<td>Bruco Diagnostic</td>
<td>Willmann, Jurgen</td>
<td>Characterization of Focal Liver Lesions With Sonomed-Enhanced Ultrasonung: A Phase III, Introparative Comparative Study vs Unenhanced Ultrasonung Imaging Using Ultrasound or Combined Imaging/Clinical Data as Truth</td>
</tr>
<tr>
<td>Bruco Diagnostic</td>
<td>Willmann, Jurgen</td>
<td>Ultrasonic Molecular Imaging</td>
</tr>
<tr>
<td>EL &amp; Elyrthk L., Broad Fd</td>
<td>Willmann, Jurgen</td>
<td>Monitoring Inflammation with Molecular Ultrasonung Imaging in Patients with Refractory Early Breast Cancer Detection</td>
</tr>
<tr>
<td>NIH</td>
<td>Willmann, Jurgen</td>
<td>Molecular Ultrason for Early Breast Cancer Detection</td>
</tr>
<tr>
<td>NIH</td>
<td>Willmann, Jurgen</td>
<td>Quantification and Monitoring Inflammation in IBD with Molecular Ultrasonung</td>
</tr>
<tr>
<td>Siemens Med Solutions</td>
<td>Willmann, Jurgen</td>
<td>Ultrasound Molecular Imaging in Large Animal Inflammatory Bowel Disease Models</td>
</tr>
<tr>
<td>NIH</td>
<td>Zalewski, Greg</td>
<td>Quantifying Collagen Perfusion in Cardiovascular Disease</td>
</tr>
</tbody>
</table>
Peer-Reviewed Presentations at Scientific Meetings

ISMRM 2012 (May 5-11, Melbourne, Australia)

Interactive vs LTA Based Gradient Predistortion for Multidimensional Excitation
Adly, Griswold, Nishimura

EPT Phase Correction with LT1k-slice Trajectory Estimation
Adly, Wu, Nishimura

Combined RS-EPI and SAP-EPI for High Resolution Diffusion-Weighted Imaging
Akiyos, Holdsworth, O'llahian, Bammem

MR-Based and Optical Prospective Motion Correction for High Resolution DWI with RS-EPI
Akiyos, O'm, Holdsworth, O'llahian, Bammem

Combining Active Markers and Optical Tracking for Prospective Head Motion Correction
Akiyos, O's, Watkins, Kespping, Forman, Bammem

Reduction of Respiration Artifacts in 3D Phase Contrast Imaging with Intermittent Fat Saturation
Alley, Hiasan, Saranathan

STABLE-2: A shorter, more BI-sensitive option for adiabatic slice-selective excitation
Balchadani, Spielman, Pauly

Spin Echo and Adiabatic Spin Echo Motion Compensated Spatial functional MRI
Balchadani, Pauly, Spelmen, Glover

Experimental Validation of FDTD Magnetic Field Modeling in the Human Head at 7T
Chan, Khalighi, Rutt

Dynamics of BOLD fMRI time series: dependence on cognitive load and sensitivity to temporal pre-processing
Chang, He, Dians

Dynamics of resting-state functional connectivity associated with heart rate variability
Chen, Rogers, Rutt

Inflation contrast in tissue increases the MRI detectability of amyloid plaques in rabbit AD model
Chang, Cham, Khalighi, Rutt

Analysis of MR Signal Dynamics during Carbogen Inhalation using a Combined Spin-And Gradient-Echo (SAGE) EPI Sequence
de Rochefort, Lou, Pel absol, Darussie, Ferrante, Rutt

Precise Phase Correction for Off-resonance 3D FSE Imaging
Granlian, Chen, Gai, Hao, Leefk, Saranathan

Clinical evaluation of 3D diffusion-weighted brain imaging with dual echo steady state (DESS)
Hargreaves, Daniel

Characterization and Compensation of Eddy Current Induced by Insertable dMRI Magnet
Hargreaves, Daniel

MR Imaging of Macrophages in Tumors and Stem Cell Transplants (Workshop)
Dahlin-Legg

High-Resolution Quantitative Cerebral Blood Volume Imaging in Humans Using the Blood Pool USPIO Contrast Agent Ferumoxysolt
Christen, Qiu, Nielsen, Kvan, Moseley, Zaharchuk

Steady-state and Dynamic Susceptibility Contrast using USPIOs in Humans
Christen, Qiu, Nielsen, Kvan, Moseley, Zaharchuk

MR Imaging of Macrophages in Tumors and Stem Cell Transplants (Workshop)
Dahlin-Legg

Precise Phase Correction for Off-resonance 3D FSE Imaging
Granlian, Chen, Gai, Hao, Leefk, Saranathan

Clinical evaluation of 3D diffusion-weighted brain imaging with dual echo steady state (DESS)
Hargreaves, Daniel

