Enhancing Science and Engineering at Harvard

The Preliminary Report from the University Planning Committee for Science and Engineering

July 2006

CONTENTS

EXECUTIVE SUMMARY OF PRELIMINARY REPORT

For more than a century, Harvard has excelled in research and teaching in science, medicine, mathematics, and engineering. Until recently, boundaries of these disciplines changed slowly, but as science accelerates and boundaries crumble, the University must respond quickly and flexibly to new opportunities. Examples include:

- Using stem cells to decipher how organisms develop and to revolutionize medicine,
- The convergence of biologists, physicists, chemists, and engineers dedicated to understanding the fundamental principles that explain the organization, reproduction, function, and evolution of biological systems, and using this knowledge to advance healthcare as well as engineering,
- Using powerful arrays of computers to provide better links between large data sets and theories that seek to explain them,
- New ways of understanding the details of the evolution and diversity of living things that would allow us better protect our planet, and
- Combining basic science, engineering, and public policy to make and implement plans for sustainable energy generation and consumption.

The University Planning Committee on Science and Engineering (UPCSE) was convened to identify ways to strengthen research and education in science and engineering across Harvard, and ensure that the University could capture these emerging opportunities. Harvard is already making significant science and engineering investments, including the Northwest Laboratory and the Laboratory for Interface Science and Engineering in Cambridge, building a major new science facility in Allston, commitments to the creation of the Harvard Stem Cell Institute, the establishment of a School of Engineering and Applied Science, creating the Department of Systems Biology at Harvard Medical School, and launching the Broad Institute (jointly with MIT and the Harvard-affiliated hospitals). UPCSE was presented with the opportunity to build on these advances and develop a bold vision for the future of science and engineering at Harvard. Four overarching principles guided the committee's deliberations and discussions:

1) Harvard is first and foremost a university. Its commitment to learning should guide a transformation in the education and training of students in science and engineering.

2) Harvard must attract, recruit and promote the best scientists and engineers and provide them with the environment, resources, and opportunity to produce their best work.

3) Harvard should enhance the agility of scientists and engineers to allow them to pursue new ideas as they arise.

4) Harvard must ensure that exciting science and engineering research and education occur on all campuses.

UPCSE process

UPCSE held weekly meetings from January to July 2006, supplemented with three half-day working sessions, to identify and discuss opportunities to strengthen Harvard's science and engineering. The committee membership of 24 was drawn from the Faculty of Arts and Sciences (FAS), the Harvard School of Public Health (HSPH), the Harvard Medical School (HMS) and the Harvard-affiliated hospitals, and included the Dean of the Graduate School of Arts and Science (GSAS), Theda Skocpol. Over five months, the three committee co-chairs met with eleven departments in FAS, with nine at HMS, with the faculty of HSPH, and with the research leadership of four of the major affiliated hospitals.

Over the last five years, the University has received numerous proposals for new activities in science and engineering, and has reviewed many of them as part of the Science and Technology Task Force. We chose not to review or rank proposals, both to avoid giving the impression that new initiatives could not be approved after UPCSE's dissolution and because we believed that our energies were best directed towards making proposals about the governance of science and engineering. We recommend that HUSEC conduct a comprehensive review of existing proposals for new scientific initiatives and issue regular calls for new initiatives.

In our findings below, we identify weaknesses in Harvard's approach to science and engineering. The recommendations that follow are designed to strengthen and broaden Harvard's teaching and research and increase its scholarly agility and effectiveness. We present our committee's initial recommendations in this Preliminary Report. Many are inspired by exemplary programs already in place somewhere at Harvard. We hope that this document will stimulate thoughtful conversations across the Harvard community. We intend to stimulate and solicit responses during the summer and fall of 2006 and incorporate them into a final report to be delivered in December 2006.

Findings

Harvard's approach to education does not take full advantage of the strengths and interests of scholars across the University and its affiliated institutions. There are no formal mechanisms or incentives for non-FAS faculty to teach undergraduates, despite the strong interest some have in doing so. Many graduate students' ability to work across departments and select advisors is limited by departmental funding structures. The technical infrastructure for instruction in science and engineering is inadequate to support a shift to more hands-on learning.

Science and engineering research at Harvard proceeds with great vigor in established departments and programs. Some research is done by individual faculty and their students, while other projects are pursued by groups of faculty and students situated across departments, often in collaboration with other universities. Harvard must not abandon or undercut its existing strengths, and new appointments should continue to be made within the core disciplines and existing programs.

The University needs to do more, however, to promote collaboration and respond rapidly to emerging research opportunities. Many faculty members find it difficult to conduct interdisciplinary research or establish new educational programs, especially across school and departmental boundaries. Support for cross-departmental initiatives is ad hoc, joint appointments are challenging and time-consuming, and cross-school grant administration and protocols are not standardized. The scale of Harvard's research enterprise makes it difficult for people to know about research in other parts of the University; no central repository provides easily accessible information on research and scholarship across the Harvard complex.

The "each tub on its own bottom" philosophy of resource management has precluded a coordinated approach to managing science and engineering across the Harvard complex, leading to parallel (and occasionally competing) efforts in different parts of the University. Collaboration is inhibited by a diversity of cultures, as well as independent administrative and accounting structures among the many organizational units in which Harvard faculty teach and do research.

In the biomedical sciences, Harvard's scale is particularly large and its organizational structure particularly complex. Harvard is unusual in that its hospitals are autonomous corporations, with their own governance, fundraising and scientific decision-making processes. The hospitals house a substantial fraction of all science at Harvard, with 1,000 faculty engaged full time in research and $1.5B a year in sponsored research funding. This is twice the number of faculty (≈550), and twice the research funding, received by the rest of the University combined (FAS + HMS +HSPH). Moreover, the hospitals contribute 3M square feet of research space for use by Harvard faculty on top of the 1.8M square feet within the University. For these reasons, coordinating the full range of scientific research by Harvard faculty requires not only negotiations between schools within Harvard, but between the University and its multiple hospital partners.

Finally, inadequacies in technical infrastructure are preventing Harvard's teaching and research in science and engineering from achieving its full potential. In particular we draw attention to the poor state of our high-end research computing facilities.

Recommendations

The University faces the challenge of embracing and expanding inter-disciplinary science while maintaining its strength in the core disciplines. We make nine main recommendations to increase the University's ability to promote collaboration and cutting-edge science and engineering. Five are institutional recommendations, and three address the challenges of implementation.

Institutional recommendations

Recommendation #1: Transform the teaching and training of students in science and engineering.

We affirm the importance of providing Harvard's students with outstanding instruction, which draws upon our strength in research. The teaching mission of the University is an important integrating force that can draw together scholars from across the Harvard complex.

- Implement hands-on learning as a cornerstone in undergraduate science and engineering education.

To make science and engineering come alive for students, we recommend that Harvard enhance the existing curricula with increased hands-on learning for undergraduates and increase opportunities for non-FAS faculty to play roles in all aspects of graduate and undergraduate education. Specifically, we recommend the creation of courses that provide project-oriented undergraduate research experiences for all undergraduates with any interest in science and engineering. In many cases, the success of these courses will require new or renovated laboratory space dedicated to undergraduate education. Harvard should adjust faculty credit and incentives to recognize the importance of undergraduate learning in laboratories as well as lecture halls.

In addition, we recommend the creation of new mechanisms by which talented scholars (not necessarily only tenure-track faculty) across Harvard can design and teach new courses, including ones that provide undergraduates with meaningful research experiences, and offer expanded research opportunities in faculty laboratories.

- Maximize educational and research opportunities for graduate students in science and engineering.

Enable graduate students to find research opportunities and select advisors across traditional department and program boundaries by establishing more umbrella consortia, such as the Harvard Integrated Life Sciences (HILS) consortium of graduate programs. Specifically, we advocate the creation of a Harvard Integrated Physical Sciences and Engineering (HIPSE), equivalent to HILS, to enable students to choose their advisors from a broad set of cooperating graduate programs. HILS and HIPSE will naturally overlap and need to work together to ensure success.

Facilitate mobility and flexibility, and optimize the fit between graduate student interests and faculty research by providing comparable funding through Harvard for the first year of graduate study across all programs and departments. This would ensure that graduate students choose programs on the basis of interest rather than differential stipends, and it would allow first-year graduate students to explore research projects and advisors across departmental boundaries, avoiding situations where students are narrowly assigned on the basis of departmental or sub-departmental funding. The best students will be attracted to Harvard by such flexibility, and applications for federal and foundation funding will be more competitive, if they arrange the best fit, following the first year, between students and faculty advisors.

Recommendation #2: Create a University-wide planning committee to assess, prioritize and support Harvard's portfolio of science and engineering activity in a formal and transparent way.

We recommend the immediate establishment of a standing committee, the Harvard University Science and Engineering Committee (HUSEC), to evaluate and partially fund University-wide science and engineering research endeavors, and to advise on science and engineering education and planning issues.

This committee would include the Provost, the Deans of FAS, HSEAS, HMS, and HSPH and elected and appointed representatives from all science and engineering constituencies, including the Harvard-affiliated hospitals. It is critical that leading women and under-represented minority faculty be included in the membership and leadership of the committee. We suggest that 12 members is an appropriate size for HUSEC.

HUSEC would control and manage the allocation of 75 interdisciplinary FTEs (over ten years), as well as a portion of research space on each campus. HUSEC would evaluate and fund interdisciplinary research proposals, ensure that appropriate constituents are involved in the efforts (e.g., departments, women, minorities), and enable selected proposals by allocating FTEs, funds and/or research space. HUSEC would advise on the location of science and engineering research, ensuring a balance across all campuses. HUSEC would establish and allocate FTEs to inter-departmental committees, recommend the creation of cross-school departments to the President and Corporation, and periodically review the research endeavors within its purview. Since many interdisciplinary research endeavors will involve the broader Harvard community, HUSEC would serve as a liaison between science and engineering and interested faculty members at other schools, including those of Government, Education, and Law. In particular, HUSEC would work to improve linkages between the affiliated hospitals and science and engineering across the rest of the Harvard complex.

In addition, HUSEC would identify strategic opportunities in science and engineering to stimulate the development of new proposals, and act as an advisory body to increase the transparency of all science and engineering planning, including advising on potential overlaps between departmental hiring and space plans. HUSEC would also advise on priorities for development and fundraising.

Recommendation #3: Form agile and responsive organizational structures to support interdisciplinary science and engineering faculty recruitment, promotion, and research.

We believe that a variety of organizational structures will be required to support new interdisciplinary science and engineering efforts.

We recommend the formation of inter-departmental committees and cross-school departments (each with the power to recommend faculty appointments) to facilitate the appointment of scholars whose work bridges existing departments and schools and knits together similar work being conducted across Harvard.

Both cross-school departments and inter-departmental committees, established via the Harvard University Science and Engineering Committee (see below), would have the resources and authority to recruit and recommend promotion of faculty members. We consider it important, however, that all Harvard faculty appointments reside in one or more departments.

In addition, we recommend formalizing and clarifying a mechanism by which faculty-driven science and technology initiatives can receive FTE and space through HUSEC or through schools and departments, depending on the proposed location and nature of the initiatives.

Recommendation #4: Promote diversity in science and engineering by recruiting a more representative cross-section of scholars to campus.

Fostering ethnic and gender diversity within science and engineering will promote innovative research and intellectual vitality at Harvard. HUSEC must ensure that it adopts and applies best practices in recruitment and hiring. Key senior women and minority scientists must sit on HUSEC, and the committee must assess progress in meeting overall ethnic and gender diversity aspirations.

Similarly, HUSEC can play a key role in ensuring ethnic and gender diversity in the leadership and membership of science and technology initiatives, inter-departmental committees, and cross-school departments. Departments should ensure their evaluation and search procedures strengthen Harvard's ability to attract the best qualified people across an array of backgrounds. Departments should develop an explicit plan for increasing diversity. Their progress should be evaluated by their host schools (by HUSEC for inter-departmental committees and cross-school departments). Similar efforts should be undertaken to ensure diversity of graduate students and post-doctoral fellows.

To attract and retain a community with a diversity of backgrounds in science and engineering, we recommend exploring approaches that would increase career flexibility and support, including workforce re-entry, improving partner career support opportunities, research scientist positions and child care facilities. We recommend the formation of a HUSEC subcommittee that includes representatives from the sciences, engineering, social sciences and humanities to explore and define such opportunities in collaboration with the office of the Senior Vice Provost for Faculty Development and Diversity.

Recommendation #5: Continue to invest in core disciplines.

Harvard has an outstanding collection of scholars and teachers in science and engineering. Many work in well-established disciplines where old questions remain unanswered and exciting new questions have appeared. Harvard should continue to invest in core disciplines and encourage their growth, for three reasons:

1) Important and unanswered questions. Answering these is a critical to Harvard's mission to increase human knowledge.

2) Our students must be well educated in the fundamental aspects of biology, chemistry, engineering, mathematics, astronomy, earth and planetary science, physics, and statistics.

3) The speed and unpredictability with which disciplinary boundaries move and erode. Answering questions that lie at the center of a core discipline can create important new opportunities for inter-disciplinary research, and advances in other fields can unexpectedly bring them into contact with a core discipline.

We recommend that each of Harvard's schools continues to expand its faculty in science and engineering, including proposed appointments in core disciplines. In this context, we propose that HUSEC review departmental expansion plans and advise the relevant Deans about their implications for increasing the strength of individual departments, promoting the education of undergraduates and graduate students, stimulating interactions among departments, and avoiding duplication of effort by various schools and departments.

Recommendation #6: Establish Allston as an interdisciplinary science and engineering research, education, and cultural center that helps the surrounding communities and the world at large.

The Allston campus can influence the University and community at large through multi-disciplinary research, education, and cultural activities. Allston should bring together faculty spanning a range of disciplines in the sciences and engineering, from biology and medicine to chemistry, physics, mathematics, and engineering. Together they could tackle basic and applied problems at the interface of the life sciences, medicine, physical sciences, and engineering.

