The 81st Scientific Assembly and Annual Meeting of the Radiological Society of North America, November 26 through December 1, 1995, Chicago, Illinois.

Mallinckrodt Institute faculty present scientific sessions and refresher courses, preside over workshops and plenary sessions, and serve on program committees.

A. Ronald Evens, MD
B. Barbara Monsees, MD
C. Barry Siegel, MD
D. James Brink, MD
RÖNTGEN RETROSPECTIVE — ONE HUNDRED YEARS OF A REVOLUTIONARY TECHNOLOGY

The discovery of the X ray not only changed the practice of medicine but dramatically transformed the philosophy and culture of medical science.

MAGNETIC RESONANCE IMAGING: DIRECTIONS OF THE FUTURE

One of the newer radiologic technologies, functional magnetic resonance offers fast, noninvasive, high-resolution imaging for both initial diagnosis and treatment follow-up.

SPOT NEWS

ON THE COVER:
The official Radiology Centennial poster by artist Greg Harlin commemorates 100 years of achievements in the radiation sciences. Commissioned by Radiology Centennial Incorporated (RCI).
The following article, authored by MIR Director Ronald Evens in commemoration of radiology's centennial anniversary, appeared in the September 20, 1995 issue of *The Journal of the American Medical Association (JAMA)*, volume 274, pages 912-916, copyright 1995, American Medical Association. *JAMA* is the most widely read medical journal in the world, with a total circulation of over 700,000.
years ago, on November 8, 1895, Wilhelm Con-
rad Röntgen made a startling discovery in his
laboratory in Würzburg, Germany. The
physics professor was experimenting with the
action of electric energy in partially evacuated
glass tubes — a popular scientific activity in the last quarter
of the 19th century. Meticulously laboring in a darkened lab-
oratory with the electrically charged tube, he noticed a glow
from the far corner of the room. This observation led to a
series of experiments, and while passing his hand between a
fluorescing screen and the tube, he was astonished to see
what appeared to be the shadows of his bones.

RONALD G. EVENS, MD
It is impossible to know exactly what Röntgen thought at that moment. Most of the great technological inventions have been foreseen by “dreamers” who anticipated the discovery by prediction or fantasy. For example, people have always thought about flying — the airplane made these dreams reality. Physicians had long speculated on the possibility of a “miracle pill” to cure all infection, and the discovery of penicillin in 1928 would take medical science part of the way to that goal. But who could have predicted that it would be possible for a machine to see through the living flesh of the human body to the structure and function beneath. Over the course of the next few weeks, working in guarded privacy, Röntgen verified his observations by recording the bone shadows on photographic plates. On January 23, 1896, he presented his findings on “A New Kind of Ray” (“Eine Neue Arte von Strahlen”) to the Physico-Medical Society of Würzburg, using as partial evidence the now-famous radiograph of a human hand (either the hand of Mrs. Röntgen, his wife, or Professor Killick, his colleague). His findings were also published earlier in the proceedings of the Würzburg Physico-Medical Society (December 1895), and also published in a Vienna, Austria, newspaper on January 8, 1896, 2 weeks before his official presentation. Within a few days, journals and newspapers around the world were spreading the amazing story of the new rays.

THE EARLY YEARS

The public and professional excitement that immediately ensued was fueled in part by the ready availability of apparatus for generating the rays. A simple experimental glass tube of the type first used by Sir William Crookes in physics laboratories, a fluorescent screen or photographic plate, and a reliable generator (static electricity or coil) were the only tools that the legion of amateur scientists in the United States and Europe needed to produce radiographs, called at that time “shadow pictures.” By the middle of January 1896 the New York Times would trumpet “Hidden Solids Revealed” in a series of articles that explained in detail how the new technology worked and how the correct apparatus should be configured for reproducing Röntgen’s results. “X-ray pictures” appeared in popular magazines, scientific journals, and medical offerings. Popular publications as diverse as Scientific American, The Electrical World, Appleton’s Popular Science Monthly, and Century Magazine devoted substantial articles and attention to the new phenomenon in the spring of 1896.
Emphasizing that x-rays could be obtained easily and everywhere, this 1899 advertisement demonstrated the portable nature of the equipment.

For the most part, these early images were of foreign bodies (generally in the extremities, since these most easily yield a clear picture), of normal anatomy (feet in shoes, hands with rings), or of novelty arrangements (coins in purses, lead weights in wooden boxes).

By the time of the appearance of the first American clinical diagnostic radiograph, made at Dartmouth College by Dr. Edwin Frost on February 3, 1896, physicians were becoming increasingly aware of the extraordinary potential for the new discovery. By April, "x-ray mania" had seized the United States. X-ray studios had opened for "bone portraits," and countless photographers and electricians had set up shop as "skiagraphers."

Events in the early history of radiology have been told in several published histories and doubtless will be told and retold during this centennial year of Röntgen's discovery. Röntgen's discovery was more than a technological event (or even a breakthrough). It not only changed medical practice, but dramatically transformed the philosophy and culture of medical science in several fundamental ways. The advent of the x-ray posed questions completely new to medicine at the turn of the century — questions that would set the tone for other medical specialties in the years to come. In looking at the advent of the x-ray, we can see the radical reorientation of thought and practice that inevitably accompanies the introduction of a new and groundbreaking technology. But in a more fundamental way the x-ray profoundly altered the course of medicine, and a closer look at these changes can reveal much about our own reactions in the final years of the 20th century where innovations and breakthroughs seem daily occurrences.

Despite the obvious medical benefits of Röntgen's magical rays, in 1895 the physician was not the clear and obvious choice to make the radiographic image or to interpret its meaning. Electricians, photographers, and other technical specialists hurried to open facilities to serve the needs of neighboring physicians. In Chicago, Illinois, in 1896, for instance, the bustling "X-Ray Laboratory" of electrician Wolfram Fuchs received patients on gurneys from nearby hospitals and produced what are, even today, stunning sepia-toned radiographic prints of foreign bodies, calculi, and fractures. (Many of Fuchs' original radiographic prints can be seen at the Center for the American History of Radiology at the American College of Radiology in Reston, Virginia.) In San Francisco, California, photographer Elizabeth Fleischman bought the proper equipment and enjoyed great success in radiographing Spanish-American War casualties at the Presidio. Soon special training courses were offered in radiography, and advertisements emphasized the ease with which anyone could acquire the skills to take x-ray pictures. Electrotherapists, who for years had practiced at the margins of traditional medicine applying static electricity to a variety of aches and pains, suddenly found themselves with the right electrical apparatus and a base of patients. Many of these early technically skilled x-ray workers availed themselves of the less-than-orthodox medical degrees offered by correspondence schools and loosely organized "medical schools," so that by the end of 1896 a number of new "physicians" appeared with varying and often unpredictable medical capabilities.

WHO CONTROLS THE MACHINE AND THE IMAGE?

For 1905-1906:

For 1910-1915:
Even in the sphere of traditionally legitimized medical practice there was no clear-cut definition of a “roentgenologist.” The new technology leapt almost full-blown into hospital and clinical use, and there was little agreement on who should take the pictures, how they should be interpreted, which conditions required radiographic diagnosis — or even who should pay for the service. In many hospitals, an adventuresome physician with an interest in the physical sciences took on the task of running the Röntgen room — most often in the far reaches of the basement. The rooms were noisy, overheated, and festooned with uninsulated live wires, and were made even more uncomfortable by the noxious photographic developing fumes. In some hospitals, reluctant staff or medical students were “volunteered” to run the x-ray operations. At Philadelphia (Pennsylvania) General Hospital, young George Pfahler was “dragooned” in 1899 into heading up the “x-ray rooms” — a 12x15-foot area cordoned off into a machine room, an examining area, and a darkroom. Pfahler himself was skeptical that there was any future in the endeavor, noting, “I can see no future in the field. All of the bones of the body and foreign bodies have been demonstrated.”

Many department heads in hospitals saw this effort as the equivalent of any other hospital technical service — requiring only a technician working away to provide the raw materials from which surgeons, internists, and other specialists could make their diagnoses. Despite a growing number of specialized journals on radiography (the earliest journals included the Archives of Clinical Skiagraphy [April/May 1896] in London, later the British Journal of Radiology, and the American X-Ray Journal, which began publication in 1897) and a growing rank of physicians working exclusively in the field, there was substantial tension between those in the hospital who believed that the images “spoke for themselves” and fledgling radiologists who maintained that radiographic interpretation required new and specialized skills. The American Röntgen Ray Society was founded in 1900 in an effort to give cohesion to the growing numbers of persons calling themselves “roentgenologists.” By 1903, however, it had become apparent that very specialized medical skills and training were necessary, and nonphysicians (as well as those with degrees of dubious origin) were asked to leave the organization.

ARE PHYSICIANS REALLY NECESSARY?

Not only was there a period of adjustment in settling the question of which physicians should use and interpret the x-ray pictures, there was a pervasive sense that perhaps the miraculous new invention would eliminate the need for physicians entirely. The x-ray apparatus was the first widely used machine to interrupt the traditionally sacred relationship between physician and patient. No longer were history, inspection, touch, percussion, and auscultation the major means of confirming the nature of disease, but an energy-generating electrical machine — the sine qua non of achievement to Americans at the turn of the century — appeared to be a dramatic advance for the physician. Thomas Edison’s early enthusiasms for the x-ray, capped off by a riotous series of performances in which he attempted to radiograph the human brain “at work,” and by his more serious contribution of a working handheld fluoroscope, were based on his notion that someday this technology might be in every home. For many observers it was not difficult to imagine domestic x-ray machines taking pictures of every broken bone, major injury, or minor discomfort. The resulting picture would show the “obvious” to even the untrained eye, and the sufferer could then obtain the medication or rehabilitative treatments.
needed. To a population regularly poked, prodded, and dosed with alcohol- and narcotic-based medications, the notion of eliminating the diagnostic physician from the scene was not without its appeal. And the idea that the radiographic image existed as concrete self-evident proof, not subject to interpretation or multiple meanings, soon made it a favorite of attorneys and patients in malpractice suits.

