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**The MGH/MIT/HMS**  
**Athinoula A. Martinos Center**  
**for Functional and Structural Biomedical Imaging**



Annual Report  
May 2001

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## INTRODUCTION

While the Athinoula A. Martinos Center's first year focused on laying groundwork for establishing the Center, this second year can be seen as one of catalyzing new science and new alliances through research and educational initiatives. In the coming year and in the future, these catalyst initiatives will bring results that will develop, grow and take on lives of their own.

The Athinoula A. Martinos Center has initiated several new programs to foster biomedical imaging research at Harvard, MIT, MGH, and across these institutions. The programs include providing funds and resources for established and young investigators from various departments, including MIT's Department of Brain & Cognitive Science and MGH's Psychiatric Neuroimaging Group, who are interested in pursuing new lines of research using imaging. Another catalyst for new research is the Advanced Computational Image Processing and Analysis Center, a satellite laboratory established this year on the MIT campus. To further encourage cross-institutional research, the Center has also instituted a new Collaborative Research Start Up Grant Program. Finally, to provide researchers with clinical interests with the resources to meet the special demands of conducting patient-based and translational research, a Clinical Imaging Core is under development. One goal of all of these efforts is to foster innovative research that, once mature, will be become eligible for funding from federal sources and, thus, self-supporting

We have also catalyzed new research by hiring new faculty members and bringing visiting faculty to the Center. New hires this year include David N. Kennedy, Ph.D. and Sandy Wells, Ph.D., leaders in computational neuroanatomy and image processing, and Wimm Van Duffel, Ph.D., a primate imager. We are currently recruiting another faculty member to launch the Center's molecular imaging program. In addition, two prominent visiting scientists —Matti Hamalainen, Ph.D. from the Technical University of Helsinki and David Gadian, Ph.D. from the Institute of Child Health, University College London, UK — spent their sabbaticals at the Athinoula A. Martinos Center to exchange ideas and expertise with Center faculty and students.

Development of new educational programs is perhaps our best investment in the future success of the Center. This year we designed a graduate program in biomedical imaging that will be accessed as a special track for students and postdoctoral fellows from within the Harvard-MIT Division of Health Sciences and Technology (HST). In addition, a monthly workshop on practical topics for biomedical imagers (students and faculty) is now offered at the Center in Charlestown. These programs not only shape the biomedical imagers of tomorrow, but help keep today's researchers on the cutting edge.

Similarly, events like the Athinoula A. Martinos Center Annual Retreat and the National Foundation for Functional Brain Imaging's meeting for Imaging in Schizophrenia Research, bring together scientists from across town and across the country to inspire new insights and collaborations, and keep researchers up-to-date on their colleagues' work. In the coming years the Center will host an annual symposium (which we hope the Martinos family will help us design) that will serve to educate our scientists and the public about various topics in biomedical imaging and its impact on human health.

This year, the imaging resources and equipment of the Athinoula A. Martinos Center were greatly expanded. We have installed three new MR systems in the Charlestown location, including a second 3 Tesla (T) research system, an ultra-high field 7T system for human imaging, and a small bore 9.4T for animal studies. In addition, we have received the go-ahead to install two more human research magnets at the MGH main campus, one of which will reside in the Neuroscience Intensive Care Unit for study of inpatients and other previously difficult-to-study populations.

The Center continues to expand the breadth of our imaging capabilities as well. Construction began this spring on our new magnetoencephalography (MEG) imaging facility. Plans to bring Positron Emission Tomography (PET) imaging capabilities to the Center are also underway, and funding is in place for at least one PET imager.

Another major step toward catalyzing new science and new collaborations is in designing the physical space that will be the Athinoula A. Martinos Center. Planning and construction of the Center's permanent home at MIT will continue for some time. Meanwhile, the Center's temporary home at the MGH in Charlestown is being renovated to create a unique multidisciplinary research space. The new facility will bring researchers from many specialties and departments together in one space, thus creating the truly integrated basic and clinical research center that the Martinos family has envisioned to commemorate their daughter, Athinoula.

