This Biennial Report is Dedicated to

Edward Shapiro, PhD
1917-2003

Scientist, Humanitarian, Friend and Benefactor

Pennsylvania State University, PhD Biochemistry
Manhattan Project 1942-1945
President, New England Nuclear Corporation 1956-1980
Board of Directors, E.I. Dupont Corporation 1980-1987
CONTENTS

The Department’s Mission .......................................................... iv
Chairman’s Overview ............................................................... 1
Radiology Administration .......................................................... 6
Radiology History Timeline ....................................................... 8
Educational Programs ............................................................... 10
  Residency Training Program .................................................... 10
  Fellowship Program .................................................................. 13
  Medical Student Training Program .......................................... 14
  Technologist Training Program ............................................... 15
Research Programs ................................................................. 16
  Electron Paramagnetic Resonance Center .................................. 16
  Magnetic Resonance Spectroscopy and Imaging Lab .................. 17
  Outcomes Research .................................................................. 19
  Functional Magnetic Resonance and Morphometrics Research Program ................................................................. 19
Veterans Affairs Division .......................................................... 22
Clinical Programs ...................................................................... 24
  Body Imaging – CT .................................................................... 24
  Body Imaging – MRI ............................................................... 25
  Breast Imaging ....................................................................... 27
  Cardiovascular Imaging ........................................................... 29
  Chest Imaging ........................................................................ 30
  Diagnostic Physics .................................................................... 32
  Gastrointestinal Radiology ....................................................... 32
  Musculoskeletal Radiology ....................................................... 34
  Neuroradiology ....................................................................... 35
  Nuclear Medicine .................................................................... 37
  Pediatric Radiology .................................................................. 38
  Ultrasound ............................................................................. 39
  Uroradiology ......................................................................... 40
  Vascular and Interventional Radiology ...................................... 40
Appendices ............................................................................... 44
  Diagnostic Radiology Faculty ................................................ 44
  Diagnostic Radiology Research Associates .............................. 45
  Diagnostic Radiology Residents .............................................. 45
  Diagnostic Radiology Fellows ................................................ 45
  Alumni Residents ................................................................... 45
  Alumni Fellows ..................................................................... 46
  Bibliography ........................................................................... 47
  Journal Articles ....................................................................... 47
  Presentations .......................................................................... 51
  Book Chapters ........................................................................ 57
  Abstracts ................................................................................ 58
The Department’s Mission

The Department of Diagnostic Radiology at Dartmouth-Hitchcock Medical Center is dedicated to serving the needs of regional physicians and patients in the delivery of superior, cost-effective radiologic services and consultation at all levels of care.

The department is committed to perpetuating an environment in which medical students and residents may acquire a superior educational experience and where students and faculty at all levels can enhance their professional development through patient care, teaching, research, and other scholarly pursuits.

The department is dedicated to building a solid research program in selected disciplines of radiology complementing the strengths of other medical school departments and university faculties.
The growth in departmental activity in the past three years has been significant. In all three major areas of endeavor (patient care, research and teaching) we have seen dramatic changes: increased volumes, greater depth and breadth of scientific work, larger grant revenues, new equipment and technology, and an expanded teaching program.

We have installed new state-of-the-art angiography equipment, and started a PET program through a mobile service, soon to be upgraded to a PET-CT. In collaboration with Cardiology, we have initiated a Cardiac Imaging Section, and we have greatly expanded our capabilities for clinical care. To augment programs in cross-sectional imaging, we have added a third helical CT scanner, (a General Electric 16-row Lightspeed scanner), another GE Lightspeed with fluoroscopy for vascular and interventional procedures, and three powerful, Vitrea 3D workstations that are helping us produce remarkable 3D images. We have enhanced our ultrasound program with a sixth ultrasound room. We installed a new MRI magnet (a GE 1.5 Tesla Twin Speed with EXCITE technology) in July 2003 in the new MR3 building.

The greatest strength of our department continues to be the quality of its entire staff, who work together in a coordinated and collegial fashion. The department’s clinical leaders, our team of dedicated and highly-trained radiologists, work closely with the department’s business and technical management, led by our administrative director, Monte Clinton. This joint leadership has fostered a superb team of technologists, nursing and support staff, who work on a 24/7 basis to deliver clinical care that complements the teaching and research which fulfill our department’s mission.

In addition to the technology, we have made some key personnel recruitments and changes that have strengthened our staff to a great degree. Kevin Dickey, MD, has joined us as Director of Vascular and Interventional Radiology (VIR). Dr. Dickey was formerly Chief of VIR at the Hospital of St. Raphael in New Haven, Connecticut, and a Radiology faculty member at Yale University, New Haven, Connecticut. Anne Silas, MD, has joined the Division of Vascular and Interventional Radiology, and has expertise in cross-sectional imaging as well. Yvonne Cheung, MD, was recruited from Harvard Medical School to join our Division of Musculoskeletal Radiology. Dr. Cheung possesses strong clinical expertise in the interpretation of bone and joint injuries and disease, with special interest in imaging of the foot and ankle, which has led her to initiate a research project to measure the mechanical properties of the diabetic foot. Cliff Eskey, MD, PhD, has joined our Neuroradiology Division, recruited from Mass. General Hospital. Not only has Dr. Eskey added strength and depth in neuroradiology, he has also assumed responsibility for non-neuro head and neck imaging.

Our program in cardiac imaging has been made possible by the recruitment of Justin Pearlman, MD, ME, PhD, to lead the Cardiovascular Section, a joint effort of the DHMC Radiology, Cardiology and Medicine Departments, and Dartmouth’s Thayer School of Engineering. Dr. Pearlman is board-certified in both cardiology and radiology. Under Dr. Pearlman’s direction, DHMC now offers advanced cardiovascular imaging including cardiac MRI, with detailed function evaluation, strain mapping, perfusion, and other advanced capabilities. The Cardiovascular Section will also conduct research in the fields of molecular imaging and the development of new vessels (angiogenesis). Dr. Pearlman’s report on Cardiovascular Imaging, in the clinical section of this report, gives more information.

Jim Roberts, RT, BS, a Senior Technologist, has become Radiology’s Clinical Operations Manager. Jim previously spent 28 years here at DHMC as a VIR Technologist, Assistant Director of Cardiology, and Radiology Team Leader and Supervisor. Lori Key, BSN, MBA, was recruited from the MHMH nursing staff as the new VIR Nursing Team Leader. Lori is a 22-year employee of MHMH, who previously worked in the cardiothoracic intensive care unit.

Geoff Bretches, BA, has become Radiology’s Business/Financial Manager. Geoff has worked in...
the healthcare field for eight years, conducting financial analysis for a state Medicaid Program as well as for DHMC Patient Financial Services. Geoff’s goals include strengthening electronic financial analysis systems and billing processes, and improving financial outcomes.

For a long time, our growing department had needed a resource to handle editing and grant writing, to support our busy academic clinicians and further the department’s academic mission. The hospital and DMS leadership approved creation of this position in 2002, and Robyn Mosher, MSE, has been recruited to lead this effort. In addition to her experience as a published medical writer and editor, Robyn was trained as a biomedical and electrical engineer. Prior to this position, she worked for 19 years as a biomedical researcher, engineer, writer/editor, and manager.

New leadership in vascular and interventional radiology (VIR) has brought new procedures. Vertebroplasty, performed as a partnership between neuroradiology and VIR, has enhanced lives and reduced pain in many patients with osteopenic fractures of the vertebral bodies. To improve the clinical aspects of the VIR practice, we have created a dedicated VIR clinic, located with other DHMC physician clinics. Patients referred to VIR are evaluated, examined and scheduled for appropriate procedures by interventional radiologists. The pending recruitment of a nurse practitioner (or physician’s assistant) in VIR will improve the quality of clinical care and follow-up.

We continue to be a customer-focused department, driven by patient and referring physician needs, but also by our educational and research missions. Virtually all of our recent expansion has happened without additional space, up to this point. We have “cannibalized” support, space and offices to allow technological growth. Without such growth, we cannot serve the needs of our patients.

Perhaps the single most important advance to date has been the transition of MR, CT and ultrasound to a completely digital environment, where printing of films has ceased on a routine basis. This was made possible with the outstanding support of Information Systems. We have added a Picture Archive and Communication System (PACS), to electronically store and archive digital radiography images for better and easier clinician access. Our PACS system is a joint venture between our longstanding radiology information system vendor, IDX, and a new technology developed by IDX Imagecast Corporation. As we build our archive of prior examinations for comparison, the PACS system will leverage existing technology in making our radiologists even more efficient and productive.

Before we incorporated these digital and PACS systems, it was virtually impossible for radiologists to get through the day in a timely fashion, because the growth in cross-sectional imaging volumes and the number of images per exam required them to hang an unmanageable number of comparison films. Our PACS system has been incredibly successful in helping us streamline the interpretation of ultrasound, CT and MRI. We plan to transition routine radiology, as well as some mammography, into a direct digital format in the fall of 2003; nuclear medicine and VIR will be incorporated soon afterward.

These technological enhancements provide better imaging quality for patients and also provide the ultimate “classroom” for our residents and fellows to learn in. Our department’s teaching programs have expanded. The residency program under Jocelyn Chertoff, MD, has grown to 16 residents, and we are eagerly anticipating the recruitment of our first neuroradiology fellow this year. The medical student radiology elective program, under Petra Lewis, MD, is now offered six times per year, and combines didactic presentations and workshops with viewbox teaching. One of the highlights for students is the conference devoted to student presentations, which allows the students to explore the imaging findings of a particular case and/or disease process in depth. These student presentations have always been high-quality. A recent accolade from “AuntMinnie.com”, a case publication emanating from the Massachusetts General Hospital, included the DHMC Radiology Department among the top 15 departments for learning the specialty of radiology.

Our research programs continue to flourish. We are in the top quartile of departments of radiology with respect to federally-funded sponsored research, and we have increased our annual research funding to over $3 million.

Our Breast Imaging Division continues to
participate in the New Hampshire Cancer Registry, a breast cancer surveillance consortium of nine institutions who share outcomes and pathology data. Dr. Steven Poplack and Dr. Helene Nagy continue to lead this clinical effort, as well as the clinical component of the large program project grant ($6.8 million) that was awarded to the Thayer School of Engineering. Dr. John Weaver and Dr. Jeffrey Dunn of Radiology collaborate with Thayer School Engineering staff (including Dr. Keith Paulsen) in developing and evaluating new devices for imaging breast cancers. One of these is based on MR near-infrared imaging technology and its ability to measure such properties as tissue elasticity. Dr. Dunn, Director of the NMR laboratory, has been successful in a number of areas working with his state-of-the-art 7T experimental magnet. Work on the MR/near-infrared imaging is providing important and interesting data on cerebral blood flow and oxygenation as well as protection from stroke. An important advance in Dr. Dunn's lab has been the recruitment of Dr. Roger Springett from Great Britain, whose energy and capability have already added strength and breadth to the NMR lab.

The Electron Paramagnetic Resonance (EPR) research program under Harold Swartz, MD, PhD, has continued to move its work into the clinical setting. They are utilizing the first clinical EPR magnet. This work measures tumor tissue oxygen tension in vivo, based on the enhanced radiosensitivity of tumors when in a state of higher oxygenation. In conjunction with this research, Dr. Swartz's colleague, Julia O'Hara, and Brian Pogue from the Thayer School of Engineering, have developed promising new techniques in drug-mitigated photosensitivity—which, when combined with radiation therapy, is extremely powerful in attenuating or eradicating tumors in experimental animals.

William Black, MD, Director of Chest Radiology and our Outcomes Research program, has been deeply involved in the design and planning of the nationwide, multicenter, randomized clinical trial of lung cancer screening with helical CT, sponsored by the American College of Radiology Screening Network (ACRIN) and the NCI. Dr. Black has been named as DHMC's principal investigator for this research, and has been awarded a $3.7 million grant for this multi-year trial. The National Lung Screening Trial will determine, on a prospective basis, whether screening with spiral CT improves survival in lung cancer. This protocol is being offered without charge to patients over 55 with significant smoking history.

“Tremendous strength will be added to our vascular interventional research through the leadership and participation of Dr. Kevin Dickey, our new VIR director. Dr. Dickey brings extensive experience in a number of device trials, and specific expertise in both the research and treatment of venous disease, and the interventional treatment of gynecologic disorders. Dr. Dickey will oversee the continuation of research in many areas (see the VIR report in the clinical section of this Biennial Report).

What about the future? How does a department like ours meet new challenges and

“We continue to be a customer-focused department, driven by patient and referring physician needs, but also by our educational and research missions.”
maintain our leadership in this region, or nationally? How do we continue to provide vitality in patient care, excellence in education, and scientific focus in our research? We will accomplish these goals by continuing to recruit faculty and staff who possess excellent training, who bring new techniques and novel ideas to the department. These people may be expert diagnosticians or “proceduralists,” but above all, they must understand the relationship of their work to the clinical environment. Recruiting top-notch faculty is indeed a challenge in an environment where the lure of private practice is attracting a disproportionate share of the talent. However, we believe that the collegiality and high quality of the clinical and academic programs at Dartmouth, combined with the quality of life in the Dartmouth region, will continue to attract talented faculty. These aspects helped to recruit many of us, and continue to keep us thriving here.

We are constantly improving the method and speed of our clinical imaging. The expansion of PACS, and voice recognition soon to be incorporated, will help significantly in making technologists’ and radiologists’ jobs more satisfying, and in streamlining patient exam times. We are actively converting the department’s plain film components into an all-digital environment, which makes radiologists and technologists efficient in acquiring, interpreting and communicating images. These technological advancements will, in turn, help us manage the increasing workload that will result from the expansion of all clinical services, particularly orthopedics, at the medical center.

As of the writing of this report, we are beginning the construction of our multimodality Imaging Research Center, in partnership with Cardiology under their new section chief, Michael Simons, MD, the Thayer School of Engineering, Oncology, and the Norris Cotton Cancer Center. This Imaging Research Center will initially use MR, and will eventually use CT, PET and other modalities, to explore both standard and molecular imaging techniques. In 2004, we hope to add an experimental magnet with the same capability as the most advanced clinical magnet. With this magnet, we will undertake significant developmental and translational research in cardiopulmonary, vascular and oncologic imaging. We hope this research may become a “magnet” program for cardiac diagnostics, as invasive procedures transition to less invasive, more comprehensive techniques based on magnetic resonance imaging.

To accommodate our increasing clinical and academic needs, we are planning a large addition to our existing 46,000 square foot space. The expansion will involve a new nuclear medicine division, with room for two PET scanners; magnetic resonance imaging and VIR suites; and extra office and support space. The expanded space will also provide a new, modern conference/classroom for our vigorous teaching programs. A satellite imaging facility in the new Ambulatory Care Center will house additional satellite x-ray, mammography and ultrasound machines in close proximity to the clinics (so, for example, a patient will be able to have an ultrasound right across the hall from the OB/GYN Department). We will also have a digital x-ray and CT scanner within the new Emergency Department.

To meet the increased demand for x-ray technologists, Monte Clinton and Paul Roy have led a departmental effort to develop a radiologic technology training program in partnership with Lebanon College. Our department is one of the major clinical sites for the technology students, who rotate through a number of regional hospitals to obtain their clinical training. Our technologists and physicians serve as clinical faculty to teach and mentor these students.

We have come far in two years; many plans which we had on the drawing board, or in conceptual stages in our previous report, are now coming to fruition. The pressures on us as a department and as individuals are enormous, and our talented staff has been commendable in their collegiality, commitment and creativity in handling such demands. To maintain our momentum in all arenas—technical, clinical, research and teaching—we must continue to focus our energy, and, above all, be nimble. The high competence of our staff, combined with management’s support in advancing technology and improving the work environment, will help us continue to meet the challenges of today’s rapidly changing medical environment.

“Our research programs continue to flourish. We are in the top quartile of departments of Radiology with respect to federally-funded sponsored research, and we have increased our annual research funding to over $3 million.”
Diagnostic (DX) Annual Volumes, 1999 to present

Total Department Annual Volumes, 1999 to present
The Department of Radiology is led by Chairman Peter Spiegel, MD, and Administrative Director Monte G. Clinton, CRA. They are supported by Laurence Cromwell, MD, Vice-Chairman; Jim Roberts, Clinical Operations Manager; Geoff Bretches, Business Manager; Paul Roy, Asset Manager; and John Sundnas, Systems Manager. The department’s primary administrative priority is to support the ability to provide high-quality, patient-focused clinical care, teaching, and research.

Monte Clinton has been a frequent speaker on process improvement and organizational change at the American Healthcare Radiology Administrators (AHRA), Radiological Society of North America and the American Society of Clinic Radiologists. In 2002, Clinton received the AHRA President’s Award for his work on behalf of the association. Clinton has been an active participant in the 4,000-member AHRA since its inception. Over the past 18 months, Clinton led the AHRA’s certification program, a national initiative to establish qualifications for radiology administrators. Radiology administrators who pass the certification examination now use the title of CRA after their name, as an indication of their knowledge of the profession.

Jim Roberts, Clinical Operations Manager, was appointed to the position in October of 2002. Roberts has done an exceptional job in quickly leading the work redesign that was required by the installation of our six new digital radiography rooms. He is currently working on a new program to increase productivity and improve access in mammography, ultrasound, CT, and MR. In diagnostic radiology, working with the DX team leaders, Roberts managed a program to improve access and reduce patient wait times through a combination of work redesign and additional staff.