**WHAT IS THE PROPER PLACE FOR A NEW SPECIALTY?**

In fact, both physicians and patients soon learned that these new images were not as easy to obtain or interpret as photographs. In these earliest years even the range of normal radiographic anatomy was completely undefined, and exploration of the meaning and types of structural and functional variations had only begun. The advent of contrast imaging, first with postmortem injections of mercury compounds or the insertion of metal styluses, would reveal new areas of radiographic analysis. It became clear that the new technology would be the basis for a new medical specialty, with skilled practitioners and auxiliary personnel, rather than as a service adjunct to already extant hospital departments. The birth of a new medical specialty can be a difficult and torturous labor, involving as it does the inevitable ceding of turf from established fields to the newcomer. Radiology and anesthesiology, with a limited and highly focused sphere of action in the operating room, achieved departmental status in hospitals without tremendous difficulty. But the early roentgenologist seemed to be all over the hospital — presenting his or her diagnoses to surgeons and internists who felt their seniority and experience made them more than qualified to read films without assistance.

The resulting tensions would prevent some major hospitals from establishing true radiology departments until well into the 20th century. The first department head was not named at Johns Hopkins University until Russell Morgan was appointed in 1946, despite a fine tradition of radiology at the institution. The American College of Radiology, founded in 1923, and the American Board of Radiology, first convened in 1934, were two organizations started in an effort to establish firmly that the applications of Röntgen's rays were a specialty requiring specific and exacting standards and practice.

**WHAT CAN WE PROMISE TO THE PUBLIC?**

At the end of the 19th century Americans were enchanted with scientific progress and invention. Homes and cities were being changed forever by the introduction of electric lights, telephones, subway systems, and 1001 smaller inventions that promised to make life easier and more pleasant. Medicine, though, seemed stubbornly set in its ways, immune to the benefits of inventions and innovations revolutionizing other scientific fields. In 1894, a writer for the Smithsonian Institution marveled at the immediate possibilities for air and sea travel, but saw little hope for change in medicine or biology.

The impact of the announcement in December 1895 that a machine had been invented to see through the living body was, to say the least, electrifying. When, in February and March of that year, it became clear that the rays also had undefined therapeutic effects, public and professional excitement reached a fever pitch. The possibility that the x-ray could actually cure cancer (before the end of the century, Francis Williams had shown to the Boston City Medical Society cases of carcinoma of the skin and lip healed by Röntgentherapy), a disease for which there was no hope except for limited surgical
intervention, must have seemed truly miraculous to physicians and patients alike. And if the x-ray could diagnose any illness and cure others — what else could it do? To a population ready for a “miracle machine,” the possibilities seemed endless.

Tempering and directing enthusiasm for new technologies would become an ongoing problem in medicine, but in 1896 there were no constraints. Each new “miracle” observation became a promise of cure. For example, numerous researchers attempted to apply the rays (both in vitro and in vivo) to the tubercle bacillus, often seeing positive results when there actually were none. Others went further afield in their work, claiming x-rays could transmit thoughts, restore vision to the blind — even raise the dead!

The public response to reports of these efforts was predictable. Not only did everyone expect access to the new technology — whether to identify long-embedded foreign bodies or to verify their self-made diagnoses — they expected the new machines to deliver easy answers to even the most difficult clinical questions. Soon the appearance of x-ray machines in general practitioners’ offices across the United States would underline the notion that the new technology was available to diagnose any and every ailment. Some physicians even thought it would eliminate the need for laboratory analysis in medicine. Moreover, in an age in which people had come to believe there would be a “pill for every ill,” many thought there would soon be a machine for every disease. Numerous new “rays” to cure everything from smallpox to insanity were announced by both deceptive and well-intentioned practitioners after Röntgen’s discovery.

The hope, sincerity, and occasional unfortunate results of this enthusiasm cannot be discounted. The years immediately after Röntgen’s announcement saw a marked shift, from a general preoccupation with improvements in sanitation and public health as the media for medical advancement, to a notion that miracles lay just ahead ready to revolutionize medicine overnight. To sufferers this brought comfort; every physician has dealt with terminal patients who hold out hopes that “any day now some cure may be discovered.” New treatments and innovations would be given charmed popular titles; Ehrlich’s introduction of salvarsan for the treatment of venereal disease (1910) would be called the magic bullet. But magic and miracles lead not only to unfulfilled expectations — often they lead to the undervaluation of the less exciting aspects of medicine. If a miracle cure is just around the corner, why devote money and effort to studying and evaluating diseases that might just go away entirely? Such reasoning has often been just below the surface of public discourse on the direction of progress and was first seen in the years immediately following Röntgen’s discovery. Editors of Scientific American, only weeks after the announcement of the new rays, noted that the possibilities were so astonishing that they “almost dangerously increase our powers of belief.” In fact, the diagnostic and therapeutic applications of the x-ray would begin a tradition in which these powers of belief would often be stretched beyond the powers of the new technology to contain them.

Unfortunately, hope did not become reality. Not only were diagnosis and therapy by x-ray imperfect, the rays were associated with risk. In fact, many of the pioneering radiologists became victims of radiation injury and radiation-induced cancer.
WHAT WILL MEDICAL PRACTICE BE LIKE IN THE FUTURE?

The advent of the x-ray into the medical picture changed more than our expectations of medicine. For physicians it marked the beginning of a most profound revolution in practice: the need for continual adaptation to new and changing technologies. Physicians at work in 1890 experienced incremental advances in the knowledge and tools necessary to diagnose and treat patients: a new discovery about contagion, a more convenient surgical instrument, a clearer auscultation device. In hospitals, new purchases were generally limited to replacing those items that had broken or worn out: linen, lab ware, wheelchairs.

The impact of the x-ray in this relatively static medical setting would set the scene for a century of innovation. Imagine the difficult position of a young radiologist who, having convinced his institution to pay $200 or $300 for an x-ray machine in 1897, turned up in 1900 announcing that the hospital must have the newer, better model for $500? At the 1902 meeting of the American Roentgen Ray Society a number of manufacturers displayed and demonstrated their apparatus for physicians who had traveled long distances to make difficult purchase decisions. This modest display was the first true medical trade show in America, inaugurating a tradition of technological innovation that would prove a central focus of clinical, political, and financial debate throughout the century.

For the radiologist, as for all other physicians, this tradition of technical innovation has dictated a constant readjustment in expectations — both in terms of skills and in the direction of practice. Most physicians who trained even 50 years ago envisioned a world in which their medical lives would stay more or less the same — where keeping up involved staying informed about the latest medications and new treatment methods. Today's young physicians know they will spend their professional lives working with diagnostic and therapeutic technologies of ever-increasing complexity — and that they will be trained and retrained throughout their practices. Moreover, they will be surrounded by auxiliary and ancillary personnel undergoing the same continuous processes of reevaluation and reeducation. And just as hospital boards questioned the need for new x-ray machines in 1900, the choices and directions implicit in these new technologies will be under ever more vigilant scrutiny from governmental and organizational health planners.

Röntgen's discovery was clearly revolutionary and worthy of high honor, including the first Nobel Prize in physics in 1901. The x-ray encouraged a series of associated advances that created medical imaging (including ultrasonography, nuclear medicine, magnetic resonance imaging), radiation therapy, and several new medical subspecialties. It encouraged investment in a variety of medical technologies that have become the scientific basis of medical practice. But technology is not a cure-all, the dream of a magic bullet is still a dream, we certainly need physicians and their colleagues, and we continue to have turf battles and other political distractions from our clear goal of improving the health of our patients and society. Röntgen's discovery was a beginning, but there remains much to be done.

One hundred years ago young physicians were astonished by the wonderful new rays of Dr. Röntgen that allowed them to see into the living human body, aware that this would change the substance of medicine, but unaware that this would be part of an ongoing revolution that would forever mark all of medical science. Will the next 100 years be as exciting and productive? We approach November 8, 1995, with a list of technologies with the potential to improve patient care. Examples include magnetic resonance spectroscopy, positron emission tomography, three-dimensional radiation treatment planning, electronic imaging, and a variety of promising contributions by imaging to fundamental medical science. The success of the past 100 years has been based on the creative minds and hard work of many clinicians and scientists. It is easy to predict many important contributions to medical care and science from the current technological legacies of Röntgen's discovery — all that is needed is the human creativity by future generations of scientists and clinicians.

Note: Reprints of the article with references, as it originally ran in JAMA, are available by written request to the Focal Spot editor.
(left to right) Scientists Debiao Li, Weili Lin, and Mark Haacke with one of four MR research scanners.
Dr. Mark Haacke, professor of radiology and director of Mallinckrodt Institute’s magnetic resonance imaging research laboratory, is holding two images of the same coronary arteries. One is a conventional X-ray angiogram that shows the patient's left, main coronary artery bifurcating into the circumflex and the left anterior descending artery, where a stenosis has developed. The other is an innovative, three-dimensional magnetic resonance angiogram—the product of an exciting new magnetic resonance (MR) technique pioneered by Haacke’s group—which depicts the same stenosis.

“You can clearly see the narrowing in the MR image,” Haacke says. “It matches the conventional angiogram fairly well, though it is not yet quite as good. But the tremendous advantage that MR offers is the quick, noninvasive capability to do very high-resolution imaging. And the fact that we can do this at all with MR is a prelude to what radiology will see happening in the twenty-first century.”