The UPCSE vision for Allston includes three linked components:

1) Integrating elements of biology, chemistry, engineering, and physics to uncover the fundamental principles that explain how cells integrate a myriad of internal and external signals to survive and reproduce in variable environments, understand how these principles explain evolutionary plasticity, and exploit them to manipulate cells for research and medicine;

2) Bringing biology and medicine together to develop the new field of regenerative biology and tackle infectious diseases; and

3) Establishing a strong capability in multidisciplinary and computational analysis, in particular addressing our current weakness in research computing.

We recommend that a critical mass of collaborative science be located in Allston to fulfill the vision. This could include the Harvard School of Public Health, Regenerative Biology and Medicine, the Harvard Institute for Biologically Inspired Engineering (HIBIE), Microbial Sciences, Systems Biology, Chemical and Physical Biology, Innovative Computing, and significant portions of Quantitative Analysis. While professional school faculty have teaching responsibility in their schools, we recommend that all Harvard faculty members located in Allston would have a firm commitment to the University's teaching mission.

In addition to strengthening interdisciplinary science and engineering research at Harvard, Allston should provide a cultural and educational gateway to the community. We recommend a major effort in community outreach and education in Allston, including relocating the Harvard science museum complex and the Graduate School of Education (GSE) to Allston and establishing a Harvard Science Outreach group to coordinate educational efforts.

Allston also represents an extraordinary opportunity to improve the living arrangements and support for graduate students, post-doctoral fellows, and junior faculty. The creation of living quarters and daycare facilities would enhance careers in science and engineering and provide a valuable framework of child care and support.

Implementation recommendations

Recommendation #7: Establish specific cross-school departments, inter-departmental committees, and science and technology initiatives.

We have identified nine research endeavors that would benefit from being organized as cross-school departments or inter-departmental committees to support inter-disciplinary science and engineering appointments. We suggest locations for many of these activities and recognize that some of the research ideas may be able to be implemented sooner than others, depending on their level of development and maturity. Several represent important opportunities for developing novel interdisciplinary science and engineering approaches that can and should be supported in campus locations other than Allston.

- We recommend four new cross-school departments: 1) Regenerative Biology and Medicine, 2) Systems Biology, 3) Chemical and Physical Biology, and 4) Neuroscience, to unify research efforts across the University and to facilitate new inter-disciplinary faculty appointments.
- We recommend the formation of five inter-departmental committees: HIBIE, Microbial Sciences, Energy and the Environment, Human Genetics, and Quantitative Analysis. Since seed funding or donor support already exist for HIBIE and Microbial Sciences, these initiatives provide an opportunity to implement the inter-departmental committee structure immediately.
- A number of science and technology initiatives were approved by the earlier Science and Technology Task Force: Innovative Computing, Origins of Life, Quantum Science and Engineering, and Global Health. Ideas in the planning stages include a Translational Research Center, Computation and Society, Fundamental Physical Laws, and the Evolutionary Biology, Biodiversity, and Conservation initiative. Proposals in such areas, as well as others certain to emerge later, would come to HUSEC for evaluation and potential support. In due course, some efforts that start as initiatives may evolve into inter-departmental committees or departments.

Recommendation #8: Address shortcomings in Harvard's research and instructional technical infrastructure.

Teaching and research in science and engineering require access to an evolving set of cutting-edge tools and facilities. Coordinated acquisition and management of costly facilities, such as MRI machines and computational resources, would yield big dividends. In addition, Harvard should invest in technical infrastructure for innovative teaching. We propose three steps toward meeting these goals:

- Establish a database of the interests and capabilities of Harvard's scientists and engineers to increase connections among them;
- Steady renewal of teaching facilities for science and engineering, commensurate with our focus on hands-on learning;
- Invest in computational resources and the high-level technical support that will provide a foundation for research across all fields in the decades ahead.

Recommendation #9: Enable a mixture of funding mechanisms to finance new science and engineering plans.

Harvard must ensure that HUSEC has sufficient resources (FTEs, space, and funding) to support the initiation of new science and engineering research. The resources should come from a mixture of sources, including fundraising through the Development office and the alignment and coordination of the FAS, HMS, and HSPH school resource allocation. Appropriate FTE and space contributions could also come from the hospitals for specific endeavors, for example in joint ventures with the university.

If Harvard intends to take advantage of the opportunity presented by Allston, it must meet financial challenges imposed by a major expansion of the faculty. Even if the majority of the faculty at Allston were to move from Cambridge or Longwood, the University would replace them. Thus the cost of Allston is largely independent of whether we populate it through growth, transplants, or some combination of the two. The ambition of all science and engineering efforts at Harvard to grow over time, and the desire to start new programs, imply a large increase in the science and engineering faculty. We should plan accordingly.

An exception arises if an entire school, such as the Harvard School of Public Health or the Graduate School of Education, moves to Allston. In these instances we do not expect to fill the vacated space with similar activities.

We foresee two costs of establishing a critical mass of intellectual activity in Allston: 1) One-time capital construction costs, much of which can be debt-financed, and 2) ongoing operating costs of essentially indefinite duration. In calculating these running costs, the University must take into account the true cost of adding more faculty, such as additional graduate student and administrative support. We present below a framework for estimating the full costs of a major expansion.

Evaluation and funding of interdisciplinary science and engineering proposals will be formalized through HUSEC. All funds in support of interdepartmental or interdisciplinary research endeavors coming from the central administration will be administered through HUSEC.

Implementation milestones

To maintain and increase our strength in science and engineering, we recommend that HUSEC's first meetings occur no later than the summer of 2007, appropriate resources be allocated to HUSEC by January 2008, the first cross-school departments and inter-departmental committees begin recruiting by the end of the first half of 2008, and the first building in Allston be occupied in 2009.

1.0 INTRODUCTION

Research and teaching form the bedrock of Harvard's strength in science, mathematics, medicine, and engineering, and are critical to our future success. First-rate faculty appointments in these traditional disciplines are essential to our continued growth and our pursuit of excellence in research and teaching.

Harvard's aggregation of talent, the quality and breadth of research, the strength in attracting the very best researchers in the world, and the University's resources all combine to create an environment that can significantly help the world and improve society.

This report addresses how we might improve Harvard's effectiveness in science and engineering, in particular focusing on two issues: 1) How can we draw together related but currently disconnected intellectual activities underway in different components of the Harvard complex, and 2) How can we increase the effectiveness of our scholars, particularly in research and teaching that cuts across existing disciplines?

1.1 The University Planning Committee on Science and Engineering (UPCSE)

The University Planning Committee on Science and Engineering (UPCSE) was convened at the end of January 2006 to look comprehensively at the future of science and engineering across the University and advise on research and teaching opportunities. The roster of the committee is provided in Table I. The charge to the committee is presented in Appendix A.

Committee Co-Chairs	Andrew Murray (FAS)	Herchel Smith Professor of Molecular Genetics; Co-Director of the Bauer Center for Genomics Research, Chair of MCB
	Christopher Stubbs (FAS)	Professor of Physics and of Astronomy
	Christopher Walsh (HMS)	Hamilton Kuhn Professor of Biological Chemistry and Molecular Pharmacology
Faculty of Arts and Sciences	Cynthia Friend	Theodore William Richards Professor of Chemistry and Professor of Materials Science; Chair of CCB
	Dan Kahne	Professor of Chemistry and Chemical Biology; Professor of Biological Chemistry and Molecular Pharmacology
	Andrew Biewener	Charles P. Lyman Professor of Biology, Chair of OEB
	David Liu	Professor of Chemistry and Chemical Biology
	David Mooney	Gordon McKay Professor of Bioengineering

FAS (continued)	Doug Melton	Thomas Dudley Cabot Professor of the Natural Sciences
	Erin O'Shea	Professor of Molecular and Cellular Biology; Co-Director of the Bauer Center for Genomics Research
	Federico Capasso	Robert L. Wallace Professor of Applied Physics and Vinton Hayes Senior Research Fellow in Electrical Engineering
	Jeremy Bloxham	Mallinckrodt Professor of Geophysics; Harvard College Professor, Chair of EPS
	John Huth	Donner Professor of Science, Chair of Physics
	Theda Skocpol	Dean of the Graduate School of Arts and Sciences; Victor S. Thomas Professor of Government and Sociology
	Venky Narayanamurti	John A. and Elizabeth S. Armstrong Professor of Engineering and Applied Sciences, Professor of Physics; Dean of the Division of Engineering and Applied Sciences and Dean of Physical Sciences
Affiliated Hospitals & Harvard Medical School	Jeff Flier	George C. Reisman Professor of Medicine; BIDMC
	Dan Podolsky	Mallinckrodt Professor of Medicine; MGH
	Nancy Andrews	Leland Fikes Professor of Pediatrics; Dean for Basic Sciences and Graduate Studies; Children's Hospital
	David Altshuler	Associate Professor of Genetics and Associate Professor of Medicine, HMS and MGH; Director, Program in Med and Pop Genetics, Broad Institute of Harvard and MIT
	Carla Shatz	Nathan Marsh Pusey Professor of Neurobiology; Head of the Department of Neurobiology
	John Mekalanos	Adele Lehman Professor of Microbiology and Molecular Genetics; Member of the Faculty of the Harvard-MIT Division of Health Sciences and Technology; Head of the Department of Microbiology and Molecular Genetics

HMS (continued)	Marc Kirschner (resigned from UPCSE May 2006)	Carl W. Walter Professor of Systems Biology; Head of the Department of Systems Biology
Harvard School of Public Health	Dyann Wirth Gokhan Hotamisligil	Richard Pearson Strong Professor of Infectious DiseasesDepartment of Immunology and Infectious Diseases James Stevens Simmons Professor of Genetics and Metabolism Department of Genetics and Complex Diseases

Table I. University Planning Committee for Science and Engineering Membership.

The Committee was given a broad mandate to look across all Harvard schools and campuses, to explore the optimal organizational and governance structures to facilitate science and engineering research and teaching, and to identify the most compelling research ideas and initiatives.

We recognize that strategic planning was underway at Harvard before the establishment of our Committee, and that it will continue after we disband. We have drawn extensively on work done by the Task Force on Women in Science and Engineering (report issued in 2005 by Harvard University), and the various Allston Task Forces (see references).

We also note that over the past five years the university has made major commitments to three efforts in science and engineering that provide a platform and context for the current deliberations and future plans. These are: (1) the Harvard stem cell institute between FAS, HMS and the hospitals; (2) the Broad Institute with support from Harvard and MIT; (3) the planned School of Engineering and Applied Sciences within FAS.

We structured our approach to engage Harvard faculty in our discussions, soliciting their input through multiple channels: conversations with UPCSE members, research proposal submissions, and co-chair meetings with science and engineering faculty. The co-chairs met with faculty in 11 departments across the Faculty of Arts and Sciences (FAS), 9 in the Harvard Medical School (HMS), the faculty of the Harvard School of Public Health (HSPH), and the executive research committees at the five major Harvard-affiliated hospitals (see Appendix B for list of co-chair departmental and hospital meetings). As a result of these meetings, a number of research and education proposals were submitted to UPCSE for review and discussion.

The Committee met weekly from January through June of 2006, supplemented by three half-day sessions. We drew upon "lessons learned" at Harvard and elsewhere to better understand the results of experiments in organizational structure and resource allocation.

The Committee co-chairs kept Harvard leadership apprised of progress and developments. One midcourse meeting and a final meeting were held with the Deans of FAS, GSAS, HMS and HSPH. The co-chairs also presented the executive summary to President Summers and to incoming Interim President Bok. The Harvard Corporation met with the co-chairs at the start of

the Committee deliberations, and is scheduled to consider these initial recommendations in their July 2006 meeting.

We are very grateful to Provost Steve Hyman for his continual support of this effort, for his steadfast encouragement and his keen insight. Eric Buehrens was a critical participant in our planning meetings, and the Committee is indebted to him for his many important contributions.

We were fortunate to have received very substantial assistance from consultants from McKinsey & Company. We are very thankful for their perspective, their engagement and their tenacity.

The heroic work of Catherine Barba, Brooke Pulitzer and Trinette Faint was essential to our efforts, and we are very grateful for their patience and their diligence.

We also wish to acknowledge the many members of the Harvard community who took time from their busy schedules to attend and contribute to the various UPCSE meetings.

1.2 UPCSE's Interim Report: Structure and Objectives

This interim report will be distributed to the science and engineering faculty at Harvard for comments and feedback. Town hall meetings will be set up for FAS, HMS, HSPH, and the major Harvard-affiliated hospitals to provide a forum for discussion of this report's findings and recommendations. The report will be finalized by UPCSE and submitted in December 2006.

This report summarizes our findings and recommendations. It is organized into five sections:

- Science and Engineering at Harvard
- Findings and Opportunities
- Recommendations
- Implementation Considerations
- Concluding Thoughts

2.0 SCIENCE AND ENGINEERING AT HARVARD

The scale of science and engineering at Harvard is impressive in its breadth and depth. The Faculty of Arts and Sciences (FAS, including the Division of Engineering and Applied Sciences (DEAS) and its recently announced successor, the Harvard School of Engineering and Applied Sciences (HSEAS), the Harvard Medical School (HMS) and the Harvard School of Public Health (HSPH) and the Harvard-affiliated hospitals all carry out vigorous research and teaching in science, mathematics and engineering. Appendix C presents an overview of this activity in Harvard's schools and hospitals. In FAS, HMS, and HSPH, there are approximately 550 principal investigators who generated over $450M in external funding in 2005 and occupied over 1.7M net assignable square feet (NASF) of research space across the University. The 18 Harvard-affiliated hospitals and research institutes add more than another 10,000 faculty with Harvard appointments who are engaged in research and clinical care, of whom more than 1,200 engage in basic research as their primary effort. In total, Harvard's scientists and engineers generated over $1.5B in external funding in 2005, and occupied greater than 3M NASF of research space.