Geoff Bretches, Business Manager, has done an outstanding job in improving the business operation, which includes reception, scheduling, coding, finance, transcription, secretarial support and compliance. He has done an exceptional job at developing statistical tracking programs, which allows the other managers to track productivity and opportunities for improvement.

Paul Roy, Asset Manager, has done an excellent job in maintaining the department’s inventory of complex imaging equipment. His responsibilities include overseeing preventative equipment maintenance, monitoring service contracts,

“For 25 years, this has been my extended family,” said Joy Ferola, Diagnostic X-Ray Technologist, on her recent 25th anniversary working in Radiology. Joy’s coworkers have hardly changed through the years, she says. “We all moved here, married, raised our kids here….It’s a different environment than the city, and we all loved it and chose to stay.”

managing the film library and its transition to digital imaging and Picture Archive and Communication Systems (PACS), and serving as our liaison with equipment manufacturers. Roy is playing an important role in the hospital’s physical expansion into the new doctor’s building and the diagnostic and treatment building, scheduled for competition in 2004 to 2005.

John Sundnas, Systems Manager, has again proven to be an outstanding asset to the department during the conversion to PACS. Sundnas has done an exceptional job at spearheading the preparations for the PACS; working with the IDX staff and the DHMC Information Systems staff. The PACS conversion of CT, MR and ultrasound went exceptionally well—a true reflection of Sundnas’ thoroughness and attention to detail. He also monitors the ongoing maintenance and upgrades of the IDXrad RIS.

Over the past three years, the department has begun the process of its phased equipment replacement program, replacing much of the original equipment installed when the new hospital opened in 1991. In addition, new equipment has been added in mammography, VIR, nuclear medicine, and ultrasound.

The DHMC Radiology website, introduced in 1999, has become a nationally recognized, frequently visited site with an average of 4,000 visits per month. The website, under the able
supervision of the department’s webmaster, Dennis Johnson, serves as an information resource to the public, referring clinicians, residents, fellows, and healthcare administrators. The website can be visited at: http://www.DHMC.org/Dept/Radiology.

The department has been able to meet the challenges of providing high quality services to our patients and referring clinicians through the consistent support and encouragement of the Dartmouth-Hitchcock Clinic and the Mary Hitchcock Memorial Hospital administrative team, particularly that of Ron Sliwinski, Vice President for Cardiac, Surgical and Diagnostic Services. Ron’s energy, wisdom and collegiality has added tremendous value to the administrative team.

We feel it is a testament to the DHMC organization and the Radiology Department that people who work here tend to stay an unusually long time on their jobs. During the 2002 awards for long-term employees, we had one person who has worked in the department for 35 years (Chairman Peter Spiegel, MD), as well as three people who have worked here for 25 years, eight employees who have worked here for 20 years, four who have worked here for 15 years, seven who have worked here for 10 years, and four who have worked here for five years. We strive to continue this atmosphere and look forward to the next 35 years!

“For 25 years, this has been my extended family,” said Joy Ferola, Diagnostic X-Ray Technologist, on her recent 25th anniversary working in radiology. Joy’s coworkers have hardly changed through the years, she says. “We all moved here, married, raised our kids here….It’s a different environment than the city, and we all loved it and chose to stay.”

“We feel it’s a testament to the DHMC organization and the Radiology Department that people who work here tend to stay an unusually long time on their jobs.”

—Monte G. Clinton, CRA, Administrative Director
Dartmouth Medical School, the fourth oldest medical school in the U.S., is founded by Dr. Nathan Smith.

Mary Hitchcock Memorial Hospital (MHMH) is built by Hiram Hitchcock in memory of his wife, Mary Maynard Hitchcock.

Arthur B. Meservey (DC 1906) joins physics department at Dartmouth, takes over x-ray operation and teaches radiologic physics to residents for many years, through the 1950s.

An old RCA Snook x-ray machine. This apparatus was slightly “Franken-steinian”: it often sparked, crackled; smelled of ozone; and made a racket. RCA was later bought out by General Electric.

First nuclear imaging starts, in Pathology Department, under Dr. Elizabeth French, MD. First cardiac catheterization/angiography room installed in the OR, with modern fluoroscopic intensification, cinefluorographic and biplane rapid serial film-changing equipment. Early procedures were mostly cardiac caths, by cutdown rather than percutaneously.

Dr. William C. McCarty, trained at Mayo Clinic, joins Dr. Sycamore as the 2nd Radiologist in the department. 9,933 x-ray studies done. First myelography, arteriography and ventriculography done, jointly with surgeons.

Dr. Sycamore starts the MHMH Radiology Residency program, with one resident per year, and a 2-year program. Paul C. Briede is the department’s first resident.

MHMH buys new more powerful x-ray equipment for $1500. Pictures which formerly took 15 minutes can now be done in a few seconds. First GI studies with bismuth contrast agent, first fluoroscopy.

First mechanical film developer/processor (Kodak), develops and dries film in 7 minutes, “practically a miracle” at the time.

First automatic processor installed, a Kodak Xomat x-ray automatic processor.

**Timeline**

<table>
<thead>
<tr>
<th>Year</th>
<th>Event</th>
</tr>
</thead>
<tbody>
<tr>
<td>1797</td>
<td>Dartmouth Medical School founded.</td>
</tr>
<tr>
<td>1893</td>
<td>First Clinical X-Ray in America is performed at Dartmouth College by Professor of Physics Edwin Frost.</td>
</tr>
</tbody>
</table>
| 1896 | Harry T. French, MD, (DMS 1915) is appointed “Assistant Roentgenologist”.  
French had no special training in radiology. |
| 1899 | Leslie K. Sycamore, MD, (DMS 1925) returns to campus after training under Dr. George Holmes at Massachusetts General Hospital. Dr. Sycamore becomes the first specially trained chief of radiology at Hitchcock Clinic, and was the first trained radiologist between Boston and Montreal.  
3500 x-ray exams are done per year. |
| 1903 | Edward Wells, Hanover native, (DMS 1940), becomes first Hanover resident to graduate from the Hitchcock program. Wells helps operate a “Snook” machine (a dangerous device with sparks flying out of the top) for intravenous pyelograms, backs, chests, and occasional GI studies. |
| 1904 | First production x-ray apparatus is placed at MHMH.  
Arthur B. Meservey joins physics department at Dartmouth, takes over x-ray operation and teaches radiologic physics to residents for many years, through the 1950s. |
| 1911 | First GI studies with bismuth contrast agent, first fluoroscopy.  
Dr. John Bowler (DMS 1917) founds the Hitchcock Clinic, one of the country’s early multispecialty group practices. |
| 1914 | 3500 x-ray exams are done per year.  
3500 x-ray exams are done per year. |
| 1917 | Edward Wells, Hanover native, (DMS 1940), becomes first Hanover resident to graduate from the Hitchcock program. Wells helps operate a “Snook” machine (a dangerous device with sparks flying out of the top) for intravenous pyelograms, backs, chests, and occasional GI studies. |
| 1922 | First mechanical film developer/processor (Kodak), develops and dries film in 7 minutes, “practically a miracle” at the time.  
First mechanical film developer/processor (Kodak), develops and dries film in 7 minutes, “practically a miracle” at the time. |
| 1927 | First automatic processor installed, a Kodak Xomat x-ray automatic processor.  
First nuclear imaging starts, in Pathology Department, under Dr. Elizabeth French, MD. First cardiac catheterization/angiography room installed in the OR, with modern fluoroscopic intensification, cinefluorographic and biplane rapid serial film-changing equipment. Early procedures were mostly cardiac caths, by cutdown rather than percutaneously. |
| 1934 | First automatic processor installed, a Kodak Xomat x-ray automatic processor.  
First nuclear imaging starts, in Pathology Department, under Dr. Elizabeth French, MD. First cardiac catheterization/angiography room installed in the OR, with modern fluoroscopic intensification, cinefluorographic and biplane rapid serial film-changing equipment. Early procedures were mostly cardiac caths, by cutdown rather than percutaneously. |
First image intensifier in NH, KelliKet. Before this, radiologists had to wear red goggles beginning at breakfast at home, used fluoroscopic screen.

Radiation Oncology, under Frank Lane, MD, and Diagnostic Radiology, under William McCarty, MD, split into separate sections.

First ultrasound unit installed in Radiology, a Picker Gray Scale Scanner, under Harte Crow, MD.

First balloon angioplasty of leg done.

Radiology installs first whole body CT scanner, gift of the Hubbard family, which takes 1.5 minutes for 2 slices, 6-8 minutes for a head, 15-20 minutes for a body.

Radiology Nursing Division created. Frost Society created to commemorate history of Radiology at MHH on 100th Anniversary of first clinical x-ray.

The Nuclear Magnetic Resonance laboratory is created with the recruitment of Jeffrey Dunn, PhD, and acquisition of a 7 T small bore magnet. Six clinical appointments also began this year. Formal Fellowships begin in Cross Sectional Radiology and Angiography.

New medical center opens. Radiology Department expands to 44,000 feet.

The department’s first basic science laboratory created—the Electron Paramagnetic Resonance (EPR) Center, under Harold Swartz, PhD, MD.

The Nuclear Magnetic Resonance laboratory is created with the recruitment of Jeffrey Dunn, PhD, and acquisition of a 7 T small bore magnet. Six clinical appointments also began this year. Formal Fellowships begin in Cross Sectional Radiology and Angiography.

First MRI in the department, a 1.0 Siemens with self-shielding unit installed a prefabricated building adjacent to Radiology.

First balloon angioplasty of leg done.

Radiology becomes a full Medical Center department. Dr. Spiegel continues as Department Chairman after being Section Chairman since 1976. Residency program expands from 2 to 3 residents per year. 122,885 procedures done.

First selective coronary angiography performed in Radiology by Robert Jeffery, MD.

Ultrasound becomes totally digital and filmless. DEXA Scan (Dual Energy X-Ray Absorptiometry) bone mineral screening service initiated.

Department now has 19 radiologists. Residency program expands to 4 per year. World’s first neurointerventional room with biplane 16/12 intensifier installed.

PACS installed for CT, MR—filmless operation. PET service begun, transitions to PET/CT. Entire Radiology Department Staff—230 people.


---

### By the Numbers

<table>
<thead>
<tr>
<th>Total Cases</th>
<th>181,769</th>
</tr>
</thead>
<tbody>
<tr>
<td>CT</td>
<td>22,413</td>
</tr>
<tr>
<td>MRI</td>
<td>11,443</td>
</tr>
<tr>
<td>MRA</td>
<td>1,707</td>
</tr>
<tr>
<td>VIR</td>
<td>4,385</td>
</tr>
<tr>
<td>Nuclear Medicine</td>
<td>6,149</td>
</tr>
<tr>
<td>Ultrasound</td>
<td>14,051</td>
</tr>
<tr>
<td>Breast Ultrasound</td>
<td>1,589</td>
</tr>
<tr>
<td>Mammography</td>
<td>17,377</td>
</tr>
<tr>
<td>CAD Mammography</td>
<td>7,821</td>
</tr>
<tr>
<td>Routine/Diagnostic X-Ray (DX)</td>
<td>100,477</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Faculty and Staff</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Clinical Faculty</td>
<td>33</td>
</tr>
<tr>
<td>Adjunct Clinical Faculty</td>
<td>3</td>
</tr>
<tr>
<td>Full Time Research Faculty</td>
<td>16</td>
</tr>
<tr>
<td>Residents</td>
<td>16</td>
</tr>
<tr>
<td>Fellows</td>
<td>3</td>
</tr>
<tr>
<td>Technologists</td>
<td>67</td>
</tr>
<tr>
<td>Technologist Team Leaders</td>
<td>9</td>
</tr>
<tr>
<td>Aides</td>
<td>5</td>
</tr>
<tr>
<td>Nurses</td>
<td>8</td>
</tr>
<tr>
<td>Administration and Support Staff</td>
<td>89</td>
</tr>
</tbody>
</table>

---

2002 Data for procedures, 2003 data for staff. All historical figures are best estimates from available historical data.
E D U C A T I O N A L  P R O G R A M S

Education continues to be a top priority for the Radiology Department. Our teaching constituency includes residents, fellows, medical students, radiographers, nurses, other radiologists, referring clinicians and even our patients. We are striving to be educators in the broadest sense, serving as a resource for radiology education throughout New England.

Our department has kept pace with the tremendous technologic advancement of diagnostic radiology over the last decade. These changes have resulted not only in increased volumes but also in increased sophistication, specificity, timeliness, and added value to the services we are able to provide to patients and referring physicians. These changes in radiology create an opportunity and a responsibility to educate our trainees to excel in our rapidly evolving field, and to be poised to anticipate future changes.

Resident Training Program

Jocelyn Chertoff, MD, Director

In recognition of the excellence of our program in resident education and the opportunities that DHMC offers, the institution and the Accreditation Council for Graduate Medical Education (ACGME) approved expansion of our residency program from 12 to 16 residents. This change lets us use the resources available here, gives us more flexibility to design educational programs suitable to the residents’ needs, and increases opportunities for subspecialty elective experiences. This program expansion represents the culmination of our efforts and accomplishments over the last decade.

Our goal is to train our residents to function independently, at a high level in a broad spectrum of imaging modalities, so they will be well prepared to pursue either academic or private practice careers. We also endeavor to groom them with the information and skills that will make them leaders in their future practices—including the ability to analyze new information and deal with issues in medicine, technology, management, and finance that affect the practice of radiology.

In an effort to validate our actions and constantly improve our teaching, we invite both internal and external reviews at periodic intervals. Our most recent invited external review, performed by Dr. Paul Capp, Executive Director of the American Board of Radiology, reported that “there appeared to be a total commitment of the entire radiology faculty to teaching” and “the Department of Radiology has demonstrated excellence in its clinical service, excellence in its teaching, and has made great strides in its research activities in the past five years.”

An internal review conducted by our office of Graduate Medical Education reported that “most

“One of the strengths of DHMC’s program is the close personal interaction between residents and staff, who are truly interested in watching us learn and mature throughout residency.”

—Fayyaz Barodawala, MD, DHMC Radiology Chief Resident, 2002-2003

in the institution consider the radiology residents to be among the most mature and helpful in the entire institution, and the radiology residency training program may be the strongest of all the training programs in the institution.” Our most recent formal evaluation, performed by the Residency Review Committee for Radiology (a ACGME committee, composed of representatives of the American College of Radiology, the American Board of Radiology, and the AMA Council on Medical Education), granted the program continued full accreditation for five years. We are currently preparing for the next review.

We continue to refine our core curriculum, organized along the ten sections delineated by the American Board of Radiology. In each section, we have developed a series of conferences to be given over a two-year period, including a
comprehensive, in-depth course in radiological physics, with evaluation of our residents’ progress by a nationally administered examination. Our “Managed Care Curriculum,” designed to address outcomes research, evaluative sciences, ethics, and management, is in the vanguard of resident education in the country. It has become a model curriculum for the Association of Program Directors in Radiology (APDR), and one of the core documents for a joint committee of the American College of Radiology and the APDR charged with the development of a national curriculum. The committee has produced a series of videotapes on the non-imaging curriculum that is available to all radiology residents nationwide.

Dr. William Black, our Director of Chest Radiology, is a faculty member at Dartmouth’s world-renowned Center for Evaluative Clinical Sciences (CECS), and is a nationally recognized expert in outcomes research. He brings enhanced critical thinking skills and clinical research design to the educational program through his knowledge and collaboration with the CECS. Dr. Chertoff is currently working towards a Master’s degree at the CECS, and will be bringing those skills to the residency program as well.

Dartmouth-Hitchcock Medical Center has a new program called the DHMC Leadership in Preventive Medicine Residency. This unique integrated program gives residents the opportunity to gain a Master’s in Public Health Degree from the CECS, along with being board-eligible in preventive medicine and their own specialty. Radiology is participating in this program, and Dr. Chertoff is the radiology coach. The program’s aim is to attract and develop physicians capable of leading change and improvement of the systems where people and health care meet. In conjunction with existing clinical residency and fellowship programs, participants’ academic, applied leadership and practicum experiences in preventive medicine will focus on measuring outcomes and improving the technical, service and cost excellence of care for patients and populations.

Close communication and collaboration with our clinical colleagues provides the foundation for our clinical and academic mission. We strive to integrate hands-on experience, view box teaching and core curriculum conferences. The department holds regular joint teaching conferences with numerous clinical services, including Urology, General Surgery, Gastroenterology, Pulmonary Medicine, Thoracic Surgery, ENT, Maternal/Fetal Medicine, Neurology, Neurosurgery, and Pediatrics.

A vigorous visiting professor program brings diverse academicians and new ideas to the department, and provides the residents with international leaders as role models. Residents are encouraged to attend the scientific sessions of the New England Roentgen Ray Society and the New Hampshire Radiological Society. Residents present grand rounds in a program of formal lectures that include presentations by residents, fellows, and faculty. At our monthly journal club, residents have an informal setting in which to critically evaluate and discuss some important advances in radiology, based on the literature.