CANDACE O’CONNOR
Both the field of radiology and the area of magnetic resonance imaging have reached important milestones: Radiology celebrated its centennial in 1995, while MR will mark its 50th anniversary in 1996. Magnetic resonance research began in 1946 when physicists Felix Bloch and Edward Purcell and their colleagues, working in separate labs, developed the concept of nuclear magnetic resonance.

Today, Mallinckrodt Institute of Radiology (MIR) scientists are involved in research projects, often paired with promising clinical applications, that stand at the forefront of worldwide magnetic resonance work. Haacke’s lab is one of many research groups at Mallinckrodt Institute: Joseph Ackerman, PhD, professor of chemistry who holds a joint appointment in radiology, leads another group working on MR spectroscopy, which provides insights into the body’s metabolic processes. Michael Vannier, MD, professor of radiology and director of the 3-D image processing laboratory, is using MR to do sophisticated, three-dimensional imaging for brain mapping, craniofacial surgery, cardiovascular research, and even the fitting of artificial limbs. Magnetic resonance also is widely used in the clinical domain as well, from neuroradiology to musculoskeletal imaging.

Haacke’s lab is involved in what he calls “head-to-toe MR imaging” of the cardiovascular system, including intracranial, carotid, coronary, pulmonary, renal, and peripheral arteries—with a special emphasis on a whole range of cardiovascular and brain function projects. Altogether, this research represents every major thrust in MR imaging today. “What we’re working on here are directions of the future,” says Haacke.

Haacke’s group conducts their research in the Mallinckrodt Institute of Radiology at Washington University Imaging Center, a one-year-old, high-tech facility. The three-story structure with the distinctive green-glass facade is furnished with state-of-the-art MR equipment: two small-bore systems manufactured by Varian/Sisco Instruments and two large-bore, human-imaging systems by Siemens Medical Systems. Plans are underway for the acquisition of a high-field, full-body scanner, a joint effort between Siemens and Varian.

“Most universities would be very happy to have just one machine dedicated to research but soon Mallinckrodt Institute will have five,” says Haacke. “This could position the Institute as one of the largest MR research sites in the United States, if not in the world.”
The MR research group, which moved to St. Louis from Case-Western Reserve University in the summer of 1993, now has 12 members who are involved in a variety of research projects in close collaboration with Washington University Medical Center clinicians. Through an international visitors' program established in 1994, scholars from foreign universities join Haacke's research lab for training in magnetic resonance. A number of clinical fellows and faculty also share office space with Haacke's group in order to be more actively involved with the research.

Last June, the MR research lab held an international workshop on quantitative flow imaging to acquaint scientists with Mallinckrodt Institute's work in MR imaging and, in particular, angiography. Some 115 people attended, half from outside of the United States.

THE PRESENT AND THE FUTURE

Like those scientists at the workshop, Haacke is enthusiastic about the many current and future uses of MR. "It has given us at Mallinckrodt Institute answers to questions that were much more difficult with other modalities, because they were invasive and more expensive," he says. "MR also offers us this tremendous opportunity for functional brain and cardiac imaging. It's exciting to know that around the world thousands of institutes with this equipment are all now capable of doing functional imaging."

And that imaging does not end with diagnosis, he adds. If a heart is not working properly, for example, functional MR will not only pick up the original problem but can also tell the physician whether or not a repair has worked. Thus, magnetic resonance becomes a tool that can offer an ongoing perspective into how the body is working for both initial diagnosis and treatment follow-up.

In this way, MR complements an array of other imaging processes, especially computed tomography (CT) and positron emission tomography (PET). Each technology has its own strengths. CT, for example, can image patients who have contraindications for MR, such as a cardiac pacemaker. PET, on the other hand, can perform receptor studies that cannot be done easily with magnetic resonance imaging, while MR allows for multiple noninvasive, rapid imaging. Plans exist at the Institute now to conduct comparative studies between PET and MR.

Some day, Haacke says, an MR system may be built on such a small scale that it could become standard equipment in a physician's office. In fact, the prototype for a small system to image children already exists and has been installed at a hospital in London, England. On an intermediate scale, some systems are built "open" so that a surgeon can operate on a patient while the patient is in the magnet.
NEUROIMAGING AND MR ANGIOGRAPHY

Functional Brain Imaging

In an application that sounds like science fiction, Haacke says, MR may also allow us to read people’s thoughts. Using a new technique called echo-planar imaging, which Haacke’s lab is helping to refine, some 10 brain images per second can be collected as researchers watch the effect of blood flow changes on the MR images. If the person being scanned moves his fingers, the slight blood flow increase generated by this movement will also create a changing amount of deoxyhemoglobin in the patient’s brain. In turn, that change generates a tiny reaction in a certain, predictable region of the motor cortex.

“When students are in the magnet, I jokingly say ‘be careful what you think about,’ ” says Haacke. “It has literally come to the point that using these new, fast-imaging techniques, scientists can see which areas of the brain are used when volunteers not only perform a task physically but also when they are thinking about it, such as moving fingers or visualizing objects at rest or in motion. The day will probably come when researchers can actually follow certain broad categories of thought while a patient is in the magnet. This could have great clinical impact for elderly or disabled patients as well as offering tremendous advances in neuroscience.”

Cerebral Blood Flow and MR Angiography

Several of these brain imaging methods involve measuring cerebral blood flow and blood volume. Weili Lin, PhD, assistant professor of radiology, and physicians in the Department of Neurology (including Doctors Chung Hsu, William Powers, and Richard Paczynski) are using MR imaging methods to identify the location of a stroke. With Neuroradiologist Mark Bahn and Pediatric Neuroradiologist Benjamin Lee, Lin is using functional MR images to pinpoint epilepsy seizures.

In the mid-1980s, Haacke’s group co-invented MR angiography. Today, this procedure is widely used throughout the world, especially in cases involving the head and neck.

Members of the magnetic imaging research lab work regularly with scientists from Siemens Medical Systems in Iselin, New Jersey, and Erlangen, Germany. The Institute has a long-standing collaboration with Siemens, which provides advanced access to new software and hardware. In turn, MIR tests these new systems and provides Siemens with new techniques that are then implemented in the equipment.

Carotid Artery

Several experiments, all involving Lin, deal with plaque formation in carotid arteries. North American Symptomatic Carotid Endarterectomy Trials have shown that patients with 70 percent or greater stenosis in the internal or common carotid arteries will benefit from vessel surgery (endarterectomy or plaque removal). Digital subtraction angiography (DSA), an invasive procedure, is normally used to measure the amount of stenosis.
Lin and his clinical colleagues — neuroradiologists Mark Bahn, Christopher Moran, DeWitte Cross, and Daniel Kido, and Dana Abendschein, research associate professor of internal medicine — are currently working with animal models that have induced stenoses to test the accuracy of MR angiography in measuring the vessel narrowing. They are also looking at characterizing the content of the plaque, since certain kinds of plaque — ulcerated plaques, for example — are more likely to lead to stroke. But ulcerated plaques are hard to detect, either with DSA or with MR.

Lately, in an exciting discovery, the investigators have found that when they use a contrast agent in conjunction with ulcerated plaque, the agent infuses the vessel wall — and they can see the enhanced vessel wall using MR angiography techniques. The importance of this work, says Lin, will lie in the ability to “characterize plaques, to look at the degree of stenosis. From the MR point of view, this has been difficult to do. But we are steadily moving along in this direction.”

CARDIAC MRI

But among all of these projects, perhaps none is more exciting than the groundbreaking cardiovascular research going on in Haacke’s lab.

Coronary Artery Imaging

It is very difficult to image the heart with MR, says Debiao Li, PhD, assistant professor of radiology whose major focus is in cardiac MR imaging research. And the reason has to do with motion, both from the heart’s own beating and from the patient’s breathing, which moves the heart up, down, and around.

Years ago, MR physicists and radiologists solved the heartbeat problem through “cardiac triggering,” in which they triggered the scan by the R-wave (or respiration) of the electrocardiogram signal, then collected data while the heart was in diastole and its motion was quieter. But the breathing problem still existed.

Scientists at Beth Israel Hospital in Boston later developed a method called the “fast-imaging breath-hold technique,” in which patients hold their breath and one image of the coronary vessels is taken. It was impossible to guarantee that every time patients held their breath, their heart would be in exactly the same position. This variable caused problems in gathering repeat images of the same portion of the heart.

“It was also difficult to ask very ill patients to hold their breath many times, especially if they had emphysema or lung disease alongside their coronary artery disease. And patients might be unconscious,” says Pamela Woodard, MD, a fellow in chest radiology. Woodard is coordinating a clinical trial to assess the “retrospective respiratory gating” technique for detection of coronary stenoses.
Haacke’s group has recently developed the retrospective respiratory gating technique to decrease or eliminate respiratory motion. In this technique, a navigator echo is placed on the patient’s diaphragm to detect the diaphragm’s position and is then used to monitor motion. Any data acquired when the diaphragm is not in the same location is discarded. The resulting images contain markedly less blurring.

Collecting MR data on coronary vessels involves other challenges as well. It is very hard to achieve good resolution of the vessels because of their tiny size—ranging from 3 to 5 millimeters in diameter—and especially hard to pick up any narrowing. In a series of two-dimensional images, tortuous (or twisted) vessels may also wind in and out of plane or may appear to show stenoses that in reality are not there.

The “gold standard” of conventional angiography, which produces crisp, reliable images, also has some disadvantages: The procedure involves the use of a contrast agent, which can cause an allergic reaction in some patients. Patients also must lie flat for six hours during the procedure. And like any invasive procedure, there are some risks.