MR Imaging of Macrophages in Tumors and Stem Cell Transplants (Workshop)
Dahlin-Legg

Precise Phase Correction for Off-resonance 3D FSE Imaging
Granlian, Chen, Gai, Hao, Leefk, Saranathan

Clinical evaluation of 3D diffusion-weighted brain imaging with dual echo steady state (DESS)
Hargreaves, Daniel

Analysis of MR Signal Dynamics during Carbogen Inhalation using a Combined Spin-And Gradient-Echo (SAGE) EPI Sequence
Hankov, Christen, Schmidtsdka, Bammem, Moseley, Zaharchuk

Quantitative slice-encoding for reduced scan time
Islam, Glover

Reduction of Motion Artifacts in MGdUS in the Brain using Hybrid Thermometry
Ishii, Butt, Pauly, Griswold, Rieke

Fourier Reconstruction for O-space imaging
Johnson, Pauly

T 2p Dispersion in Articular Cartilage: Relationship toMechanical Properties and Macromolecules.
Keman KE, Bousc TF, Smith RL, Pauly JM, Delp SL, Beaupre GS, Gold GE

A Low-Power Asymmetrically-Selective Adiabatic Pulse
Kerr, Larson, Gytnrger, Pauly

Minimum-Duration Adiabatic Spectral-Spatial Refocusing Pulses
Kerr, Larson, Gytnrger, Pauly

Parallel Transmit SAR Estimation using FDTD Modeling in the Human Head at 7T
Khalighi, Chan, Rutt

Adiabatic pulse design for Bloch-Siegert B1+ Mapping
Khalighi, Chan, Rutt

Intensity Correction at 7T Using Bloch-Siegert B1+ Mapping
Khalighi, Zeinel, Rutt

Intensity Correction at 7T Using Bloch-Siegert B1+ Mapping
Khalighi, Zeinel, Rutt

Multi-Component Relaxation In Untreated Relapsing-Remitting Multiple Sclerosis
Kiert, Nueck, Su, Schilde, Ziensenn, Dens, Rutt

Parallel Imaging Using a 3D Conometric Cylinders Trajectory
Kwon, Wu, Lan, Nishimura

Non-contrast-enhanced Flow-independent Perfusion Angiography using a 3D Conometric Cylinders Trajectory
Kwon, Wu, Shin, Cako, Nishimura

Next Generation Delta Relaxation EnhancedMRI with +0.367 delta B
Lee, de. Rochefort, Ferrante, Rutt

kT-points RF Pulsues for Pre-Compensation of B1+ Heterogeneity in DESPOT1
Levesque, Su, Khalighi, Pauly, Rutt

Rapid 3D Quantitative DESS T2 and T2* Mapping in the Meniscus.
McWalter, EJ, Swinsonn, B, Sternowitzcki, E, Alley MT, Hargreaves BA, Gold GE

Rapid 3D quantitative DESS T2 and T2* Mapping in the Meniscus
McWalter, Swinson, Sternotweski, E, Alley, Hargreaves, Gold

Dual Echo Steady State Quantitative T2-mapping in the Breast
Moran, Granlrand, Daniel, Swinson, Starnowitzcki, Alley, Hargreaves

Evaluation of 3D Enhanced Echo Train T-weighted imaging for the Characterization of Breast Lesions
Nguyen MHJ, Chen W, Gold GE

Quantitative Assessment of Cartilage using CubesQuant.
Nguyen, Qiu, Christen, Schmidtsdka, Bammem, Moseley, Zaharchuk

Cerebral MR Signal Changes Induced by Ferumoxysolt and Saline Dilution Boluses: Initial Human Experience
Ooi, Aksoy, Wommm, Bammem

High Precision Tracking of Un-Tuned Micro-Coils for Real-Time Motion Correction Applications
Pal S, Reuse TF, Frederiscn M, Beaupre G, Delp SL, Gold GE

Patellar maltracking is Related to Patella Height in Patellofemoral Pain Subjects: An Upright, Weightbearing MRI Study.
Park, You, Ren, Haun, Rutt

Gadolinium-based "Smart" MRI Probes for Enzyme-targeted Cancer Imaging
Park, Hurd, Josam, Yen, Pfefferbaum, Mayer, Spielman, Butts Pauly

Park, Josam, Yen, Hurd, Spielman, Mayer, Butts Pauly

Assessment of Dichloroacetate Effect on TCA Cycle Metabolism in Rat Brain In Vivo using MR of Hyperpolarized [2-13C]Pyruvate
Park, Hurd, Josam, Yen, Merchant, Vem, Hurd, Spielman, Mayer, Butts Pauly

Metabolic Response of Glutam to Dichloroacetate Measured by Hyperpolarized 13C MRI
Park, You, Ren, Rutt