We require our residents to conduct research and this has led to numerous opportunities for them to attend national meetings to present their original work; this has produced an impressive “resident bibliography.” We send a resident to the highly competitive RSNA/AUR/ARRS “Introduction to Research” program, where they have the opportunity to network with other residents while they attend lectures designed to prepare them to perform meaningful clinical research. In 2002, Rita Kinback, MD, was chosen by the New Hampshire chapter of the ACR to represent the organization in the resident physician section of their annual meeting. We send our chief residents to the annual meeting of the Association of University Radiologists (AUR), which also hosts the American Association of Academic Chief Residents in Radiology meetings.

At the 2003 51st annual AUR meeting, our

“Dartmouth has incredible facilities—from the hospital to the equipment, which is all state-of-the-art. We get outstanding teaching in all facets of radiology from very dedicated staff. More importantly, I think Dartmouth is attractive because of the atmosphere at work. There is a mutually supportive, comfortable relationship between all employees of the radiology department, as well as between different departments within the hospital. Because of this, I look forward to coming to work every day.”

—Robert K. Myers Jr., MD, DHMC Radiology Chief Resident
group of staff and residents shared the distinction of winning the Kay Vydareny Film Interpretation Competition, teaming up with Brown University/Rhode Island Hospital and the University of Cincinnati School of Medicine. We will share the honor of hosting the competition next year, and providing cases to challenge next year’s meeting participants.

These meetings give residents the opportunity to network and interact with the leaders of radiology, which benefits our department when they share their experiences and insights in formal presentations upon their return.

The department also participates in the Roentgen Research Award program. Recent resident winners were Joseph Pekala in 2002, and Erik Rhodes in 2003.

Our residents rotate to the Veteran’s Affairs (VA) Medical Center, in neighboring White River Junction, Vermont, which provides an excellent opportunity for graduated responsibility. DHMC Radiology recently met with the VA staff to analyze this rotation to maximize the strengths of the VA and DHMC. The clinical rotation at Boston Children’s Hospital continues to provide a superb core experience in pediatric radiology. We also offer a month of pediatric radiology at DHMC, where residents train with our expert pediatric radiologists and see pediatric patients from the Children’s Hospital at Dartmouth. This rotation gives residents the opportunity to follow pediatric patients with specific disease processes through their entire imaging workup. The Armed Forces Institute of Pathology (AFIP) rotation is now scheduled in the third year, providing an organizational framework for disease processes by organ system, and a radiologic-pathologic correlation that is invaluable in the assimilation of the vast quantities of information in the field of modern radiology.

As part of our effort to constantly upgrade our teaching resources, we developed a dedicated Radiology Learning Laboratory. The lab contains the American College of Radiology (ACR) teaching file, with thousands of referenced, annotated teaching cases on film, CD-ROM and laser disc format, an in-house teaching collection, and audiovisual seminars in general radiology and emergency radiology. We have also developed “interactive radiology education” computer tutorials for residents and medical students.

We take pride in the dedication and professionalism of our faculty which underlies our teaching mission. Our residents continue the tradition of awarding a much-coveted Teacher of the Year award, which was presented in 2001 to Alex Mamourian, MD, of the neuroradiology division, and in 2002 to Cliff Eskey, MD, also of neuroradiology.

The residency program continues to attract quality applicants from across the country, and our residents have gone on to highly competitive fellowships in their chosen subspecialties. Among the nine residents who graduated from our program in the years 2001-2003, four chose to pursue fellowships in vascular and interventional radiology, two chose fellowships in cross-sectional imaging, one chose a neuroradiology fellowship, one a musculoskeletal fellowship; and one went directly into private practice.

Our graduating residents are well-prepared to be productive members of any academic department or private practice. The positive feedback we consistently enjoy from fellowship programs and clinical practices clearly indicates the high regard in which our graduates are held.
Fellowship Programs

Michael Tsapakos, MD, Director,
Cross-Sectional Imaging Fellowships

Kevin Dickey, MD, Director,
Vascular and Interventional Radiology (VIR) Fellowships

Alex Mamourian, MD, Director,
Neuroradiology Fellowships

The subspecialty fellowship programs in the Department of Radiology provide a wide breadth of experience to the trainees that undertake them. As their final step in training, the fellows are provided excellent teaching from a nurturing faculty, a wide case mix and a collegial hospital environment. These experiences have proven to be an effective combination in preparing each trainee for a fulfilling career; one that has produced radiologists that have contributed much to the specialty in clinical excellence and original research.

Our Cross-Sectional Imaging Fellowship, which includes neuroradiology, abdominal imaging in CT/MRI, musculoskeletal MRI, and ultrasound, has been established for over a decade. We continue to tailor this competitive fellowship by adding more opportunities for subspecialized electives and for research, which has resulted in increased academic productivity. Electives can include cardiac imaging, which is done in conjunction with the Department of Cardiology; mammography; and musculoskeletal radiology. We accept one to two candidates per year for this program. We have recently initiated a one-year MRI fellowship program, which will involve all aspects of MRI, including cardiac, neuro, musculoskeletal, abdominal, and pelvic imaging, and MR angiography. We will accept one candidate per year for this position.

Our ACGME-accredited Fellowship in Vascular and Interventional Radiology (VIR) has an excellent reputation, as demonstrated by its competitive recruitment of up to three fellows per year. This one-year program establishes technical, intellectual, and research experience, and produces excellent clinical interventionalists who possess the flexibility to maintain expertise in this ever-changing field. Fellows handle a heavy daily workload of cases, ranging from simple diagnostic to complex interventional procedures; they attend a daily work conference, and have active management and follow-up of patients. As new techniques to treat various diseases emerge in this subspecialty, the fellows experience them first-hand, and contribute to the establishment of these techniques into the services provided by VIR at Dartmouth as well as into their own individual expertise. Moreover, clinical and basic research is encouraged, either formulated from an original idea of the trainee or through participation in ongoing protocols. Throughout the last several years, fellows have actively participated in several clinical and laboratory research studies, have presented at national and international meetings, and have published several articles in peer-reviewed journals. Graduates of this fellowship leave with the ability to launch fulfilling careers in either academic or private practice.

We have a new Fellowship in Neuroradiology. This one-year, ACGME-accredited fellowship is offered by a strong Neuroradiology Division that is committed both to teaching and research, with an ongoing collaboration between Radiology, Neurology, and Neurosurgery. Following a successful match in 2003, we will welcome our first neuroradiology fellow in 2004.

“During my yearlong Vascular and Interventional Radiology fellowship at DHMC, I was surrounded by dedicated interventional radiologists, talented technologists, and diligent nurses, all of whom readily shared their expertise and knowledge with me. I managed to acquire the technical and clinical skills necessary to be an independent interventional radiologist, to help me think through and solve problems and to act on unknowns. Along the way, personal relationships formed with staff and co-workers that further nurtured a sense of uniqueness among those of us lucky enough to be here.”

Anne M. Silas, MD, FRCPC, Assistant Professor, former VIR Fellow in 2000-2001

One validation of the strengths of these programs is that in 2001, three of our current senior residents remained as fellows, despite the tremendous practice opportunities available to them in the current environment. Also, in 2003 and in 2004, several graduating residents will remain in the department as fellows.
Medical Student Radiology Elective Program

Petra Lewis, MD, Director

The DHMC Department of Radiology offers Dartmouth Medical School (DMS) students the opportunity to undertake a four-week elective in the department or at the VA. This has been a very popular course, with approximately 60% of the medical school class choosing this elective. Medical residents from other disciplines also have the option of rotating through radiology for two to four weeks as part of their subspecialty training. The student elective program runs five months of the year, accommodating up to seven students per month.

Our program’s quality and popularity are demonstrated by the high number of our graduating doctors who choose to spend their careers in radiology. In 2002 and 2003 combined, 13.2% of the DMS graduating classes were accepted into radiology residencies. This compares to the national average of 5.5% of US medical school graduates choosing radiology as their resident specialty in 2002-2003.

During the last two years, we have continued to refine and expand the radiology elective program. While a certain amount of tailoring to individual student career plans occurs, our primary aim is to provide a broad experience in basic image interpretation and cost-effective image management. Through the elective experience, the student should acquire a defined core of radiologic knowledge, and should synthesize this information with his or her prior medical knowledge base. This elective provides a platform for students entering radiology residencies, and also enables students entering other medical specialties (besides radiology) to order appropriate imaging studies, explain them to their patients, and recognize common and (particularly) emergency conditions on plain films.

During the four-week elective, we have expanded the elective format to include an intensive lecture series to the students given by both staff and residents; a film quiz; image management workshops; a radiology ‘jeopardy’ contest; and a student case presentation conference as well as rotations through the clinical areas. The student presentation conference has been a very popular session with staff, residents and students with extremely high quality presentations. Students also submit cases to the student teaching file, which is now becoming a comprehensive collection of basic and emergency teaching films. This is in addition to the expanded CD-ROM and Internet-based teaching resources dedicated for student use. We have developed a student elective website which integrates several of the computer-based teaching resources, web links for teaching file collections, scheduling and evaluation tools including the end of elective exam. Students are offered the possibility of spending a day or more in one of several private practice settings in the area. Students planning careers in radiology frequently elect to take this opportunity. Specialist electives in neuroradiology and vascular and interventional radiology are also offered to students, with several students a year taking advantage of these focused elective periods.

Presently we are developing a prototype problem-based CXR teaching module, which could be accessed on the Internet by all medical students.

In addition to the elective period, the department also teaches a required course in radiology to the third-year medical students as part of the interdisciplinary core experience (ICE) course. The radiology component consists of six hours, which encompasses a basic introduction to imaging, with an emphasis on plain film interpretation and imaging management. This course includes lectures, interactive image-management workshops, and a radiology jeopardy session that contains 50 “must see, must know” radiology images and facts. Both the third- and fourth-year radiology courses are organized by Dr. Petra Lewis.

In conjunction with the Dartmouth Medical School New Directions Curriculum, the VA Medical Center’s Department of Radiology has established an elective for first- and second-year medical students in clinical radiologic anatomy using a problem-based format.
Technologist Training Program

Jim Roberts, RT, BS, Clinical Operations Manager, and Manager of Technologist Training Programs for DHMC Radiology

The department has an ongoing commitment to continuing medical education. This includes radiology administrators, radiographers, and community radiologists. The Department of Radiology's technologist education task force continues to organize and sponsor biannual continuing education conferences every May and October. These efforts started in the fall of 1993, in preparation for mandatory continuing education requirements for all registered technologists. The task force's goal is to create an opportunity for both DHMC-employed technologists and regionally employed radiographers to acquire accessible, interesting and cost-efficient credits as required by the American Registry of Radiologic Technologists.

These educational opportunities provided at Dartmouth-Hitchcock Medical Center feature a wide spectrum of speakers, including DHMC Radiology faculty, technologists, nurses, clinicians, and pharmaceutical representatives, as well as members of our administrative management team. The conferences are generally entitled: "Radiology Education at Dartmouth-Hitchcock Medical Center."

Brenda Sleasman has been instrumental in the development and continuation of this unique in-service program for technologists which also has become the primary radiologic technologist training source for the entire northern New England region. In addition, our staff radiologists were invited speakers at the annual New England Conference of Radiologic Technologists. We also organize and run a biennial ultrasound conference that features our staff, as well as guest lecturers, targeting sonographic technologists in the eastern United States.

Allied health program affiliates in northern New England are participants in our continuing education program here at DHMC. Our department is affiliated with the New Hampshire Technical Institute (NHTI) in Concord, NH; The Lebanon College in Lebanon, NH; the University of Vermont (UVM) in Burlington, VT; and Rutland Regional Medical Center in Rutland, VT.

The dedicated and highly skilled DHMC staff of radiologic technologists provides the students with an experience rich in knowledge, technology and professionalism. The recent addition of digital imaging in the diagnostic section prepares the DHMC radiologic technology students to meet the challenges of today's high tech medical imaging field. Dawn Mead, RT, is the clinical instructor for the radiologic technology students. During the past three years, we have collaborated with NHTI's ultrasound program by having one student participate in learning how to scan in our Ultrasound Division two days per week.

Our Nuclear Medicine Division is affiliated with UVM and hosts one student each year for three continuous months of hands-on learning. Finally, on an annual basis, we collaborate with Rutland Regional Hospital's hospital-based radiography training program by offering "shadowing" experiences in our VIR, DX, and MRI divisions.
**RESEARCH PROGRAMS**

**Electron Paramagnetic Resonance (EPR) Center**

Harold Swartz, MD, PhD, Director

The EPR laboratory is internationally recognized for its capacity to conduct EPR spectroscopy for the measurement of oxygen and other parameters in viable systems (defined as living functioning systems, including isolated cells and whole animals). In the past two years, we constructed a clinical EPR spectrometer, located at DHMC, and used this in preliminary clinical studies. Our close collaboration with the Biomedical NMR laboratory (led by Dr. Dunn), and other basic science and clinical programs at DHMC, has been extremely productive, as illustrated by Dartmouth’s selection as the site of an annual meeting of the leading society in the field, the International Society on Oxygen Transport to Tissue.

**EPR Research Programs**

The full-time staff in the EPR Center includes 12 doctoral level investigators and three support staff members. We usually host between one and four visiting scientists as well. Several faculty members at Dartmouth carry out major parts of their research in collaboration with the EPR laboratory. Also, students at various levels conduct research in our center. Our research programs are described below.

**Development and Application of EPR Oximetry**

This research aims to extend and exploit the capabilities of EPR oximetry to measure pO2 in tissues *in vivo*. Our method provides the only way to measure tissue oxygen repetitively and non-invasively from the same site. This method is gaining widespread use in animal models and could lead to significant clinical applications, especially in oncology for guiding tumor therapy, and in peripheral vascular disease. This research is supported by a NIH program project grant, which began on May 1, 1995 and has been renewed twice, with funding through June, 2006.

**The Measurement and Significance of Intracellular Oxygen**

This research aims to measure gradients of oxygen within cells and across the extracellular membrane, and to understand the gradients’ mechanism and significance. Such gradients were not expected and hence are controversial, because of the implications they have regarding cell structure and the potential effects on many physiological and pathophysiological processes. Other laboratories have provided data that support our finding of significant gradients. We have begun collaborative research with the University of Maryland with the goal of confirming and extending our results with EPR, using a complementary optical method. This research is supported by a grant from NIH that is in its 15th year, and is funded through December 31, 2003.

**EPR Center for the Study of Viable Systems**

In this research, we develop and apply instrumentation and techniques to solve biomedical problems that are accessible with EPR, with some clinical applications. The measurements we make with *in vivo* EPR include *in vivo* oximetry, detection and characterization of reactive free radicals, measurement of free radical intermediates of drugs and toxins, and many parameters related to physiology and pharmacology. This research is supported by a Center grant from NIH, which was funded on September 30, 1996 and has been renewed through May 1, 2005.

**Measurement of Radiation Dose After Accidental Exposures, Using In Vivo EPR of Teeth**

This research program uses *in vivo* EPR spectrometers to measure radiation dose non-invasively, based on the stability of radiation-induced unpaired electrons in teeth. (The method was successfully used in live rats without removing the teeth. Parallel studies in isolated human teeth show that the method applies to human subjects.) This is the first method that can directly measure the physical dose of radiation in individuals following exposure to clinically significant amounts of radiation. We currently are completing the development of an instrument...
that can routinely measure clinically significant exposures after radiation accidents, such as
occurred at Chernobyl or might occur during nuclear war. We are working closely with a
company, Resonance Research, Inc., for the commercialization of this instrument. This
research is supported through a contract with the Department of Defense, which has been funded
from August 1, 2002 through July 31, 2004.

Clinical Applications of In Vivo EPR
We have established the world's first EPR facility
that has been specifically designed for clinical use.
It is located in the DHMC Division of Radiation
Oncology and shares a room with the hyperbaric
oxygen facility. Initial studies, using approved
protocols, will measure the oxygen in tumors
during radiation therapy, and also in vulnerable
tissues in peripheral vascular disease. Clinicians
will know the status of the oxygen in these critical
tissues, and can apply this information to stage
disease, measure the response to therapy, or modify
the treatment of individual patients. This should
enhance the therapeutic ratio and effectiveness of
the therapy. We also are conducting the initial
studies for dosimetry in human subjects, based on
radiation-induced EPR signals in teeth, in the
clinical EPR facility while the magnet for the
transportable version of this instrument is being
constructed. Additional clinical studies that we will
begin shortly include measurements of
oxygenation in wounds during healing, and the
effects of hyperbaric oxygen on tissue oxygenation.
This research is supported through the EPR
Center and by private donations.

EPR External Funding and Recognition
We believe that the most important indication of
external recognition is success in obtaining external
funding; in publication of papers and books; in
requests to review manuscripts and to serve on
editorial boards of leading journals; and in
invitations to participate as featured speakers in
scientific meetings. Judged by these criteria, our
productivity has continued to expand significantly.

The average annual external support for grants
directly to personnel of the EPR Center has
averaged about $1.2 million (direct costs) during
this period. The support comes principally from
three long-term grants from NIH. There also has
been substantial support from shorter term grants
from NIH, from industry for collaborative
research, and from private donations. The faculty
and staff of the EPR Center also are named
collaborators and co-investigators on other grants
that have approximately $500,000/yr. in annual
direct costs.