The following report describes these and other accomplishments in more detail.

## **BUILDING NEW BRIDGES**

An important goal of the Athinoula A. Martinos Center is to create and develop imaging resources and to use them to impact a broad range of biomedical investigation. Such an ambition requires the contribution of individuals with distinct expertise and perspectives working in many different disciplines. It requires that the best engineers, computer scientists, cognitive scientists, clinicians, and many others combine their talents and work together. To foster the kinds of collaboration we envision, this year the Center established three new biomedical imaging initiatives within the MIT and Harvard Medical communities and a fourth important initiative to inspire collaboration across these communities. These efforts include (a) the Advanced Computational Image Processing and Analysis Center at MIT, involving researchers from MIT, HST, MGH and the Brigham & Women's Hospital (BWH), (b) support of the Functional Neuroimaging effort in the MIT Department of Brain & Cognitive Sciences, and (c) a Clinical Neuroimaging Core within the MGH Clinical Neuroscience Departments. To help initiate new collaborations across these and other biomedical imaging programs, the Athinoula A. Martinos Center has established a Collaborative Research Start Up Grant Program that will support joint projects across the institutions.

### ***Advanced Computational Image Processing and Analysis Center***

The first Athinoula A. Martinos Center laboratory on the MIT campus was established this year. The Advanced Computational Image Processing and Analysis Center (ACIPAC) was set up in collaboration with the MIT Artificial Intelligence (AI) Laboratory. ACIPAC focuses on the practical image processing and analysis issues relevant to biomedical imaging. Two prominent investigators have joined the Martinos Center faculty to direct the program. David N. Kennedy, Ph.D., former co-director of the MGH Center for Morphometric Analysis and an MIT graduate, brings his expertise in morphometric analysis and anatomy-based databasing to the Center. Sandy Wells, Ph.D. of the BWH Surgical Planning Lab is a world leader in computational image processing. Close collaboration with the AI Lab brings the theoretical expertise of the MIT visual computational students and faculty, led by Dr. Eric Grimson, to problems in biomedical imaging. ACIPAC provides a direct avenue for MIT and HST students to become involved in biomedical imaging research.

### ***BCS Functional Neuroimaging Group***

Another important new initiative aimed at building bridges between the Athinoula A. Martinos Center and the MIT research community is in the form of Martinos Center support for the MIT Brain & Cognitive Sciences (BCS) Functional Neuroimaging Group. Research currently supported by the initiative includes investigation into the basic cognitive neuroscience of vision and memory, and the clinical neuroscience of Alzheimer's Disease, amnesia, and stroke recovery. In addition to furthering the work of established BCS investigators, the Center supports pilot work by young researchers and students, allowing them access to imaging resources for not-yet-funded projects, and inspiring new inquiry into the function of the brain using imaging.

### ***Clinical Neuroimaging Research Core***

Within the MGH Community, the Athinoula A. Martinos Center is fostering clinical and translational neuroimaging research with the recent establishment of a Clinical Neuroimaging Research Core. Under the direction of Scott Rauch, M.D., Director of the Psychiatric Neuroimaging Group at MGH, the new Center supported Core will provide resources for clinical and translational neuroimaging research, such as patient recruitment services, biostatistics, physiological monitoring, and clinical testing facilities. In addition, the Center is providing imaging support for the pilot studies of new clinical investigators to test new hypotheses and new biomedical imaging applications for the better understanding and treatment of human disease.