Paul, Hurd, Josam, Yen, Pfefferbaum, Mayer, Spielman, Butts Pauly

Real-Time Interlaced Temperature and ADC Measurements For Early Assessment of Tissue Viability during Prostate
Plata, Hallbrom, Prakkm, Jones, Doulishtech, Smmner, Butts Pauly

Characterization of Blood Pool Half Life of USPIO Contrast Agent Ferumoxysolt in Humans
Qiu, Christen, N, Zaharchuk, Mossley

Characterization of Blood Pool Half Life of USPIO Contrast Agent Ferumoxysolt in Humans
Qiu, Christen, N, Zaharchuk, Mossley

Vascularization Visualization using Blood Pool USPIO Contrast Agent Gadofosveset Trisodium
Qiu, Christen, N, Zaharchuk, Mossley

Functional Blood Volume Imaging (fBVI) using Blood Pool Gadolinium Contrast Agent Ferumoxysolt
Qiu, Christen, N, Zaharchuk, Mossley

T1 Contrast-Based High-Resolution Cerebral Blood Volume Mapping (T1-BVI) using Gadofosveset Trisodium in Humans
Qiu, Christen, N, Zaharchuk, Mossley

Enhanced MRI Sensitivity using CBV based Contrast with ch Blood Pool USPIO Agent Ferumoxysolt in Humans
Qiu, Christen, N, Zaharchuk, Mossley

3D balanced SSFP Dixon imaging with Band-Reduction at 3T
Quan, Hargreaves, Daniel, Saranathan

Appendix
Peer-Reviewed Presentations at Scientific Meetings

RSNA 2011 (Nov 27-Dec 2, Chicago, Illinois)

Xu J, Greenman H, Napel S, Rubin D.L.
Automated Temporal Tracking And Segmentation Of Lymphomas On Serial CT Examinations

Zaharchuk G
SSA16-06: Perfusion Imaging of Transient Ischemic Attack

WMIC 2011 (Sept 7-10, San Diego, CA)

Development of a Novel Activatable Theragnostic Superparamagnetic Iron Oxide Nanoparticle. World Molecular Imaging Congress (WMIC), San Diego, 2011. WMIC proceedings 2011

Anvari C, Golovko D, Raffel B, Castaneda R, Covassins L, Daldrup-Link H.
Clinically applicable USPIO detect tumor associated macropages in breast cancer. World Molecular Imaging Congress (WMIC), San Diego, 2011. WMIC proceedings 2011

Bachawal SV, Jenson KC, Foygel K, Tranput H, Willmann JK.


Fan-MingHua H, Chan C.T., Feldner D.W., Gambhir S.S.
A Quantitative High Throughput Molecular Imaging based Drug Screening Identifies an Anti-Prostate Drug as an Anti-Cancer Agent for its Inhibitory Effect on the c-myc Oncoprotein.

Ganu E., Zavala C., Sensens S., Liu J.T., Mandella M.J., Gambhir S.S., Costing C.
Fabrication and Characterization of a Raman-Based Endoscopic Imaging Probe for Cancer Detection.

Gurudeo R, Honning TD, Aboua H, Mandrassow I, Wendland M, Demuynck N, Link TM, Daldrup-Link H.
MR Imaging of Ferumoxsil Labelled Macropharyngeal Stem Cells in Cutislle Defects in vitro and in vivo investigation. World Molecular Imaging Congress (WMIC), San Diego, 2011. WMIC proceedings 2011

Gonzalez E., Oktay P.D., Levin C.S.
Multi-Isotope Positron Emission Tomography. Accepted for presentation at the 2011 World Molecular Imaging Congress, San Diego, USA, September 7-10, 2011.

Gu Y., Levin C.S.

Habte F., Run G., Doyle T.C., Cheng Z., Paik D.
Quantification evaluation of a simplified high throughput multiple-mice small animal PET/CT imaging. Poster presentation at the World Molecular Imaging Conference, San Diego, USA, Sept. 7-10, 2011.

Hackl B.J., Kimura R., Sathirachinda A., Chin F.T., Gambhir S.S.
18F-Labeled Cysstein Knot Peptides for PET Imaging of Integrin αvβ6.

Hakel B.J., Sathirachinda A., Chin F.T., Gambhir S.S.
Impact of Protein Hydrophobicity and Charge on biodistribution and tumor Targeting.

Hopfmann S., Hackel B., Liu H., Qi S., Gambhir S.S., Cheng Z.

Hopfmann S., Yang X., Wu S., Miao Z., Chua M. Cheng Z., So S.
GlycoPET-3 as a Target for the Detection of Hepatocellular Carcinoma using ImmunoPET. Poster presentation at the World Molecular Imaging Conference, San Diego, USA, Sept. 7-10, 2011.