---

Magnetic Resonance Spectroscopy and Imaging Laboratory
(Biomedical NMR Laboratory)

Jeffrey Dunn, PhD, Director

The Radiology Department’s Biomedical NMR
laboratory continues to impact multiple areas
of basic research, teaching and development in
Dartmouth College, Dartmouth Medical School,
Thayer School of Engineering, and in DHMC
Diagnostic Radiology. Dr. Dunn’s laboratory
focuses on the field of cerebral oxygenation and
energetics, and is developing a new NMR/optical
imaging modality to study brain metabolism and
oxygenation. Dr. Dunn also assists in a range of
MR projects undertaken by students, faculty and
outside companies interested in utilizing the
investigative advantages of Radiology’s 7T animal
MR scanner.

NMR Research
The main focus of the laboratory continues to be
the study of brain metabolism and oxygenation.
Advances in NMR imaging technology have
allowed us to image cerebral blood flow without
contrast agents in animals. We hope that this pre-
clinical work will translate to future human
studies. Our tumor biology research has shown
that the oxygenation status of glial tumor models
can be manipulated by breathing hyperoxygenated
gas, and that the capacity of the tumor to respond
depends on its capacity to regulate blood flow.
Such imaging methods could potentially identify
brain tumors which would respond poorly to
radiation treatment, and which would require
other treatment methods. Our study of how the
brain physiologically responds to anesthesia is one
important component in understanding the
appropriate use of “anesthesia cocktails.” We have
shown that an anesthesia cocktail, commonly used
in animal models, causes a reduction in cerebral
blood flow. To study the brain’s capacity to adapt
to low oxygen, we stimulated the natural
responses by adapting animals to low pressure,
and were able to increase brain capillary density by as much as 50% within 3 weeks. Such a change in vessel density has a major impact on the delivery of oxygen to the brain. In the future, this information may help capitalize on the brain's natural mechanisms to improve blood flow in humans after trauma and stroke.

The work on blood vessel growth is being done in part with a physiology PhD student, Ms. Marcie Roche. In collaboration with Genzyme, we are studying the potential to manipulate the brain's response to hypoxia and ischemia via modifying the brain's genetic material.

Our main technological focus is to combine near-infrared imaging with NMR imaging. We have recruited Roger Springett, PhD, from London, England, to construct the NIR system, and have undertaken a major collaboration with the Thayer Engineering School (Brian Pogue, PhD, Hahmid Deghani, PhD, and Keith Paulsen, PhD) to study methods of reconstructing these new images. We also have a PhD student, Mr. Heng Xu, working on these reconstructions. This new imaging modality will be able to obtain spatially resolved data on cerebral blood flow, blood oxygenation and blood volume—parameters which are key to understanding and tracking responses to cerebral ischemia and to studying brain tumor biology.

As a multidisciplinary NMR facility, we continue to encourage collaborations. Our main collaboration continues to be with Dr. Harold Swartz, in the department's national Electron Paramagnetic Resonance (EPR) center. We have shown that we can monitor brain tissue pO2 (oxygen partial pressure) over months in awake animals using EPR oximetry. We are using this to study brain oxygenation during exposure to low oxygen conditions. We are also developing methods of studying brain tumors in transgenic mice, working with the laboratory of Dr. Mark Israel, Director of the DHMC Norris Cotton Cancer Center. In conjunction with the Cardiology Section, including Dr. Michael Simons, we are studying the development of new blood vessels and vasculature after the onset of ischemia. We are collaborating with Dr. Barney Dwyer of the VA to study edema formation after traumatic brain injury. Methods for tracking cells with MR contrast agents are in development with Dr. Elijah Stommel, who is studying toxoplasmosis infiltration in the brain. The high field of the 7T NMR system continues to be of benefit to those working on microimaging (the NMR microscope). This includes the work of Dr. Douglas Goodwin in the area of cartilage structure.

**NMR Teaching and Development**

Dr. Dunn initiated a graduate elective course in Physiology, which teaches how MRI and Magnetic Resonance Spectroscopy (MRS) can be used to study disease models. This course attracted students from the Medical School, Dartmouth College and the Thayer School of Engineering. Dr. Dunn continues to work as a consultant in Diagnostic Radiology's clinical MR spectroscopy program. The new Dartmouth Medical School elective on spectroscopy has been taken by three medical students and one resident. We collaborate in teaching with the Thayer School of Engineering, where our faculty members give guest lectures in the biomedical imaging course. There is a steady stream of medical students, undergraduate students, and PhD students in the NMR laboratory, who study brain metabolism, high-field NMR imaging and optical imaging.

**NMR Funding**

Grant funding has been continuous, with Dr. Dunn having an NIH RO1 and a component of Dr. Swartz's PPG through this period. Dr. Julia O'Hara has also contributed to the NMR center through her PPG component. An NIH shared equipment grant was used to add a new Varian console to the 7T NMR system. An NIH RO1 is funded to combine optical imaging with NMR imaging to study brain oxygen delivery. We will continue to focus on imaging oxygen with MRI. Future funding initiatives are directed to the study of angiogenesis in brain, and the manipulation of brain biochemistry and physiology to improve outcome from stroke.
Outcomes Research
William Black, MD, Director

In 1991, Dr. Black was recruited to DHMC by Dr. Peter Spiegel, chairman of the Department of Radiology, and Dr. John Wennberg, director of the Center for Evaluative Clinical Sciences (CECS) to involve DHMC Radiology in outcomes research and enrich the educational resources of the department. Since his arrival, Dr. Black has written numerous articles about both the theory and practice of screening. Specific topics that he has written about during the past two years include the following: the quality of the medical literature in regard to radiological testing and its effects on outcomes; the decision analytic approach to evaluating population-based health; and bias in the classification in cause of death. However, the one topic that Dr. Black has written and spoken about most frequently is screening for lung cancer with helical CT.

Prior to 2002, Dr. Black received support from the American College of Radiology Imaging Network (ACRIN) to help design a multi-center randomized clinical trial of lung cancer screening. The National Lung Screening Trial (NLST) proposal was finally approved and funded by the National Cancer Institute (NCI) in November 2002. Dr. Black is the local principal investigator at DHMC, which plans to enroll 1,000 participants (about 300 were enrolled as of May 2003). This study is the first randomized clinical trial of a screening intervention performed at DHMC.

Dr. Black is very involved in educational activities. He developed a core curriculum for radiology residents and others interested in technology assessment. The curriculum, which focuses on basic principles of testing, screening, and quantitative decision analysis, consists of classic articles from the medical literature, formal lectures, workshops, and problem-solving exercises. Dr. Black teaches the curriculum to radiology residents at noon conferences and during individualized sessions focused on specific research projects. He also teaches the curriculum to medical students, non-radiology residents and fellows, and students in the CECS MS and PhD programs in a variety of forums at DHMC. Dr. Black is also frequently invited to lecture at other medical centers and national meetings, including the annual meeting of the Radiological Society of North America.

Because of his work and reputation, Dr. Black has been asked to serve on several national advisory committees related to screening. These include 1) Monitoring and Advisory Panel for Multi-Center Prostate, Lung, Colon and Ovary Screening Trial, National Cancer Institute; 2) American College of Radiology Commission on Research and Technology Assessment; 3) American College of Radiology Screening Task Force; and 4) Numerous NCI-sponsored workshops on lung cancer screening.

Functional Magnetic Resonance and Brain Morphometry Research Program

Andrew J. Saykin, PsyD, Director

Functional MRI (fMRI) is a noninvasive technology that uses local changes in blood oxygenation to map brain activity. Morphometry is the study of volume and 3D shape features of normal and lesioned brain regions. DHMC’s fMRI and morphometry research program is a collaborative, multidisciplinary brain imaging effort, with investigators from Psychiatry, Radiology, Neurology, Neurosurgery and other departments at Dartmouth Medical School, plus faculty from Computer Science and Cognitive Neuroscience at Dartmouth College.

Our research program has four major goals:

(1) Clinical Neuroscience Research—Apply advanced functional and anatomic imaging technology to better understand brain disorders and their mechanisms, with the ultimate aim of enhancing diagnostic assessment, treatment planning and outcome measurement. For functional imaging research, we currently use fMRI, but in the future may include other functional modalities, such as PET and SPECT.

(2) Advanced Education and Training—Provide training and experience for new neuroscientists in functional and morphometric neuroimaging research.

"An innovative two-year postdoctoral fellowship in Clinical Neuropsychology and Neuroimaging Research, developed at DHMC, is the first in the country to graduate clinical neuroscientists with combined formal training in both areas."

Andrew J. Saykin, PsyD, Director of the fMRI and Brain Morphometry Research Program
(3) Technical Development—Develop, assess and validate emerging technologies that optimize the use of fMRI, including stimulus delivery systems and image processing strategies.

(4) Study Normal Human Brain Function—Further the understanding of normal brain function from a developmental life-span perspective including sources of variability among individuals.

Facilities for fMRI at Dartmouth include several 1.5T MRI units in DHMC Diagnostic Radiology, the Brain Imaging Laboratory located in DHMC Psychiatry, and a research-dedicated 1.5T magnet at Dartmouth College. These facilities bring state-of-the-art brain mapping capability to the Northern New England region; DHMC is the only medical center between Boston and Montreal that currently employs this advanced technology. Looking ahead, a new Advanced Imaging Research Center is under construction.

An integrated program of sponsored research on fMRI and brain morphology investigates a range of neurological and neuropsychiatric disorders using advanced neuroimaging methods. Our program emphasizes disorders affecting memory, language and executive and attentional processes. Executive functions in the human brain are critical for the overall organization of behavior, application of learning strategies, and for solving daily problems. The frontal lobes are the cornerstone of a brain network that underlies these functions. Sponsored research at the Brain Imaging Laboratory (BIL) includes studies of preclinical Alzheimer’s disease, traumatic brain injury, multiple sclerosis, epilepsy, stroke, schizophrenia, post-traumatic stress disorder, obsessive-compulsive disorder, and bipolar affective disorder.

Sponsored research at the Brain Imaging Laboratory (BIL) includes studies of preclinical Alzheimer’s disease, traumatic brain injury, multiple sclerosis, epilepsy, stroke, schizophrenia, post-traumatic stress disorder, obsessive-compulsive disorder, and bipolar affective disorder.

The DHMC fMRI research group has active federal grants from the National Institute of Neurological Disorders and Stroke, National Institute on Aging, the National Institute of Disability and Rehabilitation Research (US Department of Education), the National Cancer Institute and the National Science Foundation, and State support from New Hampshire Hospital. Foundation and industry support includes the Alzheimer’s Association, the Anxiety Disorders Association of America, the Hitchcock Foundation, the Ira DeCamp Foundation, the National Alliance for Research on Schizophrenia and Depression, the National Multiple Sclerosis Society, the Neuroscience Education and Research Foundation, the Obsessive-Compulsive Foundation, Pfizer Inc. and the Stanley Medical Research Institute.

Another important goal of the fMRI research program has been training young scientists in neurocognitive, neuroimaging and computational techniques. An innovative two-year postdoctoral fellowship program in clinical neuropsychology and neuroimaging research developed at DHMC is the first in the country to graduate clinical neuroscientists with combined formal training in both areas. Advanced training for faculty has resulted in clinical research career development awards. For example, Heather Wishart, PhD, is studying the use of advanced neuroimaging to examine the basis of cognitive and motor symptoms in patients with MS (2001-2004). Medical students, residents in neurology and psychiatry, and undergraduates from pre-medical and science programs have participated in research rotations. In collaboration with Dartmouth’s Computer Science Department, several PhD students are completing computer science theses on joint fMRI and morphometric projects, jointly supervised by Fillia Makedon, PhD, Professor of Computer Science. Some examples of topics being researched by these CS PhD students include “Characterization and Classification of Human Brain Data: Spatial Comparisons of fMRI Brain Activations” (James C. Ford) and “Data Analysis and Mining of Structural Brain Images” (Li Shen).

Highlights from Recent Published Research by the Brain Imaging Laboratory include:

• Alzheimer’s Disease. The Alzheimer’s team, led by Dr. Saykin, published some of the first fMRI findings on memory in AD and the relation of
fMRI changes to atrophy. Expanded regions of activation in patients suggest compensation for degenerative changes. The clinical application of this research includes early diagnosis and assessment of medication effects for Alzheimer's patients. Early detection has become increasingly important, and an ongoing 5-year NIH grant focuses on the earliest stage known as mild cognitive impairment or MCI. Results of a new study using fMRI to measure medication effects suggests that cholinergic enhancement boosts frontal lobe function during working memory in patients with MCI. Working memory is temporary “on-line” storage and processing of information. One aim of our research is to determine if such functional enhancements in Alzheimer's patients (expanded regions of activation, and enhanced frontal lobe function) have temporary or longer lasting effects, and whether genetic risk factors can predict outcomes.

**Traumatic Brain Injury (TBI).** The TBI team, led by Thomas McAllister, MD, published the first controlled study using fMRI to examine brain activation patterns during working memory after mild TBI. These results suggest that, in the absence of visible structural abnormalities, there are physiological activation differences during working memory. One of our goals is to study whether such differences occur in all people with traumatic brain injury, or in only some people depending on the severity of the injury and factors such as genetic risk. Two ongoing grants are using fMRI to evaluate neuropharmacological treatment of TBI-induced memory problems by stimulating dopamine and adrenergic pathways.

**Schizophrenia.** Patients who are unaware of their mental illnesses are much less likely to avail themselves of, and comply with, treatment. Laura Flashman, PhD, recently published the novel finding that “unawareness” was associated with smaller brain size, suggesting a neural basis for this symptom. In related work on memory circuits, the DMS schizophrenia team used advanced morphometric techniques to show that the shape of the hippocampus, a structure critical for memory, is different between schizophrenia patients and healthy controls. In this study, imaging of a person's hippocampus could be used to predict whether that person is normal or schizophrenic with high accuracy using sophisticated shape analysis measurements. On fMRI, schizophrenic patients also showed an abnormal pattern. We are actively studying the association between abnormal brain function and psychiatric conditions other than schizophrenia, as well. For example, Robert Roth, PhD, received grants to study bipolar disorder and OCD with fMRI.

**Multiple Sclerosis.** Heather Wishart, PhD, used fMRI and MRI-based lesion analysis to examine brain reorganization of motor and memory systems in response to “lesion load” in MS. (MS involves distributed plaques in the brain, and “lesion load” or “burden” refers to the total volume of brain tissue classified as plaques.) She found that the brain's neural circuitry reprograms or adapts in response to the injury from the lesion. In collaboration with the Dartmouth Multiple Sclerosis Center, we are also using MRI to quantify how some novel immunomodulating medications for MS affect lesion burden.

**Cancer Chemotherapy.** In NCI-sponsored studies, Drs. Saykin, Ahles and colleagues have reported on how advanced brain imaging can examine the mechanisms underlying cancer chemotherapy's negative effects on cognitive function. These changes, sometimes referred to as “chemo-brain,” occur in some patients undergoing chemotherapy—but the neural basis has not previously been systematically investigated with neuroimaging. Because white matter changes have been reported after cancer treatment, diffusion tensor imaging (DTI), a new technique implemented at the BIL last year, is expected to be particularly useful for this study.
Richard Morse, MD, Director

The Veterans Affairs (VA) Medical Center has realized a 22% growth in the number of examinations over the last two years. This is due primarily to the very successful strategic effort made to increase the number of veteran enrollees. We continue to have four Community-Based Outpatient Clinics, serving the cities of Burlington, Vermont; Rutland, Vermont; Bennington, Vermont; and Littleton, New Hampshire.

The VA Radiology Section's administrative responsibilities are handled by Dr. Richard Morse, who is also acting Chief of the VA Radiology department, and supervisor of the cross-sectional division. We continue our efforts to recruit a full-time general diagnostic radiologist. Due to the section's persistent staffing vacancies, a locum tenens service has been contracted to fill 1.0 of the 1.5 FTE radiology vacancies. The market for qualified radiologists continues to be very challenging nationwide. We are hoping that in the near future we may secure permanent staff who can fulfill the section's needs, both in managing clinical workload, and in teaching our medical students and residents.

The VA's Department of Medicine recently recruited a new service chief, Dr. James Geiling, to replace Dr. Peter Mogielnicki, who retired last year. Dr. Geiling is a critical care specialist who was the former director of the Health Care Clinics at the Pentagon. He also previously taught and practiced clinical care medicine at Walter Reed Hospital, and is a recognized national leader in the areas of emergency preparedness and bioterrorism. Dr. Frank Pindyck, the VA's Chief of Surgery, has continued to expand the surgical service by returning previously lost capabilities and instituting new services. This surgical expansion has led to an increased role for radiology, enabling us to provide additional valuable services to our veteran patient population, such as percutaneous carotid artery stents and abdominal aortic endograft placements. We continue our efforts to recruit doctors for additional surgical specialties (urology, general surgery and orthopedics), as well as medical specialists in gastroenterology and cardiology. Our expanded services strengthen our institution, and provide patients with more convenient access to a wider array of treatments.

It continues to be challenging to secure capital for equipment purchases. However, we have recently acquired two important pieces of equipment. One is a digital radiographic/fluoroscopic unit and the other a dual-headed gamma camera. We have begun installing both pieces of equipment, and we anticipate they will be “up and running” this summer. These enhancements, along with our previous digital equipment, have put us closer to our goal of having a filmless radiology department. The VA has already made a substantial investment in the development of a high-speed network that our digitally-capable pieces of equipment will utilize. Our local clinicians, and off-site consultants within VISN 1, will conveniently access these images at their desktop computers, via the VISTA Imaging capability of the electronic medical record. They will also have access to EKGs, pathology (both gross and microscopic specimens), endoscopic and fundoscopic evaluations, and scanned reports from outside institutions. This capability will save clinicians’ time, and should enrich the educational experience for students, house staff and clinicians. The ability to transfer comprehensive patient information throughout the VA system, expected to occur in the near future, will be invaluable.

