Diagnostic Radiology Chief Residents
(left to right) Vincent Mellnick, MD; Jessica Huang, MD; Caitlin Lopez, MD

Photograph by MIR Photography Lab
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ON THE COVER Daniel Marcus, PhD, is shown with part of the computer network that supports the NIAC goal of taking new imaging technology from basic science to clinical studies to patient care. Photograph by Tim Parker.
Matching Program results announced

The 2011-2012 diagnostic radiology resident program will welcome 18 trainees from the following schools:

- Indiana University School of Medicine
- Saint Louis University School of Medicine
- Stanford University School of Medicine
- University of California San Francisco School of Medicine
- University of Illinois College of Medicine, Urbana-Champaign
- University of Kentucky College of Medicine
- University of Medicine and Dentistry of New Jersey/Robert Wood Johnson Medical School
- University of Michigan Medical School
- University of North Carolina School of Medicine, Chapel Hill
- University of Pittsburgh School of Medicine
- Vanderbilt University College of Medicine
- Virginia Commonwealth University School of Medicine
- Washington University in St. Louis School of Medicine

42nd Wilson Award presented

In May, following Washington University’s 149th Commencement ceremony, Seth Bartel, a Medical School student, received the 2010 Hugh M. Wilson Award for Meritorious Work in Radiology. Bartel’s work under the mentorship of David Gierada, MD, professor of radiology, and Mark Conradi, PhD, professor of physics, included the designing of databases for the quantitative histology, computed tomography (CT), hyperpolarized helium magnetic resonance (MR), and physiologic measurements; creating a computerized lung model used for stimulations of helium diffusion; and analyzing CT scans and helium MR images for features relevant to emphysema.

The annual Wilson Award honors Mallinckrodt Institute’s second director, an advocate of the advancement of education.

BJC Institute of Health dedicated

A Collaboration Celebration on June 16 marked the formal dedication of the BJC Institute of Health at Washington University School of Medicine. Honored guests at the dinner celebrating the event were U.S. Secretary of Health and Human Services Kathleen Sebelius and Francis Collins, MD, PhD, director of the National Institutes of Health.

The 11-story research building houses laboratories and support facilities for BioMed 21, Washington University's multidisciplinary and translational research initiative for basic scientists and research-clinicians. Artist Maya Lin designed the reflecting pool and plaza, known as Hope Plaza that welcomes visitors to the Institute of Health. Lin, is perhaps best known for designing the Vietnam Veterans Memorial in Washington, DC.
Of note

• Amy Fowler, MD, PhD, third-year diagnostic radiology resident, was selected by the Radiological Society of North America (RSNA) editors and Board members to receive the 2010 RSNA Editorial Fellowship for Trainees. As part of her training, Fowler will visit the editorial offices of the journals Radiology and Radiographics, which will provide her with first-hand knowledge of peer-reviewed research and the publication process.

• Jay Heiken, MD, professor of radiology, was elected to a one-year term as president of the Society of Gastrointestinal Radiologists (SGR). Established in 1971, the SGR’s mission includes providing continuing medical education in gastrointestinal and abdominal radiology to community-based and academic-based radiologists.

• Joseph Ippolito, MD, PhD, third-year diagnostic radiology resident, received a Research Resident Award from the Radiological Society of North America Research & Education Foundation. Ippolito’s $30,000 award will provide one-year of funding for his research on “High throughput RNA interference and pharmaceutical screens of GABA metabolism in prostate cancer hypoxia.”

WU campuses tobacco-free

Effective July 1, Washington University policy prohibits smoking and tobacco use on all university-owned and managed properties. Washington University Medical Center became tobacco-free on March 1, 2010. The policy applies to all employees, patients, and visitors, and covers all medical school and hospital property, including parking lots and garages.

At the 2010 Missouri Center for Patient Safety Conference, Carol Hofley, MHA, BSN, RN, assistant director of the Missouri Center for Patient Safety, presented the Missouri Excellence in safe Care Award to James Duncan, MD, PhD, associate professor of radiology. Duncan’s project “Patient safety in radiology: optimizing radiation dose” described work done at St. Louis Children’s Hospital and Barnes-Jewish Hospital. Projects were rated in four areas: project planning/problem definition, implementation, data analysis/modifications, and innovation/sustainability/reproducibility. The dose optimization project received an overall score of 223 out of 225 points. Project team members: Mandie Street, RT(R)(MR), WUSM quality and safety coordinator; Stephen Currie, second-year WUSM student; Paula Vise, manager of radiology, SLCH; James Noes, RT(R), supervisor of BJH interventional radiology; Gary Brink, manager of radiology, BJH; Ronald Evens, MD, director of MIR special projects.
Imaging Sciences Retreat
21st-Century Imaging Sciences: Pathways to Discovery

Imaging Sciences Pathway (ISP)—Washington University’s innovative, interdisciplinary curriculum for training scientists—began in 2006. The program offers a unique learning experience for undergraduate and graduate students by giving them a cross-pollination of courses in several disciplines, including imaging sciences, molecular cell biology, and engineering. In April, the Imaging Sciences Retreat highlighted the ISP as well as the students enrolled in this challenging paradigm for education.

Above left: Parinez Metaa, PhD, research associate in neuroradiology, and (right) Lisa Rohrer, MS, research assistant in the Division of Radiological Sciences.

Above: J. Radiology.
Below: MALLINCKRODT INSTITUTE OF RADIOLOGY
Top left: Diwekar Turaga, PhD student in anatomy and neurobiology.

Top right: David Piwnica-Worms, MD, PhD, professor of radiology and director of Washington University's Molecular Imaging Center, was among the ISP Retreat faculty.

Below: Carolyn Anderson, PhD, ISP codirector, presented "Imaging Sciences Pathway: an update."

Above: James Johnson (right) postdoctoral research scholar in the Division of Radiological Sciences, discusses the poster exhibit he coauthored.

Below: Keynote Speaker Eric Herzog, PhD, associate professor of biology, presented "As times glow by: watching circadian clocks in the brain."
When it comes to finding treatments for cancer, the key is working together every step of the way. Now a new study has shown that one powerful team in fighting cancer is the combination of gold and tiny particles called nanocages. Injected into mouse models, these gold nanocages accumulate in tumors. When laser light hits them, they convert this light into heat, which kills the cancerous cells—an effect known as photothermal therapy.
The research group that developed these innovative findings, published online in the March issue of the journal Small was a collaborative effort, too. Mallinckrodt Institute of Radiology (MIR) scientists worked with colleagues from the Washington University Department of Biomedical Engineering, who are long-time experts in the use of nanoparticles. One member of each department—Charles Glaus, PhD, from MIR, and Jingyi Chen, PhD, from Biomedical Engineering—were the lead researchers on the project.