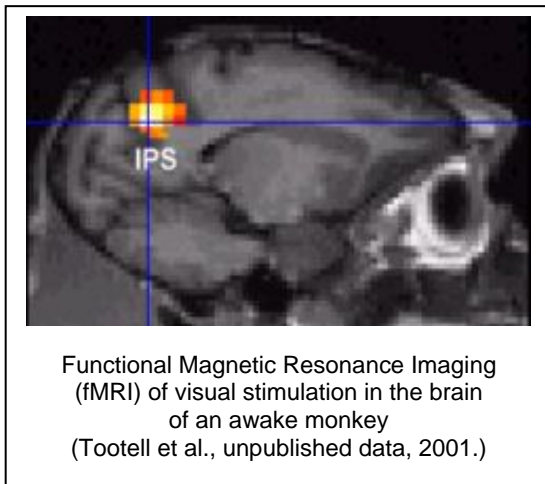
### ***Collaborative Research Start Up Grant Program***

The Athinoula A. Martinos Center Collaborative Research Start Up Grant Program was designed to inspire collaboration across the various institutions that make up the Athinoula A. Martinos Center: MGH, MIT, Harvard Medical School, and the Harvard teaching hospitals. Newly formed cross-institutional research teams will be invited to apply for this competitive grant to support research projects in biomedical imaging that bridge the basic science/engineering and clinical/translational disciplines. Grants will be for one year of support and, when appropriate, will be renewable for a second year. The first call for proposals will occur this summer for awards to be granted in the fall. The Martinos family will be invited to participate in the grant review and selection procedure. Knowledge and data acquired as a result of these start up grants will eventually support requests for independent funding from national sources.

## **NEW RESEARCH INITIATIVES**

### ***Primate Functional Imaging***

The non-human primate is an important model for studying biological systems and behavior. While there are many similarities in the brains of human and non-human primates, the physical requirements for studying these two systems and the types of information that can be obtained can be very different. The monkey brain can be studied



Functional Magnetic Resonance Imaging (fMRI) of visual stimulation in the brain of an awake monkey (Tootell et al., unpublished data, 2001.)

invasively and non-invasively, providing both verification for work that can only be performed non-invasively in humans and additional levels of attainable detail. While a full primate imaging facility is being planned at the future MIT site of the Athinoula A. Martinos Center, we have begun to establish our primate imaging initiative here at the Charlestown campus. Our own Dr. Roger Tootell initiated the effort in his collaborations with a group in Belgium with considerable expertise in functional neuroimaging of the awake behaving monkey. Dr. Wimm Van Duffel of

the Belgium group paid an extended visit to the Center earlier this year, contributing considerably to launching our primate imaging program. We look forward to this fall when Dr. Van Duffel will be joining the faculty of the Center permanently.

### ***Molecular Imaging***

Genome research has rapidly progressed from the cataloging of genes to seeking a more detailed understanding of their functions. To optimally assess and measure the products of normal and pathological gene expression and to evaluate therapeutic modulation of gene expression in gene therapy, animal studies must be conducted in which various products of gene expression can be visualized in vivo at the cellular level across the whole body in real time. Eventually, similar methodologies will need to be developed for making the same measurements in humans, thus taking gene imaging from the most basic research to high level clinical trials. To tackle this enormously complex and challenging goal will require integration across many sub-specialties. We have begun to launch our molecular imaging efforts this year and are currently recruiting some of the leading molecular imaging researchers, including Dr. Thomas Meade of the California Institute Technology.

## **EDUCATIONAL INITIATIVES**

### ***Multidisciplinary, Cross-Institutional Training Program***

Both the scientific and medical communities would both benefit enormously from the availability of formal training at the interface between the technologies of quantitative imaging and the basic and clinical sciences. The lack of such interdisciplinary training programs has inspired a collaborative effort between the HST and MGH faculties to produce a biomedical imaging program through the Athinoula A. Martinos Center. The program will consist of a special educational track for graduate students and post-doctoral fellows within HST, jointly taught by HST and Martinos Center faculty, and will include a comprehensive biomedical imaging research experience for trainees at the Center.

Through the planning and organizational efforts of Randy Gollub, M.D., Ph.D. of the MGH Psychiatry Department, the first course in the program has been developed and approved by the HST faculty. This survey course of functional imaging techniques will be offered in the Fall 2001. The course will be open to students in HST, other MIT and Harvard departments, and students of investigators conducting research at the Athinoula A. Martinos Center.