Haacke’s group, including Li and research associates Pari-tosh Dhawale and Shantanu Kaushikkar, is developing an exciting new technique — collecting MR data in three dimensions, which allows physicians to see an entire coronary vessel at once. In addition, the images can be rotated, allowing views of the patient’s vessels from all angles.

In this noninvasive method, which entails only one to two hours of scanning time, the researchers acquire 16 contiguous, two-dimensional images with a single scan. With some sophisticated processing, they condense or “stack up” these two-millimeter-thick images into one three-dimensional projection. The images can be segmented — creating a separate image of the vessels or myocardium, for example.

The magnetic imaging research lab recently completed the first phase of a clinical trial in which they imaged 12 patients with coronary artery disease and compared those images with conventional angiograms. They are planning a blind trial in which radiologists will evaluate 3-D images for lesions, without knowing what the cardiac catheterization has already shown.

This project has involved a close collaborative effort, with consultation from radiologists Fernando Gutierrez, Jeffrey Brown, and Scott Mirowitz, who is radiologist-in-chief at Jewish Hospital. Referrals have come from cardiologists Ben Barzilai, Alan Braverman, Alan Weiss, and Philip Ludbrook, as well as from Charles Canter and Mark Johnson for cases of anomalous coronary arteries.
The three-dimensional method still has some limitations, say Li and Woodard. Right now it is best at picking up stenoses in the first five centimeters of the coronary arteries; distal stenoses are hard to image. The method also misses some stenoses that may still be too small to be seen. But the researchers all agree that this technique holds tremendous promise for future use. With enhancements, it may some day replace conventional angiography. In the near future, 3-D MR will serve as a useful screening tool for patients with suspicious symptoms.

"About twenty percent of the patients who go through conventional angiography turn out to have negative angiograms, so they are going through unnecessary risk and expense," says Li. "If we could screen out these patients beforehand, that would be a significant improvement for patient management."

At meetings—such as the MR Angiography workshops, the American Heart Association, and the Society of Magnetic Resonance—where the MR imaging researchers have presented their results, Li adds, the response has been "overwhelmingly positive." Two years ago, they published a well-received paper in Radiology, a leading scientific journal, and a paper this year in the Journal of Computer-Assisted Tomography. "Clinicians and researchers agree that Mallinckrodt Institute has the best MR images of coronary arteries in the world right now," says Li.

CORONARY BLOOD FLOW, PERFUSION, AND OXYGENATION

In another project, currently still at an early stage, Haacke’s group is looking at blood flow in the coronary arteries. Any time there is a narrowing in a heart vessel, the velocity of the blood flow in that area will increase—one more indication that a stenosis exists. In case of collateral flow, it may also be important to know the direction of the flow in a vessel.

So far, the group has been able to calculate flow direction, but the accuracy of flow velocity is still difficult to determine because of the narrow diameter of the blood vessels. Dhawale will focus his efforts on optimizing the technique to measure blood flow speed accurately. Then clinicians and researchers will validate those MR measurements in humans by comparing them with coronary artery measurements made with a Doppler wire.

"The reason this flow information is useful," says Robert Gropler, MD, assistant professor of radiology and medicine, "is that it will permit physicians to determine the severity of the patient’s stenosis detected by MR angiography or conventional coronary angiography." Gropler is a coinvestigator with Li and Doctors Steven Bergman, a professor of medicine and radiology, and Patricia Rubin, an instructor in medicine.
As an extension of this project, the investigators have also begun perfusion experiments in normal volunteers. The patients are given a contrast agent that enters their bloodstream. When that blood flows into the myocardium, the contrast agent enhances its signal.

"By looking at that signal," says Li, "we can tell which part of the myocardium has inadequate blood supply. If an area has less enhancement than its surrounding tissue, we know that it may have an infarction or ischemia."

Perhaps the most exciting among this group of projects, says Gropler, is the testing of the blood oxygenation level dependent (BOLD) effect. The researchers have designed a series of experiments to see whether they can detect any changes in the blood oxygen signal in the heart muscle.

"The goal is to demonstrate that the signal moves the way it should physiologically," says Gropler. "Ultimately, our long-term goal is that if we can measure blood flow with MR, and measure this signal quantitatively, we can then measure directly the oxygen usage by the heart muscle—and that is powerful information in patients with coronary artery disease."

"This BOLD imaging method is the same concept as that used for functional brain imaging," says Haacke. "This work comes from our experience in functional brain imaging. It is a good example of how a group of researchers working together can lead to the important cross-fertilization of ideas and to more rapid progress."

Heart Contractility

Begun in 1989 and funded by two grants from the National Institutes of Health, this ongoing project involves a study of the mechanical properties of the heart muscles and how they contract. The study is headed by Michael Pasque, MD, professor of surgery and associate professor of radiology, with assistance from Vannier’s 3-D image processing lab and Li from the MR research lab. The research, which has involved both animal and human testing, is designed to develop advanced mathematical models of the heart and eventually to apply them in clinical care.

"We’re in the process of developing a tool that will some day help us address clinical issues regarding timing of surgery and prognosis for recovery after myocardial interventions," says Pasque.

Left Ventricular Blood Volume Calculation

Ultrasound is the conventional method for measuring the amount of blood pumped in each cardiac cycle. In collaboration with the Department of Medicine’s Doctors Julio Perez and Victor Davila-Roman, the MR research lab’s Kaushikkar is using MR to calculate the total amount of blood pumped by looking at the change in blood volume from systole to diastole. Kaushikkar has developed a fast and accurate technique to facilitate this calculation by separating the blood pool from the myocardium.
THE DIRECTOR'S OFFICE REPORT

PROMOTIONS
Frederick G. Kuhns, MSEE, research assistant in radiology, was promoted to research associate in radiology, Division of Radiological Sciences.

Ronald K. Walkup, BS, systems analyst, was promoted to research assistant in radiology, Division of Radiological Sciences.

CHANGE IN STATUS
Shannon J. Sullivan, MD, visiting research associate, was appointed as research associate in radiology, Radiation Oncology Center.

Tong-Zeng Yang, PhD, research associate in radiology, Division of Nuclear Medicine, was appointed as instructor in radiology, Division of Radiological Sciences.

JOINT APPOINTMENT
Zhaohai Li, PhD, assistant professor, Department of Biostatistics, received a joint appointment as assistant professor of radiology, Division of Radiological Sciences.

NEW STAFF
Maria Cecilia Giron, MS, research assistant in radiology, Division of Radiological Sciences.

Deborah W. McCarthy, PhD, research associate in radiology, Radiation Oncology Center.

Lisa A. Ridnour, PhD, research associate in radiology, Radiation Oncology Center.

Adina L. Roskies, PhD, research associate in radiology, Division of Radiological Sciences.

Emilia Tormo, MD, research associate in radiology, Division of Radiology, received an appointment as instructor in radiology, Division of Radiological Sciences.

OFF STAFF
Laurent Buffat, PhD, visiting research associate, Radiation Oncology Center, is continuing her research work at Los Alamos National Laboratory in Los Alamos, New Mexico.

Ping Hou, PhD, research associate in radiology, Radiation Oncology Center.

James A. Brink, MD, associate professor of radiology, and Scott A. Mirowitz, MD, associate professor of radiology and radiologist-in-chief at Jewish Hospital, were appointed to the editorial board of Radiology, a leading scientific journal.

Jeffrey J. Brown, MD, associate professor of radiology, was appointed as assistant editor of MR Pulse, the newsletter of the Society of Magnetic Resonance.

Louis A. Gilula, MD, professor of radiology and surgery and chief of musculoskeletal radiology, was appointed as chairman of the Convention Planning Committee for the International Skeletal Society.

Marcus E. Raichle, MD, professor of radiology, neurology, and anatomy and neurobiology, and codirector of the Division of Radiological Sciences, was appointed to the editorial board of Neuroimage.

Barry A. Siegel, MD, professor of radiology and medicine and director of the Division of Nuclear Medicine, was appointed to the editorial board of the Journal of Computer Assisted Tomography.

Michael W. Vannier, MD, professor of radiology and chief of the image processing laboratory, was appointed as chairman of the Missouri State Medical Association Committee on Continuing Medical Education.

APPOINTMENTS/ELECTIONS

FELLOWSHIPS/GRAINS

Timothy J. McCarthy, PhD, instructor in radiology, as principal investigator, received a two-year grant of $139,864 from The Whitaker Foundation for the project "Investigation of in vivo Kinetics of Inhaled Nitric Oxide: Application of Positron Emission Tomography."

David Piwnica-Worms, MD, PhD, associate professor of radiology, as principal investigator, received a one-year grant in the amount of $100,000 from Mallinckrodt Medical Inc. to investigate "Functional Imaging of Multidrug Resistance in Cancer with Q Complexes." One of the human body's naturally produced proteins (called P-glycoprotein) acts as a multidrug resistor by pumping out the tumor cells many of the most potent chemotherapeutic drugs used in cancer treatment as well as the body's natural anti-cancer agents. Piwnica-Worms and coinvestigators Vallabhaneni V. Rao, PhD, instructor in radiology; Carolyn L. Crankshaw, senior medical research technologist; and Gary D. Luker, MD, instructor in radiology, are focusing their research on the discovery and develop...
opment of tracers that will enable noninvasive functional imaging of the multidrug resistance tumor phenotype and will assist nuclear physicians and oncologists in treatment planning.

Jerold W. Wallis, MD, assistant professor of radiology, and Tom R. Miller, MD, PhD, professor of radiology, are co-principal investigators for a research agreement with Siemens Medical Systems. The researchers will work on reconstruction algorithms in single photon emission tomography (SPECT), with the goal of improving the accuracy and resolution of the reconstructed images. The two and one-half year agreement is funded in the amount of $367,628.