Together, this team devised a novel approach to tumor therapy. While it has not yet been tested in humans, it appears so far to be a promising way to eradicate tumors, without adverse effects. Thanks to new funding from the National Cancer Institute (NCI), the researchers will soon add enhancements (such as loading the nanocages with chemotherapeutic agents) that may give them still greater tumor-fighting impact.

“We think this method has a lot of potential,” says Glaus, a post-doctoral research associate. “These particles are unique in some of their optical qualities and, as gold makes it an attractive metal to use in human therapies.

“There are actually gold products sold as over-the-counter medicine—Aurasol, a nutritional supplement, for example,” says Michael Welch, PhD, professor of radiology, of chemistry and of molecular biology and pharmacology. “It is therefore likely that therapy utilizing these particles could be readily translated to the human situation.”

The heat they produce can be used to destroy malignant tissue.”

RESEARCH BACKGROUND
For centuries, hopeful patients have used gold to treat various ailments: tuberculosis, psoriasis, and, most commonly, rheumatoid arthritis. While other metals are toxic when ingested, gold is a relatively inert substance, and that makes it an attractive metal to use in human therapies.

Younan Xia, PhD, in his Danforth Campus lab.

FOCAL SPOT, SPRING/SUMMER 2010
Younan Xia, PhD, professor of biomedical engineering, had been experimenting with gold for some time in conjunction with nanoparticles. These particles, the size of the smallest virus, have an important application: as “photothermal transducers” that absorb light at a certain wavelength, begin vibrating at an atomic level, and then generate heat. The heat they produce can be used to destroy malignant tissue.

These nanoparticles come in different shapes, each with its own physical and optical properties. While other researchers have focused on gold nano-rods or shell-shaped nanoparticles, Xia’s group demonstrated that the gold nanocage—a hollow, cube-like structure—was the most versatile to use in terms of large-scale synthesis and conversion of light into heat.

Having studied the photothermal effects of these nanocages in cell culture, Xia wanted to move to the next level and study them in vivo. So Xia and Chen, a research assistant professor of biomedical engineering, approached Welch and his radiology team early in 2009 to find new applications. Glaus and Chen began working together to design the studies.

**Planning the Experiments**

They decided to use mice with tumors in each of their hind limbs. Then, they separated the mice into two groups: one injected with the nanocages; the other, with a saline solution. They would let the nanocages circulate in the mouse’s body for a few days and accumulate in the tumor. After that, the right-side tumor in each animal would be exposed to light from an 810-nanometer diode laser for 10 minutes. During this photothermal treatment, researchers would monitor temperature increase using infrared imaging.

**We had tuned the physical dimensions of the nanocages...and we could get good depth penetration with the light.**

Colorized transmission electron microscopy image of gold nanocages.
"We had tuned the physical dimensions of the nanocages so that their absorption peak would be in a wavelength where tissue is most transparent, and we could get good depth penetration with the light," says Glaus. "We knew that eight-ten-nanometer light penetrates tissue very well, so we wanted to make cages that have an absorption peak at that point."

In advance, the researchers had also carefully studied the level of gold that would result in the most efficient heating effect. After dishes were filled with solutions of gold nanocages at increasing concentrations, Chen shone laser light on the dishes to determine how much gold nanocages was needed for the best heating result. They had also looked at another factor: Does heating the cages cause them to degrade or do they continue to do their jobs?

To discover this, Chen measured the absorption before laser irradiation and then after. There was no change in the absorption spectrum. The cages were holding up despite the heat.

With this preliminary work, the research team was well prepared for experiments on the mouse models. Here, they provided checks and balances as well: Not only was there a control group that got saline solution along with the nanocage-injected study group, but in both groups the laser light was shone on one tumor but not on the other. "In that way, if the cages alone were having some toxic effect on the tumor, and the laser light was not involved, we would see that the tumor was affected independently of the laser," says Glaus. "If the laser alone was adversely affecting the tumor, we would control for that by giving some mice the saline injection. Then we would know that the laser was causing changes."
RESULTS

In their journal article, the researchers described, and pictured, the vivid results. Among the mice who received the saline, the infrared camera picked up essentially no temperature increase. But in the nanocage-injected tumors with laser application, there was a dramatic difference: a more than 20-degree increase in temperature after laser heating.

They also tested the effect on the cancerous tissue by using positron emission tomography (PET), in conjunction with FDG, to look at tumor metabolism both before and after treatment. Here, too, the nanocage-injected mice that had laser treatment showed a significant result. Only in this study group did PET images indicate a decrease in tumor metabolic activity—an indication of effective therapy. When the team analyzed the tumor tissue microscopically, they also found significant damage to the tumor cells.

How did they make sure that the nanocages were concentrated in the tumor and did not spill over into normal tissue, which would then be destroyed by the laser illumination? The team took advantage of the biological nature of tumors, which have blood vessels feeding them with oxygen and nutrients. Because the tumor is growing erratically, these vessels are also poorly formed and porous, with erratic branching.

That means the tumor tends to accumulate agents, only eliminating them gradually. So the team could inject the nanocages intravenously and wait until they had washed out of the normal tissue but were still present in the tumor; at that point, the team applied the laser heating, directing the beam carefully to the tumor alone.

...nanocage-injected mice that had laser treatment showed a significant result... a decrease in tumor metabolic activity—an indication of effective therapy.

Top left: Infrared image of nanocage-injected tumor with laser application shows dramatic temperature increase.
Top right: Saline-injected tumor shows little temperature change.
Above: Tumor in mouse model.

FUTURE WORK

With the success of this study, the team is now looking toward more experiments, made possible by the NCI funding. In the future, they will monitor survival in the mice. How long do the two groups live? If the tumors persist in the treated group, do they grow much more slowly?
“This project has the potential to provide a new method based on the photothermal effect, which would be highly selective with essentially no adverse effect,” says Xia. “It can be combined with chemotherapy to enhance the treatment efficacy; it can also be combined with an imaging modality for image-guided therapy. This research will open the door to many new opportunities.”

For the next five years, the team will be working in animal models, not in humans, to test the potential of this method. If this concept reaches clinical trials, as they hope, the many strengths of Washington University in the translational area will be crucial.

“This project has the potential to provide a new method based on the photothermal effect, which would be highly selective with essentially no adverse effect.”