Ito K., Smith B.R., Parasharuma N., Yoon J., Song S.V., Friesebo H., Crasiti V., Mischng C., Love S., Gambhir S.S.
Imaging of Lymphoma Cancer Progression in a Murine Model Using a Novel Lymph Node Internal Window Chamber Strategy.

Joković J.V., Gambhir S.S.
Small Silica Particles are an Alternative to Microbubbles for Ultrasound Tracking of Stem Cells in vivo.

A Novel Multimodality Targeted Gold Particle for Concurrent Raman/Photoacoustic Imaging.

Kothapalli S.R., Deshpande N, Ren Y, Willmann JK.
Correlation between Targeted Contrast-enhanced Ultrasound Imaging and 18F-FDG PET in Murine Inflammatory Bowel Disease: a Preliminary Study. Abstract 264

Wang H, Deshpande N, Ren Y, Willmann JK
Quantization and Monitoring of Angiogenesis by KDR-targeted Contrast-enhanced Ultrasound Imaging in Murine Colitis. Abstract 233

Kothapalli S.R., Deshpande N., Chan C.T., Khur-Kabad B., Gambhir S.S.
In vivo MR imaging of ferumoxsil labeled adenosine derived stem cells in cartilage defects. World Molecular Imaging Congress (WMIC), San Diego 2011. WMIC proceedings 2011

Kothapalli S.R., Deshpande N., Chan C.T., Khan-Yakub B., Gambhir S.S.
Small Chromophores for Photoacoustic Labeling of Biologically Active Molecules.

In Vivo Imaging of Protozoa Activated Photoacoustic Probe.

MA Pyse, J Grazicar, K Foygel, and JK Willmann
In vivo Real-Time Quantification of Targeted Contrast-Enhanced Ultrasound Imaging Signal in Cancer. Abstract # T138

Massoud T.F., Paulmurugan R., Gambhir S.S.
Toward a Generalizable Intramolecular Complementation Strategy for Split-Reporter Gene Imaging of Protein Folding.

Namavari M., Yoon Song S., Sathirachinda A., Paulmurugan R., Gambhir S.S.
2-Doxyc-2-[18F]Fluoro-β-D-arabinofuranosyluracil and 3-Doxyc-3-[18F]Fluoro-β-D-arabinofuranosyluracil as in vivo Probes for Gene Expression with PET.

Natarajan A, Gambhir S.S.
Development of 89Z-exonuclease peptidePET Tracer for Monitoring Lymphoma Therapy in a Humanized Transgenic Mouse Model.

Paulmurugan R, Sukar NM, Sukar TV
In vitro and In vivo delivery of AntagomiRs by Biodegradable Polymer Nano-carrier to Inhibit Tumor Metastasis and Invasion.

Ran G., Doyle T., Cheng Z., Gambhir S.S., Paik D.
High-throughput Multiple Mouse Imaging on MicroPET and MicroPET-CT Scanners. Evaluation on Image Quantification Effect.

Ran Y, Fischbach M. D., Foygel K, Moblin L, Latz AM, Koong AC, Jeffrey BL, Tian L, Willmann JK.

Sanjani S.S., Taghibakhsh F., Levin C.S.
A promising new PET block detector design for clinical PET/CT based on large-area tiling of silicon photomultiplier arrays. Accepted for presentation at the 2011 World Molecular Imaging Conference, San Diego, CA, September 7-10, 2011.

Quantitative, Dynamic, and Long Term In Vivo Imaging of Intravascular Circulating Tumor Cells in Awake Animals, with a Novel Miniatuer Mountable Fluorescence Microscope.

[18F]FICMT-146: A Novel Sigma-1 Receptor (SIR) Radioligand for Imaging Pain with PET/MBI.

Smith B.B., Ghose E.E., Tabakman S., Dai H., Gambhir S.S.
Exquisitely Selective Uptake of Single-Walled Carbon Nanotubes into a Specific Monocyte Subset in Living Mice.


Spansod Z., Deshpande N., Tabakman S., Dai H., Willmann JK.

Taghibakhsh F., Levin C.S.
A simple method to determine 511 keV photon interaction depth in individual scintillation crystals for high resolution PET. Accepted for presentation at the 2011 World Molecular Imaging Congress, San Diego, CA, September 7-10, 2011.

Wang H, Deshpande N., Ren Y, Willmann JK
Correlation Between Targeted Contrast-enhanced Ultrasound Imaging and 18F-FDG PET in Murine Inflammatory Bowel Disease: a Preliminary Study. Abstract 264

In vivo and in vivo MR imaging of ferumoxsil labeled adenosine derived stem cells in cartilage defects. World Molecular Imaging Congress (WMIC), San Diego 2011. WMIC proceedings 2011

Wang H, Deshpande N., Ren Y, Willmann JK
In vivo Real-Time Quantification of Targeted Contrast-Enhanced Ultrasound Imaging Signal in Cancer. Abstract # T138
First in man experience with the rarefied infusion system: a dedicated microcatheter system to eliminate reflux during embolotherapy.