Michael J. Welch, PhD, professor of radiology and codirector of the Division of Radiological Sciences, as MIR principal investigator, in collaboration with Newton Scientific Inc. of Winchester, Massachusetts, received a Small Business Technology Transfer Program Phase II grant from the U.S. Department of Energy (DOE). The research team will continue work begun in a DOE Phase I grant to develop an automated procedure for the production of radiopharmaceuticals used in positron emission tomography studies. The Small Business Technology Transfer Program was initiated two years ago by the DOE and the National Institutes of Health to encourage collaboration among small businesses and academic institutions. Total funding for the two-year grant is $996,222. Coinvestigators are Ruth E. Shefer, PhD, and Robert E. Klinkowstein, PhD, of Newton Scientific Inc.; Paul Boisseau, PhD, Pyramid Technical Consultants; Carolyn J. Anderson, PhD, assistant professor of radiology; Deborah W. McCarthy, PhD, research associate in radiology; and Sally W. Schwarz, RPh, MS, research instructor in radiology.

As MIR principal investigator, Barry A. Siegel, MD, professor of radiology and medicine and director of the Division of Nuclear Medicine, received a five-year grant from the National Cancer Institute. The multicenter study will evaluate the accuracy of positron emission tomography (PET) with F-18 fluorodeoxyglucose in determining axillary lymph node involvement in women with newly diagnosed breast cancer and will assess PET's ability to predict prognosis. Total funding for the study is $2,801,485. Coinvestigators include MIR alumni Richard L. Wahl, MD, University of Michigan, and R. Edward Coleman, MD, Duke University, and researchers from Brown University and the American College of Radiology.

James A. Brink, MD, associate professor of radiology, and Scott A. Mirowitz, MD, associate professor of radiology and radiologist-in-chief at Jewish Hospital, received the 1995 Editor's Recognition Award for Special Distinction in Reviewing from Radiology. The journal initiated the award in 1986 to honor reviewers who consistently produce scholarly, detailed reviews of Radiology manuscripts.

Wei Li Lin, PhD, assistant professor of radiology, received an Honorable Mention for the Robert G. Sieker Young Investigator Award in Stroke. The paper, "Quantitative Regional Cerebral Water Measurement in a Stroke Model with MRI," will be presented in January in San Antonio, Texas, at the 21st International Joint Conference on Stroke and Cerebral Circulation. Coauthors are Richard Paczynski, MD, research fellow in neurology ICT; Ramesh Venkatesan, MS, graduate research assistant in radiology; Yong Y. He, research associate in neurology; William J. Powers, MD, associate professor of neurology; Chung Hsu, MD, PhD, professor of neurology; and E. Mark Haacke, PhD, professor of radiology.

Marcus E. Raichle, MD, professor of radiology, neurology, and anatomy and neurobiology, and codirector of the Division of Radiological Sciences, received the 1995 William James Book Award presented by the American Psychological Association for his book Images of Mind, coauthored with Michael Posner, MD, Department of Psychology, University of Oregon.

Vijay Sharma, PhD, instructor in radiology, received an Award of Excellence from the Indo American Society of Nuclear Medicine for his presentation "Synthesis and Initial Characterization of Novel Aryl-isonitrite TC-99m Complexes Targeted to Multidrug Resistance (MDR) P-Glycoprotein" (coauthored with Harvard Medical School's Lee W. Herman, PhD; Eva Barbarics, PhD; and Lisa A. Herman, MSc; and MIR's Vallabhani V. Rao, PhD, instructor in radiology; and David R. Piwnica-Worms, MD, PhD, associate professor of radiology). The paper was presented at the Society of Nuclear Medicine Annual Meeting, held in June of 1995 in Minneapolis, Minnesota.

Jeffrey F. Williamson, PhD, professor of radiology, coordinated and served as a faculty member of the training course, "Clinical Brachytherapy and Treatment Planning," sponsored by the International Atomic Energy Agency (IAEA).
LECTURES/PRESENTATIONS

Mark M. Bahn, MD, PhD, assistant professor of radiology, presented “Special Techniques in Neuro MRI” to the Greater St. Louis Society of Radiologists, St. Louis, Missouri, September 19.


Clifford K.S. Chao, MD, instructor in radiology, spoke on “Radiation Therapy for Carcinoma of the Uterine Cervix” at the University of Rochester, New York, August 2. He presented “Management of Locally Advanced Malignancies of the Head and Neck” at the Southeast Missouri Regional Cancer Center’s Fall Cancer Symposium, Cape Girardeau, Missouri, November 4.

Thomas E. Conturo, MD, PhD, assistant professor of radiology, spoke on “Diffusion Imaging with Tetrahedral Encoding Gradients for High Diffusion Sensitivity and Analysis of Anisotropy” (coauthored with Robert C. McKinstry, MD, assistant in radiology; and Bruce H. Robinson, PhD, professor of chemistry, University of Washington, Seattle) and “A Phantom System for Accurate and Precise Quantitation of Contrast Agent Susceptibility and Single Vessel Bolus Flow Dynamics” (coauthored with Erbil Akbudak, MS, graduate research assistant in radiology) at the Society of Magnetic Resonance meeting, Nice, France, August 19 - 25.

DeWitte T. Cross, MD, assistant professor of radiology, presented case material at the Interventional Neuroradiology Peer Review Conference, Jackson, Wyoming, August 1 - 5. He spoke on “Imaging in Cerebrovascular Disease” at the Interventions in Peripheral Vascular Disease Conference, St. Louis, Missouri, September 16.

P. Duffy Cutler, PhD, assistant professor of radiology, spoke on “Clinical Evaluation of Local Threshold Segmented Attenuation Correction for Whole-Body PET Imaging” (coauthored with Ming Xu, MS, research associate in radiology, and Jeffrey A. Dobkin, MD, former assistant professor of radiology) at the IEEE Medical Imaging Conference, San Francisco, California, October 23 - 29.


Ronald G. Evans, MD, professor of radiology and director of the Institute, as the 61st Annual Carman Lecturer, sponsored by the Minnesota Radiological Society, presented “The Impact of Electronic Radiology on the Practice of Radiology in the Era of Managed Care” at the Mayo Clinic, Rochester, Minnesota, November 4. He spoke on “A Centennial Report on the Specialty of Radiology” and “Modern Radiology, Its Challenges and Opportunities” at the Centennial Anniversary of the Chilean Radiological Society, Santiago, Chile, October 26 - 29.


E. Mark Haacke, PhD, professor of radiology and director of the magnetic resonance imaging laboratory, presented “The Basic Mechanisms of Functional Brain Imaging,” “Fast Imaging Concepts with Gradient Echos,” and “High Resolution MRAs: How Far Can We Go?” at the Topical NMR Imaging Symposium, Beijing, China, October 22 - 24. Haacke and V. H. Cho, PhD, University of California, Irvine, organized the symposium.

Jay P. Heiken, MD, professor of radiology and chief of abdominal radiology, spoke on “MRI and CT of the Liver: Technique and Detection of Focal Lesions,” “Characterization of Hepatic Lesions with CT and MRI,” “MRI of...


Paul S. Hsieh, MD, instructor in radiology, spoke on "How to Evaluate Rotator Cuff Problems - MRI or Arthrogram?" at the Third Annual Radiology Update for the Clinician meeting, sponsored by the Memorial Hospital of Carbondale, Illinois, November 4.

Daniel K. Kido, MD, professor of radiology and chief of neuroradiology, presented the poster "High Resolution MRI of the Mesiobasal Temporal Lobe" (coauthored with John W. Miller, MD, associate professor of neurology; Mark M. Bahn, MD, PhD, assistant professor of radiology; Daniel L. Silberfeld, MD, assistant professor of neurologic surgery; Michael G. Crowley, PhD, instructor in radiology; and Avinash M. Sud, MD, instructor in radiology) at the American Epilepsy Society meeting, Baltimore, Maryland, December 5.


Weili Lin, PhD, assistant professor of radiology, spoke on "High Resolution MR Imaging of the Carotid Artery Wall" at the VII International Workshop on Magnetic Resonance Angiography, Matsuyama, Japan, October 12 - 14.

William H. McAlister, MD, professor of radiology and pediatrics and chief of pediatric radiology, spoke on "Credentialing in Pediatric Radiology" and "Practice Standards for Pediatric Radiology" at the SCORCH Meeting, Chicago, Illinois, October 7. As the Carman Lecturer, McAlister presented "Sinusitis in Children," Washington University School of Medicine, St. Louis, Missouri, October 17. He spoke on "Megaepiphyses" at the Annual Gorlin Dysmorphic Conference, Minneapolis, Minnesota, October 23.


Jeff M. Michalski, MD, assistant professor of radiology, presented "The Future of CT Simulation in Radiation Oncology" and "Efficient CT Simulation of Complex Radiation Fields" at the ACQ Sim Users Meeting, Miami, Florida, October 5. He spoke on "Quality Assurance Aspects of 3D Radiation Therapy Cooperative Group Trials" at the Antoni van Leeuwenhoek Hospital, Amsterdam, The Netherlands, October 25. Michalski presented "Dosimetric Considerations in the Outcome of Medulloblastoma" to the European Society of Therapeutic Radiology and Oncology, Paris, France, November 1.

Barbara S. Monsees, MD, associate professor of radiology and chief of breast imaging, presented "Mammography Screening Controversies" at the 4th District Meeting of the Missouri Society of Radiologic Technologists, Jewish Hospital, St. Louis, Missouri, November 18.