Two vital aspects of the VA’s mission are education and research. Recently, due to staffing limitations, there has been a reduction in the time that the radiology residents are spending at the VA. Rather than five days a week they are now rotating to the VA for three half-days a week during a four-week interval. It is our goal to recruit and stabilize our radiology staff to a level that we can once again offer a full-time radiology resident rotation within our section. We do, however, continue our teaching of the medical residents/interns and medical students through conferences, which include a daily medical conference as well as weekly tumor board, morbidity and mortality conference, and combined gastrointestinal/surgical conference. Consultations with the attending staff are frequent, which provides an effective method for communicating clinical information and follow-up.

There is an ongoing multi-center collaborative research effort, the National Lung Screening Trial, locally led by Dr. William Black, which will assess the utility of screening CT scans for the detection of lung cancer. An additional area of study includes the ultrasound assessment of the penis in patients with Peyronnie's disease. The goal is to
measure the plaques which occur in this disease process, before and after treatment. Dr. James Lenz, who heads the VA's Interventional and Nuclear Medicine sections, has been actively involved with the Dartmouth Medical School (DMS) Anatomy Department to develop a database of diagnostic images which are linked to clinically relevant teaching cases. Once completed, this repository of clinically correlated diagnostic imaging and anatomy will be an invaluable tool for the teaching of medical students. Dr. Susan Harper dedicates half of her time to the Medical School as Assistant Dean of Medical Education. The main focus of her job is to advise the medical students in years 3 and 4 as they proceed through the residency application process. She also acts as the DMS school official to the National Residency Matching Program, overseeing the Electronic Residency Matching Program for DMS, and directing the Mock Internship Interview Course.
As in most institutions, the increasing use of computed tomography to assess patients has prompted a dramatic increase in demand for scanner time. To meet these needs, we added a third helical scanner, General Electric’s 16-row Lightspeed scanner. Our section’s technical staff has grown to 11 CT technologists and one CT tech aid. The added human- and machine-power allows us to handle many more emergent patients, and to offer imaging appointments in the desirable daytime hours.

We are proud of our technological capacity. Our new 16-row scanner lets us perform intricate vascular and three-dimensional work. This enhanced imaging capacity inspired us to buy several three-dimensional workstations, including the Vitrea workstation manufactured by Vital Images. This powerful system is helping us produce remarkably lifelike 3D images. Several of our technologists and faculty attended hands-on training sessions in Minnesota, and we can now perform angiographic imaging, excretory urographic imaging, and endolumenal imaging. All these areas are likely to see rapid growth in the near future.

CT was fortunate to be one of the first sections to utilize the department’s PACS system, which allows us to read digital CT, ultrasound and MR images, and links them to the electronic patient record. The change is phenomenal, allowing us to read studies in record time. Clinicians can now review CT studies from outside of the department, which helps tremendously as they negotiate their busy clinical schedules.

Despite the CT section’s technological advances, we still maintain patient care at the forefront. Spurred by personal interest and the recent media concerns over radiation exposure, we have mounted a tremendous effort to minimize radiation doses when performing our CT studies. It is paramount to reduce radiation exposure in all patients, but particularly when caring for pediatric patients, and men and women of reproductive age. Influenced by the work of several prominent radiologists, including Dr. Donald Frush at Duke University Medical Center, we have updated our scanning dose reduction based upon patient weight for pediatric patients. We have also reduced our scanning doses for chest CT scans, and for abdomen and pelvis studies aimed at assessing possible urolithiasis, dropping our scanning techniques by roughly 50%.

CT research continues to grow. Dr. William Black is leading the DHMC component of the National Lung Cancer Screening Trial, performing screening chest x-rays or screening unenhanced CT examinations of the
chest on qualified patients at risk. Several other researchers at DHMC (radiologist Dr. John Gemery, and radiology research fellow Dr. Zhenwu Zhuang) are using our enhanced CT angio capabilities to examine the etiology and treatment of many complex vascular processes. The CT section also actively supports the numerous investigators at the Norris Cotton Cancer Center, by providing imaging for patients on various treatment protocols.

Lectures covering the computed tomographic findings of various disease processes have largely been incorporated into individual sections such as neuroradiology, thoracic imaging, uroradiology, etc. However, we have developed several core lectures to help residents handle the myriad of CT cases they will encounter as they take call over their 4 years of residency. The new lectures focus on abdominal imaging, and cover the examination of the trauma patient, the assessment of urolithiasis with computed tomography, and the evaluation of acute abdominal pain using CT. By providing dedicated lectures in these areas, we hope to help residents feel more comfortable when using CT to evaluate complex patient cases, and to help them better design their CT studies, when “on call” and subsequently, as they enter practice.

---

**Body Imaging – MRI**

*Michael J. Tsapakos, MD, PhD, Director*

Body MRI consists of MRI examinations of the chest, abdomen and pelvis and has grown significantly in the past two years. (MRI of the musculoskeletal system and head is conducted by our two separate divisions, Musculoskeletal Radiology and Neuroradiology.) Body MRI is used as an adjunct to body CT in specific cases to augment and/or clarify findings noted on CT; one such use is hepatic imaging. MRI has liver-specific intravenous contrast agents for the MR evaluation of liver abnormalities. Another application of body MRI is kidney imaging, where MRI helps clarify kidney lesions. (The MR image shows whether a lesion contains fat, which determines if it is benign or malignant; the same holds true for an adrenal gland lesion). MRI allows the radiologist to modify the contrast in fat and “negate” fat. MRI also helps augment pancreatic imaging. We have recently developed a Cardiac MRI program in conjunction with Dr. Justin Pearlman and the Cardiology Department (see separate clinical report on Cardiovascular Imaging).

The overall number of body MRI examinations performed has increased by 39 percent in the past two years (2001-2002 as compared to 1999-2000). We maintain two 1.5 T magnets, plus one mobile 1.5T magnet. We have been using the third permanent MRI magnet (a GE 1.5 Tesla Twin Speed with EXCITE technology) since its installation in July 2003 in the new MR3 building. Our exam volumes and equipment upgrades reflect an increased need in the community and demand by clinicians for MRI services overall. We have periodically upgraded the software to state-of-the-art availability, and updated the MRI sequences to provide faster exams and shorter scan times. Many examinations are now performed using single breath-hold techniques, virtually eliminating breathing motion artifact. The result is very clear images.

A corollary to body MRI is body magnetic resonance angiography, MRA. This area has seen a particularly strong growth with the number of examinations performed increasing 65 percent in a two-year period (2001-2002 versus 1999-2000). We routinely use gadolinium-based contrast agents combined with breath-hold techniques. The gadolinium chelates have been shown to have negligible effects on renal function in patients with renal failure, unlike iodinated agents, used in CT, which have a deleterious effect in patients with compromised kidney function. At DHMC, patients with a history of renal disease or a history of allergy to iodinated contrast agents routinely undergo MR imaging. These conditions are a major indication for MR vascular and body imaging.

Education continues to have a high priority in the Body MRI Division. Our cross-sectional imaging fellows actively participate in reading the MRI studies, while learning the intricacies of the imaging parameters, which we individually tailor to answer each patient’s clinical questions. We have incorporated cardiac imaging into our residency training as an adjunct effort with
Cardiology. Our dedicated and conscientious team of MRI technologists maintain their technical expertise with periodic continuing medical education.

A bimonthly body MRI conference is given which reviews the prior two week’s cases, with discussions of the pathology and techniques used in the examination. This conference is open to all and is well-attended by our residents. In addition to conferences within our department, Dr. Tsapakos has given conferences on various topics in MRI to other departments within DHMC, helping clinicians outside of radiology learn the wide utility of MRI in body imaging. We attend the weekly multidisciplinary genitourinary-radiology conference, the gastrointestinal tumor board conference, and a GI-radiology conference to review MRI and CT studies in a case presentation format. We work closely with the GI Department to provide service to their patients; MR cholangiopancreatography (MRCP) is a growing noninvasive corollary to endoscopic retrograde cholangiopancreatography (ERCP). Dr. Tsapakos is a speaker at the annual hepato-cholangiopancreatography conference, sponsored by the Gastroenterology Department.

Body MRI provides many opportunities for investigational research. We have recently completed a multicenter trial, funded by Mallinckrodt Medical, of a new formulation of contrast agent, gadolinium chelates, for tumor imaging. Our research team helped participate in getting this contrast agent approved by the FDA. We are involved in other clinical trials to approve separate formulations and applications of gadolinium chelates.

Our goal is to maintain excellence in the Body MRI Division, meeting the needs of the community through additional updates in our technology, continued educational efforts both inside and outside of the department, and continued advances through research. Areas of future increased utilization of body MRI include cardiac MRI, hepatobiliary MRI, and MRA.

---

**MRI Annual Volumes, 1999 to present**

<table>
<thead>
<tr>
<th>Year</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>1999</td>
<td>2,000</td>
</tr>
<tr>
<td>2000</td>
<td>4,000</td>
</tr>
<tr>
<td>2001</td>
<td>6,000</td>
</tr>
<tr>
<td>2002</td>
<td>8,000</td>
</tr>
<tr>
<td>2003</td>
<td>10,000</td>
</tr>
</tbody>
</table>

---

**MRA Annual Volumes, 1999 to present**

<table>
<thead>
<tr>
<th>Year</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>1999</td>
<td>400</td>
</tr>
<tr>
<td>2000</td>
<td>1,200</td>
</tr>
<tr>
<td>2001</td>
<td>1,600</td>
</tr>
<tr>
<td>2002</td>
<td>2,000</td>
</tr>
<tr>
<td>2003</td>
<td>2,000</td>
</tr>
</tbody>
</table>

---
Breast Imaging

Helene Nagy, MD, and Steven Poplack, MD, Co-Directors

The Breast Imaging Center (BIC) provides routine screening, diagnostic and interventional services. There has been a steady growth in volume, with over 32,000 exams performed in the past two years, including 1,000 image-guided core needle biopsies and 72 sentinel lymph node injections.

The division will soon have its first full-field digital mammogram unit, located in the main department. In addition, two screening mammogram units are planned for the new outpatient facility. The main hospital site will also enlarge, with a new dedicated ultrasound/biopsy room and a consultation room.

The Breast Imaging Division is a component of the Comprehensive Breast Care Program (CBCP) at DHMC which co-ordinates and oversees interdepartmental breast cancer patient care. Dr. Helene Nagy and Dr. Steven Poplack participate in the weekly CBCP tumor board, which is also an interdepartmental teaching and CME accredited conference. They also co-ordinate and run the monthly Pathology-Radiology review session, where core needle biopsy (CNBX) cases are reviewed and discussed.

Teaching is an integral part of the BIC. Each radiology resident has three, month-long rotations in the BIC, during which they are taught all aspects of breast imaging from screening to diagnostic workups to interventional techniques. Also, we provide monthly didactic lecture and senior oral board review sessions. The BIC is committed to providing a learning experience for the senior surgical residents, and for fourth-year medical students, in the Women’s Health elective through the Department of Obstetrics and Gynecology.

The Breast Imaging Division is engaged in scientific research on a number of different fronts. The staff of the BIC continues to support the New Hampshire Mammography Network, which gathers and collates mammographic and pathologic data on registered New Hampshire women. Dr. Poplack and Dr. Claudia Kasales also actively participate in the scientific investigations conducted by the New Hampshire Mammography Network, which address the role of breast imaging in breast disease, and evaluate the effects of hormone replacement therapy on breast cancer. Under the leadership of Dr. Richard Barth (from the DHMC Department of Medicine’s Surgery Section) we have also contributed to a study on how breast cancer detection methods, like screening mammography, affect treatment decisions, including the need for
mastectomy and chemotherapy.

The division is also active in the NCI Alternative Breast Cancer Imaging Modalities grant. This major research effort, now in the fourth year of a five-year program, aims to study several alternative breast imaging techniques, based on near-infrared and electrical impedance imaging. In concert with engineers from Dr. Keith Paulsen’s lab at Dartmouth’s Thayer School of Engineering, Dr. Steven Poplack and Dr. John Weaver have developed three entirely novel ways to image the breast using near-infrared laser light, electrical current and microwave transmissions. Over the past two years we have fine-tuned these systems and tested them on normal volunteers. We have begun to recruit women for a formal clinical trial to test the usefulness of these methods in characterizing breast disease.

In concert with engineers from Dr. Keith Paulsen’s lab at Dartmouth’s Thayer School of Engineering, Dr. Steven Poplack and Dr. John Weaver have developed three entirely novel ways to image the breast using near-infrared laser light, electrical current and microwave transmissions.
Cardiovascular Imaging
Justin Pearlman, MD, ME, PhD, Director

Cardiovascular disease is the leading cause of death and disability in America, affecting more than one in four readers of this article plus many more. Cardiovascular disease is usually silent (or asymptomatic) until it threatens or presents with catastrophic damage. Related problems include angina (chest heaviness), fainting, palpitations, atherosclerosis, cardiac arrhythmia, cardiomyopathy, dyspnea (shortness of breath), heart failure, chronic venous insufficiency, diabetes, heart attack, high cholesterol, high homocysteine, high triglycerides, hypertension, insulin resistance syndrome, mitral valve prolapse, endocarditis, aortic stenosis, aortic aneurism, coarctation, transient ischemic attacks, and stroke. Many risk factors associated with cardiovascular disease may be managed to slow down, prevent, or even reverse the development of cardiovascular disease. Until age 50-60, men are at greater risk than women of developing heart disease (over twice the risk before age 35), though once a woman enters menopause, her risk catches up to that of men. Because cardiovascular disease is so often “silent,” we are developing new preventive techniques to detect the disease in time to avoid catastrophic consequences and also to guide the treatment approach and dosage.

The Cardiovascular Section is a joint effort of the Radiology and Cardiology/Medicine Departments. Under the direction of Justin D. Pearlman, MD, ME, PhD, Dartmouth-Hitchcock Medical Center now offers advanced cardiovascular imaging including cardiac MRI, with detailed function evaluation, strain mapping, perfusion, and other advanced capabilities. New clinical applications include:
• Diagnosis of aortic disease, including dilated aorta, possible dissection or coarctation.
• Diagnosis of intracardiac or paracardiac mass or tumor or cyst.
• Evaluation of an aneurysm or pseudo-aneurysm.
• Precise measurement of LV or RV dimensions and function.
• Evaluation of unexplained exertional dyspnea for assessment of restrictive cardiomyopathy or constrictive pericardial disease and determination of presence and extent of pericardial adhesions.
• Evaluation of unexplained fainting for RV dysplasia or aberrant coronary origins.
• Precise scar mapping to delineate ischemic damage in patients with CHF and/or to determine viability and potential for benefit from revascularization.
• Measurement of LV mass, stroke volumes, accurate dimensions, EF and ejection curves to follow patients for timing of valve replacement or transplant referral.
• Diagnosis of myocarditis.
• Anatomic and functional imaging in patients with poor echo views.
• Custom evaluations for specific unresolved clinical questions.

Cardiac PET is also now clinically available for assessment of myocardial viability by insulin clamp fluorodeoxyglucose imaging.

It is vitally important to screen the general population to identify coronary artery disease.

Prevalence of Cardiovascular Diseases in Americans Age 20 and Older by Age and Sex
United States: 1988-94

<table>
<thead>
<tr>
<th>Age Group</th>
<th>Females</th>
<th>Males</th>
</tr>
</thead>
<tbody>
<tr>
<td>20-24</td>
<td>5.5</td>
<td>4.6</td>
</tr>
<tr>
<td>25-34</td>
<td>10.4</td>
<td>6.1</td>
</tr>
<tr>
<td>35-44</td>
<td>17.4</td>
<td>10.4</td>
</tr>
<tr>
<td>45-54</td>
<td>34.2</td>
<td>28.9</td>
</tr>
<tr>
<td>55-64</td>
<td>51.0</td>
<td>48.1</td>
</tr>
<tr>
<td>65-74</td>
<td>65.2</td>
<td>65.2</td>
</tr>
<tr>
<td>75+</td>
<td>70.7</td>
<td>79.0</td>
</tr>
</tbody>
</table>

Source: NHANES III (1988-94), CDC/NCHS
(CAD) and hope to forestall a major event by intervention. Without screening and identification, up to 50% of first presentations with CAD are death (650,000/year in US) or major heart attack with permanent disability. Coronary artery disease causes more than 25% of all deaths in people over 35. Intermediate diagnostic tests can help avoid the risks and costs of catheterization. A comparison of diagnostic costs for patients undergoing SPECT/ETT vs. PET Rb82 determined that PET yields a 36% savings in total management costs per patient, because of 50% lower false positive rate. Other clinical applications under development include perfusion-sensitive MRI and cardiac CT. Applied either as first tests or exams following marginal PET results, these might offer a lower false positive rate than PET. With further development, these MR and CT tests might be very helpful to select cases that require full bypass or minimally invasive bypass, leaving just intervention as the primary reason to go to the cardiac catheterization laboratory. Furthermore, cardiac CT and/or interventional MRI could play a very useful role in interventional catheterization by providing 3D visualization of blood vessels, yielding faster safer procedures, and determining the improvement in perfusion during the procedure to improve success rates.