Samuelsdon SD, Hofmann LV, Kathy N, Loi S, Louis JD, Kuo WT, Hovsepian D, Sei DY, Huang GL.  


Umur K, Kathy N, Lam GJ, Hovsepian DL.  

Prophylactically topicalized ice to prevent cutaneous complications of nontarget chemoembolization and radiosensitization of liver tumors.


Wang DS, Louis JD, Shah RP, Kathy N, See DY.  

IEEE NIS/MIC 2011 (Oct 23-29, Valencia, Spain)  
Biniowsk M. F., Ockert P. D., Levin C. S.  

Chinn G., Levin C. S.  

Cui J.-Y., Chiu G., C. S. Levin  

Cui J.-Y., Purns G., Prevelak S., Zhang B., Shao L., Levin C. S.  

Gonzalez E., Ockert P.D., Biniowsk M., Levin C. S.  
Gonzalez E., Cui X.-Y., Pruts G., Ostert P.D., Biemöck M., Levin C.S.

Grant A.M., Ostert P.D., Levin C.S.
All-Optical Encoding of PET Detector Signals (paper J1-5). Oral presentation at the 2011 Nuclear Science Symposium and Medical Imaging Conference, Valencia, Spain, October 22-29.

Grimmer B., Falehr R., Himlebaw W., Gao H., Kachelleb M.
Empirical Cupping Correction for CT Scanners with Primary Modulation (ECCP) MIC21.S-66

Gu, Levin C.S.
*Studies of Electrode Design for a Sub-mm Resolution 3-D Position Sensitive CZT PET Detector (paper MIC5-5). Oral presentation at the 2011 Nuclear Science Symposium and Medical Imaging Conference, Valencia, Spain, October 22-29.*

Kim E., Ostert P.D., Levin C.S.

Lau F.W.Y., Vandenbroucke A., Reynolds P.D., Olcott P.D., Levin C.S.

*“Simultaneous Perfusion and Permeability MR Imaging in Brain Tumor Patients”*

*“Diffusion tensor imaging (DTI) with retrospective motion correction for large-scale pediatric imaging”*

Van A, Holdsworth S, Bannemer R.
*“Eliciting Subresolution Microstructure with Oscillating Diffusion Gradient MRI”*

Zaharchuk, Christen, Qiu, Ni, Schmiedlkamp, Bannemer, Mosley.
Cerebrovascular and Functional Magnetic Resonance Imaging with the Blood Pool Agent Ferumoxytol - Initial Experiences in Normal Subjects.

ISIC 2012 (Jan. 31-Feb. 3, New Orleans, LA)


Kleinman J.T., Steiner R.W., Aksey D., Mlynash M., Fischbein N., Gean A.D., Eyong J., Vinkumbashamun C., Finley, Cuillielid A, Bannemer R, Wijman C.A.C.


Myhal A., Kemp L., Lansberg M., Mosley, Ricci
*Performance Of Color ADC Maps As A Prognostic Tool In Cerebrovascular Disease Patients. International Stroke Conference (ISC), New Orleans, LA, 2012, (Platform Abstract 2585)*

Tipirneni A., Straka M., Lansberg M.G., Mlynash M., Bannemer R., Albers G.W.

Wijman C.A.C., Fuchs F., Gean A., Hanley D., Kase C.S., Nayarana R., Marks M., Bannemer R., Mosley M.
*Diagnostic Accuracy of MRI in Susceptibility intra-cerebral Hemorrhage (DASH). International Stroke Conference (ISC), New Orleans, LA, 2012, (Platform Abstract 3765)*
 Peer-Reviewed Presentations at Scientific Meetings

**Efficacy of fixed filtration for rapid kVp-switching dual energy x-ray systems: experimental verification**
Yao Y, Wang A and Pelc NJ

Image-based synthetic CT: simulating arbitrary low dose single and dual energy protocols from dual energy images

**Hsieh SS and Pelc NJ**
A volumetric reconstruction algorithm for stationary source inverse-geometry CT

**Pelc NJ**
Monu UD, Worters PW, Hargreaves BA, Gold GE.
Jordan C, Samathan R, Bangerter NK, Hargreaves BA, Gold GE.
Mona UD, Worters PW, Hargreaves BA, Gold GE.