### ***Monthly Biomedical Imaging Workshops***

Education at the Center does not end after graduation. Advances in biomedical imaging techniques and applications are rapidly changing the field. To keep our researchers and their teams up-to-date in the use of these technologies, we have begun a Biomedical Imaging Workshop series which will provide a half day per month of detailed and often hands-on training in a variety of important imaging topics.

The first workshop conducted this April focused on respiratory physiology, the impact of respiration and blood gases on imaging measures, and techniques for monitoring and manipulating respiratory parameters during imaging experiments. We are

planning workshops on physiological monitoring during imaging, experimental design for event-related fMRI, data analysis software options, and optical imaging for brain mappers.

### ***Student Committee***

More than 50 graduate and post-doctoral students currently receive training and conduct their research at the Athinoula A. Martinos Center. As the programs catalyzed by the Martinos family gift expand into full operation, we expect that many more students will take part in this experience. To ensure the quality of training from the student perspective, we have established a Student Advocate Committee, composed of graduate students and fellows from HST, MIT, Harvard, MGH, and laboratories of the Center's users. The committee, led by HST students David Tuch and Scott Packard, has founded two student-faculty working groups to support and encourage excellence in scientific and career mentoring, and to facilitate and advance a range of student administrative and quality of life issues. They have also created a web site full of practical information for students of the Center.

## **NEW FACULTY**

Bringing fresh talent and new capabilities to the Center is important for inspiring ideas and creating new ways to combine expertise. With the unique facilities and resources of the Athinoula A. Martinos Center, it is not difficult to attract the top people in biomedical imaging. This year we have had or are in the process of recruiting several new additions to the faculty, and we have hosted some important temporary visitors as well.

Some new faculty hires this year include David N. Kennedy, Ph.D. and Sandy Wells, Ph.D., who will direct the new Athinoula A. Martinos Center satellite laboratory — the Advanced Computational Image Processing and Analysis Center — co-located with the AI Lab at MIT (see Advanced Computational Image Processing and Analysis Center, p. 4). Dr. Kennedy, former co-Director of the Center for Morphometric Analysis at the MGH, and Dr. Wells of the BWH Surgical Planning Lab, are leaders in computational neuroanatomy and image processing.

Seppo Ahlfours, Ph.D., formerly of the Albert Einstein College of Medicine in New York, is now an important member to the Center's MEG Core. Wimm Van Duffel, Ph.D., of the Katolieke Universiteit at Leuven, Belgium, a pioneer in primate functional imaging, also will join the faculty this summer to guide our primate imaging initiative (see Primate Functional Imaging, p. 5). To launch the Center's molecular imaging program (see Molecular Imaging, p. 6), we are currently in the process of recruiting Tom Meade, Ph.D. of the California Institute of Technology.