The Cardiovascular Section performs clinical and basic research. We have a particular interest and expertise in the development of new vessels (angiogenesis) which has applications for very early cancer detection and treatment without toxic side effects, as well as improvement in blood supply in patients with ischemic heart disease or other vascular diseases, to “bypass bypass surgery” and restore blood flow without requiring surgery. We also are actively investigating molecular imaging, a set of techniques that offer the potential to identify the molecular basis for disease in individuals by imaging, and target treatment very precisely to maximal benefit while minimizing side effects, eliminating trial-and-error approaches.

The Dartmouth Advanced Imaging Center (DAIC) is completing the development of approximately 12,000 sq ft expandable space dedicated to research and development of advanced medical imaging. Planned modalities include a new whole body 1.5 Tesla MRI Excite twin gradient cardiac magnetic resonance imaging system, a 3.0 T MRI, cardiovascular CT, electron paramagnetic resonance imaging, ultrasound and positron emission tomography (PET), paired with micro-imaging capabilities. We hope to add more advanced imaging capabilities to the Dartmouth Advanced Imaging Center to include fast cardiac CT, positron emission tomography, three dimensional ultrasound, and electron paramagnetic resonance imaging, both whole body, and micro.

The center will apply multi-disciplinary teams to problems in cardiovascular imaging as well as cancer, brain, and breast imaging. Specific targets include very early detection and accurate image-based treatment guidance for heart disease and cancer. The new imaging capabilities of the DAIC will enable molecular imaging, the identification of changes in gene expression at the molecular level, accurate treatment delivery with molecular targeting to maximize benefit and minimize any side effects, and new minimally invasive image-guided and/or activated treatments and cures.

The Cardiovascular Section is very active in teaching. Residents, fellows, staff and visiting professors are trained in both theory and practice, including how to decide when advanced tests are most useful, when such tests are cost effective (often an “expensive” test actually saves money), what they show, how to use them to the best advantage, and what pitfalls to avoid. Medical students, residents and fellows participate in lectures on the theory and practice of cardiovascular imaging. Advanced imaging capabilities in this field change and expand constantly, so a student needs a solid foundation in the medical principles to stay on top of the technological advances. We aim to expand our teaching program, to bring in further top talent.

**Chest Imaging**

*William Black, MD, Director*

Chest imaging remains a major component of diagnostic radiology. Plain chest radiography and chest CT comprise about 20% of all procedures performed in the radiology department in 2003. Over the past two years, more than 100,000 chest radiographs and numerous chest CT scans were performed and interpreted. The number of chest CT scans to rule out pulmonary embolism continues to increase; we are now conducting about 40 such exams per month.

The PACS system has provided efficient new technology which helps us manage this continued
as well as a quiz. During the past several years, Dr. Black has greatly expanded his digital teaching file, which serves as a valuable resource for teaching. Dr. Black has also recently mentored a 4th year medical school student and future DHMC radiology resident, Paul Farris. Mr. Farris presented his and Dr. Black’s work, on the analysis of CT pulmonary arteriography interpretations, at the Annual Meeting of the American Roentgen Ray Society Meeting in May 2003.

The Chest Imaging Division is strongly involved in clinical research. Dr Black also conducts active outcomes research (see the Research Section of this Biennial Report for a description). During the past several years, Dr. Black has also written papers and given invited presentations on the subject of lung cancer screening (see presentations and publications).

Dr. Black has been integrally involved in the design and planning of the National Lung Screening Trial, a nationwide multi-center randomized clinical trial of lung cancer screening with helical CT. A member of the Cancer Control Research Program at the DHMC’s Norris Cotton Cancer Center, Dr. Black is one of five co-chairs for the trial. Dr. Black is also DHMC’s principal investigator for this research, and has been awarded a $3.7 million grant for this multi-year screening.

Now underway at DHMC’s Norris Cotton Cancer Center, the National Lung Screening Trial will compare two imaging modalities as early screening tests for lung cancer: the standard chest x-ray, and the spiral CT scan, the latter of which can be reconstructed into a three-dimensional model of the lungs. The research’s main goal is to determine if lung cancer deaths can be prevented by screening for the disease before symptoms appear. “Lung cancer kills more people than cancers of the breast, prostate, colon, and pancreas combined.” states Dr. Black. “Also, lung cancer is the single leading cause of death in smokers between the ages of 55 and 74 years.” The National Lung Screening Trial is enrolling 50,000 current and former smokers at 30 medical facilities around the country, with research to continue through 2009.
Diagnostic Physics

John B. Weaver, PhD, Director

Directed by John B. Weaver, PhD, the Clinical Physics Division continues to satisfy the quality control, regulatory and radiation safety requirements of the radiology department, including ACR accreditation for the mammography center, and inspections by the State of New Hampshire and the FDA. The quality of our safety programs is evidenced by the compliments we have received during annual inspections of the radiographic units and of the mammography center.

Dr. Weaver continues to teach diagnostic physics to radiology residents to satisfy that essential part of their residency requirements. All residents completing the program in the past two years have met the examination standards of the American Board of Radiology (ABR) in physics. (We updated our physics curriculum to match some radical changes in the ABR physics exam that have occurred in the past two years. Specifically, the ABR now uses fewer questions overall. They made the test include more conceptual questions, and fewer questions on details.) Dr. Weaver continues to teach parts of an introductory course in biomedical engineering and a bioinformatics course at Thayer School of Engineering. Dr. Weaver also started a four-month course on the physics of imaging for the cardiology fellows that will be taught biannually.

Research in radiological physics has been very productive. Dr. Weaver is working in several multidisciplinary groups that include faculty from the Thayer School of Engineering at Dartmouth College and the Department of Radiology. The first project, an effort to image the elasticity or stiffness of breast tissue, continues to progress, and is funded by the National Institutes of Health. The group involved in this effort includes Professors Keith Paulsen and Francis Kennedy from Thayer School, and Drs. Steven Poplack, Helene Nagy, and Marvin Doyley from the Department of Radiology. This group is one of only four in the world studying MR elastography, and has made significant contributions toward understanding the fundamental physical processes describing the elasticity in the breast, such as anisotropy, non-linearity and damping. The second interdisciplinary project studies microwave heating of the malignant breast cancer which has been detected using MR images. This group is funded by the DoD, and includes Professors Keith D. Paulsen and Paul M. Meaney from Thayer School. The third project studies simultaneous near-infrared optical and MR imaging. Near-infrared optical imaging can track blood oxygenization, but suffers from poor spatial resolution. The MR images will provide accurate maps of the anatomy that will improve the NIR reconstructions, as well as provide co-registered anatomical information to the radiologist interpreting the studies. This group is funded by the National Institutes of Health and includes Professors Keith D. Paulsen and Brian W. Pogue from Thayer School. Finally, in a fourth project, Dr. Weaver’s collaboration with Dr. Yvonne Cheung of Radiology, and Dr. Richard Comi of Endocrinology, has begun to use MR elastography to study the plantar soft tissues of diabetic patients.

Dr. Weaver continues his collaborations with Drs. Andrew Saykin and Thomas McAllister from the Department of Psychiatry, using fMRI to study psychiatric patients, and with Drs. Jeffrey Dunn and Douglas Goodwin from the Department of Radiology, studying the relaxation parameters of cartilage.

Gastrointestinal Radiology

Jocelyn D. Chertoff, MD, Director

The Division of Gastrointestinal Radiology continues its vital activity with steady growth and improvement in the clinical, educational and research arenas.

Our division seeks to constantly update our technology. Digital fluoroscopy improves cost effectiveness by allowing us to decrease film utilization. State-of-the-art digital units in three fluoroscopy rooms provide rapid, efficient studies while minimizing radiation exposure for both patients and staff. The speed of the digital units is especially important when performing pediatric studies. Our concurrent use of videofluoroscopy lets us further decrease radiation exposure, as well as expediting review and critique of the studies, both for teaching, and for documentation of real-time aspects of these dynamic studies. Having two pediatric radiologists has allowed us to add an in-house rotation in pediatric radiology, with a strong fluoroscopy component, thereby increasing our depth of coverage in pediatric fluoroscopy and strengthening our relationship with Children’s
Hospital at Dartmouth. We plan to upgrade to a pulsed digital fluoroscopy room, to further decrease radiation, especially for pediatric cases.

We are moving toward an increase in the utilization of tubeless enteroclysis, a dedicated small bowel contrast study better accepted by patients, which offers additional sensitivity for the evaluation of small bowel pathology. We also plan to start CT colonography, a noninvasive method of evaluating the colon. Working with our colleagues in Gastroenterology, we hope to have a significant impact on the need for colon screening for our aging population. The section has been approached by a local company, Creare, to collaborate in a study to improve the imaging technology for this exciting new approach to imaging the colon.

GI Radiology’s success is based, to a large degree, on our close collaboration with the medical center’s clinical services of Gastroenterology, General Surgery, and Internal Medicine. This collaboration is evident during the weekly multidisciplinary GI conference, which has been CME-accredited since 1993. Here, diagnostic and therapeutic issues are presented in a case-based format to house staff and students, and selected clinical problems are studied in depth through a collaborative process with the presentation of recent advances by subspecialty experts. The performance of imaging studies in a focused, expedient and logical progression is one positive outcome of this multidisciplinary conference. This has been enhanced by the presence of Dr. Michael Tsapakos, whose expertise in MRI imaging of the abdomen has strengthened our imaging armamentarium and enhanced the educational component of the conference. Local physicians from outside the medical center continue to attend this conference, bringing in new ideas and questions and strengthening our ties to the community. It has become a standard part of the program for visiting professors in gastroenterology.

We continue to implement the core curriculum in GI Radiology. Core presentations are given by department faculty and are supplemented by visiting professors, New England Roentgen Ray meetings, and Grand Rounds. One-on-one review of teaching file cases is a very useful and popular part of the fluoroscopy rotation, and Dr. Chertoff’s experience as a GI examiner for the American Board of Radiology examination enhances the review sessions held for the senior residents.

Dartmouth-Hitchcock Medical Center (DHMC) serves as a tertiary referral center for a large multi-state area, often requiring patients to travel long distances for their clinic appointments and their procedures. State-of-the-art expertise and technology are available at DHMC. However, the delivery of high quality care of patients with complex disorders requires both optimal coordination of the services provided by the different departments and close consultative communication among the physicians involved. Recognition of this need has led to the development of two important initiatives—the New England Hepatobiliary Disease Center and a multidisciplinary Swallowing Clinic.

The New England Hepatobiliary Disease Center (NEHBDC), whose mission is to become the leading center for the diagnosis and treatment of hepatobiliary diseases, is the result of a coordinated collaboration between Gastroenterology, Surgery, and Radiology. The NEHBDC focuses on the care of patients with complex hepatobiliary diseases that require multidisciplinary services. The NEHBDC’s goals include the provision of state-of-the-art diagnostic and therapeutic services for patients with hepatobiliary diseases, the promotion of research directed towards the development of new methods for diagnosing and treating hepatobiliary diseases, and the dissemination of information about hepatobiliary diseases.

We are also collaborating in the development of a multidisciplinary Swallowing Clinic, or “clinic without walls,” combining the expertise of specialists from Gastroenterology, Otolaryngology, Neurology, and Rehabilitation Medicine to streamline and coordinate care for patients with dysphagia and swallowing problems. The scheduling of these complex patients is expedited, to facilitate access to our experts and avoid the need for multiple trips to the DHMC. Monthly clinic meetings will allow multidisciplinary review of the pertinent studies and coordinated planning, and give the patient the benefit of a combined approach.

Our section continues its commitment to the improvement of communication with our referring physicians. We stress communication with the referring physicians, both before studies, to ensure that the specific clinical question is addressed, and after, with prompt communication of significant results.
Musculoskeletal Radiology

*Douglas Goodwin, MD, Director*

The Division of Musculoskeletal Radiology includes Douglas Goodwin, MD, and Yvonne Cheung, MD. Dr. Cheung joined the department in 2001, after working for many years at St. Vincent’s Hospital in New York and the Beth Israel Deaconess Hospital in Boston. She has extensive experience in musculoskeletal radiology, and a strong interest in foot and ankle imaging. The division provides image interpretation as well as consultation and interventional services for the medical center with particular focus on injuries and diseases of the bones and joints. Patients are typically referred from the Department of Orthopedics, the Section of Rheumatology, and the Emergency Department, which includes a Level One Trauma Center.

Although our division still spends a majority of our time in interpreting x-rays, we are steadily increasing our use of cross-sectional imaging, including MRI, CT and ultrasound. Our new state-of-the-art equipment lets us do the highest quality imaging of the musculoskeletal system. Interventional radiology, directed toward the musculoskeletal system, is also increasingly popular, and includes arthrography services, epidural steroid injections and biopsy of bone and soft tissue. Bone densitometry is performed with DEXA by three technologists who are all certified by the International Society of Clinical Densitometry (ICSD). DEXA measurements are interpreted by one of four physicians who are also certified by the ICSD; these include Dr. Alan Siegel, Dr. Jocelyn Chertoff, Dr. Goodwin, and Dr. Cheung.

The musculoskeletal radiology division’s education mission is centered on the month-long rotation of residents through our division. During that rotation, we give students the opportunity to interpret many diverse studies, and they gain experience in arthrography and biopsy techniques. Weekly orthopedics and rheumatology conferences, and a monthly osteoporosis conference, supplement the department’s lecture series.

In addition to the patient care and education missions of the division, both Drs. Goodwin and Cheung are active in ongoing research. Dr. Goodwin continues his research with Jeffery Dunn, PhD, in the MR evaluation of articular cartilage. The Hitchcock Foundation and the Radiological Society of North America have both provided funding for this work in the department’s NMR research center. Dr. Cheung has been funded by the Hitchcock Foundation to investigate the use of MR elastography in the evaluation of diabetic feet. She is working in collaboration with John Weaver, PhD, also of the Department of Radiology.

Recently, Drs. Dunn and Goodwin and members of the Thayer School of Engineering, including John Collier, PhD, and John Currier, MS, have begun a collaborative effort to correlate the structural and mechanical properties of articular cartilage with MR imaging. At this past year’s annual meetings of the RSNA and the Society of Skeletal Radiology, Drs. Goodwin and Cheung presented more clinically directed research, including exhibits of ankle imaging and MR imaging of articular cartilage.
Neuroradiology
Laurence Cromwell, MD, Director, and Alex Mamourian, MD, Co-Director of MR

Over the past three years, the Division of Neuroradiology has applied the department’s new technology to our latest clinical procedures to produce extraordinary images of the human brain. The advanced CT and PACS systems let us go “faster and farther” in creating and viewing digital angiographic images. In the clinical arena, we enhanced our division with new procedures, increased volumes of our standard procedures, hired an excellent new staff radiologist, and continued our close work with the departments of Neurology, Neurosurgery, Orthopedic Surgery, Otolaryngology, Ophthalmology, Anesthesiology, and Plastic Surgery.

Our focus on quality education was demonstrated by the Resident Teaching awards that our staff won in both 2001 and 2002, and also, the fact that our residents gained exemplary scores (in the 90th percentile) on the neuroradiology section of the national inservice exams.

We are proud to have Dr. Anthony Merlis as our “new” staff member. Dr. Merlis formerly led the DHMC Neuroradiology Division in the 1980s, then left in 1985 to pursue private practice in Wisconsin. He has returned “to the fold” part-time, and we welcome his expertise. Dr. Merlis is certified in both vascular and interventional radiology and neuroradiology.

Our clinical work includes the interpretation of routine and advanced neuroimaging studies and performance of interventional procedures. The general neuroimaging studies we offer include routine CT and MRI of the brain, spine, and head and neck; MR and CT angiography of the head and neck; MR diffusion weighted imaging; MR and CT perfusion imaging; single and multivoxel MR proton spectroscopy; functional activation studies with BOLD imaging evaluation; myelography, and cerebral and spinal angiography.

Interventional procedures include carotid artery stenting; preoperative embolization of head and neck and spine tumors; WADA testing; balloon occlusion testing; embolization for epistaxis; image-guided nerve root and facet injections; vertebral and head and neck biopsy, and vertebroplasty.

In 2001, Dr. Cliff Eskey introduced vertebroplasty to DHMC. Vertebroplasty is a minimally invasive procedure in which bone cement is injected into the spine in order to relieve the pain from compression fractures. This innovative procedure relieves many patients of back pain, in a less invasive and more immediate manner than traditional back surgery—and it allows them to gain back height they have lost to osteoporosis. Dr. Eskey and Dr. John Gemery have conducted over 50 procedures in the last two years.

Dr. Alex Mamourian’s clinical work focuses on MR spectroscopy and functional MRI (fMRI), an imaging technology in which different areas of the brain light up when a patient conducts different tasks.

Traditional angiograms yield the most detailed images of the brain’s vasculature, especially when there are suspected clinical problems. CT and MR angiography, done with vascular image contrast, provide a less invasive, yet high-quality, complement to angiograms. Our division has seen both a marked expansion of CT angiography and an increased
Our advanced neuro interventional cases are being managed by Alex Norbash, MD, from Brigham and Women's Hospital in Boston, through a special arrangement where Dr. Norbash comes to DHMC and/or patients go to him in Boston.