They will also test an exciting possibility: loading the hollow nanocages with chemotherapy agents that can leach out slowly, even after the heating is done. And they will not just rely on the passive accumulation of the nanocages in the tumor. Instead, the researchers will “decorate” the cages with a targeting molecule, like a small peptide or antibody that binds to a specific form of cancer such as breast or prostate.

Finally, they also plan to test a highly sophisticated method of delivering the light inside the body: an endoscopic approach. A patient will receive an injection of these nanocages and then undergo laser irradiation endoscopically.

“MIR has the infrastructure and faculty to carry out collaborations with scientists in other Washington University Medical School departments and on the Danforth Campus,” says Welch. “The application of imaging to novel therapeutics in animal models is exemplified in this collaboration. This type of cross-disciplinary work is essential for the translational research being carried out by many groups.”

Glaus agrees: “In an institution like this, you can take research from beginning to end, and that is a powerful ability.”
In 2009 the National Council on Radiation Protection and Measurements released a striking report about the increasing radiation exposure of the United States population. According to the Council, radiation exposure from medical imaging is up sevenfold since the 1980s. Medical imaging plays a vital and often lifesaving role in patient care, but how much imaging radiation is too much? This is especially concerning in light of the children who make up approximately 10 percent of those exposed.
Child-sized considerations

Practitioners who are mindful of the risks and benefits of medical radiation are guided by ALARA—"as low as reasonably achievable." Although radiation doses used in most medical imaging are relatively small, radiation should only be used to the extent that it will improve the health of a patient. Doctors are encouraged to choose modalities, such as ultrasound or magnetic resonance imaging, that don’t use ionizing radiation. When ionizing radiation is indicated, exposure should be adjusted based on the patient’s size, and the area scanned should be kept as small as possible.

ALARA is especially important given the unique concerns that radiation exposure poses in children. Medical physicists are not sure if medical radiation causes cancer. However, it is important to act conservatively and act as if it is possible. Children have more years during which to develop a potential complication such as cancer from radiation exposure. A child's growing body is more sensitive to radiation than an adult's body. This is especially worrisome because children may be scanned using adult parameters—so they may receive radiation doses that are not only unnecessary for their small bodies but also are more likely to cause damage over time. In addition, the lack of pediatric radiation protocols at some hospitals may result in widely variable exposures.

Such concerns are the impetus behind the creation of the Image Gently Campaign—an initiative of the Alliance for Radiation Safety in Pediatric Imaging. The goal of the campaign is to change practice by increasing awareness of opportunities to lower radiation dose in pediatric imaging. The campaign includes a triad of radiologists, medical technologists, and medical physicists who are alerting the medical community of the need to child-size radiation dose when imaging children and are helping practitioners to appropriately alter their practice.
The challenge of change?

Doctors are encouraged to perform a risk-benefit assessment before recommending a pediatric imaging study that involves radiation exposure, but this assessment is now complicated by the lack of standards by which a doctor can determine risk. With new imaging technologies, there is a gap in the ability to accurately quantify exposure. To address this gap, in February, Mallinckrodt Institute of Radiology hosted the Image Gently Pediatric Digital Radiography Summit—an event that brought together members of the campaign, industry leaders, and Food and Drug Administration (FDA) representatives in order to address pediatric radiation dose standards and the challenges in child-sizing new technology.

New imaging technologies like computed radiography (CR) and direct radiography (DR) have made the risk of imaging more complicated to assess. Projection radiography, including older plain-film X rays, constitutes the bulk of pediatric imaging studies. CR and DR allow technique in cases of overexposure, so we need a better way to easily recognize these problems.

There are no visual cues to show the problems with technique in cases of overexposure, so we need a better way to easily recognize these problems.

The Steering Committee

Seated (left to right): Janine Wuebbles; Susan John, MD; Marilyn Goske, MD; Steven Don, MD; Ellen Charkot, MRT(R); Susan Smith, RT(R)(CT)

Standing (left to right): Coreen Bell; Chuck Willis, PhD; Stephen Vastagh; Bruce Whiting, PhD; Greg Morrison, MA, RT(R); CNMT, CAE; Penny Butler, MS; Tracy Herrmann, Med, RT(R); Laura Coombs, PhD
radiologists to process and enhance images as needed for better viewing; the images are stored electronically, making them more readily accessible to clinicians. The modalities are touted as dose-reducing techniques, but according to Alliance Chair Marilyn Goske, MD, professor of radiology at Cincinnati Children’s Hospital Medical Center, these technologies also bring the potential to increase dose when not used correctly.

Radiation dose indicators on CR and DR machines vary by vendor (Agfa, Analogic, Canon, Carestream, Fuji, General Electric, Konica, Philips, Siemens, and Swissray), presenting a barrier to universal adoption of uniform protocols. The lack of a universal language in equipment has left the system fraught with confusion. "With the inexactness of this science, errors are compounded when attempts are made to track medical radiation exposure," says Goske. "We are unable to accurately assess risk-benefit for our patients if we cannot be more accurate in assessing risk."

The conference organizer, Steven Don, MD, associate professor of radiology at Mallinckrodt Institute and chair of the Image Gently CR/DR Committee, elaborated on the complications arising in the transition to digital technology: "In the past, alterations in the technique of taking film-screen radiographs were easily visualized on the images. Underexposure made areas of the image too white and overexposure made areas too dark. With newer post-processing techniques in digital imaging, underexposure is apparent due to noise, but overexposure now provides a visually pleasing image, even though it took more than the needed amount of radiation to make the image. We’ve eliminated a visual feedback loop. There are no visual cues to show the problems with technique in cases of overexposure, so we need a better way to easily recognize these problems."

According to Don, images should be obtained using the least possible dose needed to produce a diagnostic image—one that provides adequate detail to answer the clinical question.
An underexposed image has more quantum mottle, a problem recognized by radiologists and technologists as “noise.” Alliance members encourage radiologists to become more comfortable with noise as long as they can answer the clinical question with the image provided. “We want to lower the exposure,” says Don, “as long as it’s not decreasing diagnostic accuracy.”

The Alliance for Radiation Safety in Pediatric Imaging

The Alliance represents more than 54 medical professional societies and agencies—and more than 700,000 concerned medical professionals—whose goal is to promote radiation protection for children worldwide. The Alliance also is an advocacy group that identifies challenges in the area of radiation protection for children, working with organizations to advance scientific knowledge in this area of pediatric patient care.

Founding organizations
- Society for Pediatric Radiology
- American College of Radiology
- American Society of Radiologic Technologists
- American Association of Physicists in Medicine

Establishing unified standards

Radiology technologists, the professionals who use the imaging equipment in clinical practice, bear the brunt of this challenge. Ellen Charkot, MRT(R), BHA, director of Clinical Services in Diagnostic Imaging at the Sick Kids Hospital in Toronto, stresses that radiology technologists need more training with new technology. “Technologists are using their knowledge of old-fashioned film-screen X rays to analyze data in the digital world” says Charkot. “But what they once understood no longer applies.”