**Peer-Reviewed Presentations 2011-2012**

- **Kristensen EM, Son M-S, Goodman SB, Hargreaves B, Chen D, Delp S, Beaupre GS, Gold GE.**
- **Atlas, SW**
  - “America’s Health Care and the Principles for Reform”
  - Hoover Institution Board of Overseers Annual Meeting
  - Willard Intercontinental Hotel Washington D.C. 2/27/2012
- **Atlas, SW**
  - “America’s Health Care and the Principles for Reform”
  - Hoover Institution Desert Conference Vacist Club Indian Wells, CA 3/19/2012
- **Atlas, SW**
  - “Health Care Reform: Setting the Record Straight on America’s Health Care”
  - Fall Retreat Hoover Institution 4th Annual Retreat Stanford, California 10/17/2011
- **Atlas, SW**
  - “Health Care Reform: Setting the Record Straight on America’s Health Care”
  - November Retreat Hoover Institution 4th Annual Retreat Stanford, California 11/17/2011
- **Atlas, SW**
  - “Health Care Reform: Setting the Record Straight on America’s Health Care”
  - Special Seminar Hoover Institution Stanford, California 11/8/2011
- **Atlas, SW**
  - “Rheumatology and the Brain: The Role of Imaging”
  - BDO Diagnostic Clinic Sao Paulo, Brazil 9/17/2011
- **Atlas, SW**
  - Targeted contrast-enhanced ultrasound imaging using KDR-targeted microbubbles for early breast cancer detection in a transgenic mouse model.
  - Poster Symposium of Center for Biomedical Imaging at Stanford, Stanford, CA, USA; Apr 4-5, 2012. Abstract 61. Poster was highlighted.
  - Ultrasound molecular imaging for early breast cancer detection.
  - Poster. 5th Annual Cancer Institute Members Retreat at Canyon Conference Center, Menlo Park, CA, USA; Apr 16, 2012
- **Bachawal S, McKinney J.K., Brooks J.D, Gambhir S.S, Willmann J.K.**
  - Angiogenesis Imaging Using Targeted Microbubble Contrast Enhanced Ultrasound for Early Detection of Prostate Cancer.
  - Symposium #0, September 17, 2011, 7th Early Detection Research Network (EDRN) Scientific Workshop, Hemdon, Virginia, USA.
- **Bammer**
  - Dec 2012 - DEFUSE 2 Investigator Meeting: “MRI Artifacts and Pitfalls in the DEFUSE 2 Acute Stroke Trial”
  - Jan 2012 - Medical University Vienna: “Hybrid Imaging: Technical Trends in PET-MRI”
- **Bammer**
- **Barnes**
  - Child abuse and the mimicry controversies in the era of evidence-based medicine.
  - Cook County Public Defenders’ Conference, Oak Brook IL. September 8-9, 2011.
- **Barnes**
  - Fetal and neonatal brain imaging. “Perinatal Care: All About The Family” Annual Conference. VMC Foundation.
  - Santa Clara Valley Medical Center, San Jose CA, November 3, 2011.
- **Barnes**
  - Oklahoma City University School of Law, Oklahoma City, OK, Sep. 21, 2011.
Jeffrey

Ultrasound Pearls in Patients with Acute Abdominal Pain SGB/SUR Abdominal Radiology Course, March 26-27, 2012; Scottsdale AZ.

Jones RH, Oketz EW, Shah S, Jeffrey RB, Do R, Shin LK


Kamaya


Kamaya


Kamaya


Kamaya


Kamaya

“Pregnancy and Postpartum Related Complications”, Innovations in Ultrasound, Newport Beach CA, November 5, 2011

Kamaya

“Pregnancy and Postpartum Related Complications”, LA Radiologic Society Pausenda CA May 5, 2012

Kamaya

The case for CT when Imaging the Pancreas”, Imaging in Hawaii Course: The Center for Promotion and Education in Personalized Medicine. March, 2012

Kamaya


Kamaya


Kamaya


Kamaya


Kamaya


Kamaya


Kamaya


Levin


Levin


Levin

Research topics in time-of-flight positron emission tomography. Presented at the Medical Physics Seminar Series, University of Wisconsin, April 9, 2012.

Lai, P.; Fang, M. M.; Vasanthula, S. S.; Brua, A. C


Liu F.W.Y., Reynolds P., Vandenbroucke A., Levin C.S.


Kothary

IR and the Lung Nodule. Pulmonary and Critical Care Grand Rounds, Stanford University School of Medicine, Stanford, CA

Kamaya

“Pregnancy and Postpartum Related Complications”, Innovations in Ultrasound, Newport Beach CA, November 5, 2011.

Kamaya

“Pregnancy and Postpartum Related Complications”, LA Radiologic Society Pausenda CA May 5, 2012

Kamaya


Kamaya


Kamaya


Kamaya


Kothary

IR and the Lung Nodule. Pulmonary and Critical Care Grand Rounds, Stanford University School of Medicine, Stanford, CA

Lai, P.; Fang, M. M.; Vasanthula, S. S.; Brua, A. C


Liu F.W.Y., Reynolds P., Vandenbroucke A., Levin C.S.