Each school and hospital has ambitious research and teaching growth plans over the next five years. The three Harvard schools mainly engaged in science and engineering plan to grow their science and engineering faculty by approximately 13 percent by 2010, and the affiliated hospitals have growth plans of their own. As an example of the growth in Harvard's efforts in science and engineering, in the period 2001-2005 external funding for research in FAS grew from $98M to $44M. A comprehensive overview of the evolution of externally funded activity can be obtained from the Annual Reports issued by the Harvard Office of Sponsored Projects.

Harvard scientists span the range of the life, physical, medical, and engineering sciences. Their number and range represent both a strength and a weakness. In principle, there are almost limitless opportunities for interdisciplinary collaboration, but our size makes it hard for each investigator to find potential collaborators in the larger community of scholars, especially outside their fields. As a result, collaborations are often the result of chance encounters. We lack the searchable databases that would help scientists learn more about activities underway across the campus.

2.1 Breadth of research

Harvard is well represented in the life, physical and engineering sciences, many of which have communities of researchers at all three Harvard science and engineering schools (FAS, HMS, HSPH) and the affiliated hospitals. When considering the entire enterprise, the research and attendant educational efforts reach from the very basic to the applied.

¶ Research and education span numerous disciplines in the life sciences, physical sciences, and engineering and includes the following departments:

- FAS: Astronomy, Biological Anthropology, Chemistry and Chemical Biology, Applied Math, Mechanics, Bioengineering, Applied Physics, Material Science, Computer Science, Electrical Engineering, Environmental Science and Engineering, Earth and Planetary Sciences, Mathematics, Molecular and Cell Biology, Organismic and Evolutionary Biology, Physics, Psychology, Statistics.

- HMS: Biological Chemistry & Molecular Pharmacology, Pathology, Cell Biology, Genetics, Health Care Policy, Molecular Genetics & Microbiology, Neurobiology, Social Medicine and Systems Biology on the HMS quadrangle plus dozens of clinical departments located in the affiliated hospitals. There are also inter-departmental graduate programs in biophysics, chemical biology, immunology, systems biology, neuroscience, and virology, which are administered at HMS but span FAS and HMS.
- HSPH: Laboratory sciences (Immunology and Infectious Diseases, Genetics and Complex Diseases, Environmental Health, Nutrition), quantitative disciplines (Epidemiology, Biostatistics), social sciences (Health Policy and Management, Population and International Health, Society, Human Development and Health).

In addition to the historical and current strength in disciplinary research and education, multiple interdisciplinary science and engineering activities have been launched at Harvard. A number of multi-disciplinary institutes have been formed or committed to (e.g., Bauer Center for Genomics Research, Broad Institute, Brain Science Center, Stem Cells). Harvard has also launched interdisciplinary undergraduate concentrations (e.g., Chemical and Physical Biology) and an umbrella for graduate programs in the life sciences (Harvard Integrated Life Sciences or HILS) that enable and foster cross-disciplinary training.

2.2 Research space overview

In the near term, there are no space constraints if Harvard's schools are considered as a single entity. The University has recently invested in science and engineering through new science space in the Northwest Laboratory and LISE building in Cambridge and has committed to building the first new science and engineering building in Allston. Near-term growth in Allston, therefore, will be driven by the strategic benefits of a new campus rather than the need for additional space.

Faculty growth plans imply, however, that each school will eventually face space constraints (see appendix for a complete overview on space). HSPH is currently out of space and cannot meet growth needs without building new facilities. By 2011, FAS, with the opening of the NW building in 2008 and other renovations, will have space sufficient for 55 net new FTEs in Cambridge. While this is sufficient to meet near-term growth plans, there are few options for expansion in Cambridge beyond those 55 FTEs, limiting the ultimate size of the science and engineering efforts on that campus. HMS has greater flexibility and sufficient space to meet its expansion needs for the foreseeable future, but must reprogram space that it controls but has leased to third parties. Without such reprogramming, HMS will become space constrained in 2009.

Figure 1 shows the anticipated evolution of research space needs in Cambridge under various scenarios.

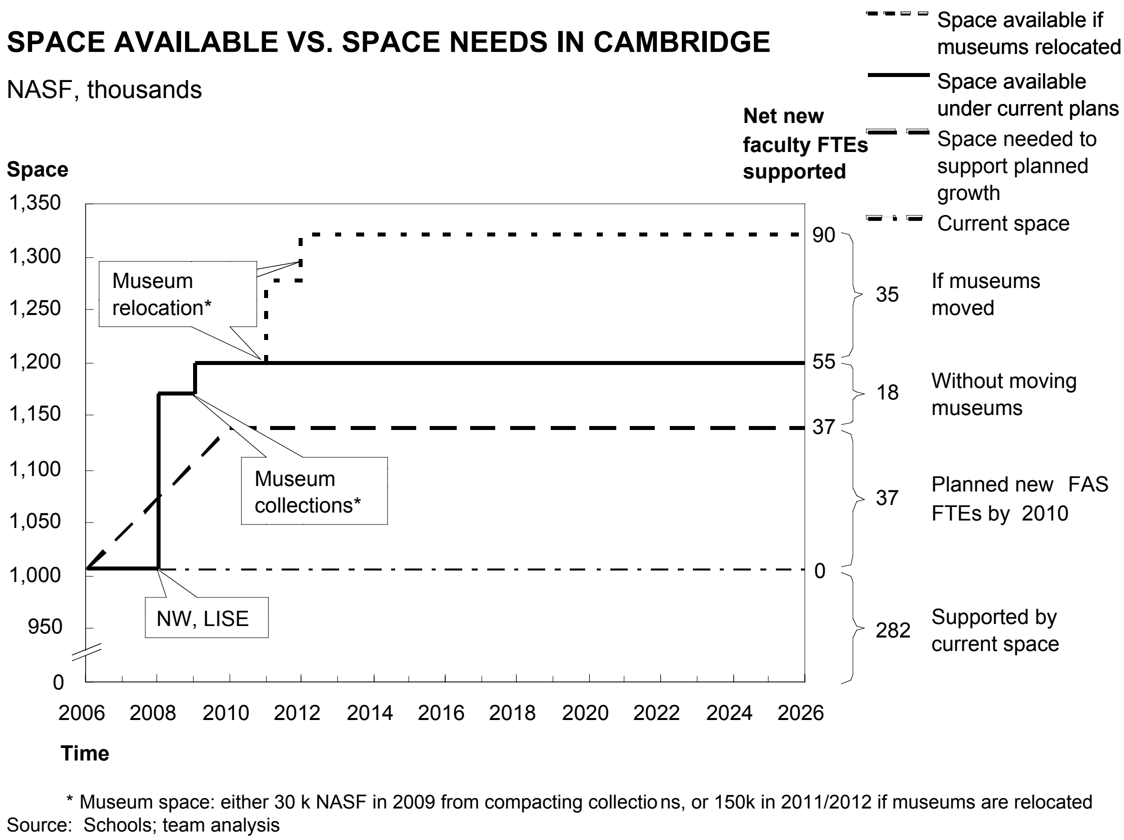

Figure 1. Evolution of Harvard's space needs in Cambridge for science and engineering. The solid line indicates space in net assignable square feet (NASF, left vertical axis) or in FTE equivalents (right vertical axis). Note: Cambridge has a space deficit through 2008, when the NW and LISE buildings become available. These buildings will allow the addition of 55 faculty above the existing 650. Any further growth in Cambridge will require new space. Moving the museum complex is one option.

3.0 FINDINGS: CHALLENGES AND OPPORTUNITIES

While recognizing Harvard's many successes, the Committee identified multiple areas where our current practices do not serve us well. We identify these in the sections that follow. These are the problems our recommendations attempt to solve, and the opportunities we hope to exploit.

3.1 Undergraduate Education

Harvard University attracts outstanding students at both the undergraduate and postgraduate levels. Access to Harvard's educational programs is highly competitive, with demand far in excess of supply. We are fortunate that this brings to our campus a cadre of highly accomplished, motivated, and passionate students.

Harvard College is a four-year residential liberal arts college embedded in a major research University. The Faculty of Arts and Sciences (FAS) has primary responsibility for establishing undergraduate educational policies, for meeting the educational needs of the undergraduate population, and for awarding undergraduate degrees. The teaching of undergraduates and the administration of the undergraduate program are major responsibilities for all members of the FAS. Promotions, raises and tenure decisions in the FAS all take undergraduate teaching into account, and the nine-month compensation of FAS faculty recognizes these responsibilities.

Some of our science and engineering concentration options align directly with FAS departments (mathematics, physics, astronomy, etc.) while others (chemistry and physics, program on the environment, etc.) are intrinsically cross-departmental. Information on concentrations and their respective requirements can be found in the Harvard College Handbook for Students (Harvard University, 2006).

The ability to create undergraduate concentrations in response to evolving intellectual interests and student demand is a great opportunity to knit together scholars from across the Harvard complex, and our committee heartily endorses this flexibility. The FAS mechanisms for evaluation and assessment of new concentrations seem sound and effective, and we see no need to suggest any modifications.

The curriculum review of 2005/2006 has sparked innovation at the introductory course level for both the life sciences and the physical sciences, and we applaud this development. The science and engineering component of the curriculum review focused mainly on these introductory classes, and on the general education requirements for non-science majors (Curricular Review Reports, Harvard University, 2006). We will therefore direct our attention to the later stages of undergraduate instruction, with a focus on students who select science and engineering concentrations.

The fact that Harvard is doing a good job at undergraduate education does not mean we should not strive to do better. The recent book, *Our Underachieving Colleges* (Bok 2006), makes this point clearly: there is certainly room for improving the effectiveness of undergraduate instruction, even at Harvard. We propose taking steps that will both improve undergraduate learning and draw the science and engineering community closer together.

Hands-on Learning

There is now ample evidence that lecture based instruction in the sciences is less effective than many would like to think (Handelsman et al 2004, DeHaan 2006, Boyer Commission 1998). Despite a succession of reports from the National Academy of Sciences (NAS 2003a, 2003b) and others that point out the need for a revision in the way science is taught, change has been slow in coming.

We advocate that Harvard take a leadership role in exploring new methods for enhancing student learning in the science and engineering arena. While the University does have some science education pioneers in its ranks (E. Mazur and others), it has no clear process for implementing new educational ideas, and for assessing their effectiveness. Harvard has no clearly defined resources for technical curriculum development, and its framework for allocating teaching fellows and class support does not recognize the demands of curricular innovation.

In particular, we believe that hands-on learning should play a much larger role in undergraduate instruction in science and engineering. By trying new approaches and monitoring their effectiveness, Harvard can evolve to a position of a world leadership in innovative science and engineering instruction.

It is an unfortunate fact that many students now graduate with a Harvard concentration in the sciences and engineering without ever really experiencing what it's like to actually *do* science. Most of these students will not pursue careers as scientists or engineer, but we believe that confronting the reality of research is an important learning experience that complements classroom experiences.

Not all undergraduate research experiences meet our expectations (G. Fowler, 2000). Harvard must actively monitor and mentor the process, from start to finish. This will impose considerable demands on the faculty, and we see this as an important incentive to increase the total number of FAS science and engineering faculty.

Incentives are not in place to encourage greater student or faculty involvement in creating undergraduate research experiences. Many students will engage in research experiences in affiliated hospitals for the experience, but may not receive academic credit for their work. This can deter some students from seeking out interesting research experiences, as either the barriers to entering into the research are too high, or the perceived benefit, without being able to obtain academic credit for the work, is too low.

Similarly, many faculty have little incentive to teach in the undergraduate curriculum, or to sponsor and mentor an undergraduate research project in their lab. Some non-FAS faculty have expressed a desire to become more involved in teaching and advising students, but these faculty get little credit for teaching undergraduate courses and counter-incentives exists for their home schools to allow this. FAS faculty receive little if any credit for the time they spend supervising undergraduates engaged in independent study in their laboratories. Across all schools, there is little financial support for sponsoring undergraduate, project-based labs.

In addition to these barriers, there is unevenness in the quality of project-based lab experiences, for both faculty and students, within and among the different schools at Harvard.

In this context, we note that in terms of research opportunities, Harvard has two major and largely underutilized resources. The scholars in the Harvard-affiliated hospitals are powerful scientists and technologists, some of whom have considerable interest in mentoring the learning of undergraduates. On the physical science side Harvard has the Smithsonian Astrophysical Observatory (SAO), again with many colleagues who are keen to supervise a Harvard undergraduate.

We therefore see an opportunity to draw upon the strengths and interests across the Harvard intellectual complex to support each science and engineering undergraduate in gaining real-world research experience. There is presently an asymmetry here, in that the scientists in the Harvard-affiliated hospitals typically have a Harvard appointment of some kind, while those in the SAO do not. This is presumably an artifact of the governance and administrative structures Harvard has inherited, and we suggest the administration rectify this imbalance.

To increase the hands-on learning component of an education, Harvard must provide:

1. Equitable compensation and rewards for FAS and non-FAS colleagues for their efforts in supervising undergraduates;
2. A uniform approach to hospital and SAO scientists;
3. Staff support to help match student interests with opportunities; and
4. Clear guidance on the expectations and responsibilities of those who supervise undergraduate research.

Harvard will reap two major benefits from these changes: students will emerge with a wider breadth of experiences, and new connections will form between different parts of the Harvard research complex.

3.2 Graduate Education

We recognize the value of increasing graduate students' ability to explore a range of inter-disciplinary topics early in their training. Graduate students today, however, cannot always select research groups and thesis advisors based on intellectual interests. Because funding is often tied to specific departments, or even to endowed sub-groups or faculty projects within departments, students are often pre-assigned at the time of admission.

Even in the case of science departments that receive most of the funding for first-year students through the Graduate School of Arts and Sciences, students tend to be discouraged from moving across departmental lines for fear that departmentally dedicated resources will be lost. Enabling graduate students to work with faculty in other departments can be seen as subsidizing another department's research efforts.