Technologists must understand variations in the equipment of different vendors, but there is no universal language. And often the educational material available is written in the language of a medical physicist and doesn’t translate well in the real world of taking X rays in a busy hospital.

Greg Morrison, chief operating officer of the American Society of Radiologic Technologists, finds that technologists and radiologists both need better understanding of the concepts behind image acquisition. “Many of them rely on the vendor community and on-the-job training, which results in the users knowing how to do something but not knowing why it works.” This limits their ability to troubleshoot.

While the technologists might recognize suboptimal quality in an image, they may not know why it happened.

“With the infusion of new technology and new applications of existing technology, practitioners face the challenge of changing old ways and keeping their education up to the speed of the changing workplace” says Morrison.

One place where implementing change is especially important is at nonpediatric hospitals. Most scans performed at these hospitals are done on adults, so radiologists and technologists may be less experienced with imaging children and may not adjust practices accordingly. A large part of the Alliance’s work is focused on helping nonpediatric hospitals to develop protocols that reduce dosing while maintaining diagnostic-quality images.

The Alliance is urging vendors to help. Susan John, MD, professor of diagnostic imaging and of pediatrics at the University of Texas in Houston, says, “Radiography vendors are critical team members....

If nothing else, this effort provides a single unified standard so that data can be entered into a centralized system to help track performance and trends...
They know their technology best and are in a position to recognize change much sooner than are users. They need to be at the forefront of this effort.

Also at the forefront will be the FDA, which has just launched an initiative to reduce unnecessary radiation exposure from medical imaging. They intend to issue requirements for imaging equipment manufacturers to incorporate safeguards into machine design.

The American Association of Physicists in Medicine (AAPM) and the International Electrotechnical Commission (IEC) have independently developed standardized terminology and exposure documentation to eliminate confusion. According to Bruce Whiting, PhD, research assistant professor at Mallinckrodt Institute of a member of the Image Gently CR/DR Committee, as a result of this summit the AAPM will work to revise their report to harmonize with the IEC standard. The new standard will help to provide guidance in determining minimum exposure requirements for producing diagnostic-quality images. This commitment will ease collaboration among physicists, radiologists, technologists, and vendors on the development of pediatric digital radiography standards.

“If nothing else, this effort provides a single unified standard so that data can be entered into a centralized system to help track performance and trends,” says Don. “This is a major accomplishment.”
MIR’s COMPUTATIONAL NERVE CENTER

NIAC converts raw imaging data into useful images for researchers and clinicians.

It’s a big leap from the digitized data initially yielded by computed tomography and magnetic resonance imaging to snapshots of the brain where a spot of yellow here and a swathe of blue there provide insights into a tumor, a traumatic injury, or the neural circuitry of a patient with Alzheimer’s disease.

In between the raw and the realized stands the Neuroimaging Informatics and Analysis Center (NIAC), which supports a wide range of investigators and clinicians—everyone from psychologists and physicists to radiologists and neurosurgeons—at the Washington University Medical Center as well as the University’s Danforth Campus.

by Robert Lowes
We're trying to destroy the silo syndrome where scientists in different disciplines don't talk to each other," says former NIAC Director Mark Mintzer, MD. "What makes this a powerful center is that people who have solved a research problem in one discipline can help people in another discipline solve their problem."

In translating raw data into useful information, NIAC also helps a far-flung medical community take new imaging technology from the level of basic science to clinical studies and finally to patient care, adds Daniel Marcus, PhD, assistant professor of radiology and the new director of NIAC. "That's a big push of the National Institutes of Health, which wants to see that what it's investing in on the research side will make its way to clinicians."

The truth of that observation was recently underscored when the NIAC received a $3.8 million, five-year renewal grant (titled the NINDS Center Core for Brain Imaging) from the National Institute of Neurological Disorders and Stroke. With some 20 scientists, computer programmers, and support staff scheduled to move into new quarters on the third floor of Mallinckrodt Institute of Radiology's (MIR's) East Building, NIAC is a figurative—and vital—nerve center of activity for MIR and the entire university.

Integrating information

The pretty images of brain tissue and their bursts of color on a black background don't come straight off a magnetic resonance imaging (MRI) or positron emission tomography scanner. It can take from two to 30 hours of computer processing to create an image, depending on the complexity of the processing algorithms, says Marcus. In diffusion tensor imaging, for example, NIAC computers must transform thousands of individual snapshots of the brain into a single image suitable for scientific analysis.

To give meaning to all those colors, brain-scan images need to incorporate outside information such as a patient's genetic status, excerpts from a medical or family history, or results of blood tests, cognitive tests, and pathology work conducted in parallel with imaging.

- It can take from two to 30 hours of computer processing to create an image

Marcus in his new office in MIR's East Building.
A single MRI brain study can produce one to two gigabytes of raw data. "With data processing, that amount can grow to five to ten gigabytes," says Marcus. Since NIAC processes data from thousands of patients a year, the center's computers must handle data loads measured in terabytes, each one equaling 1,000 gigabytes, or the text in roughly 1 million books. Future research projects promise to push storage needs to the petabyte level—1,000 terabytes.

Fortunately, NIAC has access to a new supercomputer in MIR's Electronic Radiology Lab that can chew through petabytes worth of information without blowing a fuse. "Before, when we processed our most advanced images, we could run up to sixty-four patient studies at a time," says Marcus. "The supercomputer can handle twenty times that number." As a result, research will proceed at a quicker pace.

Speaking of speed, NIAC is always striving to streamline its data processing—the technical word for this is "optimization"—to reduce run times. "If a clinician has to wait ten hours for images to be ready, that would be a deal breaker," says Marcus. "We'd like to get it down to a few minutes instead."

**From bench to bedside**

The story of qBOLD, a form of functional MRI, illustrates what NIAC is all about, says Marcus. The qBOLD method is a technological descendent of blood-oxygen-level-dependent MRI, or BOLD. As its name suggests, BOLD images the level of deoxygenated hemoglobin, a valuable measure of how much oxygen that brain tumors are consuming. Dmitriy Yablonskiy, PhD, professor of radiology and adjunct professor of physics, and Xiang He, PhD, instructor in radiology, modified BOLD so it can quantify the percentage of bloodstream oxygen extracted by brain tissue—hence, quantitative or qBOLD.