Marcus E. Raichle, MD, professor of radiology, neurology, and anatomy and neurobiology, and codirector of the Division of Radiological Sciences, spoke on "Imaging of the Brain in the Localization of Function" at the WHO Neuroscience Program - Symposium on Advances in Neurosciences in the Decade of the Brain, and delivered talks to the Ministry of Space Aviation and to the faculty of Beijing University, Beijing, China, September 25 - 28. He presented "Expanding Our Knowledge of Our Brains, Minds, and Behavior: the Role of Modern Imaging Techniques" (with coauthors Bruce Rosen, MD, Massachusetts General Hospital) at the 8th Aspen/Wye Communications Conference, Aspen, Colorado, October 6 and 7. Raichle spoke on "Images of the Mind" at the William H. Danforth Scientific Symposium - Medicine at the Millenium, held at Washington University's Eric P. Newman Education Center, St. Louis, Missouri, December 5.
Tracy L. Roberts, MD, assistant professor of radiology, spoke on "Mammographic Pathology, Part II" at the 4th District Meeting of the Missouri Society of Radiologic Technologists, Jewish Hospital, St. Louis, Missouri, November 18.


Barry A. Siegel, MD, professor of radiology and medicine and director of the Division of Nuclear Medicine, presented "Scintigraphic Diagnosis of Pulmonary Embolism" at the National Naval Medical Center, Bethesda, Maryland, October 19.

Marilyn J. Siegel, MD, professor of radiology and pediatrics, presented "MRI/CT of the Pediatric Mediastium," "CT of Pediatric Renal Disease," and "MRI of the Pediatric Abdomen" at the 5th Summer Practicum of the Society of Computed Body Tomography and Magnetic Resonance Imaging, The Greenbrier, West Virginia, August 7-10. As visiting professor, she spoke on "Ultrasound of the Acute Pediatric Abdomen" and "Thymic Imaging in Children and Adolescents" at Duke University, Raleigh-Durham, North Carolina, September 28. As invited lecturer, Siegel presented "Imaging of the Acute Pediatric Abdomen" to the Richmond Radiological Society, Richmond, Virginia, October 26. She lectured on "Ultrasoundography of Acute Abdominal Pain in Children," "Pediatric Retropertioneal CT/MR," "Ultrasoundography of Pediatric Renal Diseases," and "CT/MR of the Pediatric Pelvis" at the Alex Newman Radiologic Seminar on Abdominal Imaging and MRI, Scottsdale, Arizona, November 3 and 4. As visiting professor, Siegel presented "Ultrasoundography of Acute Pediatric Gastrointestinal Disease" and "CT/MR of Pediatric Pelvic Masses" at Michigan State University, Lansing, Michigan, November 6 and 7.

Cellette Sugg Skinner, PhD, assistant professor of radiology, spoke on "Breast Cancer Education for Older, Low-Income Women: We Can Make It Understandable" (coauthored with Roslyn K. Sykes, RN, PhD, and Cynthia L. Arkfen, PhD, of the Department of Medicine's Center for Health Behavior Research) at the annual meeting of the American Public Health Association, San Diego, California, November 1.

Richard M. Slone, MD, assistant professor of radiology, presented "Radiologic Assessment of Lung Volume Reduction Surgery Candidates" at the 4th Volume Reduction Seminar, St. Louis, Missouri, November 2.

He spoke on "Volume Reduction and the Role of the Radiographer" at the 4th District Meeting of the Missouri Society of Radiologic Technologists, Jewish Hospital, St. Louis, Missouri, November 18.

Michael W. Vannier, MD, professor of radiology and chief of the image processing laboratory, presented "Introduction to 3D Imaging" and "3D Surface Anthropometry" at Anthropology Relating to Radiology, sponsored by the Kaiser Permanente Radiology Education Committee of the Bess Kaiser Medical Center, Portland, Oregon, October 14. He spoke on "Surgical Simulation and Planning" (coauthored with Jeffrey L. Marsh, MD, professor of surgery, and Gary E. Christensen, DSc, research assistant professor of surgery) and "GI Tract: Virtual Endoscopy and Unraveling via Spiral CT" (coauthored with Ge Wang, PhD, assistant professor of radiology; Elizabeth G. McFarland, MD, assistant professor of radiology; Jay P. Heiken, MD, professor of radiology; and James A. Brink, associate professor of radiology) at the 3rd International Workshop on Rapid Prototyping in Medicine and Computer-Assisted Surgery, University of Erlangen-Nürnberg Institute of Medical Physics, Erlangen, Germany, October 19-21. As keynote speaker, Vannier presented "3D Anthropometry of the Human Body" at the IEEE Symposium on Frontiers in Biomedical Visualization, Atlanta, Georgia, October 29-November 3. He spoke on "Below Knee Residual Surface Measurement Precision & Repeatability" at the Workshop on Lower Limb Prosthetics (cosponsored by the National Center for Medical
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Rehabilitation Research, the National Institute of Child Health & Human Development, the National Institutes of Health, and Sandia National Laboratories), Albuquerque, New Mexico, November 8 - 10.

O. Clark West, MD, assistant professor of radiology and director of emergency and trauma radiology, spoke on “Imaging in Acute Cervical Spine Trauma” to the St. Louis Emergency Physicians Association, St. Louis, Missouri, October 20.


**SYMPOSIA**

**COMPUTER ASSISTED RADIOLOGY**

The following Mallinckrodt Institute staff members (highlighted in boldface type) participated in the 9th International Symposium on Computer Assisted Radiology, Berlin, Germany, June 21 - 24.

**CAR'95 TUTORIAL**

Michael W. Vannier, MD, “Medical Workstations.”

**SESSION 2: Image Processing and Display - IPD**

John W. Haller, PhD; Gary E. Christiansen, DSc; Sarang Joshi, MS; Michael I. Miller, PhD; Michael W. Vannier, MD, “Digital Atlas-Based Segmentation of the Hippocampus.” *Washington University School of Medicine, St. Louis, Missouri.*

**THE AMERICAN ASSOCIATION OF PHYSICISTS IN MEDICINE**

The following Mallinckrodt Institute staff members (highlighted in boldface type) participated in the 37th Annual Meeting and Technical Exhibits of the American Association of Physicists in Medicine, Boston, Massachusetts, July 23 - 27.

**SESSION 6: Miscellaneous**

Kirk E. Smith, AAS; Paul K. Commeau, BEE; Gulab Bhatia, MS; Michael W. Vannier, MD, “Lower Limb Remnant Volumetry - Validation of Spiral CT and Optical Surface Scanning.”

**SESSION 3: 3D Graphics for CAS**

Michael W. Vannier, MD, session cochair.

Vivek V. Patel, ME; Michael W. Vannier, MD; Jeffrey L. Marsh, MD; Rupak K. Das, PhD; Daniel Keleti, MD; Yimin Zhu, DSc; Ali S. Meigooni, PhD; Jeffrey F. Williamson, PhD, “Validation of Monte Carlo Dose Calculations near I-125 Brachytherapy Sources in the Presence of Bounded Tissue Heterogeneities.” *University of Kentucky, Lexington.*

Jeffrey F. Williamson, PhD, cochair, “Brachytherapy: Dosimetry, Location and Sources.”

Robert E. Drzymala, PhD, cochair, “Stereotactic - Delivery and Planning.”

**SESSION 4: Quality Assurance and QA**

Eric E. Klein, MS; Zuofeng Li, DSc; Daniel A. Low, PhD, “Electron Dosimetry with a CL2100C Multileaf Collimator.” *Barnes Hospital, St. Louis, Missouri.*

**SESSION 5: Miscellaneous**

Eric E. Klein, MS; James A. Purdy, PhD, “Dynamic Wedge: Clinical Experience and QA History.”

**SESSION 6: Miscellaneous**

Eric E. Klein, MS; Astrid E. Morrison, MD; James A. Purdy, PhD; Virgil M. Wilcut, MS, “Humanoid Dosimetric Study of Lung Irradiation Comparing 6 and 18 MV Photons.” *Barnes Hospital, St. Louis, Missouri.*

**SESSION 7: Miscellaneous**

Eric E. Klein, MS; Todd H. Wasserman, MD, “Clinical Introduction of a Commercial Treatment Chair to Facilitate Thorax Irradiation.”

Rupak K. Das, PhD; Harold Ferera, PhD; Zuofeng Li, DSc; Jeffrey F. Williamson, PhD, “Accuracy of Monte Carlo Photon Transport Simulation in Characterizing Brachytherapy Dosimeter Energy Response Artifacts.” *Hahnemann University, Philadelphia, Pennsylvania.*

**SESSION 8: Miscellaneous**

Russell L. Gerber, MS; James A. Purdy, PhD, “Quality Assurance Procedures and Performance Testing for CT Simulators.”

**SESSION 9: Miscellaneous**

Assen S. Kirov, PhD; Jeffrey F. Williamson, PhD; Ali S. Meigooni, PhD; Yimin Zhu, DSc; “Dosimetry of an Ir-192 Source for High Dose Rate Brachytherapy and Validation of Monte Carlo Dose Calculations.” *University of Kentucky, Lexington.*

**SESSION 10: Miscellaneous**

Eric E. Klein, MS; James A. Purdy, PhD, “Dynamic Wedge: Clinical Experience and QA History.”

**SESSION 11: Miscellaneous**

Eric E. Klein, MS; Astrid E. Morrison, MD; James A. Purdy, PhD; Virgil M. Wilcut, MS, “Humanoid Dosimetric Study of Lung Irradiation Comparing 6 and 18 MV Photons.” *Barnes Hospital, St. Louis, Missouri.*

**SESSION 12: Miscellaneous**

Eric E. Klein, MS; Todd H. Wasserman, MD, “Clinical Introduction of a Commercial Treatment Chair to Facilitate Thorax Irradiation.”
Jeffrey F. Williamson, PhD, "Generalized Sievert Integral Algorithm with Isotropic Scattering Correction for Dose Calculation around Low Energy Brachytherapy Sources."
*Barnes Hospital, St. Louis, Missouri.