Arrangements already exist within the university to overcome barriers to movement by graduate students. The Division of Engineering and Applied Physics has done much to promote interdisciplinary ties to the physical sciences. And the recently created consortium, Harvard Integrated Life Sciences (HILS), promotes cooperation and integration across life science programs in Cambridge and Longwood. Although each of the twelve PhD programs in HILS admits and funds its own students, once at Harvard, students may do rotations and choose research projects and advisors outside their native programs. HILS uses funds to smooth such transitions and ensure that programs and faculty do not experience losses when graduate students move.

More than graduate student flexibility is achieved through HILS. This arrangement enhances the adaptiveness and competitiveness of life science research at Harvard, because it prevents mis-matches between students and faculty and helps training grants produce new researchers whose interests match those of the various federal funding agencies.

Harvard University should also ensure, in a uniform way, at least the first year of funding for all graduate students in natural science PhD programs, and this should occur in ways that do not tie individual entering students to particular departments, projects, or training grants. Offering uniform Harvard funding for all first-year graduate students would eliminate many of the barriers to flexibility in choice of research labs and advisors, and thus would encourage interdisciplinary research. This measure would also enhance the competitiveness of faculty-run projects that must compete for federal or foundation funding by proving a good fit between research objectives and the achievements of affiliated faculty and students.

3.3 Faculty Appointments, and Faculty Diversity

Appointing faculty is arguably the single most important task in University management. Harvard does a good job of identifying, recruiting and appointing individuals whose scholarship fits comfortably within its existing departmental boundaries, but there is considerable difficulty in making appointments that cut across departmental lines. There are two obstacles.

Within FAS there is a perceived opportunity cost when a department is asked to contribute a half-FTE position for a cross-disciplinary researcher. These resources are often seen as coming at the expense of an appointment in the department's area of core research. This has been an ongoing challenge, especially as Harvard strives to launch new, multi-disciplinary initiatives.

The second problem arises during promotion and tenure decisions on inter-departmental faculty members. As their efforts might span two or more departments, they often do not receive sufficient support from their primary appointing department and so have difficulty progressing through promotion and tenure decisions. The double jeopardy is especially difficult when there are major differences between the intellectual values and priorities of the departments.

The challenges of recruiting, appointing, and mentoring faculty who scholarly interests are broad are well recognized (NAS, 2005). Given the importance of this issue, we invested considerable time thinking about how Harvard might address it. There is a clear tension here between the desire to broaden the scope of scholarship Harvard supports and the need to evaluate appointment and promotion cases rigorously. We favor the idea of retaining the requirement that all Harvard faculty appointments reside within an established department.

Our recommendations suggest ways Harvard can broaden the appointment process while preserving its tradition of excellence.

We recognize the value of having a gender and ethnically diverse community of scientists and engineers. Harvard, like most universities, needs to ensure that diversity is taken into account for leadership and committee membership decisions, and in recruitment and promotion procedures.

The challenges of attracting and maintaining a representative faculty and student body are well documented (Rosser 2004, Preston 2004).

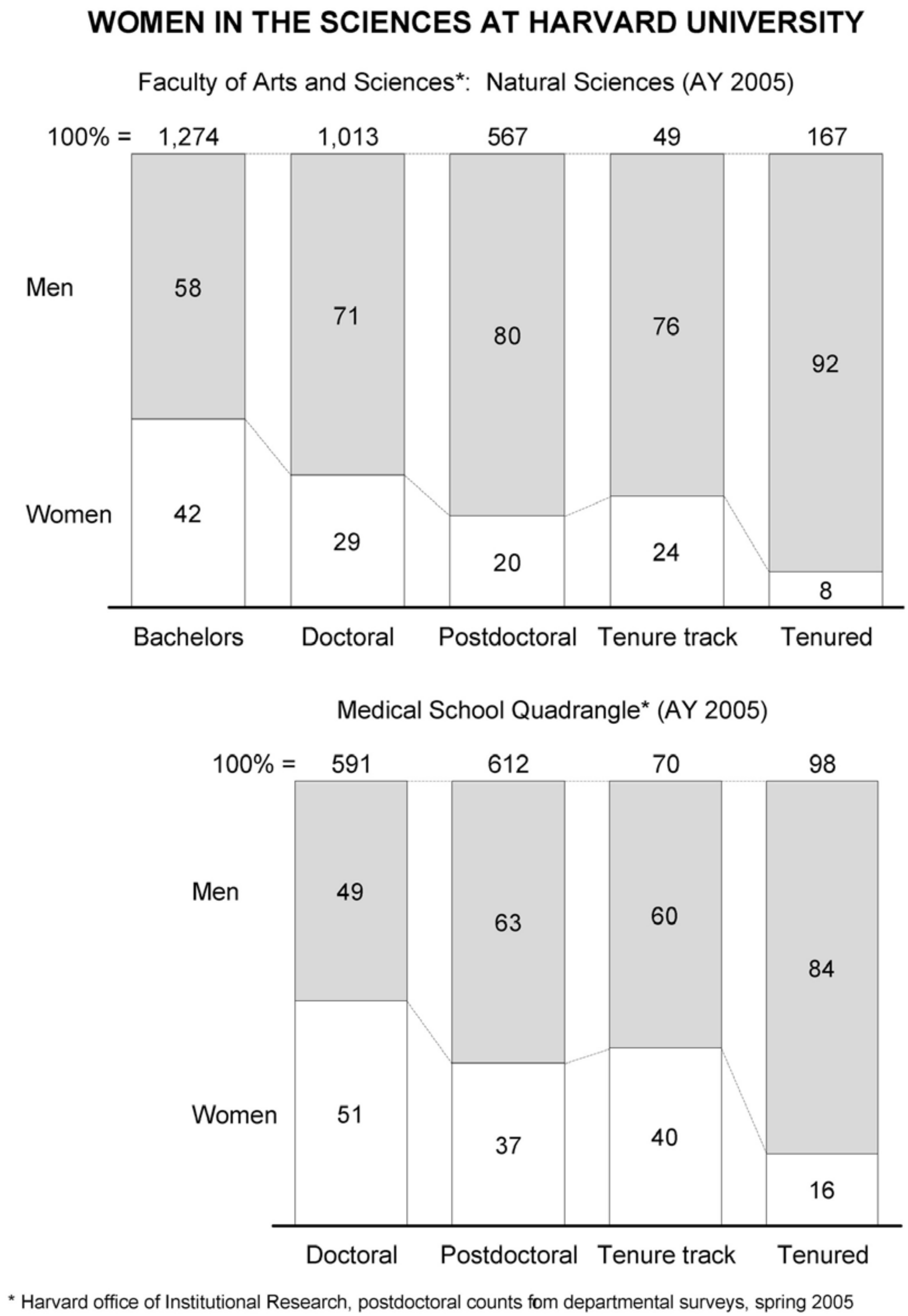

Figure 2. Fraction of Women participating in Science and Engineering vs. Career Stage.

Although there is a strong interest in science and engineering among women at the University in undergraduate and graduate programs, this number drops sharply in the faculty ranks. This is illustrated in Figure 2. Science and engineering career paths in academia offer few opportunities for flexibility or re-entry options. The lack of options beyond tenure track positions places constraints on recruiting and retaining a truly diverse set of researchers. Strong interest exists amongst the faculty to explore options to increase flexibility of research positions and re-entry points to enable greater diversity of backgrounds and experiences.

Few non-tenure-track positions exist at Harvard, outside the hospitals, and the non-hospital positions have been created on an individual basis. For example, HSPH has a total of 56 full- and part-time research scientist positions, and FAS (life and physical sciences and DEAS) has 21 research fellows.

No incentives exist to reward parts of the University that best succeed in meeting diversity objectives.

3.4 Collaboration

Fostering an environment that encourages and facilitates inter-disciplinary research and collaboration will be critical to maintaining Harvard's leading position in science and engineering research and teaching. This can take place at various level of aggregation. Harvard should strive to support each distinct scale of intellectual partnership, from pairs of principal investigators up to Centers and Initiatives and new Departments.

University-wide information databases: Harvard's scale and dispersed geography make it difficult to know what other research is taking place across the University or what lab and research capabilities exist in other departments, schools or hospitals. No searchable databases exist for research or teaching expertise, and there is no central repository of Harvard faculty abstracts and ongoing research. This is a fairly straightforward IT problem. Our recommendations suggest ways Harvard can use information technology to inform its researchers about the interests, skill and experience of other researchers on campus.

Grant administration: Grant administration and overhead policies are not uniform across the schools, making writing and administering joint grant proposals difficult. Limited grant-writing support exists for submitting cross-school grant proposals, and in many instances each collaborative proposal requires a separate negotiation. There are no uniform policies for IRBs or animal protocols to standardize research approaches across schools and hospitals.

3.5 Duplication of Effort

Given the scale of the scholarly enterprise at Harvard, it is no surprise that similar research often occurs in different parts of the University. Our committee determined that similar efforts are often only loosely coordinated. It is not uncommon to find closely related intellectual efforts underway in the Medical School, in FAS, and in one or more of the hospitals.

Harvard does not reap the full intellectual benefit of these efforts. In our recommendations, we present ideas on how much closer links could be made across the Harvard complex.

3.6 Legacy Organizational Structures and Attitudes

Creating and maintaining the next generation of research and education, both within and among disciplines, will require structural and cultural changes throughout science and engineering in the University. These changes require moving from an outlook that centers primarily on the sovereignty of schools, departments, and individual faculty members to one that promotes inter-departmental ties and changes the administration and allocation of resources to more fluidly support cross-school research and teaching.

The three enabling resources for new initiatives are funds, FTEs and space. Harvard's current structure, where certain funds for initiatives reside at the Central level, while FTEs and space are managed by Schools, makes it difficult and time-consuming to launch a University-wide initiative. This problem is exacerbated by the absence of any formal University-wide deliberative body with the authority to allocate these three critical resources. In our view, Harvard would benefit from a University-wide mechanism for setting priorities and allocating resources to research activities. Currently, science and engineering resource and space planning is largely done within the departmental and school structures, hindering the University's ability to make overall decisions about investments in its research portfolio. There is no forum for University-wide science and engineering discussions to coordinate planning or to offer the Harvard-affiliated hospitals a mechanism to participate in discussions.

Beyond the principal investigator level, there are no clear processes for launching or supporting inter-departmental initiatives. Much of the inter-disciplinary funding is obtained through the Provost's office. However, the ad hoc nature of the process can make it difficult to obtain support in a timely manner. There are no standardized criteria for initiative proposals, making it difficult to articulate the rationale for selecting some and rejecting others.

Several of the hospital executive research committees provide good case examples for standing committees that formally review research activities and increase decision-making clarity. For example, the Massachusetts General Hospital's (MGH) Executive Committee on Research (ECOR) provides a forum for discussing all strategic issues affecting research and formulating research policies. ECOR has responsibility for allocating research space and institutional funding at the hospital. A similar, University-wide, committee would improve science and engineering planning at Harvard and help regularize the selection and funding of inter-disciplinary research proposals.

3.7 Impediments to Intellectual Agility

If one plotted Harvard's existing efforts in science and engineering as the scale of effort (in FTEs) vs. duration of the activity, there would be two main clusters. At the scale of one to a few investigators, there are great many research efforts that last as long as a typical research grant, three to five years. There are also tens of FTEs grouped by departments, engaged in activity of essentially indefinite duration. The middle ground, namely groups of five to ten faculty working on projects that last ten years, is thinly populated. This is the domain of initiatives and Centers. While Harvard does have a large number of existing such activities, we would benefit from a structure where faculty could propose new activities in response to emerging opportunities and have their proposals evaluated in a predictable way. At present, Harvard has no well-defined process for soliciting such proposals, and their evaluation tends to be an ad hoc.

By establishing a clear set of criteria for evaluating proposals and a commitment to periodic solicitations for new ideas, we could empower Harvard's scholars to respond to new intellectual opportunities. Sustaining activity with a fixed level of investment would of course require that we be determined to shut down initiatives at the same rate as we initiate them.

Harvard has no well-defined way to facilitate cross-University science and engineering themes, in either research or teaching. They exist only by the sheer will and commitment of participating faculty, and are often paralyzed by differences in promotion criteria, appointment procedures, salaries, resources, and teaching requirements.

3.8 Deficits in Harvard's Existing Infrastructure

Teaching and research in science and engineering require tools. Harvard's instructional laboratories are designed and equipped mostly for the laboratory component of lecture classes, rather than for hands-on learning and student projects. Harvard does not administer a pool of resources to which faculty can apply to support, sustain and rejuvenate these facilities. We draw particular attention to the fact that research computing at Harvard falls far short of what one would expect from a leading institution. The lack of system administration and scientific programming personnel impedes scholars who aspire to undertake computationally challenging research projects. There is no clear understanding of roles and responsibilities regarding computational facilities, and many groups are forced to have students or postdocs serve in the role of system administrator. While the Initiative on Innovative Computing is addressing some of these problems, we need a more comprehensive approach, which will bring cutting edge research computing tools within reach of every researcher on campus.

4.0 RECOMMENDATIONS.

RECOMMENDATION #1: Transform the teaching and training of students in science and engineering.

Enhance undergraduate education

Undergraduate laboratory experiences should move toward including project-based efforts in addition to training in laboratory skills. While it will still be necessary to train students in the basics of how to work in a laboratory, performing a series of experiments to ask a novel question will increase educational value and a student's excitement about a career in science or engineering. A set of project laboratory courses that integrate with the didactic curriculum to build both technical and "investigational" skills will fulfill this goal.

To increase the number of faculty available to supervise an undergraduate, project-based laboratory experience, the University should offer any full-time faculty the opportunity to supervise an undergraduate lab experience. Where appropriate, the University should encourage faculties of its schools to teach students of other schools within Harvard. This flexibility should include Harvard-affiliated hospital faculty.

The University should establish means to monitor the teaching and training that both undergraduate and graduate students receive during project-based research in the laboratories of individual faculty. We recommend the establishment of a group of faculty and instructors to perform this function.

Maximize the mobility of science and engineering graduate students

We make two specific recommendations to facilitate graduate student mobility.