Kothary

IR and the Lung Nodule. Pulmonary and Critical Care Grand Rounds, Stanford University School of Medicine, Stanford, CA

Lai, P.; Fang, M. M.; Vasanthula, S. S.; Brua, A. C


Liu F.W.Y., Reynolds P., Vandenbroucke A., Levin C.S.


Kothary

IR and the Lung Nodule. Pulmonary and Critical Care Grand Rounds, Stanford University School of Medicine, Stanford, CA

Lai, P.; Fang, M. M.; Vasanthula, S. S.; Brua, A. C


Liu F.W.Y., Reynolds P., Vandenbroucke A., Levin C.S.


Kothary

IR and the Lung Nodule. Pulmonary and Critical Care Grand Rounds, Stanford University School of Medicine, Stanford, CA

Lai, P.; Fang, M. M.; Vasanthula, S. S.; Brua, A. C


Liu F.W.Y., Reynolds P., Vandenbroucke A., Levin C.S.

"Correlation of TICI reperfusion with MR reperfusion, infarct growth and clinical outcome in the DEFUSE 2 trial."


Other Presentations 2011-2012

Levin

Levin

Levin
The status of integrating PET and MRI. Presented at the Center for Biomedical Imaging at Stanford Medical Imaging Seminar Series. Li Ka Shing Center, Stanford University, December 7, 2011.

Levin

Levin
Updates on research projects with clinical translation. Presented to the Nuclear Medicine Division, Department of Radiology, Stanford University School of Medicine, Dec. 2, 2011.

Lipson
"Title: “Breast Cancer Screening” Date: 9/22/2011 Forum: HealthPack Headquarters (Palo Alto, CA), arranged by Stanford Strategic Partners. Audience: 30 HP employees + 300 on-line attendees (broadcast worldwide as webinar)"

Lipson
"Title: “Breast Tomosynthesis” Date: 10/6/2011 Forum: Monthly meeting of Stanford radiology technologists and administration. Audience: 40 Stanford radiology technologists + administrators"

Lipson
"Title: “Imaging work-up of palpable abnormalities; RSNA Refresher course preview” Date: 10/22/2011 Forum: Mid-Atlantic Kaiser/DC ACR Breast Imaging CME (Washington, DC) Audience: 80 conference attendees (physicians)"

Lipson

Lipson


Lipson
10/26/11 Colorectal Cancer Support Group in the Division of Gastroenterology and Hepatology Stanford University. Lecutred about Liver Directed Therapy.

Lipson

Lipson
11/19/11 CSRFT (California Society of Radiologic Technologists) 72nd Annual Conference: “C-Arm CT: New Vision for the Cath lab”

Lipson
29/12 - 2/12/12 Are you ready? Y90 Conference. Scottsdale, Az. Advanced Angio for Y-90 Lecture: Cone Beam CT and Y90

Lipson
3/9/12 Cath Lab Staff Education Series: Radiosynthesis

Lipson
3/3/12 Radiation Oncology Morning Conference: Interventional Oncology

Lipson
3/28/12 Chrome Venous Occlusion Workshop at 37th annual meeting of the Society of Interventional Radiology. San Francisco, Ca

Lipson

Mallick
AAAR Molecular Biology in Clinical Oncology

Mallick
Agilent Corporation Seminar Series

Mallick
Amgen Corporation Seminar Series

Mallick
Molecular Imaging Program at Stanford Seminar Series

Mallick
Stanford Center for Cancer Systems Biology

Marks

Moseley

Moseley

Moseley
Invited Speaker. NPO Amaakana. Hiroshima University, November 2011. New Thinking in MRI.

Moseley

Moseley
Invited Speaker. Shimane University, November, 2011. DWI and PWI at J.

Moseley
Plenary Speaker. Japan 1st Annual ICRST. Kobe, November 2011. Advances in 3D MRI.

Moseley

Practical Considerations for Radioscio Jodine Therapy for Thyroid Cancer (2011). ThyCa Workshop. Los Angeles, CA.

Napel

Nino-Murica

Occto

Occto

Paulmurugan

Paulmurugan
Epigenetics- New Therapeutic Targets to Treat Cancers by Altering Cellular Homeostasis, King Institute for Preventive Medicine, Chennai, India, January 12, 2012.

Paulmurugan
Nanoparticles mediated delivery of microRNAs- A new therapeutic approach to treat cancers by altering cellular homeostasis, 2nd Molecular Materials Meeting (M3) @ Singapore, 09-12, January 2012, Biopolis, Singapore.

Paulmurugan
Practical Considerations for Radioscio Jodine Therapy for Thyroid Cancer (2011). ThyCa Workshop. Los Angeles, CA.

Paulmurugan

Paulmurugan
The Ins and Outs of Nuclear Imaging for Thyroid Cancer (2011). ThyCa Workshop. Los Angeles, CA.