NIAC, says Marcus, is working with Yablonskiy and He to turn qBOLD into a clinical research tool that radiologists and neurosurgeons have begun to use in studies to predict a tumor's response to radiation therapy. Currently, NIAC staff is working to incorporate
qBOLD scans into the surgical planning software that Washington University neurosurgeons use when they perform stereotactic procedures to excise or to radiate brain tumors.

“They’re deploying it as a research tool to validate its usefulness,” says Marcus. The ultimate goal, though, is to gain approval for qBOLD as a patient-care tool from the United States Food and Drug Administration, he says. “It’s called taking science from the bench to the bedside.”

**Bringing two campuses together**

Though based at MIR, Marcus works closely with investigators in the Department of Psychology (at the University’s Danforth Campus) who are big users of MIR scanning services and NIAC data processing and analysis. “They do a lot of imaging-related research of basic cognitive functions—how we think, how memory works,” he says.

One NIAC “client” is Deanna Barch, PhD, professor of psychology and associate professor of radiology, who is delving into the cognitive and language deficits of schizophrenia. “The NIAC is critical and essential part of the type of large-scale neuroimaging research that we need to do in order to understand the neural bases of major psychiatric disorders,” says Barch. “Without the type of systems and facilities developed by Doctor Marcus, we would not be able to do the type of cutting-edge research needed to advance the field of psychiatric neuroimaging. The NIAC is allowing us to do research using imaging to predict and to measure treatment response, as well as to understand basic pathophysiological mechanisms.”

**The path to NIAC**

With his hand in a multitude of academic disciplines and projects, Marcus has come a long way from the days when, as part of his own doctoral dissertation work, he endlessly studied neuron activity in monkeys while they played video games.

“We trained the monkeys for years before we were able to collect any data,” says Marcus, smiling.

Today, at NIAC, the data comes at Marcus fast and furious from all directions. And when NIAC is through with it, researchers and clinicians have those colorful, tie-dyed images of the brain that help to save and restore lives.
The shock fronts of war challenge military and medical experts alike. With improved physical protection of military personnel in combat zones, more soldiers are now surviving blast exposures from improvised explosive devices (IEDs)—exposures that in the past would have been fatal. The result is a rise in blast-related traumatic brain injury (bTBI), also known as the “signature injury” of the ongoing conflicts in Iraq and Afghanistan. bTBI can have serious long-term consequences, particularly in cases of repetitive blast exposure.
Researchers at Washington University Medical Center are at the core of the battle to better understand and advance the treatment of blast-related TBI. In collaboration with the United States Army and the Landstuhl Regional Medical Center in Germany, a multidisciplinary team from Washington University is adapting findings from a civilian study to look at how advanced imaging may provide better information about TBI suffered by military personnel. Primary goals include advancing the ability to predict who is at high risk for long-term complications of blast-related TBI and finding ways to determine the length of recovery time needed before returning to duty following a blast exposure.

A unique pathologic entity
Traumatic brain injury (TBI) is a disruption in the normal function of the brain due to an external force—a blow, jolt, or penetrating injury—that can have transient and/or permanent neurologic effects with a wide range of severity. Some injuries are mild and allow recovery to normal function, while others are immediately life threatening and require intensive care to preserve basic neurologic function. In addition, there are milder forms of TBI that are typically not life-threatening but often have long-term neurologic sequelae including persistent headaches, vomiting, balance problems, irritability, and difficulty concentrating—also known as post-concussion syndrome. The symptoms are caused by some degree of neuronal damage that is not necessarily identified by standard neuroimaging: computed tomography or traditional magnetic resonance imaging (MRI). Research on sport-related repetitive head impact has demonstrated a “window of vulnerability” following a concussion, during which metabolic markers of the brain are abnormal and a second head impact before recovery.

Blast-related TBI comprises a more complex combination of forces interacting with the brain. The first is the overpressure wave, or shock front, during which a rapidly accelerating pressure wave causes a sudden impact to the brain via. There is secondary energy transfer to the brain from blood pressure alterations that lead to dramatic changes in cerebral blood flow. Following the shock front, there may be secondary and tertiary insults to the head related to vehicle injuries, projectile objects, and penetrating shrapnel.
Complicating matters, soldiers exposed to a blast may suffer mild TBI but remain unaware they sustained a serious injury, resulting in the potential for repeat exposure to blasts. The long-term morbidity is not yet well defined but appears to include chronic debilitating symptoms, such as reduced cognitive performance and impaired vigilance. In addition, blast exposure is linked to depression and post-traumatic stress disorder (PTSD), conditions that military personnel are already at high risk of developing.

The capacity to further refine diagnosis of brain-injury is critical for several reasons. For one, it provides patients with answers. Patients with TBI commonly complain that no one, including insurance companies, believes them. Without a clear diagnosis, medical records are often deemed ineligible for reimbursement, leaving patients to pay out of pocket for expensive tests and treatment. Rehabilitation is another area that would improve with a better understanding of injuries because therapists would have more information available to help determine the best treatment strategies. Similarly, a long-term effect of improved diagnosis could lead to the development of more effective drugs for TBI. For example, diffusion tensor imaging (DTI), an MRI technique extremely sensitive to subtle brain pathology, is especially sensitive to changes in white matter, making it a good measure of nerve integrity. Therefore, this imaging method could help to identify in advance those patients who are most likely to benefit from a drug that specifically targets axonal injury.

**Experts convene**

The conversation about blast-related TBI began in earnest at Washington University in October 2008, when Mallinckrodt Institute of Radiology hosted a workshop on the topic. The event brought together experts in civilian trauma, military injuries, animal modeling, and imaging—all with the common goal of better defining blast-related TBI and exploring possibilities for earlier and more accurate diagnoses that will hopefully lead to better prognoses and treatment recommendations.

“Clinicians and researchers recognize that the blast-related injuries being suffered in Iraq are different from what we see in civilian trauma and are also different from any animal models,” says Tammie Benzinger, MD, PhD, assistant professor of radiology and a workshop attendee who contributed to a follow-up report on the event.

Specifically how these injuries are different and how advanced imaging methods could determine unique pathological changes unique to these injuries were central questions discussed at the TBI workshop.

**Civilian study**

As TBI experts gathered to discuss the role of imaging in improved outcomes for military personnel, a team of researchers from Washington University’s departments of Neurology and Radiology were looking at how these advanced techniques might help civilians. Whether blast-related or from other causes, TBI is not fully understood through traditional MRI, which provides superior spatial resolution to evaluate brain...
anatomy but doesn’t reveal great detail about more subtle changes in structure or overall brain function. The resulting lack of an objective imaging finding to explain their symptoms often leaves TBI patients frustrated by their condition and the doctors uncertain about how to treat them.