The University should establish a consortium for the physical sciences and engineering similar to the Harvard Integrated Life Sciences (HILS) consortium. HILS is an excellent model for broader integration of grad programs in science and engineering. Establishing such an umbrella consortium (Harvard Integrated Physical Sciences and Engineering, or HIPSE) would greatly increase graduate student mobility and advisor choice. For example, uniform degree requirements could be required across related programs. Proper oversight of student recruitment, advising, and progress to degree would also be optimized among programs. The two consortia (HILS and HIPSE) should work together to encourage students who want to work at the boundaries between the life sciences, physical sciences and engineering. Faculty who served on the guiding committees of both consortia would encourage such cooperation.

As umbrella structures for interrelated sets of graduate programs, HILS and a newly created HIPSE should encourage new interdisciplinary PhD programs where appropriate. Such emerging areas as translational research in biomedical science and bioengineering may be ripe for the development of new doctoral training programs in the near future, and such programs would appropriately include faculty from the Harvard-affiliated hospitals as well as those from science departments in FAS and the Medical School.

Harvard should also provide at least first-year funding for all graduate students that is independent of departmental resources. Offering central funding for the first year of graduate study would eliminate many of the barriers to student mobility, notably the potential perception that a student must pick an advisor from the department or program that is supporting the student.

Implementation Considerations:

To give students a more in-depth laboratory experience, several issues must be addressed. Harvard will need more laboratory space that can support project-based lab courses and is easily reconfigured to support different sets of experiments as courses change. The University must do a better job of ensuring equity of teaching loads within each school and department. An important step is to find metrics that appropriately recognize the effort expended in different forms of teaching including large service courses, smaller lecture or seminar courses, project-based laboratory courses, and the supervision of individual undergraduates and graduate students within faculty labs.

A major initiative in hands-on learning has implications for our teaching laboratories, and we address this in the recommendation on infrastructure, below.

The summer months provide an opportunity for undergraduates to fully engage in working within a research group. We applaud the PRISE program, that provides stipends and lodging for students engaged in summer research activities. We suggest that Harvard plan for expansion in this program, as we anticipate a steady growth in student demand in response to a shift towards hands-on learning.

Organizational barriers to certain aspects of our proposals on undergraduate education need specific attention. Teaching expectations differ widely across the schools, and few schools encourage or reward their faculty for teaching in other schools. In some cases, there are active impediments. For example, if an HMS faculty member in a soft money position is compensated for teaching in FAS, their department fails to recover overhead on these monies. Administrative, oversight, and incentive structures at HMS, HSPH, FAS, and the affiliated Hospitals need to be realigned to allow and encourage faculty to supervise laboratory experiences and teach in the standard didactic curricula, when appropriate, of schools where they do not have a primary affiliation.

We recommend that all graduate programs have clear criteria for faculty membership and that these include participating in activities including teaching, attendance at student research presentations, and program administration. Department-independent funding for the first year or more of graduate student training will have clear cost implications that an education-focused committee will need to consider. Adequate funding of graduate students is crucial for the recruitment and promotion of junior faculty in the sciences and engineering.

RECOMMENDATION #2: Create a University-wide science planning committee to undertake formal, transparent, and inclusive procedures to assess, prioritize, support and monitor the portfolio of University-wide science and engineering activity.

To better support and manage inter-disciplinary research, we recommend creation of a Harvard University Science and Engineering Committee (HUSEC) to evaluate inter-disciplinary science and engineering research efforts across the University and to partially fund new clusters of appointments in particular research areas. This formal standing committee of faculty, including

Deans, would increase the transparency of Harvard's decisions on science and engineering through a combination of executive activities and advisory roles.

HUSEC would have five main responsibilities:

1) Evaluating research proposals
2) Allocating resources
3) Setting development priorities for science and engineering
4) Authorizing the formation and periodic review of inter-departmental committees and cross-school departments
5) Advisory role.

<u>Evaluating research proposals</u>

In its executive capacity, HUSEC would evaluate inter-disciplinary science and engineering research proposals at Harvard. Faculty would have the opportunity to submit detailed proposals to HUSEC on an annual basis to request resources to support a cross-departmental science and technology initiative. All applications must address a standard set of criteria that HUSEC would then use to evaluate each proposal. A greater level of detail and rigor would be required for proposals over a certain level of investment. As part of the evaluation process, HUSEC would ensure that appropriate constituents were involved in the efforts, ask whether it should involve a broader faculty group (such as additional departments), and make sure that women and ethnic minorities were adequately represented in leadership and initiative positions. HUSEC would need to control a set of pooled funds (discussed in more detail below) to provide funding to such proposals.

HUSEC would also encourage or generate external proposals in important areas of science and engineering research where Harvard is currently weak.

<u>Allocating Resources (more detail below)</u>

For research endeavors, HUSEC assigns FTEs, space, and funding to cross-school departments, inter-departmental committees and research initiatives based on the proposal's priority compared to that of other inter-disciplinary proposals.

<u>Setting development priorities</u>

HUSEC would play a critical role in proposing and evaluating where the Development office should focus its fund-raising efforts for science and engineering.

<u>Authorizing the formation and periodic review of inter-departmental committees and cross-school departments</u>

HUSEC would authorize inter-disciplinary searches through the creation of inter-departmental committees. In cases where the research endeavor will be an intellectual effort of long-standing duration, HUSEC would recommend the formation of cross-school departments to the President and Corporation. HUSEC and the participating schools would provide FTEs and space for these efforts. HUSEC would ensure that women and under-represented minorities were considered for and represented in the mix of leadership positions, committee members, and other roles created by these new structures.

HUSEC would be responsible for initiating periodic reviews of all such endeavors, including cross-school departments, inter-departmental committees, and science and technology initiatives.

Advisory role

In addition to its executive responsibilities, HUSEC would play an equally important advisory role in increasing the visibility and transparency of decision-making about science and engineering research across the University. HUSEC would confer with the Deans of FAS, HMS, HSPH, and HEAS and the Executive Committees of each hospital on the mix of activities for their research portfolios. This standing committee would also provide a discussion forum for research space planning and discussions on how the University's science and engineering efforts are meeting gender and ethnic diversity goals.

HUSEC will play an important role in improving coordination between activity in the affiliated hospitals and other components of the Harvard complex. We see significant opportunity in building and exploiting these connections.

As many of the efforts HUSEC evaluates and supports are interdisciplinary in nature, the committee will also serve as a liaison between the science and engineering communities and other interested and involved faculty members at the University. It will also serve in the same liaison capacity with the broader community outside of Harvard (such as industry, governmental bodies, etc.).

Although not directly involved in decisions about undergraduate or graduate education (which would continue to be administered through traditional channels), HUSEC could advise on science- and engineering-related curriculum and educational activities as needed.

HUSEC will be responsible for reviewing inter-departmental committees and science and technology initiatives. Reviews can be conducted at different levels including continuous informal monitoring by HUSEC, a formal evaluation conducted by HUSEC, a formal evaluation conducted by appointed Harvard faculty and commissioned by HUSEC, and a formal evaluation conducted by appointed external faculty and commissioned by HUSEC. Such reviews will be coordinated with the Board of Overseers, which commissions the visiting committees that review departments.

Another important proposed advisory role for HUSEC will be determining development priorities in the sciences and in engineering.

Committee structure

A standing committee should be assembled that represents in totality the life sciences at HMS, HSPH, FAS, FAS physical sciences, FAS Division of Engineering and Applied Sciences, and the major Harvard-affiliated hospitals (MGH, BWH, BIDMC, Children's, DFCI).

HUSEC would report to the President. HUSEC would have a standing executive committee appointed by the Deans with a chair and two vice-chairs who represent a balance of life science, physical science, and engineering perspectives. The chair would rotate every three years.

The committee should have approximately 12 members, including the Provost, the Dean of FAS, Dean of HSEAS, Dean of HMS, Dean of HSPH, and research faculty from the four schools and the major Harvard-affiliated hospitals. Like MGH's Executive Committee on Research (ECOR), HUSEC should have a mixture of representatives appointed and approved by the three Deans and representatives elected by the science and engineering faculty. Representatives from the hospitals would be nominated by each hospital's Executive Research Committee and approved by the Provost who would set the rotating schedule for the hospital membership. Attention should be given to achieving a balance of gender and ethnic diversity in the committee's membership.

Appointments would be for three years and renewable for appointed representatives as determined by the Deans. Elected representatives would also be eligible for renewable appointments if re-elected. Hospital representatives would also rotate on a three-year basis.

Resources under HUSEC control

HUSEC must control FTEs, space, and funding if it is to identify and implement new integrated opportunities across the science and engineering schools of the University and be more than just an advisory body.

<u>FTEs</u>

HUSEC would have at least 75 incremental inter-disciplinary faculty FTEs to allocate over the next 10 years. It would offer partial FTEs (that schools or departments would have to match) or full FTEs for science and technology initiatives and full FTEs for inter-departmental committees. These FTEs would revert back to HUSEC over time through departures or retirements. When a cross-school department was recommended to the president and the board of fellows, FTE, space, and dollar allocations proportionate to faculty involvement across the four schools would need to be provided.

<u>Space</u>

HUSEC will control a defined amount of space across all four campuses (Allston, Cambridge, Longwood, and MGH in the event of any joint ventures between MGH and the University) to ensure that initiatives thrive at all locations. Over time, this space could include part of the Northwest building, all new science and engineering space in Allston, the vacated science museum space in Cambridge (if the museums were to move to Allston), and the vacated HSPH space in Longwood (if HSPH were to move to Allston).

We recommend that HUSEC will advise on the location of all new science and engineering endeavors, ensuring a balance across all campuses by utilizing the following guidelines. A critical mass of collaborative science must be located in Allston to ensure that there is an intellectually vital and attractive community of scholars in this new campus location (see Recommendation 5). Similarly, each of the other Harvard campuses (Cambridge, Longwood and any collaborations or joint ventures occurring at Harvard-affiliated hospitals) must not only retain a critical mass, but also, and perhaps more importantly, be sites of new and exciting intellectual endeavors.

In evaluating the proposals submitted to UPCSE to decide which of the recommended efforts (both new proposals and those generated in the previous Allston Planning Process) should be located in Allston (see Recommendation 5), we combined the criteria of ensuring that each campus had exciting opportunities with those of meshing new activities with communities of scholars that are already in place and forming intellectually cohesive communities. HUSEC will use the same criteria in proposing locations for specific proposals.

Funding

The Committee would also have a set of funds separate from the hospitals and schools that would be available to provide seed funding to early-stage initiatives, partial funding for shared equipment, and financial support for inter-disciplinary post-docs and graduate students. The funds would be a combination of newly raised philanthropy, centrally-controlled funds, a reallocated portion of school (FAS, HMS, HSPH) endowments, and hospital contributions (in the event of any joint ventures between affiliated hospitals and the University).

Implementation Considerations

For HUSEC to be a legitimate and effective body, it must be empowered with control of FTEs, space and funding from its inception. It must also be clearly identified as the mechanism by which central support is provided for new technology, engineering and science. These resources will ensure that it is able to evaluate the breadth of science and engineering occurring at the University, facilitating its role in managing the portfolio of investments in science and engineering at Harvard.

The composition of HUSEC is critical to its success. All constituencies in science and engineering across the University need adequate representation, and the relevant Deans must be active participants in HUSEC deliberations to ensure transparency in the allocation of resources, and give the committee a sense of legitimacy in its early efforts. HUSEC should be a particularly valuable venue for the science and engineering deans to help them frame, implement, and evaluate integrated agendas through a mixture of cross-school departments, interdisciplinary committees, and science and technology initiatives.

As HUSEC will be involved in evaluating and generating proposals and setting the direction of science and engineering at the University, it will require high-level staffing to fulfill its mission.

RECOMMENDATION #3: Form agile and responsive organizational structures to support interdisciplinary science and engineering faculty recruitment, promotion, and research.

We recommend the formation of two new organizational structures to facilitate the recruitment and promotion of cross-disciplinary faculty and take advantage of faculty talent across departments and across the several schools of the University where science and engineering are carried out:

- Inter-departmental committees (IDCs)
- Cross-school departments

We also recommend the continuation of Science and Technology Initiatives.

DIFFERENCES BETWEEN ORGANIZATIONAL STRUCTURES

	Traditional departments	**Cross-school departments**	**Inter-departmental Committee**	**Science and technology initiatives**
Scope	• 1 school	• Multiple schools	• Varies	• Varies
Duration	• >20 years	• >20 years	• >10 years	• ~5-10 years
FTEs over time	• Return to school (*usually* to dept)	• Return to HUSEC (*usually* to dept)	• New FTEs revert back to HUSEC	• New FTEs revert back to HUSEC or school
Space allocation	• Dept	• Dept	• Varies (either HUSEC or depts/schools)	• Varies (either HUSEC or depts/schools)
Undergrad concentrations	• Yes	• Yes	• Varies	• No
Major role in Grad program	• Yes	• Yes	• Usually	• Usually
Assigns teaching	• Yes	• Yes	• Depends on individual arrangements	• No
Recruitment	• Yes	• Yes	• Yes	• Initiative-based search w departments
Tenure decisions	• Yes	• Yes	• Yes	• No (goes through depts)

Table II. Distinctions between existing departments, proposed cross-school departments, inter-departmental committees, and initiatives. The undergraduate aspects currently apply mainly to FAS.

Inter-Departmental Committees

We recommend that HUSEC have the authority to create inter-departmental committees (IDCs) with faculty appointment powers, responsible for the recruitment and promotion of specific faculty who span departments across the University. Ordinarily, IDCs will be a standing committee formed around an intellectual effort (such as an undergraduate concentration) or a research initiative (such as the Microbial Sciences Initiative). Allocated a specific number of inter-disciplinary faculty FTEs by HUSEC, inter-departmental committees will have the ability to hire, mentor, and recommend promotion of those faculty. All IDC faculty will be part of an existing department in one of the schools of the university and will have teaching and service obligations to their host department.