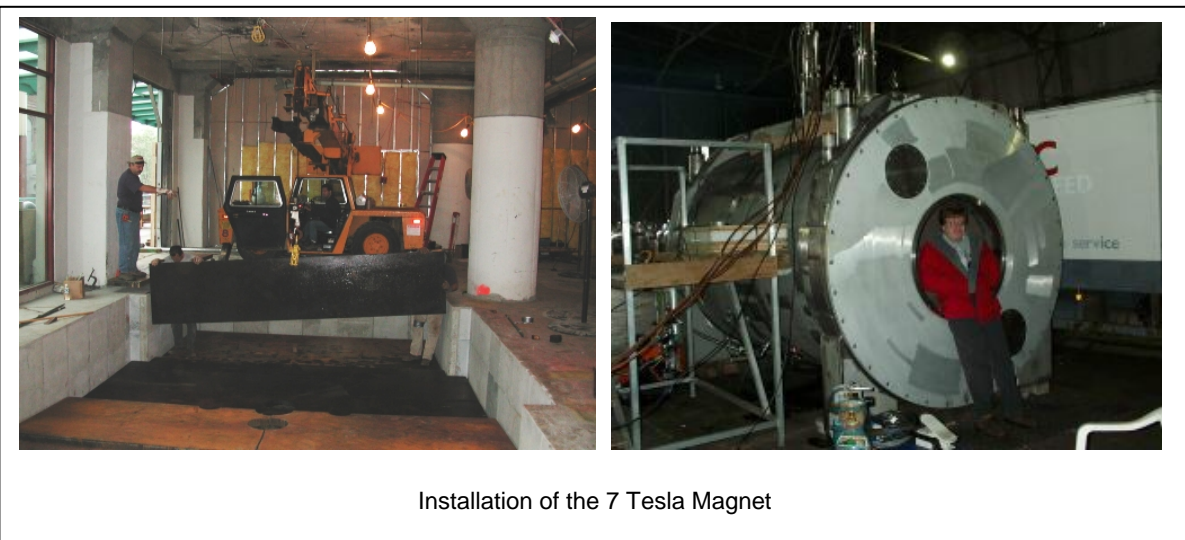
In addition, Matti Hamalainen, Ph.D., an MEG expert from the Technical University of Helsinki, is on sabbatical at the Center working with our faculty on combining functional Magnetic Resonance Imaging (fMRI) with MEG. David Gadian, Ph.D., a professor from the Institute of Child Health, University College London, UK recently completed a six-month sabbatical at the Center working on a number of areas of mutual interest, including MRI, magnetic resonance spectroscopy (MRS), brain morphometry, and stroke. It is hoped that his visit will provide a number of opportunities

for collaborative studies between the Athinoula A. Martinos Center and Dr. Gadian's research group London.

## **NEW IMAGING RESOURCES**

### ***New MR, MEG, Optical Imaging and PET Resources***

This has been a year of considerable expansion and growth of the Center's imaging technology resources. In addition to our existing 1.5 and 3.0 Tesla wide bore and 2.0, 4.7 and 9.4 Tesla small bore magnetic resonance (MR) systems, we have installed in our Charlestown facility additional 3 and 7 Tesla human MR systems and a 9.4 Tesla small bore system for imaging rodents. The 7T ultra-high field system is one of only three such systems in the world. Funding is also in place for an Athinoula A. Martinos



Center 3 Tesla MR system to be installed in the MGH Neuroscience Intensive Care Unit exclusively for clinical research. An additional 1.5T system is to be installed shortly at the MGH main campus to facilitate translation of experimental imaging protocols to the patient environment.

In addition to the new MR resources, installation of our 306-channel MEG system is currently underway. With the help from new faculty member Seppo Ahlfours, Ph.D. and David Cohen, Ph.D. of the MIT MEG Laboratory, under the supervision of Eric Halgren, Ph.D., Director of the Martinos Center MEG Core, the system should be ready for use by late fall this year.

Our optical imaging initiative has also grown extensively this year. The Optical Lab has developed and is constructing novel near infrared optical imaging devices to accommodate the new interest in the developing technology evident in the demand for additional collaborative research.

Finally, we have begun to plan our (PET) imaging facility. A new PET imager has been obtained through a National Center for Research Resources (NCRR) Shared Instrument Grant awarded to Anna-Liisa Brownell, Ph.D. of the MGH Radiology Department. We are currently working to secure funding for a cyclotron to create

radioisotopes for use with this system and with additional PET imagers for the Center. A separate NCRR Research Facilities Construction Grant was also submitted to obtain additional funds for installation and construction of the PET Center.

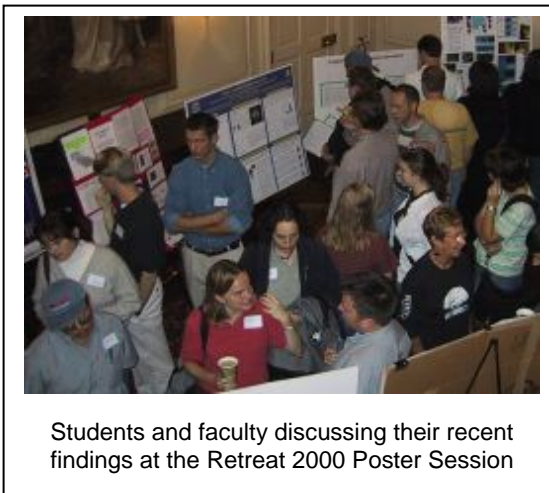
Together these resources, representing the major imaging technologies available today, make the Athinoula A. Martinos Center a unique and truly exceptional environment for clinical and basic biomedical imaging research and training.