NEW CONTRIBUTION: IDENTIFICATION OF CHANGES IN NEURAL NETWORKS THAT CORRELATED WITH PERFORMANCE ON FUNCTIONAL TASKS.

“These injuries can be seemingly mild—a high school football player, for example, who took a hard hit—but yet the patient may chronically suffer from issues with things like memory, learning and reading,” says Joshua Shimony, MD, PhD, assistant professor of radiology, who worked on the civilian study. “Still, when you scan these patients’ brains with conventional MRI, there is no objective manifestation.”

Under the direction of David Brody, MD, PhD, assistant professor of neurology, the study recruited patients from the Traumatic Brain Injury Clinic located at the Rehabilitation Institute of St. Louis. The study included 20 patients with chronic TBI who had been experiencing symptoms for a minimum of six months. Participants were led through a battery of assessments and were scanned according to three imaging modalities: conventional MRI, DTI, and resting state functional connectivity imaging (fcMRI—a specialized brain scan that looks at blood oxygen levels as an indicator of neuronal activity in different areas of the brain). Images were then compared to determine whether DTI and/or fcMRI offered improved sensitivity over conventional MRI.

DTI showed a strong correlation between compromise in white-matter structural integrity and the ability to perform cognitive tasks that require decision-making and reasoning. This correlation has
SUDDEN IMPACT

Christine MacDonold, PhD

been demonstrated in earlier studies, but the addition of fcMRI data amounted to a new contribution: identification of changes in neural networks that correlated with identification of changes in neural networks that correlated with

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Research in action

"PATIENTS WITH TBI ARE COGNITIVELY IMPAIRED AND, THEREFORE, MAY BE UNABLE TO DO FUNCTIONAL TASKS." says MacDonald. "Patients with TBI are often cognitively impaired and, therefore, may be unable to do functional tasks," says MacDonald. "However, poor performance on a test does not necessarily explain what’s going on. For example, if the patient is paralyzed and the test requires pressing a button, that test score will be a zero. The paralysis might be the result of a lesion that caused a problem with the pathway between the brain and arm—but not a problem with the area of the brain that controls the patient’s cognitive ability to do the test."

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Given the abundant benefits of better understanding TBI, it is only appropriate that these findings are now being applied to the biggest surge of TBI cases in the United States military since the Vietnam War.

“The results from the civilian study were really the jumping-off point for the military project,” says MacDonald.

Washington University researchers are not currently at liberty to discuss particulars of the military study. However, publicly available abstracts describe an undertaking similar to the one performed with civilians—but exclusively focused on blast-related TBI, the kind most commonly suffered by active duty military personnel. One goal is to determine whether the amount of injury identified through DTI and fcMRI can serve as a predictor of outcome. Researchers also will be looking for links between injuries to specific brain regions and certain clinical conditions such as post-traumatic stress disorder.

Like the civilian study, the military-focused effort seeks to provide earlier and more accurate diagnoses that lead to better prognoses and treatment recommendations. Wounded service members and their families especially hope that these findings will help to make better informed decisions about if and when these servicemen and women can return to duty.
In this section, the names of employees who are full-time faculty or staff or who have an appointment in the Department of Radiology are highlighted in boldface type.

NEW FACULTY
Jonathan McConathy, MD, PhD, assistant professor of radiology, Division of Radiological Sciences.

PROMOTIONS
Walter Akers, PhD, instructor in radiology, was promoted to assistant professor of radiology.
Mikhail Berezin, PhD, instructor in radiology, was promoted to assistant professor of radiology.
Jennifer Demertzis, MD, instructor in radiology, was promoted to assistant professor of surgery.
Geetika Khanna, MD, assistant professor of radiology, was promoted to assistant professor of surgery.
Robert Pallow, MD, assistant professor of radiology, was promoted to assistant professor of surgery.

GRANTS
Tammie Benzinger, MD, PhD, assistant professor of radiology, as principal investigator, received a one-year grant in the amount of $75,000 from the Institute of Clinical and Translational Sciences, Washington University in St. Louis, for “QBOLD MR measurements of oxygen extraction fraction in patients with brain tumors.”
Mikhail Berezin, PhD, assistant professor in radiology, as principal investigator, received a two-year grant in the amount of $358,000 from the National Cancer Institute/National Institutes of Health for “Development of optical nanothermometers for medical applications.”
Kevin Black, MD, associate professor of psychiatry, of neurology, of radiology, and of neurobiology, and
Bradley Schlaggar, MD, PhD, associate professor of neurology, of anatomy and neurobiology, of radiology, and of pediatrics, as coprincipal investigators, received a three-year grant from the Tourette Syndrome Association for “Tourette Syndrome Association neuroimaging consortium pilot.”
Colin Derdeyn, MD, professor of radiology, of neurology, and of neurological surgery, and Mark Goldberg, MD, professor of neurology and neurobiology, as co-investigators, received a four-year grant in the amount of $888,670 from the National Institutes of Health/National Institute of Neurological Disorders and Stroke for “Washington University SPOTRIAS Stroke Trials Registry/Web Interface.”
Tamara Hershey, PhD, associate professor of psychiatry and of radiology, as principal investigator, received a $290,222 grant from the National Institute of Diabetes and Digestive and Kidney Diseases for “Central dopamine receptors in obesity.” Coinvestigators for the five-year grant are Kevin Black, MD, associate professor of psychiatry, of neurology, of radiology, and of neurobiology; Samuel Klein, MD, professor of medicine; and Joel Perlmutter, MD, professor of neurology, of radiology, and of occupational therapy.

JOINT APPOINTMENTS
Robert McKinstry, MD, PhD, professor of radiology, was appointed professor of pediatrics.
Naganathan Mani, MD, assistant professor of radiology, was appointed assistant professor of surgery.
Robert Pallow, MD, assistant professor of radiology, was appointed assistant professor of surgery.

Linda Larson-Prior, PhD, research associate professor of radiology, as Washington University principal investigator, received a $242,500 grant from the National Institutes of Health/National Institute of Child Health and Human Development for “Creation and testing of pediatric head models.” University coinvestigators are Fred Prior, PhD, research professor of radiology, and David Politte, DSC, instructor in radiology. Electrical Geodesics, Inc. is the industry partner for the grant.