IDC Structure

Ordinarily, an inter-departmental committee will be formed around an initiative or educational program for recruiting purposes (typically, but not necessarily, for appointments that lie at the intersections of two or more departments' interests; most faculty would be appointed to one department within one or more schools of the university). Such a committee will be responsible for conducting multiple searches and recommending the appointment of multiple faculty (up to the resource limit for the intellectual effort). A new search committee will, therefore, not need to be convened for each search within an IDC. Faculty appointments to an IDC will be for terms of three to five years, and will be reviewed by HUSEC to ensure some continuity. Occasionally, an ad hoc search committee can be convened for an individual scholar of particular merit, typically to be hired as a senior faculty member. While a standing IDC will be composed of faculty engaged in a common intellectual effort (initiative, educational, etc.), not all faculty engaged in that effort need be members of the IDC. The IDC is constituted to enable movement into new intellectual areas, recommend appointments, mentor and support junior faculty, and make recommendations for promotion and tenure of IDC faculty into participating departments.

Composition of an IDC

The IDC membership will be divided between faculty representatives of the interdisciplinary initiative or educational concentration (or other intellectual effort) from relevant departments and schools across the university as warranted. The departments into which new IDC faculty would be hired are likely to be represented by existing faculty of the IDC but this will not be a requirement. As soon as appointment is made, that department has a member on the IDC. Women and under-represented minorities should be appropriately reflected in the overall composition and leadership of the committee. HUSEC will make formal recommendations on forming IDCs and selecting their initial faculty to the President.

Reporting Structure

IDCs will report to the Deans of the schools represented in its membership and we strongly recommend that HUSEC be involved in commissioning, advising, and periodically conducting formal reviews of the progress of IDCs, and that HUSEC should have the authority to recommend dissolution of an IDC.

Cross-School Departments

We recommend the occasional formation of cross-school departments in cases where the inter-disciplinary field requires longstanding research and investigation, there is a desire for a "permanent" intellectual community to propel research and education, and the University sets a high priority on this field of endeavor. These could be entirely new departments or arise by reorganizing existing departments currently within one or more schools of the university. Cross-school departments would perform all the functions of a traditional academic department, but report to an executive council of the Provost and Deans of HSEAS, HMS, HSPH, FAS and any other schools with a significant effort in science and/or engineering, rather than a specific school. HUSEC would evaluate proposals from interested groups of faculty, recommend the formation of any cross-school department, and ensure that gender and ethnic diversity is reflected in its key leadership roles and structure where possible.

Composition

Faculty members would be appointed into the cross-school department, each with a school affiliation (FAS, HSEAS, HMS, HSPH) designed to match their research interests and teaching expertise. All faculty members in a cross-school department would have equivalent teaching expectations, but could fulfill their requirements in a variety of ways (such as teaching classes to undergraduate, graduate, or medical students, advising students in the lab, clinical training and mentoring).

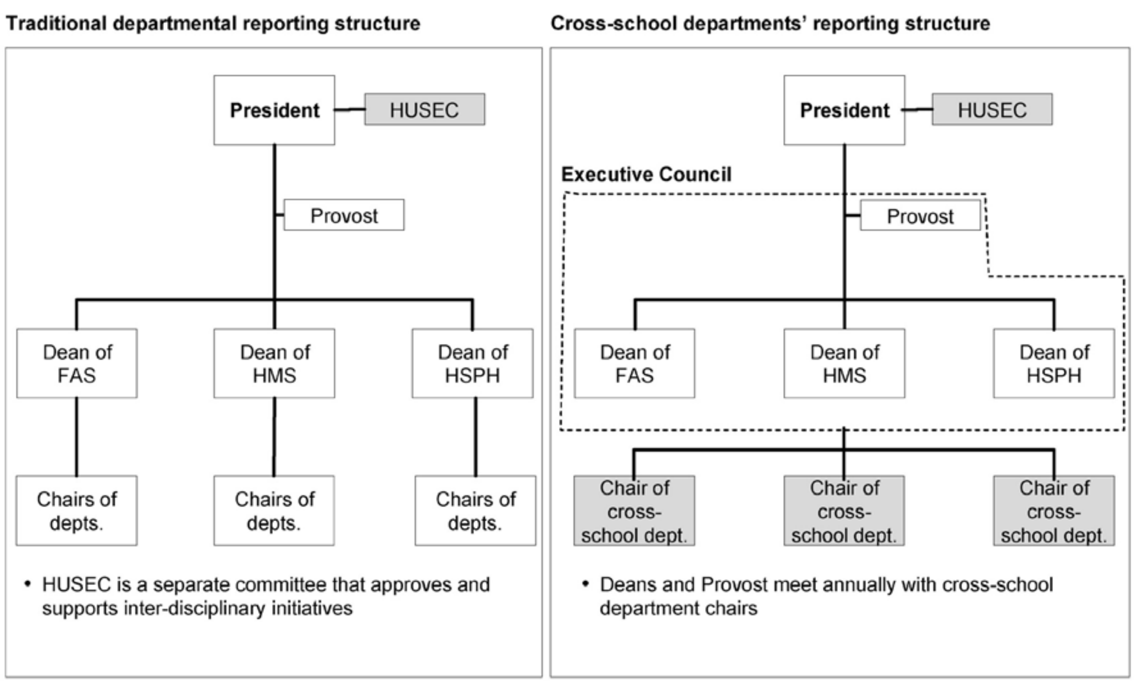

Figure 3. Proposed reporting structure of new cross-school departments, compared with existing structure.

<u>Reporting structure</u>

The Chair of the cross-school department would report to an Executive Council of the Provost and the Deans of HMS, HSPH, FAS and any other schools with a significant effort in science or engineering. HUSEC, acting in coordination with the appropriate oversight bodies, would commission periodic reviews of cross-school departments. Figure 3 shows the suggested reporting structure for these new cross-school departments.

Science and Technology Initiatives

We advocate formalizing the process of evaluating initiatives brought forward by Harvard faculty. These initiatives can vary in scale and scope, and some may evolve over time into other structures, such as those described above, while others may be terminated. We hope the University can engage in an ongoing process of selecting a few meritorious initiatives in an steady state of renewal and intellectual innovation. We see the opportunity to apply for resources (often at a seed funding level) to jumpstart an initiative as an important ingredient in fostering a campus culture of agility and collaboration.

HUSEC would develop and apply a clear set of criteria in the evaluation of proposals for new initiatives.

Implementation Considerations

The formation of cross-school departments will likely begin with the selection, by the Deans of involved schools, of a group of existing faculty as an "executive committee." This group will nucleate the new department, which will then conduct both internal and external searches for new departmental faculty. As this group will make the decisions about the initial faculty composition of the new department, it is critical that the involved Deans carefully consider the composition of the executive committee. At the outset, or after the department is formed and functional, the Deans will agree upon and designate a chair from among the department members. In a cross-school department the Deans will have the opportunity to propose rules for the term and authority of the department chair that could reflect the different traditions for academic chairs, such as those in FAS and HMS.

Since we explicitly endorse continuing the policy that all Harvard faculty appointments reside within Departments, we faced the challenge of devising an equitable scheme under which faculty recommended for appointment by an IDC are presented to the relevant department(s). We suggest the following mechanism: Members of the IDC would be expected to provide a confidential letter to the administration in which they articulate and justify their position on the appointment in question. All members of a department in which the appointment would reside are then invited (but not required) to send a confidential letter to the Dean(s). We think this strikes a sensible balance and maintains a strong Harvard tradition, which we consider valuable. We recommend that during their initial stages, the search committees for both IDCs and cross-school departments should include faculty who are not part of the initial membership.

The selection of faculty members for IDCs is critical to ensuring that newly recruited and appointed faculty receive adequate mentoring. As new recruits will also reside in two or more departments, it will be incumbent upon the members of the IDC to ensure these scholars are given proper guidance and developmental opportunities during their tenure at the University, as the departments in which the new recruit sits may have the same lack of incentive they do today. For this reason, care should be taken to include on the IDC only faculty committed to the development of junior faculty in the Harvard system.

Recommendation of tenure appointments by an IDC would be the responsibility of the IDC faculty and would be in accord with the procedures of the department(s) in which an IDC faculty member was gaining a permanent appointment.

RECOMMENDATION #4: Promote diversity in science and engineering by recruiting a more representative cross-section of scholars to Harvard.

Harvard must strive to ensure that recruitment and hiring in science and engineering change and evolve to increase faculty diversity. These considerations must also be taken into account at all levels of education and training, from undergraduates through post-doctoral training. Recruitment and hiring practices should be reviewed for every department, and explicit plans to increase diversity should be developed, through the existing checks and balances that have been established for this purpose. Keeping good data on all searches will enable assessments of progress and evaluation of the success of various approaches.

Explicit efforts should be made to ensure a balance of gender and ethnic diversity in committee and leadership positions. As new research endeavors get formed, HUSEC will ensure the involvement not only of the appropriate departments, but also of the relevant female and ethnic minority faculty members. Similarly, diversity considerations should be taken into account in the formation and leadership of inter-departmental committees and cross-school departments.

To attract and retain a diversity of backgrounds in science and engineering, the University should explore alternative job positions that increase flexibility and workforce re-entry choices. Improving partner career support opportunities, for instance through the creation of a research scientist track or a pool of FTE appointments held by the Provost, which can be used to make tenure track appointments available for spouses. Similarly, providing childcare facilities in the Allston campus design (see Recommendation 6) would improve career support for some faculty. We recommend that HUSEC form a subcommittee that includes representatives from the social sciences and humanities to explore and define alternative career options and other concrete ways to increase and support diversity in the University in collaboration with the office of the Senior Vice President for Faculty Development and Diversity.

Implementation Considerations

For Harvard science and engineering to fully reflect and benefit from an appropriately diverse community, diversity must be an explicit and implicit consideration and priority at all levels of the University, from undergraduates to Harvard leadership.

One challenge will be defining and evaluating performance in meeting gender and ethnic diversity aspirations. The Senior Vice Provost for Diversity has made great progress in this regard, and should be solicited as an active partner to ensure that the recommendations of this committee are implemented in a way that takes advantage of every opportunity to promote a diverse and intellectually vibrant community at Harvard.

For appointments, it is important to search for candidates instead of relying only on responses to the posting of positions. All members of the intellectual community should be encouraged to identify promising members of under-represented groups at all stages of their careers and to track their progress so that they can be encouraged to apply for positions at Harvard when they reach a suitable stage of their career. Departments, inter-departmental committees, and initiatives should submit annual reports on their activities in this area.

RECOMMENDATION #5: Continue to invest in core disciplines.

Harvard has an outstanding collection of scholars and teachers in science and engineering. Many work in well-established disciplines where important and long-standing questions remain unanswered and exciting new questions have appeared. Harvard should continue to invest in core disciplines and encourage their growth, for three reasons:

1) Important and unanswered questions in core disciplines. Answering these is critical to Harvard's mission of increasing human knowledge;

2) The need to make sure our students are well-educated in the fundamental aspects of biology, chemistry, engineering, mathematics, physics, and statistics;

3) The speed and unpredictability with which disciplinary boundaries move and erode. Answering questions that lie at the center of a core discipline can create important new opportunities for inter-disciplinary research and advances in other fields can unexpectedly bring them into contact with a core discipline.

We recommend that Harvard's schools continue with their plans to expand their faculty in science and engineering, including proposed appointments in the core disciplines. In this context, we propose that HUSEC review departmental expansion plans and advise the relevant Deans about the implications of these plans for increasing the strength of individual departments, promoting the education of undergraduates and graduate students, stimulating interactions between departments, and voiding duplication of effort between schools.

RECOMMENDATION #6: Establish Allston as an interdisciplinary science and engineering research, education, and cultural center that helps the surrounding communities and the world at large.

Allston represents a rare opportunity to bring together multi-disciplinary activities, across the life and physical, as well as social, sciences. Such efforts will not only include some of the most exciting science and engineering, but will often focus on topics that have potential to influence community and world at large. The creation of a new campus offers the chance to build a community dedicated to teaching and research and to encourage a campus-wide commitment to interactions both within the campus and between it and other campuses that are stronger than the institution's historical norm. In addition to exciting research, there exists an opportunity to use these groups of scholars to enhance and reform science and engineering education at all levels, including pre-collegiate. Similar to the opportunities in broadening Harvard's research and education mission, Allston provides a unique cultural and educational gateway to a wider community.

Research

Our scientific vision for Allston includes three linked scientific components:

1) Integrating those elements of biology, chemistry, engineering, and physics needed to uncover the fundamental principles that explain how cells integrate a myriad of internal and external signals to survive and reproduce in variable environments, understand how these principles explain evolutionary plasticity, and exploit them to manipulate cells for research and medicine;

2) Bringing together biology and medicine to develop the new field of regenerative biology and tackle the problem of infectious diseases;

3) Establishing a strong capability in multidisciplinary and computational analysis that can be used to promote interactions between biology, engineering, and other sciences and will address our current weakness in research computing.

We recommend a critical mass of collaborative science be located in Allston to fulfill the vision. These should include the following groups and efforts, for the reasons noted:

- The Harvard School of Public Health, whose mission is to educate leading scientists and practitioners in public health and foster innovation and new discoveries that will lead to improved health in both developed and developing nations.

- Regenerative Biology and Medicine, whose mission is to understand the basic biology of mammalian cells and their role in the development, maintenance, and regeneration of tissues and organs, and to apply this knowledge in treating human diseases, such as diabetes and Parkinson's disease, that arise from damage to a particular class of cells.

- The Harvard Institute for Biologically Inspired Engineering (HIBIE) is dedicated to the interface between biology and engineering and will create nanoscale methods to measure and alter the function of cells, understand, mimic, and improve on the properties of biological materials, and study the circuits that control biological behaviors and use this knowledge to inspire the creation of new control strategies that can be used by human engineers

- Part of the Microbial Sciences Initiative. This group brings together faculty from departments with FAS, HMS, and HEAS who strive for a comprehensive understanding of microbes, which constitute the vast majority of species and cells on the planet. This initiative brings together molecular biologists, geochemists, oceanographers, evolutionary biologists, and environmental engineers who work together to understand the role of bacteria and fungi in controlling the earth's history, present, and future.