The CT Division has implemented pediatric-specific CT scanning protocols which limit radiation in children, and our division modified these further to make specific neurological study protocols for pediatric patients, based on head size and skull thickness.

The Neuroradiology Division gained a share in the department's new equipment, including the new CT scanner, and the PACS system that lets us view filmless CT and MRI images integrated with the patient electronic record. We have used the new MRI magnet (a GE 1.5 Tesla Twin Speed with EXCITE technology) since its installation in July 2003 in the new MR3 building. These advanced CT and MR systems make “faster and prettier” images, while the PACS allows us to view “soft copy” images from any PC. Clinicians may view images at the same time.

Dr. Eskey has developed a neuroradiology division website which can be viewed on the DHMC Radiology website. Go to the link http://www.dhmc.org/dept/radiology, select “Clinical Sections” from the menu bar at left, then select “Neuroradiology.”

Dr. Alex Mamourian won the Teacher of the Year Award in 2001. Not to be outdone, Dr. Cliff Eskey won the Teacher of the Year award in 2002!

We are honored that the DHMC radiology residents chose both of our staff neuroradiologists as Teacher of the Year. Also, our department's radiology residents gained high scores on national in-service exams, scoring in the 90th percentile in the neuroradiology division.

The Neuroradiology Division has maintained its strong links with all the neuroscience groups in the DHMC clinic. We continue our role as liaison with clinical neurosurgery and neuroscience (including neurovascular disease, neuro-oncology, and epilepsy). There are many joint teaching opportunities. Every Wednesday at 7am, we have our neuroradiology/ neuroscience conference. We also join Friday mega-rounds, or grand rounds with neurology and neurosurgery, whenever possible. We continue our weekly neuro-oncology tumor board session and monthly epilepsy surgery protocol (ESP) conference.

Dr. Cromwell has continued to be a guest examiner for the American Board of Radiology. In 2002, Dr. Cromwell also organized mock boards in May, inviting University of Vermont residents.

We have maintained our strong academic presence in the face of rising clinical volumes; this is a testament to our staff’s competence and efficiency. We continue to publish widely. Many publications were co-authored with residents and fellows.

The Neuroradiology Division conducts vital, active research in many facets of neuroimaging. This research is performed by the core clinical faculty and by several dedicated basic science laboratories. Dr. Mamourian and Dr. Eskey are participating in a Phase II Clinical Trial, run by Lloyd Kasper, on the Treatment of Multiple Sclerosis with anti-CD154. Dr. Eskey is a member of the Northern New England Cardiovascular Disease Study Group. This group has applied for a grant to study why approximately 30-40% of patients who have coronary artery bypass surgery later suffer cognitive impairment. Dr. Mamourian has published many papers on his research, which involves imaging of the brain as it relates to Alzheimer’s disease, cancer, multiple sclerosis, memory, aging, brain injury and epilepsy.

We continue our affiliation with both the DHMC Biomedical NMR Research Center, led by Dr. Jeffrey F. Dunn, PhD, and the Dartmouth Brain Imaging Laboratory, headed by Andrew J. Saykin, PsyD.

“During the evaluation of a pediatric brain CT performed for a patient with headaches (which is usually a very low yield indication), Dr. Clifford Eskey detected a very subtle abnormality in the posterior fossae. He recommended additional imaging which demonstrated a very early/small brain tumor. I was impressed by how his vigilance likely saved this young man’s life. I also recall the intense dedication and curiosity of Dr. Alex Mamourian. He is already an established and respected neuroradiologist, yet he is still aggressively learning and questioning the status quo. This kind of dedication, which we see through the staff, is a real inspiration to the residents.”

Joseph S. Pekala, MD, DHMC Radiology Chief Resident
The past two years has brought continued technological growth to the Division of Nuclear Medicine. We are now operating three multi-headed SPECT-capable gamma cameras and four new Philips Odyssey LX computers. We added a dedicated PET (positron emission tomography) scanner in October of 2002. DHMC was the first site to provide PET service in the state of New Hampshire.

Alan Siegel, MD, and Petra Lewis, MD provide a full spectrum of nuclear imaging procedures. The division has a busy service in Nuclear Cardiology. We have added Zevalin studies (performed in conjunction with the section of Radiation Oncology) for the treatment of non-Hodgkin’s lymphoma. We also provide functional and anatomic image fusion, importing and aligning SPECT, PET, CT and MRI studies.

The migration of teaching materials to a digital environment has continued. Teaching files, and core curriculum lectures are being transformed and the online interesting case archive has grown. (The case archive can be found on the DHMC Radiology website. Typing in http://www.dhmc.org/dept/radiology, you should see the general DHMC Radiology site. Click on “Clinical Sections” from the blue menu bar at left, and then select Nuclear Medicine. Here you can select either Case of the Month and Interesting Case Archive.)

Residents rotate routinely through the nuclear medicine division, and we provide them with the educational opportunities of a busy and diverse service. Residents have ample opportunity for hands-on processing of the full spectrum of nuclear studies, including cardiac SPECT, cerebral SPECT and PET.

In collaboration with the Section of Cardiology, we are actively involved in a large study, in which serum markers of LV dysfunction are being compared with the presence of scintigraphically detected myocardial ischemia. The marker presently being evaluated is B-type natriuretic peptide (BNP) and present enrollment in the study is over one hundred patients. Our investigation into the value of interictal brain SPECT in patients with extra-temporal lobe epilepsy was published in 2002 in Clinical Nuclear Medicine.
Pediatric Radiology

Steven K. Sargent, MD, Director

Pediatric imaging, as a component of the Children’s Hospital at Dartmouth (CHaD), continues to be busy with a very broad spectrum of clinical cases, consultations and teaching obligations. With the growth of the medical center and the reorganization of CHaD, we expect continued growth in pediatric imaging in the coming years.

On the technical front, the increased speed of both CT and MR scanning, and especially the introduction of the 16-detector CT scanner, has made children’s imaging easier. The new multi-detector scanner allows thinner sections to be obtained more rapidly, with better resolution and reconstruction capability. This will hopefully reduce the need for sedation in some children. While utilizing this new technical capacity, we are still strongly committed to minimizing the radiation dose in all children who require CT imaging. The “pain free CHaD” program, instituted by Anesthesiology, has made the pediatric sedation process more safe and smooth, and has also made some procedures more comfortable for both children and their families. (One procedure improved to be more comfortable is the voiding cystourethrogram, a study of the bladder and urethra performed most commonly in children who have had a urinary tract infection, unexplained dilatation of the urinary tract or voiding problems.)

The new IDX Imagecast PACS system makes it easy for us to correlate different pediatric imaging studies, and enhances both the consultative and clinical aspects of Pediatric Radiology.

The Pediatric Radiology Division continues its vigorous teaching service. There is a two-year pediatric radiology core curriculum for the radiology residents taught at the noon resident conferences. Dr. Steven Sargent and Dr. Therese Vaccaro deliver lectures as part of the radiology medical student lecture series. We also hold board review sessions for the senior radiology residents. To date, every resident to finish this residency has passed the pediatric section of the oral board examination. There are bi-weekly film sessions with the neonatal intensive care unit team, and weekly sessions with the inpatient pediatric service team. The Division of Pediatric Radiology participates in the monthly pediatric pathology conference, and the pediatric tumor board conference. A pediatric radiology elective has become extremely popular with the pediatric house staff.

In the past two years, Dr. Sargent and Dr. Vaccaro have given numerous presentations at local and regional sites, which included the following topics: Interpreting the Neonatal Chest X-ray, Neonatal Low Bowel Obstruction, and Pediatric Radiology for the Office Clinician. Dr. Sargent’s recent publications include journal articles on shaken infant syndrome and balloon dilation of congenital esophageal stenosis. Dr. Sargent has a quality improvement grant to institute standardized reports in radiology, and try to measure the cost impact of generating reports, report turn-around time and physician satisfaction.

![Radiology Pediatric Volumes](image-url)
Ultrasound

Robert Harris, MD, Director

The Ultrasound Division continues to be a very busy component of the Department of Radiology. In 2001-2002, we upgraded our machines, broadened our diagnostic study capacity, enhanced our education programs, and conducted vital new research.

The division enhanced its technology in 2001-2002, with the purchase of four Phillips state-of-the-art machines and a portable bedside Sonosite machine. The Radiology Department’s new PACS system links MRI, CT, and ultrasound using digital, “filmless” technology. This system has increased productivity and clinician satisfaction, since it allows the physician to view images on their PC or Mac immediately after the exam, using the Clinical Information System enterprise-wide network.

Our ultrasound program has both breadth and depth. Sonographic examinations of all areas of the patient’s body, except vascular and cardiology regions, are performed in the Radiology Department. Musculoskeletal ultrasound is a well-established modality, spearheaded by Douglas Goodwin, MD and Robert Harris, MD. We now regularly perform anal sphincter sonography, used to diagnose defects in the anal sphincter resulting from childbirth or trauma that lead to urinary or fecal incontinence. Ultrasound radiologists work closely with trained obstetricians and gynecologists, who bring a complementary perspective to the laboratory. At our monthly perinatal working group, obstetricians, neonatologists, radiologists, and geneticists gather to discuss difficult cases.

Dennis Seguin, ultrasound team leader, has been invaluable in establishing and maintaining the high quality of work in ultrasound, as well as keeping the multiple people involved happy and satisfied, despite the fact that they have sometimes different agendas.

Clinical acumen is the primary goal of the technologists and radiologists, but teaching and research are also vitally important. Education occurs at the patient bedside; in resident, fellow, and medical student training programs; in sonographer student apprenticeships; and monthly conferences on general ultrasound topics and maternal-fetal medicine.

Research is ongoing on several fronts. We are conducting a phase III trial of an ultrasound contrast agent for characterization of liver lesions (with Bristol Myers Squibb). Dr. Harris is assisting Richard Barth, MD, in an experimental trial of anti-tumor vaccine, with ultrasound-guided 3D Ultrasound of a normal 28 week fetus, resting and with a slight smile, showing an intact lip and palate (note: the usual 3D indication is to look for a cleft lip or palate).
injection of the vaccine into inguinal lymph nodes. Veljko Popov (a DMS MD-PhD student) and Dr. Harris are also exploring a low-bandwidth teleradiology/ultrasound system linking DMS and Serbia. Therese Vaccaro, MD has an institutional grant to analyze the imaging of the urinary tract in children with UTIs, a condition in which ultrasound plays a dominant role. Michele Lauria, an obstetrician specializing in maternal-fetal medicine and perinatology, has collected data on the accuracy of ultrasound in the detection of chromosomal anomalies in patients undergoing amniocentesis, to compare our center’s results with those of other leading centers. She plans to submit this to a peer-reviewed journal shortly.

The division has just applied for re-accreditation by the American Institute of Ultrasound in Medicine (AIUM), for our programs in abdominal, general, obstetrical and gynecological screening. We expect the re-accreditation to occur in 2003. This important quality assurance program certifies that the work in the division has been examined by independent outside observers and has been judged to meet or exceed standards established by the AIUM, the dominant organization in American ultrasound.

**Uroradiology**

*Claudia Kasales, MD, Director*

The Section of Urology has added several new physicians, including a specialist in laparoscopic surgery (Dr. Eric Wallen) and a specialist in male infertility (Dr. Ajay Nangia). The section also added several urology residency training slots. In parallel with this expansion, the Department of Radiology has seen an increase in uroradiology patient volumes, largely supported by CT, MR and ultrasound examinations, and an increase in the complexity of our uroradiology cases. The weekly uroradiology conference, used to evaluate the various imaging studies acquired at DHMC, the VA Hospital, and by our colleagues in the community setting, has blossomed into an energetic and sometimes intense hour. During this conference, the various imaging studies are presented in an “unknown case” format to urology residents, radiology residents and faculty. Numerous facets of patient management are discussed, and often, through the input of various specialists, innovative treatment options are designed.

Over the past two years a core series of uroradiology lectures has been developed. Repeated yearly, these lectures cover a wide range of topics, from intravenous urography techniques to the evaluation of adrenal masses and hysterosalpingography. Additional sessions for oral boards preparation are given in the spring. Though aimed at graduating seniors, “boards review” is often attended by junior residents, who acquire a better sense for “taking the unknown case” by watching the seniors perform.

**Vascular and Interventional Radiology**

*Kevin W. Dickey, MD, FSIR, Director*

Within the last three years, the Division of Vascular and Interventional Radiology (VIR) has undergone many significant changes and improvements. VIR has seen a steady growth in volume and diversity of cases. Since the year 2000, three new faculty members, Dr. Kevin Dickey, Dr. John Gemery, and Dr. Anne Silas have joined the division. Dr. Dickey, who assumed the Directorship in November 2002, most recently served as Chief of VIR at the Hospital of St. Raphael in New Haven, CT, and a Radiology faculty member at Yale University, New Haven, CT. Dr. John Gemery completed a fellowship in Vascular and Interventional Radiology at Boston University Medical Center in 1998. Dr. Anne Silas was a former VIR fellow at Dartmouth-Hitchcock Medical Center, and an imaging fellow at Beth Israel Deaconess Medical Center in Boston, MA. Dr. Michael Bettmann, the former Director of VIR, left DHMC in August 2003 to become Chairman of Radiology at New York Methodist Hospital.

VIR continues to have an excellent...
relationship with other clinical services, including nephrology, urology, gastroenterology, cardiology, oncology, vascular surgery and gynecology. These relationships have helped VIR build a vibrant clinical practice, and stay on the forefront of new therapies, such as uterine artery embolization for the treatment of symptomatic fibroids, and radiofrequency ablation of malignancies. Our liaison with the Sections of Cardiology and Nephrology has bolstered VIR’s experience in evaluating and treating renovascular hypertension and ischemic nephropathy, using renal artery stent placement. VIR’s ability to offer hemodialysis access interventions has made us an integral member of the dialysis management team. VIR has recently expanded its practice of venous access, the placement of implantable port devices. Also, the VIR team has embarked on a new field of treatment, therapy for varicose veins in the lower extremities using endovenous laser sclerotherapy. Along with the oncology staff, VIR radiologists have helped manage tumors by providing chemoembolization, radiofrequency ablation, percutaneous alcohol ablation, tracheobronchial stent placement, a comprehensive venous access service, gastrostomy placement, and other procedures.

We have enhanced the clinical aspects of the VIR practice by creating a dedicated VIR clinic, located with other DHMC physician clinics. Patients referred to VIR are evaluated, examined and scheduled for appropriate procedures by interventional radiologists. Moreover, VIR now has an admitting service, which admits selected patients to DHMC after their procedures, usually overnight. A dedicated nurse practitioner position for the VIR Division has recently been approved. This person will enhance the clinical service by performing many tasks, including evaluating patients in the clinic and performing certain procedures.

Teaching has always been an emphasis in the VIR Division, highlighted by a comprehensive fellowship program and highly-rated residency experience.

The VIR staff has revised the curriculum for resident training at DHMC. The popularity of our program has been shown through the number of residents who have chosen a career in VIR after training here. In the three years 2001-2003, four out of nine (or 44%) of our graduating radiology residents chose to continue their careers as VIR fellows. Since 2001, Dr. Dickey has been Examiner on the American Board of Radiology Oral Board Examinations. He is currently on the Executive Committee of the New England Roentgen Ray Society. He serves on several educational committees for the Society of Interventional Radiology, and was most recently Chair of the Educational Programs Committee. Dr. Dickey is also the Editor of the ACR teaching File CD-ROM for Interventional Radiology.

In the past two years, the Division of Vascular and Interventional Radiology has been involved in various research projects that traverse the entire breadth of the subspecialty, through the study of original ideas and participation in many multi-institutional trials. Our division’s research, conducted by Drs. Dickey, Gemery, Silas, Bettmann, and colleagues, is described in detail below.

The VIR Division performed several clinical research studies that compared two different types of tunneled dialysis access catheters, to characterize the efficacy of various types of catheters. We also completed, presented, and submitted studies for publication on the risk factors for failure of these widely-used dialysis catheters.

The VIR Division conducted clinical research to evaluate the outcome of various treatments for peripheral vascular disease. These studies documented the actual costs of the interventional radiologic procedures, and then compared the costs and outcomes of interventional vs. surgical interventions. The conclusion of this study showed that the outcome of intervention for claudication was essentially the same whether it was performed percutaneously or surgically; however, the percutaneous treatment cost substantially less. Our results generated great interest at the AHA and RSNA annual meetings, and were featured in many newspapers nationwide.

Other studies that our division is either conducting, or soon planning to conduct, include “The Vascular and Interventional Radiology Division has recently become more active in fibroid embolization, a minimally invasive technique used to treat uterine fibroids. In order to participate in the complete care of these patients, we have been admitting them to radiology. It has been very satisfying to provide a successful, minimally invasive alternative to surgery, in which patients are discharged the day after the procedure and usually return to work in a week.”

Robert K. Myers Jr., MD, DHMC Radiology Resident
The evaluation of a thrombolytic agent prophylactically to prolong the usability of tunneled dialysis access catheters; (2) A prospective evaluation of the efficacy and outcomes of the four most common methods of achieving arterial hemostasis; (3) A study of a new contrast agent for CT angiography (CTA); comparing the efficacy of CTA to digital subtraction angiography; and (4) Several studies evaluating a new low-molecular–weight, synthetic, heparin-like agent in the prevention of pulmonary embolism and deep vein thrombosis. We have also participated in a study of a new approach, the use of a removable IVC filter, and are about to start a study on a new, coated stent for treatment of peripheral vascular disease.