Paulmurugan
The status of integrating PET and MRI. Presented at the Center for Biomedical Imaging at Stanford Medical Imaging Seminar Series. Li Ka Shing Center, Stanford University, December 7, 2011.

Paulmurugan

Paulmurugan
Updates on research projects with clinical translation. Presented to the Nuclear Medicine Division, Department of Radiology, Stanford University School of Medicine, Dec. 2, 2011.

Sun C, Gambhir SS, Xing L, Cheng Z, Fels Dinkelborg LM, Moon DH, and Gambhir SJ, Moseley

Levin

Levin

Levin

Levin
The status of integrating PET and MRI. Presented at the Center for Biomedical Imaging at Stanford Medical Imaging Seminar Series. Li Ka Shing Center, Stanford University, December 7, 2011.

Levin

Levin
Updates on research projects with clinical translation. Presented to the Nuclear Medicine Division, Department of Radiology, Stanford University School of Medicine, Dec. 2, 2011.


Atlas SW. Assertor view: Misleading neuronal data distort rankings. USA Today, October 4, 2011.

Atlas SW. ObamaCare is At the Core of the President's War on Excellence; Investor's Business Daily, February 16, 2012.

Atlas SW. Snarking "ObamaCare" a Rejection of Overreach; Politics, March 12, 2012.


Atlas, Scott W. Infant Mortality: A Deceptive Statistic; National Review Online, September 14, 2011

Atlas, Scott W. Infant Mortality: A Deceptive Statistic; National Review Online, September 14, 2011


Atlas, Scott W. Another view: Misleading neonatal data distort rankings; USA Today, October 4, 2011.


Chen A; Olsen RK; Preston AR; Glover GH; Wagner AD. Associative Retrieval Processes in the Human Medial Temporal Lobe: Hippocampal Retrieval Success and CA1 Mismatch Detection. Learning & Memory 18:523-8 (2011)


Glover GH. Spiral imaging in fMRI. NeuroImage. PMID 22036996 (2011)


reviewed conference proceedings)


Quon A, Dodd R, Iagaru A, de Abreu MR, Hennemann S, Neto JM, Sprinz C. Initial investigation of (18)F-NaF PET/CT for identification of vertebral sites ame


Sigal BM, Munoz DF, Kurian AW, Plevritis SK. A Simulation Model to Predict the Impact of Prophylactic Surgery and Screening on the Life Expectancy of


Staroswiecki E, Granlund KL, Alley MT, Gold GE, Hargreaves BA. Simultaneous estimation of T(2) and apparent diffusion coefficient in human articular cartilage

Saranathan, M.; Rettmann, D W.; Hargreaves, B. A.; Clarke, S. E.; Vasanawala, S. S. Differential Subsampling with Cartesian Ordering (DISCO): A High Spatio-

Segall BM, Munoz DF, Kurian AW, Plevritis SK. A Simulation Model to Predict the Impact of Prophylactic Surgery and Screening on the Life Expectancy of


PMID: 22588589.


### Summary Statistics

- **116**
  - Total number of all faculty;
  - 3rd largest in the School of Medicine
- **$20M**
  - New major gift funding (2012-13)
- **# 2**
  - NIH rank according to Academy of Radiology Research, acadrad.org, 2012

### Presentations & Publications

- **44**
  - Books and Chapters
- **350+**
  - Publications
- **500+**
  - Abstracts/Presentations (faculty, postdocs, scientific staff)

For details see [http://radiology.stanford.edu/about/annual_report/](http://radiology.stanford.edu/about/annual_report/)

### Research Funding FY12

- **$46,000,000** (directs and indirects)

### Revenue Sources FY12

- **$86,000,000**

### Faculty: 116

- **Instructors**: 3
- **Professor**: 29
- **Assistant Professor**: 21
- **Associate Professor**: 19

### Trainees: 227

- **Resident**: 36
- **Clinical Fellow**: 41
- **Emeriti**: 6
- **Consulting**: 9
- **Clinical Educator -Affiliated**: 30
- **Clinical Educator**: 30
- **Undergrad**: 10
- **Graduate student**: 60
- **Postdoctoral Fellow**: 80

* Totals based on Stanford Fiscal Year

**Radiology Annual Report**
The Annual Canary Challenge ride takes place September 28, 2013. Join your friends and colleagues as a rider or a volunteer for this event. Last year, this event attracted more than 500 riders and volunteers who assembled bright and early Saturday morning to support the ride and raise funds for the early detection of cancer. The event, organized by the Canary Foundation, was by any measure a resounding success and raised $514,000 to support cancer research at the Stanford Cancer Institute and the Canary Center at Stanford.

For 2013, we expect 1,000 riders this year riding together to raise $1M to beat cancer through early detection. Meet your riding friends September 28th for an amazing and extremely rewarding event. Register online for the 2013 Canary Challenge.

canarychallenge.com