Joel Perlmutter, MD, professor of neurology, of radiology, and of occupational therapy, as principal investigator, received a $184,045 grant from the Michael J. Fox Foundation for Parkinson’s Research for “Validation of neuroimaging biomarkers for nigrostriatal neurons: FDOPA studies.” Coinvestigators for the two-year award are Tom Videen, PhD, research professor of neurology and of radiology; Morvarid Karimi, MD, instructor in neurology; and Stephen Moerlein, PhD, associate professor of radiology and of biological chemistry.
GRANTS

Continued from page 27

Jason Woods, PhD, assistant professor of radiology, as principal investigator, received a $150,000 grant from the Institute of Clinical and Translational Research, Washington University in St. Louis, for "A multidisciplinary approach to understanding BOS in lung transplant. Coinvestigators for the two-year grant are James Quirk, PhD, research instructor in radiology; Andrew Gelman, MD, assistant professor of surgery (cardiothoracic surgery); Ramsey Hachem, MD, associate professor of medicine; and Richard Pierce, PhD, research associate professor of medicine.

Dmitriy Yablonskiy, PhD, professor of radiology and of physics, as principal investigator, received a four-year renewal grant from the National Institutes of Health for "Quantification of lung ventilation and structure by 3He MRI." Collaborators for the grant are James Quirk, PhD, research instructor in radiology; Alexander Sukstanskii, PhD, senior research scientist; Jason Woods, PhD, assistant professor of radiology; David Gierada, MD, professor of radiology; Mark Conrad, PhD, professor of physics, of radiology, and of chemistry; Stephen Lefrak, MD, professor of medicine; Robert Senior, MD, professor of pulmonary diseases (medicine) and of cell biology and physiology; and Barbara Lutey, MD, instructor in medicine.

APPOINTMENTS/ELECTIONS

Colin Derdeyn, MD, professor of radiology, of neurology, and of neurological surgery, was appointed to a three-year term as chair of the American Heart Association (AHA) Stroke Council Scientific Statement Oversight Committee and to a two-year term as chair of the AHA Membership Marketing and Communications Committee.

Bennett Greenspan, MD, assistant professor of radiology, was appointed to the American Board of Radiology's Certifying Nuclear Radiology Committee.

Jason Woods, PhD, assistant professor of radiology, was elected program director of the Hyperpolarized Media Study Group, International Society for Magnetic Resonance in Medicine.

HONORS/AWARDS

Yoram Rudy, PhD, professor of engineering, of biomedical engineering, of cell biology and physiology, of medicine, of radiology, and of pediatrics, received the 2010 Distinguished Scientist Award from the Heart Rhythm Society.

APPENDIX

Yoram Rudy, PhD, professor of engineering, of biomedical engineering, of cell biology and physiology, of medicine, of radiology, and of pediatrics, received the 2010 Distinguished Scientist Award from the Heart Rhythm Society.

LECTURES


Bennett Greenspan, MD, assistant professor of radiology, spoke on "Tumor imaging in nuclear medicine—current status and future prospects" at Radiology Grand Rounds, University of New Mexico, Albuquerque, January 26, and at the Society of Nuclear Medicine Mid Winter Meeting, Albuquerque, New Mexico, January 30.

Rebecca Hulett-Bowling, MD, assistant professor of radiology, spoke on “A bit of medicine in Lesotho” at Science Café, sponsored by the Saint Louis Science Center, St. Louis, Missouri, March 18.

William McAlister, MD, professor of radiology and of pediatrics, presented “Hypophosphatasia: enzyme replacement therapy for hypophosphatasia for treatment of a life-threatening disease using bone-targeted human recombinant tissue non-specific alkaline phosphatase” at the Society for Pediatric Radiology annual meeting, Boston, Massachusetts, April 13-17.

Joel Perlmutter, MD, professor of neurology, of radiology, and of occupational therapy, spoke on “Neuroimaging of Parkinson disease: clinical utility?” at Neurology Grand Rounds, and, as visiting professor, presented, “Neurological abnormality of voice” at the University of Maryland, Baltimore, March 24. He spoke on “Starting a clinical research career” at the Parkinson Study Group Mentoring Seminar, American Academy of Neurology meeting, Toronto, Canada, April 12. He presented “PET investigations of the pathophysiology of PD dementia” at Grand Rounds, University of Toronto, Toronto Western Hospital, Canada, April 23.

Valerie Reichert, MD, assistant professor of radiology, presented “Overview of breast MRI” at a CME presentation jointly sponsored by the Greater St. Louis Society of Radiologists and the St. Louis Metropolitan Medical Society, St. Louis, Missouri, April 28.

Yoram Rudy, PhD, professor of engineering, of biomedical engineering, of cell biology and physiology, of medicine, of radiology, and of pediatrics, as the 11th Paul Zoll Memorial Lecturer, spoke on “Non-invasive electrocardiographic imaging for cardiac arrhythmias” at Beth Israel Deaconess Medical Center, Boston, Massachusetts, April 16.

David Rubin, MD, chief of Musculoskeletal Radiology, presented Jarvik (right) with a commemorative plaque.

Senturia Lecture

On February 10, Jeffrey Jarvik, MD, MPH, professor of radiology and of neurological surgery, and director of the Comparative Effectiveness, Cost and Outcomes Research Center at the University of Washington, Seattle, presented the Sixteenth Annual Hyman R. Senturia Lecture. He spoke on “Evidence cemented?—Comparative effectiveness of vertebral augmentation.”
Lectures

Continued from page 29

Barry Siegel, MD, professor of radiology and of medicine, spoke on "PET: predicting and monitoring tumor response to therapy" and "PET in lung cancer" at St. Luke's Medical Center, University of Santo Tomas Hospital, Manila, Republic of the Philippines, February 17. He presented "PET in oncology: diagnosis and staging"; "PET in oncology: monitoring and predicting responses to therapy (1 and 2)"; "PET in oncology: beyond FDG"; and "PET in gynecologic cancer" at the 6th Annual Scientific Conference of the Radiological Society of Saudi Arabia, Riyadh, March 28-31. He spoke on "The role of PET in early clinical trials" at the 4th International Meeting of Metabolic PET Imaging for a New Radiotherapy, Reggio Emilia, Italy, April 16 and 17.


Lawrence Tarbox, PhD, research assistant professor of radiology, presented "eXtensible Imaging Platform (XIP)™" at the caBIG® Clinical Trials Management Systems Workspace meeting (sponsored by the National Cancer Institute), The University of Texas, MD Anderson Cancer Center, Houston, Texas, February 3.

Jason Woods, PhD, assistant professor of radiology, presented "Caught by surprise: consequences of the helium-3 supply crisis for pulmonary MRI" to the Committee on Science and Technology, United States Congress, Washington, DC, April 22. He spoke on "Lighting up the lung: pulmonary MRI with hyperpolarized gases" at the University of Reims, France, April 27.