Assen S. Kirov, PhD; Jeffrey F. Williamson, PhD; Ali S. Meigooni, PhD, "Measurement and Calculation of Heterogeneity Correction Factors for an Ir-192 High Dose Rate Brachtherapy Source Behind Tungsten Alloy and Steel Shields." *University of Kentucky, Lexington.

**THE AMERICAN SOCIETY FOR THERAPEUTIC RADIOLOGY AND ONCOLOGY**

The following Mallinckrodt Institute staff members (highlighted in boldface type) participated in the 37th Annual Meeting of The American Society for Therapeutic Radiology and Oncology, Miami Beach, Florida, October 8 - 11.

Bahan Emami, MD, member, Technology Assessment Committee.

Perry W. Grigsby, MD, MBA, chairman, Long Range Planning Committee.

James A. Purdy, PhD, member, Education and Development Fund; member, Long Range Planning Committee.

Todd H. Wasserman, member, Long Range Planning Committee; member, Ad Hoc Committee on Quality of Life.

**SCIENTIFIC SESSIONS**

Bahan Emami, MD, comoderator, "Prostate I."

Perry W. Grigsby, MD, MBA, comoderator, "Gynecologic."

Jeff M. Michalski, MD, discussant, "Electronic Portal Imaging."

James A. Purdy, PhD, comoderator, "Prostate Conformal Techniques."

Jeffrey F. Williamson, PhD, comoderator, "Electronic Portal Imaging."

Rupak K. Das, PhD; Daniel Keleti, MD; Yimin Zhu, DSc; Ali S. Meigooni, PhD; Jeffrey F. Williamson, PhD, "Validation of Monte Carlo Dose Calculations Near I-125 Brachtherapy Sources in the Presence of Bounded Tissue Heterogeneities." *University of Kentucky, Lexington.

David R. Gius, MD; Eric E. Klein, MS; Fredrick Oehmke, dosimetrist, "Optimal 3-D Conformal Treatment Planning of Posterior Lateral Supratentorial Tumors."

Eric E. Klein, MS; Zuofeng Li, DSc; Daniel A. Low, PhD; James A. Purdy, PhD, "Feasibility of Electron Treatments with a CL2100C Multileaf Collimator." *Barnes Hospital, St. Louis, Missouri.

Daniel A. Low, PhD; William B. Harms, BS; Eric E. Klein, MS; John W. Matthews, DSc; Walter R. Bosch, DSc; William B. Harms, BS; James A. Purdy, PhD, "Verification of Two-dimensional Photon Compensating Filters for Beam Intensity Modulation Using an Electronic Portal Imaging Device." *Barnes Hospital, St. Louis, Missouri.

Jeffrey F. Williamson, PhD, "Commissioning and Quality Assurance of Treatment Planning Systems: Commissioning and Quality Assurance of the Brachtherapy Component of a Treatment Planning System."
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Matthews, DSc, “Dose Measurements and Calculations for Tumors within Lung: A Comparative 3-D Study for 6 and 18 MV Photons.”

James A. Purdy, PhD; William B. Harms, BS; Jeff M. Michalski, MD; Walter R. Bosch, DSc; James D. Cox, MD; Theodore L. Phillips, MD; Lynn J. Verhey, PhD, “Radiation Therapy Oncology Group: 3-D CRT Quality Assurance Guidelines.” “The University of Texas M.D. Anderson Cancer Center, Houston. **University of California, San Francisco.

Jeffrey F. Williamson, PhD, “The Sievert Integral Revisited: Evaluation and Extension to Low Energy Brachytherapy Sources.”

REFRESHER COURSES
Bahman Emami, MD, “3-D Conformal Radiation Therapy III: Clinical Aspects.”

Jeffrey F. Williamson, PhD, “Physics and Quality Assurance of Low Dose Rate Brachytherapy.”

RADIATION AND BIOLOGICAL SCIENCES
The following Mallinckrodt Institute staff members (highlighted in boldface type) participated in the Eleventh Annual Meeting of MIR-ROC Radiation and Biological Symposium, St. Louis, Missouri, November 3 - 5.

Joseph L. Roti Roti, PhD, chair, Organizing Committee; member, Program Committee.

Clayton R. Hunt, PhD; Douglas R. Spitz, PhD, members, Program Committee.

Kathy Bles, Florence Curry, Peggy Lentz, members, Local Arrangements Committee.

SYMPOSIUM I: Tumor Biology I, Carcinogenesis
Robert S. Malaya, MD, PhD, chairperson.

Lisa A. Ridnour, PhD; Larry W. Oberley, PhD, “MnSOD Over-expression Suppresses Tumor Formation and Decreases Metastatic Potential in a Malignant Rat Cell Line.” “University of Iowa, Iowa City.

SYMPOSIUM II: Tumor Biology II, Model Radiotherapy Studies
Prabhat C. Goswami, PhD, chairperson.

Victoria O. Culbreth, laboratory technician; Douglas R. Spitz, PhD; Marie LaRegina, DVM; Ryui Higashikubo, PhD, “Comparison of Stereotactic and Template Injection Methods of Intracerebrally Implanted 9L Glioma Rat Brain Tumors.” “Washington University School of Medicine, St. Louis, Missouri.

Michael A. Mackey, PhD, “A New Model of Normal Tissue Complication for Use in Three-Dimensional Radiotherapy Treatment Planning.”

Robert S. Malaya, MD, PhD; Robert G. Swanson, MD; Joseph L. Roti Roti, PhD, “Differential Radioprotection of Oncogene Transfected Rat Embryo Cells by WR1065 Correlates with DNA Supercoiling Changes.”

SYMPOSIUM III: Signal Transduction and Cell Cycle Control
Douglas R. Spitz, PhD, chairperson.

Prabhat C. Goswami, PhD; Joseph L. Roti Roti, PhD; Clayton R. Hunt, PhD, “Post-Transcriptional Regulation of Topoisomerase IIα Expression During the HeLa Cell Cycle and Its Down Regulation by Agents Delaying G2-M Transition.”

Ryui Higashikubo, PhD; Michael Ragouzis, medical research technician; Joseph L. Roti Roti, PhD, “Radiation-Induced Alterations in Cell-Cycle Progression Studied by the Flow Cytometric BrdUrd-Pulse-Chase Method.”

Michael A. Mackey, PhD; Douglas R. Spitz, PhD; Julia E. Bae, medical research technician; Xiafang F. Zhang, PhD, “Hydrogen Peroxide-Induced Mutagenesis.”

SYMPOSIUM IV: Biochemistry and Molecular Biology of the Heat Shock Response
Clayton R. Hunt, PhD; Shannan J. Sullivan, MD; Azemat J. Parsian, BS, “Mapping the HSP70 Gene Family.”

Nazan Turkel, RPh; Joseph L. Roti Roti, PhD, “Studies of the Mode of Cell Death after Treatment with Topoisomerase or Hyperthermia.”

Robert P. VanderWaal, PhD; George Thampy, BS; William D. Wright, PhD; Joseph L. Roti Roti, PhD, “Heat-Induced Modifications in the Association of Specific Proteins with the Nuclear Matrix.”

SYMPOSIUM V: Advances in Understanding DNA Repair and Mutagenesis
Clayton R. Hunt, PhD, chairperson.

Eric W. Ahern, medical research technician; Cindy H. Cheng, medical research technician; William D. Wright, BS; Robert S. Malaya, MD, PhD; Joseph L. Roti Roti, PhD, “Consideration Regarding Use of the Alkaline Comet Assay for Routing Screening of DNA Damage.”

Ming-Shun Chen, PhD; Andrei Laszlo, PhD; Joseph L. Roti Roti, PhD; Clayton R. Hunt, PhD, “Detection of Single Base Mutations by a Competitive Mobility Shift Assay.”

WORKSHOP I: Novel Insights into Thermotolerance
Andrei Laszlo, PhD, chairperson.
PLENARY SESSIONS
Special Focus Sessions
Ronald G. Evens, MD, coinstructor, "Reflections on Teleradiology and Its Effect on Globalization of Medicine: A Radiology Centennial Commemorative Event."

Marilyn J. Siegel, MD, panel member, "Spiral CT in Pediatrics: An Old Dog with New Tricks."

Walter R. Bosch, DSc, instructor, "Integrating the Management of Treatment Planning and Image Data."

Michael D. Darcy, MD, coinstructor, "Embolization Techniques: A 'How-Not-to' Workshop" and "Interventional Uroradiology."

Robert E. Drzymala, PhD, instructor, "Stereotoxic Radiosurgery 3D Treatment Planning."

Ronald G. Evens, MD, coinstructor, "Minicourse on Socioeconomic Issues: Strategies for Radiologists When Dealing with Managed Care - Radiology and Managed Care - Political and Economic Considerations."


William B. Harms, BS, instructor, "Commissioning a 3D Dose-Calculation Algorithm for Clinical Dose" and "Quality Assurance for 3D Treatment Planning."

Jay P. Heiken, MD, coinstructor, "Spiral (Helical) CT: Principles and Clinical Applications" and "CT and MR Imaging of Pelvic Neoplasms."

David M. Hovsepian, MD, coinstructor, "Hysterosalpingography and Selective Salpingography."

Eric E. Klein, MS, instructor, "Clinical Implementation of Multileaf Collimation."

Daniel A. Low, PhD, instructor, "Three-dimensional Treatment Planning Photon-Beam Dose-Calculation Algorithms."