## EVENTS

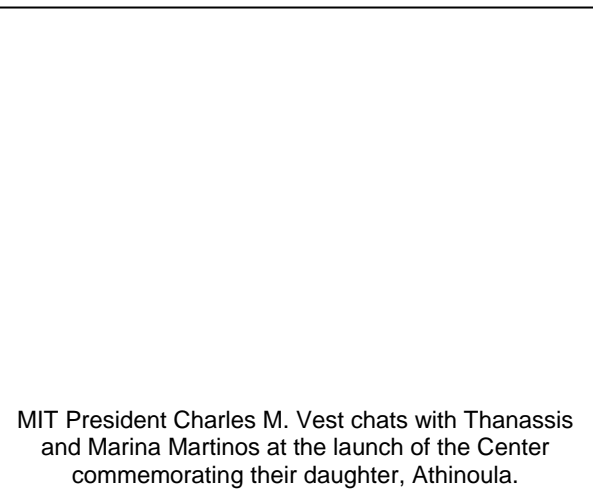
The Athinoula A. Martinos Center hosted three major events this year: the annual Center Retreat, the Launching Celebration, and the first National Foundation for Functional Brain Imaging (NFFBI) Imaging in Psychiatric Research meeting. In addition, plans are underway to establish a yearly Athinoula A. Martinos Center Symposium to focus on various topics in biomedical imaging research.

### *Retreat 2000*

On September 18, 2000, the annual Athinoula A. Martinos Center Retreat was held at Castle Hill in Ipswich, Massachusetts. Attending the event were 160 NMR Center faculty, post-doctoral fellows, and students from MGH, MIT, Harvard, Boston University, and other area hospitals and institutions. The purpose of the Retreat was to gather Center participants for a casual day of learning about each other's work and about the plans for the Center's future. First was an update of the Center's accomplishments in the first year. Then there was a poster session where students and faculty displayed and discussed the year's best scientific work, followed by afternoon breakout groups to plan new Center initiatives.



Students and faculty discussing their recent findings at the Retreat 2000 Poster Session



### *Launch of the Athinoula A. Martinos Center*

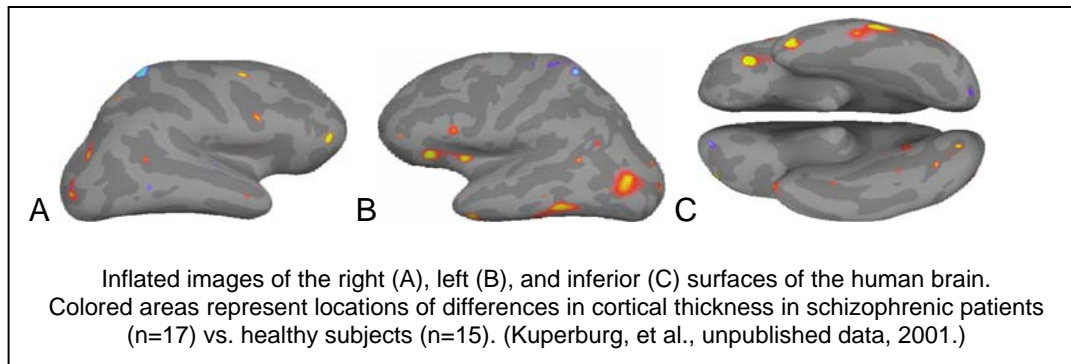
The celebration of the establishment of the Athinoula A. Martinos Center and the innovative collaborations that it has begun to foster was the year's most important event. The celebration was held on November 3, 2000 at the MGH research campus in Charlestown, the temporary home of the Athinoula A. Martinos Center. The Martinos family attended the event, as well as leaders in the local and national

biomedical imaging community.