- Systems biology will integrate groups dedicated to combining approaches from biology, physics, and computer science to understand the design principles that explain how the interactions of biological components give rise to complex behavior in cells and organisms, and use this information as a springboard for synthetic biology, the creation of novel biological devices within cells.

- Chemical and Physical Biology whose mission is to apply advances in chemistry and physics to develop new methods to perturb, visualize, and quantify biological processes and to use these methods to probe the formation and function of assemblies of biological molecules and to learn how cells monitor and respond to internal and external signals
- Innovative Computing will develop and deploy new methods (in distributed computing, in scientific databases, in computational approaches, and in visualization) that are required to collect, analyze, and present the enormous quantities of data that Harvard scientists and engineers will generate in disciplines that range from genomics to astronomy.
- Significant portions of Quantitative Analysis, a new grouping that aims to bring together mathematicians and statisticians who use a shared outlook and analytic and computational framework to address problems across a wide range of disciplines.
- An initiative in Global Infectious Disease that would bring together microbiologists, population geneticists, epidemiologists, chemists, and experts in health policy to mount a coordinated assault on infectious and parasitic diseases. This group would have a particular emphasis on diseases that primarily afflict the population of underdeveloped countries.

First Wave of Buildings in Allston

Creating a critical mass of intellectual activity is essential for science and engineering initiatives in Allston to be successful. While the first science building for Allston has now been approved and will be occupied in 2009-2010, it is highly likely that the range and mix of activities we recommend will require a second science building of comparable size. Further, the HSPH will require an additional building of comparable footprint and assignable square feet. We strongly recommend that a three-building complex be planned as a coherent cluster and implemented as part of the first wave for Allston.

The activities in Allston must be selected and managed as an integral part of the intellectual activity of Harvard. HUSEC has an important role in providing this broad perspective.

Key partnerships

Allston offers an opportunity to forge partnerships with parties beyond life, physical and engineering sciences. These will include developing ties to industry, and to other Harvard departments and schools to explore public policy and science. The Harvard Business School (HBS), located in Allston, would be a key contributor, as would the Kennedy School of Government (KSG), which is already a well-recognized global player in policy, and the FAS social sciences.

Education and community outreach

We recommend that all Harvard faculty members in Allston have a firm commitment to the University's teaching mission. While professional school faculty who are members of interdisciplinary committees and cross-school departments will have teaching responsibilities in their schools, we believe that an important part of Allston's culture will be its commitment to education and that this is best demonstrated by having these faculty contribute to undergraduate teaching. Options for measuring teaching efforts could include a point system, similar to the

KSG system, by which professors are awarded credit in differing amounts depending on the type of teaching they do. This credit would go toward satisfying a total teaching requirement to which all faculty in Allston would have to agree as a condition for being part of the effort.

We recommend a major effort in community outreach and education in Allston, including relocating the Harvard science museum complex and the Graduate School of Education (GSE) to Allston and establishing a Harvard Science Outreach group to coordinate educational efforts. A team of area-specific coordinators under a program director should be created to work with the GSE and local schools to develop science curricula that can be tested with local schools and the Crimson Summer Academy. This would require a strategic shift in the GSE's faculty and curriculum since the GSE has not traditionally focused on science and engineering education at the elementary school levels. K-12 education efforts in Allston could include science fair days and exposing Boston-area secondary school students from under-privileged areas to modern science. Building on local successes, Harvard should aspire to shape U.S. science education more broadly. The University should explore collaborations with interested parties including the Museum of Science, the public school systems of Boston, Cambridge, and nearby communities, and other groups interested in K-12 science education.

As Allston science and engineering facilities have not yet been built, it also represents an extraordinary opportunity for Harvard to improve the living arrangements and support for graduate students, post-doctoral fellows, and junior faculty. The creation of living quarters and day care facilities would enhance careers in science and engineering and provide a valuable framework of support.

Allston's outreach should also include partnerships with industry and other Harvard departments and schools to explore public policy and science. The Harvard Business School (HBS), located in Allston, would be a key contributor, as would the FAS social sciences and the Kennedy School of Government (KSG), which are already well recognized in domestic and global policy discussions.

Implementation Considerations

A focused set of building and infrastructure investments will be required to make Allston a vibrant Harvard campus. This need becomes more pressing in the light of future cross-school departments, inter-departmental committees, and science and technology initiatives that HUSEC is likely to approve and recommend be located in Allston. Our Committee's estimates of the corresponding space requirements imply the need for additional Allston buildings in the near term, as noted above.

As the University strives to establish a vibrant community in Allston, we note the merits of building office space that could be leased to commercial, scientific, and technical clients. This would help cultivate an entrepreneurial spirit in Allston, and would provide near-term cash flow as Harvard builds its Allston presence.

While Harvard's science museum complex represents enormous potential for transforming education and reaching out to the community, the relocation of the museum complex from Cambridge to the Allston campus will be expensive. The processes of constructing a new museum complex in Allston, and of moving the museums and renovating the space in Cambridge, will also require considerable lead time from decision to completion (likely more than six years), making it crucial to reach decisions well before more space is needed in Cambridge. In deciding the relative merits of such a move, one must consider not only the cost of moving the museums and renovating vacated space, but also compare that to the cost of renovating the museums with the collections and exhibits *in situ* to understand the net cost. Additionally, the space generated on the Cambridge campus will also be of considerable value to the University as it plans any expansions in the life, physical or engineering sciences. Unless the University is willing to construct new buildings in the North Yard, freeing space in the museum complex represents the only creditable option for substantial physical expansion in Cambridge.

Allston's success will depend heavily on how well Harvard's activities interact with the cultural, educational, and business concerns of the Boston area. Links to the biotechnology and pharmaceutical companies in the area, connections with Boston area museums, and work with Boston-based K-12 schools will all strengthen the intellectual community that can be built in Allston. Creative approaches should be explored to develop joint ventures and collaborations. Similarly, strong connections with HBS, KSG, and HLS should emphasize the financial, business, political, and legal implications of the research conducted at Harvard and will help scientists and engineers understand their roles in the wider world.

RECOMMENDATION #7: Establish specific cross-school departments, inter-departmental committees, and science and technology Initiatives.

We have identified nine research endeavors that would benefit from being organized as cross-school departments or inter-departmental committees to support inter-disciplinary science and engineering appointments. We suggest locations for many of these activities and recognize that some of the research ideas may be able to be implemented sooner than others, depending on their level of development and maturity.

In addition to recommending which organizational structure best suits each of the proposals, we also considered which of the proposals would be most likely candidates for immediate formation as new organizational entities. In this regard, we considered whether the funding and support for the proposal was currently directed toward an already unified effort or toward efforts by multiple parties. In the former case, we considered the proposal to be ready for immediate instantiation. In the latter case, we recommend formation as new organizational structures as soon as practicable in order to unify efforts across the University.

Selection criteria

We developed a draft set of criteria that HUSEC could consider in its deliberations (see Appendix E for HUSEC proposal requirements). Ideas for new undertakings in science and engineering must have:

- Scientific import: The research helps balance and enhance the portfolio of research activities across Harvard and expands the boundaries of current science and engineering.
- Maturity of idea: The idea should have a strong nucleus of faculty excited about and willing to support the research. Faculty champions are in place to lead the effort and a detailed proposal has been written.
- Benefits to the University: The research facilitates collaboration among like-minded scholars in areas that are difficult to address in the current Harvard structure.

- A concrete implementation plan, including space, FTE and funding requirements.
- Compelling educational vision: The idea strengthens existing educational programs and/or creates new learning opportunities.
- Practicality: The Harvard community has the necessary resources, including expertise, facilities and funds.

Cross-school departments

We recommend four new cross-school departments for Regenerative Biology and Medicine, Systems Biology, Chemical and Physical Biology, and Neuroscience, to unify research efforts across the University and facilitate new inter-disciplinary faculty appointments.

- Regenerative Biology and Medicine (Allston, described under recommendation 6). The Harvard Stem Cell Institute (HSCI) already exists with donor funding and we recommend that HSCI be immediately reconstituted as a cross-school department.

The remaining three proposed departments each have varied, but considerable, support for efforts in multiple Harvard schools. Each of these efforts should, as soon as is practicable and as a first order of business for HUSEC, be unified as single cross-school departments, rather than distributed endeavors.

- Systems Biology (Allston, described under recommendation 6)
- Chemical and Physical Biology (Allston, described under recommendation 6)
- Neuroscience (Cambridge and Longwood). Harvard has enormous strength in neuroscience, which includes the Department of Neurobiology at HMS, faculty in several departments in FAS, many of whom are participants in the Center for Brain Science, and faculty in the affiliated hospitals. Their common mission is to build an integrated understanding of how chemical and electrical events in individual cells ultimately give rise to the complex neural processes that lead to emotions and cognition and use this knowledge to better understand the human condition and prevent and treat neurological disease. Many of the faculty in this area already participate in a single Neuroscience graduate program and a cross-school department of Neurobiology would increase integration and coordination in this important subject.

Inter-departmental committees with appointing powers

Additionally, we recommend the formation of five inter-departmental committees for HIBIE, Microbial Sciences, Energy and the Environment, Human Genetics, and Quantitative Analysis. Seed funding and/or donor support already exist for HIBIE, and Microbial Sciences as unified efforts, and so these current initiatives provide an opportunity to immediately implement the inter-departmental committee structure. Energy and the Environment, Human Genetics, and Quantitative Analysis are exciting opportunities that merit support. These should, as with Systems Biology, Chemical and Physical Biology, and Neuroscience, and upon a formal plan for a unified and University-wide effort, be a first order of business for HUSEC to consider as IDCs.

- HIBIE (Allston, described under recommendation 6)

- Microbial Sciences (Allston and Cambridge, described under recommendation 6)
- Energy and the Environment (Cambridge). This initiative brings together faculty from FAS, HEAS, HSPH, and the Kennedy School. They are concerned with the broad question of how humans produce and consume energy and how these activities influence our environment. Their concerns range from new methods of producing and conserving energy, the impacts of current and future patterns of energy consumption on the environment, and public policy on energy use.
- Human Genetics (Longwood, MGH, Broad Institute). This community will exploit the availability of the full sequence of the human genome, technological and computational advances in DNA analysis, and the strengths of the affiliated hospitals and the Broad Institute to understand the genetic basis of human diseases.
- Quantitative Analysis (Allston, Cambridge, Longwood, described under recommendation 6)

Science and technology initiatives

Science and technology initiatives that we endorse include ongoing efforts in Origins of Life, Innovative Computing, Quantum Science and Engineering, Fundamental Physical Laws, and Global Health as well as new ideas for a Translational Research Center (designed to bring a variety of innovations to fruition) Evolutionary Biology, Biodiversity, and Conservation, and Computation and Society.

- Evolutionary Biology, Biodiversity, and Conservation (Cambridge). Evolution is the conceptual foundation of biology and its students ask two fundamental questions. How do organisms arise and why do they look and act the way they do? Harvard has a long history of leadership in this field and the explosion in genome sequencing, new methods of exploring evolution in the field and the laboratory, new advances in population genetics, and the need to catalog and preserve the diversity of life on earth all argue for a major new effort in evolutionary biology and conservation.
- Origins of Life (Cambridge). The previously distant fields of astrophysics, cosmochemistry, and studies on the origin of life have recently collided. The discovery of planets around other stars that might harbor life and experiments on how chemicals can give rise to self-replicating systems lead to the exciting possibility of answering how life began on earth and whether it exists on other planets. Harvard is a leader in these separate efforts and should start an inter-disciplinary center to bring these projects under one roof and build on them.
- Fundamental Physical Laws (Cambridge). Recent astronomical observations and theoretical progress both indicate that our understanding of the fabric of our Universe is incomplete. Addressing this crisis in fundamental physics will require an approach that integrates accelerator-based probes of fundamental particles and their interactions with astronomical observations, and precision laboratory measurements. This initiative will create closer ties between the astronomers, physicists, and mathematicians who will answer the fundamental questions of what our universe is made of, how it began and

evolved, the nature of the vacuum, and how the properties and interactions of its basic constituents shape the world we live in.

- Quantum Science and Engineering (Cambridge). New connections between information theory and quantum mechanics and new technologies have spawned new approaches to computation, information networks and control of fundamental systems. A new Harvard program will range from theoretical and experimental work in quantum optics and quantum information to solid-state physics and device engineering.
- Innovative Computing (Allston, described under recommendation 6)
- Computation and Society (Allston, Cambridge). The information revolution has connected the human and digital worlds. Computers are now part of the fabric of society and their development and use shapes our present and our future. How do these technologies impact the human experience, how will they change it in the future, and how should we plan to maximize changes for better and minimize those for worse? This initiative will bring together computer and social scientists and involve faculty in the schools of Law and Government.
- Global Health Initiative (Allston, Cambridge, Longwood). Only one in six of the world's population has access to adequate medical care. This initiative focuses on finding ways in which modest investments could dramatically improve the health of the majority of the world's population. It brings together doctors, public health workers, and social scientists to bridge the gap from basic to applied life sciences, including social, economic, political and ethical issues that influence global health.
- Translational Research Centers (Allston, Longwood, MGH). Science and engineering aim to increase knowledge and improve lives. The translation from research in one area to application in another is often haphazard. Doing a better job implies better relationships between basic and applied science and engineering and bridging the gaps between a variety of cultures including those of academia, clinical medicine, and business. We propose establishing translational centers at both Allston, and MGH that would be dedicated to taking promising ideas from the physical and life sciences and converting them to new technologies and instruments that would contribute to scientific research, medicine, and improving the quality of life.

RECOMMENDATION #8: Address shortcomings in Harvard's research and instructional technical infrastructure.