John W. Matthews, DSc, instructor, "Real-Time 3D Treatment Planning Systems."


Jeff M. Michalski, MD, instructor, "Accounting for Localization and Organ Motion Uncertainty in Treatment Planning."

Daniel Picus, MD, coinstructor, "Venous Thromboembolic Disease: Fibrinolytic Therapy and Inferior Vena Cava Filters."

James A. Purdy, PhD, coinstructor, "Update Course in Physics: 3D Radiation Therapy Treatment Planning."

Cary L. Siegel, MD, instructor, "Imaging Evaluation of Testicular Cancer."

Marilyn J. Siegel, MD, coinstructor, "Pediatric Body CT and MR Imaging: Problem Areas and Pitfalls," instructor, "Imaging of Pediatric Solid Tumors."

William G. Totty, MD, coinstructor, "MR Imaging of the Shoulder."

SCIENTIFIC SESSIONS
Michael D. Darcy, MD, presider, "Cardiovascular Imaging: A Multimodality Perspective."

Barbara S. Monsees, MD, member, Program Committee - General Radiology; presider, "Breast (Screening)."

Barry A. Siegel, MD, presider, "Nuclear Medicine (Lung)."

Todd H. Wasserman, MD, member, Program Committee - Radiation Oncology & Radiobiology.

K. Tyler Bae, MD, PhD; Jay P. Heiken, MD; James A. Brink, MD; "Computer Simulation of Contrast Enhancement at CT: Prediction of Aortic and Hepatic Enhancement during Abdominal CT."

Harold F. Bennett, MD, PhD; Daniel L. Overdeck, BA; William D. Middleton, MD; "Sonographic Follow-up of Patients with Testicular Microlithiasis."
**SYMPOSIA**

*continued from page 29*

James A. Brink, MD; Jay P. Heiken, MD; Ge Wang, PhD; Francis J. Schluter, MD; Elizabeth G. McFarland, MD; Michael W. Vannier, MD. “Clinical Strategies for Maximizing Longitudinal Resolution in Helical Body CT.”

James A. Brink, MD; Larry Horesh, MD; Jay P. Heiken, MD; Harvey S. Glazer, MD; Darryl A. Zuckerman, MD; Fernando R. Gutierrez, MD. “Helical CT versus Pulmonary Angiography for Detection of Acute Pulmonary Emboli in a Porcine Model: Preliminary Diagnostic Performance Study.”

Colin P. Derdeyn, MD; DeWitte T. Cross, MD; Christopher J. Moran, MD; Brent T. Allen, MD; William J. Powers, MD*. “Angiographic Errors in the Evaluation of Carotid Atherosclerotic Disease.” *Washington University School of Medicine, St. Louis, Missouri.*

Colin P. Derdeyn, MD; William J. Powers, MD*; Christopher J. Moran, MD; DeWitte T. Cross, MD; Brent T. Allen, MD*. “Role of Color Doppler US in Screening for Extracranial Carotid Artery Disease.” *Washington University School of Medicine, St. Louis, Missouri.*

Jeffrey A. Friedland, MD; Peter E. Shide, MD; Anthony J. Wilson, MB, ChB*. “Radiologists’ Use of Teleradiology: Responses to Surveys in 1990 and 1994.” *Harborview Hospital, University of Washington Medical Center, Seattle.*

Jeffrey A. Friedland, MD; Marilyn J. Siegel, MD. “CT in Appendicitis in Children.”

David S. Gierada, MD; Richard M. Slone, MD; Joel D. Cooper, MD*; Debiao Li, PhD; Michael W. Vannier, MD. “Dynamic MR Imaging of Respiratory Mechanics before and after Lung Volume-Reduction Surgery.” *Washington University School of Medicine, St. Louis, Missouri.*

Debiao Li, PhD; Paritosh Dhawale, PhD; E. Mark Haacke, PhD; Patricia J. Rubin, MD*; Robert J. Gropler, MD. “Increase in Signal Intensity Change and Reduction of Physiologic Noise at Electrocardiogram-gated Functional MR Imaging of Human Motor Cortex.”

Karthikeyan Kuppusamy, MS; Weilin Lin, PhD; E. Mark Haacke, PhD. “Quantitative Analysis of the Effect of Respiratory Mechanics on MR Imaging in Individual Children and Adolescents.” *Washington University School of Medicine, St. Louis, Missouri.*

Francis J. Schluter, MD; Darryl A. Zuckerman, MD; Fernando R. Gutierrez, MD; Larry Horesh, MD; Marshall E. Hicks, MD; James A. Brink, MD. “DSA for Detection of Acute Pulmonary Embolus: Evaluation in a Porcine Model.”

Cary L. Siegel, MD; William D. Middleton, MD; Sharlene A. Teefy, MD; Bruce L. McClenman, MD; Ralph V. Clayman, MD*. “Intraoperative Endoluminal US in Ureteropelvic Junction Obstruction.” *Washington University School of Medicine, St. Louis, Missouri.*

Richard M. Slone, MD; Thomas K. Pilgram, PhD; Joel D. Cooper, MD*; David S. Gierada, MD; Harvey S. Glazer, MD; Stuart S. Sagel, MD. “Radiologic Predictors of Outcome Following Lung Volume-Reduction Surgery.” *Washington University School of Medicine, St. Louis, Missouri.*
Richard M. Slone, MD; Roger D. Yusen, MD; David S. Gierada, MD; Mary S. Pohl, RN; Joel D. Cooper, MD; G. Alexander Patterson, MD; “Expected and Unexpected Radiographic Findings Following Lung Volume-Reduction Surgery.” Washington University School of Medicine, St. Louis, Missouri.

Keith M. Sterling, MD; Michael D. Darcy, MD; Thomas K. Pilgram, PhD; Richard M. Slone, MD; “Anatomy and Osseous Anatomic Landmarks.” Washington University School of Medicine, St. Louis, Missouri.

Alfred Tinger, MD; Joseph R. Simpson, MD, PhD; Gershon J. Spector, MD; Donald G. Sessions, MD; Nancy A. Kuck, clinical research assistant; Bahman Emami, MD, “Arytenoepiglottic Fold Anatomy.” Washington University School of Medicine, St. Louis, Missouri.

Michael W. Vannier, MD; Kirk E. Smith, AAS; Paul K. Commean, BEE; Gulab Bhatia, MS, “Spiral CT for In Situ Lower Limb Prosthesis Goodness-of-Fit Evaluation.” Washington University School of Medicine, St. Louis, Missouri.

Ge Wang, PhD; Donald L. Snyder, PhD; Michael W. Vannier, MD, “Iterative Deblurring of CT Image Restoration, Metal Artifact Reduction, and Local Reconstruction.” Washington University School of Medicine, St. Louis, Missouri.

SCIENTIFIC EXHIBITS

Richard M. Slone, MD, member, Scientific Exhibits Committee.

Robert J. Feiwel, MD, “Imaging Guide for Localization of Lesions that Cause Nystagmus.” Washington University School of Medicine, St. Louis, Missouri.

Richard M. Slone, MD; Harvey S. Glazer, MD; Sudhir Sundareshan, MD; “Surgical Changes and Staple Line Patterns Seen on Chest Radiographs after Lobectomy.” Washington University School of Medicine, St. Louis, Missouri.

InfoRAD - NEW TECHNOLOGIES SECTION

For the third consecutive year, RSNA contracted with MIR’s Electronic Radiology Laboratory (ERL) to develop software to support the electronic transfer of medical images in DICOM format throughout this year’s exhibition. Several enhancements were added to the software, and dozens of commercial exhibitors utilized the ERL software for testing and demonstrating commercial products supporting the DICOM standard protocol. The software package also supported the “Digigraphs” or electronic photographs of meeting attendees, which were displayed in many of the commercial exhibits.

Software Team: Stephen M. Moore, MS; David E. Beecher, BA; Andrew S. Gokhale; Gregory G. Reiker, MS; G. James Blaine, DSc.

Under contract with RSNA, MIR coordinated the development of a DICOM 3.0 Image Library, which contains medical studies from a variety of modalities that were solicited from universities and manufacturers. The studies, combined with appropriate descriptions and radiology reports, were available for electronic distribution and display throughout the commercial exhibits and at InfoRAD. It is anticipated that the Image Library will form the core of a growing reference set of digital images for research and demonstration purposes.

DICOM Image Library Team: Kevin W. McEnery, MD; Stephen M. Moore, MS; G. James Blaine, DSc; R. Gilbert Jost, MD.
MIR RESIDENTS, Fellows, and Trainees for 1995-1996

(seated, left to right) Doctors Valerie Reichert; Rachel Gordon; Ronald Evens, director of the Institute; Fidelma Flanagan; Isabel Soroeta; (standing, left to right) James Milburn; Terry Yeager; Robert Vogler; Phillip Gunther; Robert Feiwell; Ken Schreibman; Michael Wallace; Keith Kronemer; Glenn Strome; Glenn Coates; Glenn Hammer; Francis Schlueter; Mitchell Miller.

Not shown are Doctors David Diamond, Kenneth Ford, Laniis Hall-Daniels, Robert Kanterman, Gary Luker, John Meyers, Sean Muldowney, Perry Pikhardt, Sharon Schubach, Kent Simpson, Jeffrey Spades, Cristiane Takita, Mary Vest, Pamela Woodard.
A. James Purdy, PhD
B. Marilyn Singel, MD
C. James Blaine, DSc
D. For the third consecutive year, RSNA contracted with MIR’s Electronic Radiology Laboratory to develop software for this year’s DICOM exhibits. Left to right are the ERL’s Gregory Reiker, Robert Whitman, Menelaos Karamichalis, and Stephen Moore.
E. Stuart Sagel, MD
Focal Spot

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