The day began with a private meeting of the HST Advisory Council and luncheon, followed by faculty presentations. The main celebration featured poster presentations by HST graduate students, tours of the Center's facilities, and addresses by some of the senior administration of MIT, MGH, Partners HealthCare, HMS, and HST. Speakers included Joseph V. Bonventre, M.D., Ph.D., and Martha L. Gray, Ph.D., Directors of HST; Charles M. Vest, Ph.D., President of MIT; Samuel O. Thier, M.D., President and CEO of Partners HealthCare System; and Dennis L. Kasper, M.D., Executive Dean for Academic Programs in the Faculty of Medicine, HMS. James H. Thrall, MD, Chairman of Radiology at MGH, introduced the keynote speaker, Bruce Rosen, M.D., Ph.D., Director of the Center. Dr. Rosen spoke on the history of the HST-MGH collaborations, the medical breakthroughs that have resulted, and our shared vision for the new and productive collaborations that the Athinoula A. Martinos Center has and will continue to inspire.

### ***NFFBI's Imaging in Psychiatric Research Meeting***

The Athinoula A. Martinos Center will host the first meeting of the National Foundation for Functional Brain Imaging (NFFBI) on Imaging in Psychiatric Research on May 30, 2001. The assembly will focus on research in schizophrenia and schizophrenia spectrum disorders. The goal of the meeting is to examine the state-of-the-art in the field and to determine a course for and develop proposals for joint research on schizophrenia within the Foundation's participating institutions, which include the Los Alamos National Laboratory, the University of Minnesota, and MGH. Dr. Chris Wood, Director of the NFFBI will chair the assembly, which will be attended by Center Investigators Scott Rauch, M.D., Gina Kuperburg, M.D., Stephan Heckers, M.D., and other prominent Boston area schizophrenia specialists.



### ***Future Events - the Annual Athinoula A. Martinos Center Symposium***

The Athinoula A. Martinos Center plans to host a yearly Biomedical Imaging Research symposium at MIT. A Planning Committee for the event as been has identified and is eager to begin shaping this year's symposium. It is our hope that each year, the Martinos family will be involved in determining the focus and scope of this exciting event.

## CENTER LOCATION

Although design and construction for the MIT Neurosciences Complex — the future home of the Athinoula A. Martinos Center — is well underway, it will still be some time before the Center is relocated to MIT. In the meantime, the blueprint has been drawn for the new accommodations at the MGH Research Building in Charlestown. The Athinoula A. Martinos Center will be housed in a renovated facility on the 2<sup>nd</sup> floor. The design of this new area embraces the vision of integrating the basic imaging sciences with the clinical research initiatives that will apply new imaging technology toward furthering the understanding of disease and translating research results into clinical practice.

In this new space, the Center's faculty will be side by side with neuroimagers from the clinical neuroscience departments. The facility will house — in addition to Martinos Center faculty— the Center for Aging and Neurodegeneration, the Center for Morphometric Analysis, and the Neurodevelopmental Imaging Lab (all of the Department of Neurology), the Psychiatric Neuroimaging Group, the NCCR-sponsored General Clinical Research Center Biomedical Imaging Core Satellite, and the Pharmaceutical Imaging initiative of Millennium Pharmaceuticals. In this unique environment, the opportunities for close collaboration are outstanding.

This arrangement represents a new model, a center designed to inspire, encourage and facilitate integrated basic/clinical/translational research activity. By creating a place where biological and physical scientists, engineers, and physicians work side by side, we are fostering an environment where they will work *together* on the same research problems, not just under one roof, but as multi-specialist teams with common research goals.

The temporary site of the Athinoula A. Martinos Center at MGH will be a truly integrated basic and clinical research facility, and we plan to carry forward this important model to its future home at MIT.