Biello Lecture

Martin Pomper, MD, professor of radiology and of pharmacology and molecular science, and associate director of the InVivo Cellular and Molecular Imaging Center at Johns Hopkins University, Baltimore, Maryland, was guest speaker for the Twenty-fourth Annual Daniel R. Biello Memorial Lecture on March 10. He presented "Translational molecular imaging for oncology."

Pomper (left) with Barry Siegel, MD, chief, Division of Nuclear Medicine.
SYMPOSIA

In this section of FYI, only those faculty and staff who have Department of Radiology appointments are listed.

SOCIETY OF INTERVENTIONAL RADIOLOGY

35th Annual Scientific Meeting
Tampa, Florida
March 13-18, 2010

FEATURED SYMPOSIUM

Michael Darcy, MD, “TIPS too long”; “SIR Foundation and SIR: the big picture.”

VEIN CASE-BASED REVIEW

Michael Darcy, MD, “Intra-procedural clinical management: Cases 4-6.”

CATEGORICAL COURSES


Suresh Vedantham, MD, “The ATTRACT trial and the big picture on DVT.”

SCIENTIFIC SESSIONS

Seung Kwon Kim, MD, “Clinical efficacy of peritoneal ports for management of intractable ascites using ports designed for venous access.”

Suresh Vedantham, MD, moderator, “IVC filters, venous thromboembolic disease.”

WORKSHOPS

Michael Darcy, MD, presenter, “Pancreatico-biliary interventions.”

James Duncan, MD, PhD, presenter, “Getting started in IR research (new in 2010).”

Nael Saad, MD, presenter, “Clot management I: acute DVT and pulmonary embolism.”

Suresh Vedantham, MD, coordinator, “Clot management I: acute DVT and pulmonary embolism.”

AMERICAN ASSOCIATION FOR CANCER RESEARCH

101st Annual Meeting
Washington, DC
April 17-21, 2010

POSTER PRESENTATIONS

Jinbin Xu; Chenbo Zheng, PhD; Wenhua Chu, PhD; Fenghui Pan; Robert Mach, PhD, “Identification of progesterone receptor membrane component-1 as the putative sigma-2 receptor.”

Robin Dothager; Victor Villalobos; David Piwnica-Worms, MD, PhD, “Reversibility of click beetle luciferase heteroprotein fragment complementation systems for imaging cancer pathways in live cells.”

SCIENTIFIC SESSION

Sanjeev Bhalla, MD, “CT fluoroscopy versus conventional CT: an examination of radiation exposure and diagnostic yield during intrathoracic biopsy.”

Suresh Vedantham, MD, “CTA of the thorax: pulmonary thromboembolic disease, arterial and venous malformations, acute aortic syndromes and postoperative evaluation of the aorta.”

INSTRUCTIONAL COURSES

Christine Menias, MD, “Small bowel ischemia and obstruction.”

Sharlene Teefey, MD, “Duplex and color Doppler of the kidneys.”

REVIEW COURSES

Sanjeev Bhalla, MD, “Cardiovascular imaging: plain film.”

Cylen Javidan-Nejad, MD, “Cardiovascular imaging: cardiac MR—common applications.”

Christine Menias, MD, “Gastrointestinal imaging: pancreas.”

SCIENTIFIC SESSIONS

Cylen Javidan-Nejad, MD; Thomas Pilgram, PhD; Bruce Whiting, PhD, “CT fluoroscopy versus conventional CT: an examination of radiation exposure and diagnostic yield during intrathoracic biopsy.”

Sanjeev Bhalla, MD, “CTA of the thorax: pulmonary thromboembolic disease, arterial and venous malformations, acute aortic syndromes and postoperative evaluation of the aorta.”

INSTRUCTIONAL COURSES

Christine Menias, MD, “Small bowel ischemia and obstruction.”

Sharlene Teefey, MD, “Duplex and color Doppler of the kidneys.”
As part of her duties as a Radiological Society of North America International Visiting Professor, Marilyn Siegel, MD, professor of radiology and of pediatrics, visited three hospitals in the Republic of the Philippines: St. Luke’s Medical Center in Manila, Philippine General Hospital in Manila, and Chong Hua Hospital in Cebu. At St. Luke’s, she spoke on “Pediatric neck masses,” “Congenital lung abnormalities,” “Adult congenital heart disease,” and “CT of vascular variants.”

Editor’s Note: On page 32 of the Winter 2009/2010 issue of Focal Spot, the author listing for the first place winner of the poster competition should have read: Subham Ghosh, MS; Jennifer Avari, MD; Russell Canham, MD; Tammy Bowman, MSN; Edward Rhee, MD; Pamela Woodard, MD; Yoram Rudy, PhD.
2009/2010

Fellows & Residents

(SEATED, LEFT TO RIGHT) Doctors Wendy Silcox; Elizabeth Herf; Catherine Young; Kathryn Fowler; Norna Ludeman; Angela Ta; Jane Karimova; Michelle Miller-Themes, diagnostic radiology program assistant director; Caitlin Lopez; Vincent Mellnick; Jennifer Gould, diagnostic radiology residency program director; Gilbert Jost, director, Mallinckrodt Institute; Travis Henry, diagnostic radiology chief resident; Matthew Gipson, diagnostic radiology chief resident; James Kelly, diagnostic radiology chief resident; Andrew Bierhals, diagnostic radiology resident mentor; Ting Tao; Motoyo Yano; Kelby Napier; Colin Thompson; Adam Smith; Monika Tataria.

(SECOND ROW) Doctors Rex Parker, Victoria Chen; Kitty Ho-Cain; Sara Dyrstad; Amy Fowler; James Head; Ignacio Lopez-Costa; Jeffry Maxwell; Calvin Barnes; Alex Hoffing; Yasha Kadkhodayan; Douglas Hughes; Anand Singh; Russell Allman; Douglas Ritchin; Christopher Harbet; Desi Dennis; Absar Ahmed; Nicole Mercer-Bolton; Seth Cardall; Sanjiv Bajaj; Joseph Mettenburg; John Burkett; Cade McDowell.

(THIRD ROW) Doctors Adam Belanger; Steven Saur; Manu Goyal; Michael Yu; Rebin Quazi; Robert Honey; Andrew Homb; Sushil Sonavane; Chad Leasford; Daniel Zurcher; Daniel Wessell; Lance Reinsmith; Michael Friedman; Amer Haque; Gretchen Smith; Nicholas Rhodes; Patrick Rhoades; William Grande; Yihua Zhou; Benjamin Pettus; Jennifer Salcman; Celine Buckley.

Photograph by MIR Photography Lab