Dr. Kevin Dickey's research interests include interventions in the female pelvis, functional characteristics of hemodialysis catheters, magnetic resonance imaging of renovascular disease and renal function, and venous thromboembolic disease. Before coming to DHMC, Dr. Dickey had established a practice in the treatment of uterine cervical stenosis for the evaluation of infertility and postmenopausal bleeding. Moreover, he established an active practice in uterine artery embolization for the treatment of symptomatic fibroids, as well as in gonadal vein embolization for women with intractable pelvic pain. Dr. Dickey is interested in evaluating hemodialysis catheter tip characteristics during dialysis, and has developed an animal model for this purpose. He plans to implement similar techniques in patients. He is currently evaluating the established screening studies for measuring renal parenchymal function, both before and after intervention, hoping to use functional MR to assess the probability of optimal outcome prior to revascularization procedure. His interests in venous thromboembolic disease include the use of rheolytic devices and thrombolysis in the pulmonary arteries in cases of massive pulmonary embolism.

Dr. John Gemery's clinical research involving the incidence of impotence in male bicyclists is ongoing, as is his work on the concept of an implantable abdominal fluid pump. This pump may have several potential uses, including peritoneal-venous shunts for intractable ascites.

Dr. Anne Silas' comparative review of all gastrostomy placements by interventional radiologists and gastroenterologists is being finalized for journal submission. This gastrostomy study was done in collaboration with Gastroenterology. Dr. Silas' series involving the placement of covered stents in aneurysmal hemodialysis grafts is in press (2003) and shows
promise in the extended patency of these grafts.

Despite Dr. Bettman's departure, much of his research will be continued at DHMC by other Division staff. While at DHMC, Dr. Bettmann was involved in several projects both on the clinical side and benchtop. Along with Zhenwu Zhang, MD, Dr. Bettmann was developing a covered stent for placement during transjugular intrahepatic portosystemic shunt (TIPS) procedures. TIPS is a clinical procedure done to treat human portal hypertension, and rapid restenosis (“re-narrowing” of the vessel, after the procedure) is a potential, worrisome side effect. Our unique animal model of TIPS provides a rapid appearance of restenosis (narrowing) that allows us to characterize the restenosis process. This work has received funding from the Hitchcock Foundation and from the Radiological Society of North America (RSNA). Results have been presented at the annual meeting of the American Heart Association and of the RSNA. Dr. Bettmann was also the primary investigator for other funded projects, including an iliac stent trial, and a trial for the use of nonionic contrast for CT angiography of the visceral vessels. Recently, Dr. Rob Myers, a radiology resident, reported on a patient series that assesses the demographics, outcomes, and cardiovascular endpoints of renal artery revascularization in patients with hypertension and renal insufficiency over an eight-year period. This research was done by Dr. Bettman, Dr. Myers, and an incoming resident, Dr. Gerald Reilly, in collaboration with Nephrology.
APPENDICES

DIAGNOSTIC RADIOLOGY FACULTY

Emily R. Baker, MD
Assistant Professor of Obstetrics and Gynecology and Radiology

Michael A. Bettmann, MD
Professor of Radiology
Director, Clinical Research

William C. Black, MD
Professor of Radiology and Community & Family Medicine
Director, Chest Radiology
Director, Outcomes Research, CECS

Jocelyn D. Chertoff, MD
Associate Professor of Radiology and Obstetrics and Gynecology
Director, Gastrointestinal Radiology
Director, Diagnostic Radiology Residency Program

Yvonne Cheung, MD
Assistant Professor of Radiology

Monte G. Clinton, CRA
Administrative Director
Assistant Professor of Radiology

Laurence D. Cromwell, MD
Professor of Radiology
Vice Chairman
Director, Neuroradiology

Harte C. Crow, MD
Professor of Radiology and Obstetrics and Gynecology, Emeritus

Kevin Dickey, MD
Associate Professor of Radiology
Director, Vascular and Interventional Radiology

Jeffrey F. Dunn, PhD
Associate Professor of Radiology and Physiology
Director, Magnetic Resonance Spectroscopy Laboratory

Marvin Doyley, PhD
Research Assistant Professor of Radiology

Clifford J. Eskey, MD, PhD
Assistant Professor of Radiology

John Gemery, MD
Assistant Professor of Radiology

Douglas W. Goodwin, MD
Assistant Professor of Radiology and Surgery
Director, Musculoskeletal Radiology

Oleg Y. Grinberg, PhD
Research Associate Professor of Radiology

Susan N. Harper, MD
Assistant Professor of Radiology, VA Hospital

Robert D. Harris, MD
Associate Professor of Radiology and Obstetrics and Gynecology
Director, Ultrasound

David B. Haseman, MD
Adjunct Associate Professor of Radiology

Huagang Hou, PhD
Research Assistant Professor of Radiology

Robert F. Jeffery, MD
Associate Professor of Radiology

Nadeem Khan, PhD
Research Assistant Professor of Radiology

Claudia J. Kasales, MD
Associate Professor of Radiology
Director, Body Imaging – CT

Michele Lauria, MD
Assistant Professor of Obstetrics and Gynecology and Radiology

James E. Lenz, MD
Assistant Professor of Radiology, VA Hospital

Petra Lewis, MD
Associate Professor of Radiology
Director, Medical Student Elective Program

Alex C. Mamourian, MD
Associate Professor of Radiology
Co-Director, Magnetic Resonance Imaging

Anthony Merlis, MD
Assistant Professor of Radiology

Richard A. Morse, MD
Assistant Professor of Radiology
Acting Director, VA Hospital

Helene M. Nagy, MD
Assistant Professor of Radiology
Co-Director, Breast Imaging

Tina Nelson, MD
Assistant Professor of Radiology

Julia O’Hara, PhD
Research Associate Professor of Radiology

Steven P. Poplack, MD
Assistant Professor of Radiology and Obstetrics and Gynecology
Co-Director, Breast Imaging

Misty B. Porter, MD
Assistant Professor of Obstetrics and Gynecology and Radiology

Ildar Salikhov, PhD
Research Assistant Professor of Radiology

Steven K. Sargent, MD
Associate Professor of Radiology and Pediatrics and Obstetrics and Gynecology
Director, Pediatric Radiology

Andrew J. Saykin, PsyD
Associate Professor of Psychiatry and Radiology

Alan H. Siegel, MD
Associate Professor of Radiology
Director, Nuclear Medicine

Anne Silas, MD
Assistant Professor of Radiology

Peter K. Spiegel, MD
Chairman and Professor of Radiology

Roger Springett, PhD
Research Assistant Professor of Radiology

Judith Austin Strohbehn, MD
Assistant Professor of Radiology

Artur Sucheta, PhD
Research Assistant Professor of Radiology

Harold M. Swartz, MD, PhD
Professor of Community and Family Medicine
Professor of Radiology
Adjunct Professor of Engineering
Adjunct Professor of Chemistry
Professor of Physiology
Director, EPR Center for the Study of Viable Systems

William Trought, MD
Assistant Professor of Radiology, Plymouth

Michael Tsapakos, MD, PhD
Assistant Professor of Radiology
Director, Body Imaging-MRI

Therese J. Vaccaro, MD
Assistant Professor of Radiology

Tadeusz M. Walczak, PhD
Associate Professor of Radiology

John B. Weaver, PhD
Associate Professor of Radiology
Director, Diagnostic Physics

Robert H. Wilkinson, MD
Professor of Radiology and Pediatrics, Emeritus

Zhenwu Zhuang, MD
Research Assistant Professor of Radiology
DIAGNOSTIC RADIOLOGY RESEARCH ASSOCIATES

Akinori Iwasaki
Piotr Lesniewski
Yasuko Sakata

DIAGNOSTIC RADIOLOGY RESIDENTS

Fayyaz Barodawala, MD
SUNY at Buffalo School of Medicine and Biomedical Sciences
Les Benodin, MD
Dartmouth Medical School
Elizabeth Dann, MD
University of Miami School of Medicine
Dianne Davis, MD
University of Louisville School of Medicine
Shervin Dean, MD
University of Texas-Houston School of Medicine
Johanne Dillon, MD
Medical College of Pennsylvania
Timothy Mahoney, MD
MCP Hahnemann School of Medicine
Marc Mancuso, MD
University of Massachusetts School of Medicine
Michael Meszaros, MD
SUNY at Syracuse College of Medicine
Robert Myers, MD
University of Kentucky School of Medicine
Scott Naspinski, MD
Temple University School of Medicine

DIAGNOSTIC RADIOLOGY FELLOWS

Colleen Buffington, MD
Cross-Sectional Imaging
Eric Goldberg, MD
Vascular and Interventional Radiology
Gerald Riley, MD
Dartmouth Medical School
David Siepmann, MD
Oregon Health Sciences University School of Medicine
Tatum Simon, MD
Louisiana State University School of Medicine
Elena Wechsler, MD
Cornell University Medical College

ALUMNI RESIDENTS (PARTIAL LISTING)

Michael Bloss, MD
Dartmouth Medical School
Charles Boyd, Jr., MD
Medical College of Virginia
Michael Capriola, MD
University of Colorado
Richard Cooper, MD
University of Colorado School of Medicine
Roberta DiFlorio-Alexander, MD
Jefferson Medical College
Joan DiMarzia, MD
Boston University
Jeffrey Gambach, MD
University of Iowa College of Medicine
Ellen Gerety, MD
Dartmouth Medical School
Stephen Holtzman, MD
Dartmouth Medical School
Shawn Isaeff, MD
Loma Linda University
Rita Kinback, MD
Hahnemann University School of Medicine
Paul Koutras, MD
Dartmouth Medical School
J. Christopher Kuhn, MD
SUNY-Buffalo School of Medicine and Biomedical Sciences
Petra Lewis, MD
United Medical and Dental Schools
Robert Myers, MD
University of Kentucky College of Medicine
Tina Nelson, MD
Dartmouth Medical School
Joseph Pekala, MD
Dartmouth Medical School
James Raque, MD
University of Louisville School of Medicine
Richard Rhee, MD
Boston University
Erik Rhodes, MD
Dartmouth Medical School
Kenneth Serra, MD
University of Colorado
David Wagar, MD
University of Toronto

Note: Medical colleges shown are colleges where residents received their MD degrees.
### ALUMNI FELLOWS (PARTIAL LISTING)

<table>
<thead>
<tr>
<th>Name</th>
<th>Specialty</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thomas Barta, MD</td>
<td>Cross-Sectional Imaging</td>
</tr>
<tr>
<td>Greg Blackman, MD</td>
<td>Vascular and Interventional Radiology</td>
</tr>
<tr>
<td>Thomas Casciani, MD</td>
<td>Vascular and Interventional Radiology</td>
</tr>
<tr>
<td>John Creasy, MD</td>
<td>Vascular and Interventional Radiology</td>
</tr>
<tr>
<td>Susan Geletka, MD</td>
<td>Cross-Sectional Imaging</td>
</tr>
<tr>
<td>Stephen Holtzman, MD</td>
<td>Vascular and Interventional Radiology</td>
</tr>
<tr>
<td>Shawn Isaeff, MD</td>
<td>Vascular and Interventional Radiology</td>
</tr>
<tr>
<td>Johannes H. Jordaan, MD</td>
<td>Vascular and Interventional Radiology</td>
</tr>
<tr>
<td>Paul Koutras, MD</td>
<td>Vascular and Interventional Radiology</td>
</tr>
<tr>
<td>Stuart Miller, MD</td>
<td>Vascular and Interventional Radiology</td>
</tr>
<tr>
<td>James D. Racque, MD</td>
<td>Vascular and Interventional Radiology</td>
</tr>
<tr>
<td>Anne Silas, MD</td>
<td>Vascular and Interventional Radiology</td>
</tr>
<tr>
<td>J. Louis Solis, MD</td>
<td>Vascular and Interventional Radiology</td>
</tr>
<tr>
<td>Brian Szymanski, MD</td>
<td>Cross-Sectional Imaging</td>
</tr>
<tr>
<td>David Wagar, MD</td>
<td>Cross-Sectional Imaging</td>
</tr>
<tr>
<td>Eric Weidman, MD</td>
<td>Cross-Sectional Imaging</td>
</tr>
<tr>
<td>Jeff Weil, MD</td>
<td>Vascular and Interventional Radiology</td>
</tr>
<tr>
<td>Cary Wilfred III, MD</td>
<td>Cross-Sectional Imaging</td>
</tr>
</tbody>
</table>
BIBLIOGRAPHY

JOURNAL ARTICLES


Zhuang ZW, Teng GJ, Jeffery RF, Gemery JM, d’Othee BJ, Bettmann MA. Long-Term Results and Quality of Life in Patients Treated with Transjugular Intrahepatic Protosystemic Shunts. AJR 2002 (Dec); 179:1597-1603.


Goodwin DW and Dunn JF. MR Imaging and T2 Mapping of Femoral Cartilage. AJR. American Journal of Roentgenology 2002; 178, 1568-9; discussion 1569-70.

Nattie E, Aihua L, Meyerand E and Dunn JF. Ventral Medulla PhI Measured In Vivo by 31P NMR is Not Regulated During Hypercapnia in Anesthetized Rat. Respir. Physiol. 2002; 130, 139-149.


PRESENTATIONS

Bettmann MA. Invited Workshop Speaker, Annual Meeting of the SCVIR, San Antonio, TX.


Bettmann MA. Invited Speaker, The Role of Interventional Radiology, Bay State Medical Center, Springfield, MA, Nov 2001.


Black WC. Screening for Lung Cancer with Low-Dose Helical CT. Presented at Hematology-Oncology Grand Rounds, Dartmouth-Hitchcock Medical Center, Lebanon, NH, June 7, 2001.


Black WC. All-Cause Mortality in Randomized Trials of Cancer Screening. Presented at Norris Cotton Cancer Center Grand Rounds, Dartmouth-Hitchcock Medical Center, Lebanon, NH, April 4, 2002.


Dickey KW. Venous Thromboembolic Disease, Filters. Scientific Session Moderator at the annual meeting of the Society of Cardiovascular and Interventional Radiology (SCVIR), San Antonio TX, March 2001.

Dickey KW. Venous Thromboembolic Disease, Filters. Scientific Session Moderator at the annual meeting of the Society of Cardiovascular and Interventional Radiology (SCVIR), San Antonio TX, March 2001.

Dickey KW. Conscious Sedation. Workshop given at the annual meeting of the SCVIR, Baltimore MD, April 2002.

Dickey KW. Puncture Site Management. Scientific Session Moderator at the annual meeting of the Society of Cardiovascular and Interventional Radiology (SCVIR), San Antonio TX, March 2001.

Dickey KW. Puncture Site Management. Workshop given at the annual meeting of the SCVIR, San Antonio TX, March 2001.


Dunn JF. The Brain as a Hypoxia Tolerant Organ: Fact or Fiction. Texas Technological Institute, Lubbock TX, 2001.


Dunn JF. The Brain and Hypoxia Tolerance. Dartmouth Medical School, Dept. of Physiology, 2002.

Dunn JF. Regulation of Cerebral Oxygenation During Acute and Chronic Hypoxia. Winter Brain Conference. Snowmass Co. Session organizer, Dr. Sami Harik. Session Title: Adaptation to altitude: brain hypoxia and gene response, 2002.


Mamourian AC. The Corpus Collosum, it’s All in How You Look at it. Visiting Professor at University of Pennsylvania. January 11, 2002.


Poplack SP. The Clinical Practice of Breast Imaging. UPDATE IN WOMEN’S HEALTH: Adolescence Through Menopause, Dartmouth-Hitchcock Medical Center, Lebanon, NH, May 20th, 2002.


Swartz HM. Capabilities of In Vivo EPR. University of Otago, Dunedin, New Zealand, November 23, 2002.


Swartz HM. In Vivo EPR Dosimetry of Accidental Exposures to Radiation: Experimental Results Indicating the Feasibility of Practical Use in Human Subjects. National Institute of Standards and Technology, United States Department of Commerce, Gaithersburg, Maryland, April 25, 2001.


Swartz HM. Spatially Resolved In Vivo EPR Spectroscopy. Bhabha Research Center, Mumbai (Bombay), India, February 8, 2001.


**BOOK CHAPTERS**


ABSTRACTS


Goodwin DW, Lei H, and Dunn JF. Vertical Striations in the Radial Layer of MR Imaging of Hyaline Cartilage Are Due to T2 effects. Proceedings of the Ninth Meeting of the International Society of Magnetic Resonance in Medicine, Glasgow, Scotland, April 2001.


CREDITS

Biennial Report Editor
Robyn Mosher, DHMC Diagnostic Radiology

Photographic Contributors
Mark Austin-Washburn, DHMC Public Affairs and Marketing
Monte Clinton, DHMC Diagnostic Radiology
Jeff Nintzel

Graphic Design and Layout
Roger Goode, DHMC Public Affairs and Marketing

Cover Image, 3D Rendering
Pam Mazurek (with a Vital Images Vitrea workstation)
DHMC Diagnostic Radiology

Department of Diagnostic Radiology
Dartmouth-Hitchcock Medical Center (DHMC)
One Medical Center Drive
Lebanon, NH 03766
(603) 650-4488