Instructional facilities

Teaching and research in science and engineering require access to an evolving set of tools and facilities. In order for Harvard to undertake a major shift to hands-on learning in the sciences and engineering, it must invest in the requisite instructional facilities. This will require an initial investment as well an ongoing pool of instructional innovation funds, awarded through competitive proposals from faculty. One illustrative example of a current deficiency is our facility for computer-based instruction. While Harvard does have some computer-based instruction facilities in the Science Center, they are inadequate to support greatly increased hands-on data analysis and discovery.

We therefore recommend a program of steady investment and renewal of teaching facilities.

Shared Research Tools

Certain aspects of science and engineering can exploit shared facilities. We suggest that considerable gains (both financial and intellectual) can accrue from coordinated investment across the Harvard complex. Examples of such opportunities include analytic devices, such as mass and NMR spectrometers, sequencing technology, semiconductor device fabrication capabilities, and fMRI imaging systems. Furthermore, in many laboratories latent capabilities exist of which other scholars on campus are unaware.

We recommend that Harvard implement a program of coordinated acquisition of major research apparatus, overseen by HUSEC. In addition, as outlined below, Harvard should immediately exploit IT capabilities to better inform the scholars on campus of the capabilities and interests in other laboratories and research groups.

Research Computing

Computers have transformed our society, and science is no exception. Science and engineering now rely upon computational capabilities, on massive data storage capacity, and on the ability to rapidly transfer data around the globe. Dispersed collaborations can now work on shared data, and information from instruments and sensors around the world are increasingly being transferred to the investigator's desk in real time.

As outlined in the section on Findings, we find that Harvard's research computing infrastructure, in hardware, in supported software, and in staff support, falls far short of the minimum we should expect from one of the world's foremost research institutions. Not only are our computationally demanding researchers exasperated, Harvard is paying a huge intellectual opportunity cost in the form of projects that aren't even being considered due to inadequate vision and resources.

We recommend that the University commit to providing Harvard's scholars with access to computational resources, and appropriate technical support, that will provide a foundation for research across all fields in the decades ahead. We see this as an urgent issue that demands immediate attention.

Exploiting technology to shrink distances and build linkages

The geographic distances between researchers will increase with the addition of another science and engineering campus location in Allston. We encourage the University to use technology to facilitate interactions between campuses and make to it easier for faculty members to be aware of research being conducted elsewhere in the University. Technology solutions can range from a searchable database of Harvard lab and research capabilities to a searchable repository of abstracts of Harvard research proposals. Video conferencing rooms at each campus would also make it easier to hold cross-campus meetings.

RECOMMENDATION #9: Enable a mixture of funding mechanisms to finance new science and engineering endeavors.

As stated above, for HUSEC to succeed, it is critical that it be vested with sufficient resources (FTEs, space and funding) to support the new scientific endeavors it considers of merit. We recognize that the scale of resources being committed to HUSEC requires leveraging multiple sources. While the specifics of funding arrangements will necessarily be determined by negotiations between HUSEC and its principals, we recommend that the sources will include some or all of the following:

- Fundraising through the Development office and other philanthropy;
- Reallocation of portions of involved schools' (FAS, HMS, HSPH) endowments;
- Vigorous support from the Corporation that the programs recommended by HUSEC have sufficient priority to warrant de-capitalization of a portion of endowments;
- Appropriate FTE and/or space contributions from Harvard-affiliated hospitals to support joint ventures with the University.

In the founding of one or more cross-school departments, we recognize a central commitment of FTEs, space and startup and running costs will have to be made by the University. Those expenditures will be outside the scope and purview of HUSEC

Evaluation and funding of interdisciplinary science and engineering proposals will be formalized through HUSEC. All funds in support of inter-departmental or interdisciplinary research endeavors coming from the central administration will be administered through HUSEC.

Based on initial estimates from submitted research proposals, HUSEC would need approximately 75 inter-disciplinary FTEs over the next 10 years. We recommend that a rigorous financial planning process be put in place to model the needed funds over time for the portfolio of activities that we are recommending and to work with the associated schools and hospitals to develop plans to raise funds and reallocate endowment accordingly. HUSEC will play an important role in alignment and coordination of School and central resource allocations.

5.0 GLOBAL IMPLEMENTATION CONSIDERATIONS

Our governance, organizational, and structural recommendations represent an opportunity to increase inter-disciplinary science and engineering activities across the University and foster collaboration across traditional boundaries. The implementation of many of these recommendations will require dedicated, focused effort and a strong and sustained endorsement from leadership in administrations and faculties to ensure their success. The rewards for this commitment will be better use of the University's resources, an empowered science and engineering faculty, and a culture in which the twin goals of education and collegial and collaborative interactions assume a higher priority than they have traditionally been given.

Many of the recommended changes will require a shift in mindset of the science and engineering faculty, department chairs, and Deans on the way inter-departmental research is launched and conducted. It will be critical to put the right leaders in place to encourage collaboration and innovation from the start. For example, careful selection of the initial membership of HUSEC will be important in setting the right tone for change and frequent readjustments and evaluation of progress will be necessary in the early stages of HUSEC's existence. The Deans of the four schools will need to be committed to this new collaborative vision of university-wide science, technology, and engineering ventures, and to better engagement with the hospitals.

The University will need to clearly communicate its support for this plan to the faculty, hospitals and schools, and the larger community. Celebrating early successes (such as the creation of HUSEC, a new department being formed, new initiatives getting approved through HUSEC, and donor support for HUSEC's efforts) and communicating progress against milestones will generate momentum and ongoing support.

Science and engineering faculty across the University should meet periodically to discuss the future of science and engineering at Harvard. We recommend convening an UPCSE-like committee every ten years to take stock of Harvard's progress towards its aspirations, identify new opportunities for intellectual and organizational innovation, and generate the recommendations needed to keep Harvard at the forefront of science and engineering research and education for generations to come.

6.0 FINANCIAL CONSIDERATIONS

The expanded effort in science and engineering outlined in this report is ambitious, and implementing our recommendations will require substantial resources. We therefore outline in this section a framework for considering the significant financial implications of the actions we suggest. We have worked with the University's financial planning staff to identify and, to the best of our ability, provide a realistic order-of-magnitude estimate of the costs associated with the UPCSE recommendations. This section is meant to provide a financial tutorial on the scale of investments required, not a fully burdened cost analysis. As emphasized in our Recommendation #9, it is critical that the University continue to refine and validate financial models and projections to inform planning and decisions. More detailed cost estimates will be developed in the months ahead, but the tutorial below highlights the range of associated investments that can be anticipated over the next ten years.

Our goal in this narrative is to provide a high-level overview of the structure of Harvard's financing of science and engineering, in particular looking towards the challenges that lie ahead.

6.0.1 The Economics of Science and Engineering at Harvard University

The overwhelming majority of Harvard's financial resources are managed within the respective Schools, each of which has a distinct profile of revenue and expenses. The affiliated hospitals are independent entities. Like all academic activities, science at Harvard in all the various faculties is supported by a combination of past and present philanthropy (gifts and endowment), the preponderance of which is controlled at the school level, and various sources of unrestricted income, such as tuition. Compared to non-science activities, Harvard's intellectual effort in science and engineering also receives substantial support from and is uniquely leveraged by external support in the form of grant and contract funds that are raised by principal investigators. These external research funds come primarily from U.S. taxpayers, through federal agencies (primarily NIH, NSF, DOE, DOD, and NASA). Foundation and corporate support are also vital components of the external revenue picture.

This sponsored research support and income distributed from the endowment are the primary sources of financial support at the schools with the bulk of scientific research and teaching activity, but the composition of the sources is vary from school to school. For FAS, which includes both the arts and the sciences, endowment income comprises a significant component of annual revenue*, which is not the case at the School of Public Health. Table III shows the endowment support and sponsored funding at the schools with major science faculties and how these ratios have changed over the last decade.

School	1995		2005	
	Endowment	Sponsored	Endowment	Sponsored
FAS*	30%	21%	47%	17%
HMS	15%	51%	19%	46%
SPH	9%	71%	12%	76%

Table III. Endowment and sponsored research fraction of annual budget for Harvard's science and engineering schools. Source: Financial Report to the Board of Overseers of Harvard College, Fiscal Year 2004-2005.
*Note that FAS figures include all activities, not just science and engineering.

In looking at Table III, it is important to recognize that approximately 80 percent of the University's endowment is restricted by fund terms to specific activities; the activities permitted by fund terms are directed to science in varying proportions across HSPH, HMS and FAS. In addition to supporting direct research costs (including partial support for graduate students and postdocs), sponsored research funds generate indirect cost recovery that is used to defray, in part but not in full, the facilities and administrative costs associated with the conduct of research on the various Harvard campuses. Even the most aggressive recovery of these overhead costs through grant overhead still leaves a significant amount that must be subsidized by the Schools. Academic science is expensive, and overhead recovery does not compensate for the full cost of this activity. In addition, it is important to note that HSPH, HMS and FAS are and will continue to feel significant pressure from the current downturn in some areas of federal sponsored funding.

6.1 CURRENT INVESTMENT IN HARVARD SCIENCE

In considering the financial impact of a significant expansion in science and engineering, we must recognize the substantial ongoing investment that Harvard is presently making in these areas.

Space

Harvard's existing intellectual activity in science and engineering is carried out in a set of buildings that range from recently occupied new construction (e.g. the New Research Building in Longwood) to historical treasures; the Medical School quadrangle buildings in Longwood were opened a century ago. The construction costs for the older Harvard buildings were paid for long ago. The Northwest building and the LISE building in Cambridge are currently under construction. In addition to the cost of construction (i.e. debt service and deprecation) and operations and maintenance expenses, lab and office space of existing and new faculty is often updated, outfitted and (in some cases) substantially renovated.

Infrastructure

The University provides most of the administrative backbone upon which the science and engineering enterprise is built. Grant and contract administration, secretarial support, legal and compliance activities, health, safety and security, accounting and financial transaction support, human resources, etc. – the cost of these "back-office" functions that support science and parts of the academic enterprise are typically borne by departments, schools, and the University's central administration. The Federal government and other funding entities cap the amount of these administrative expenses that can be recovered via indirect cost recovery. The actual cost of these services at Harvard and every other major research university exceeds this cap and is therefore subsidized from other sources of revenue.

Faculty

Harvard makes a substantial investment each time a new faculty member is added to the ranks. This investment in a new science or engineering faculty member is on average significantly larger than the cost of hiring and providing for the academic needs of incoming faculty in other disciplines.

Beyond the provision of lab space, administrative support and salary, there are substantial costs associated with bringing new faculty to the Boston area and starting large and complex laboratory operations from scratch. Helping new faculty (regardless of discipline) deal with the extraordinary cost of Boston housing, and relocation and recruitment expenses are significant. Far greater are the costs of starting or relocating a large laboratory group and sustaining its research activity until sponsored funding can be secured. The support of lab technicians, graduate students and postdocs, procurement of specialized equipment, etc. are necessary expenses to sustain over multiple years against the risky hope that adequate levels of sponsored funding can be secured in the future to partially offset these upfront investments. These substantial startup costs do not exist outside of the sciences and are never fully covered by sponsored research support.

6.2 THE COST OF NEW MAJOR EXPANSION

A major expansion of science and engineering into new construction, be it in Allston or elsewhere, implies a marginal cost that far exceeds the average cost of doing science and engineering in the present mix of old and new buildings. This is because new scientific initiatives often requires the recruitment of new faculty who are expensive to recruit and startup, and may take place in newly constructed buildings, which must be paid for. We note that moving existing faculty into new construction only helps defray the University's overall building costs to the extent the faculty are able to raise *additional* grant support. The University was already benefiting from the overhead raised on their existing grants.

As a concrete illustration, we have created in conjunction with University financial officers a simple model for estimating the marginal costs of a new interdisciplinary science faculty member. This model reflects an average of both the "one time" expenses associated with recruitment and start-up, and the ongoing, year-in, year-out funding needed to support faculty salaries, technicians, graduate students and postdocs, space and facilities, and administrative and other support, offset by reasonable expectations for indirect cost recovery generated from sponsored funding. The model provides order of magnitude estimates on faculty-driven costs, but does not fully burden the costs with expenses such as capital costs and operations and maintenance on non-lab portions of new construction, the costs of shared research and core facilities, or the expenses of programmatic elements like curriculum development, undergraduate internships, conferences, seminars, or seed grants.

We then aggregate this simple model to reflect the scale of science activity and the numbers of new faculty that we believe will be needed to create vibrant activity. We have estimated that these new ventures will require about 140 faculty FTEs recruited over 10 years. We assume that as much as half of these required FTEs could overlap with the existing FTE growth plans for FAS science and engineering, HMS, and HSPH. However, many of the existing school growth plans remain largely unfunded so for the purposes of our analysis, we have chosen to range the faculty FTEs from an incremental 70 to the full 140 required.

The cost estimates (after accounting for projected indirect cost recovery) assume that, depending on the type of researcher, a science FTE costs \$500K to \$3M in one-time start-up costs and \$600-800K in annual net operating expenses (salary and fringe, research and admin support, debt service, operations and maintenance). Assuming a "typical" faculty member at about the midpoint of these ranges, this represents an endowment equivalent of approximately $14M per new FTE to cover net annual operating costs.

Assuming that between 70-140 new FTEs are needed over the next 10 years, the aggregate costs to the University would be $120-240M in one-time start-up costs and ~$50-100M in annual net operating expenses. This results in a total endowment equivalent of $1-2B. Assuming that the growth in FTEs will be linear over the ten-year period and using a straight-line amortization of start up costs, approximately $75-125M will be required per year to cover the costs.

These estimates are highly preliminary and need to be further refined. For example, to the extent all 140 new faculty are not incremental to current faculty growth planned within the science faculties, the high end of the cost range is overstated. On the other hand, while the per FTE costs include allocated space costs and lab operations (including research and administrative support), it excludes the significant cost associated with doing science in a new way, including the need for shared core equipment and infrastructure, and administrative costs of new Centers and Institutes. In addition, the cost estimates reflect sponsored funding projections that could be overly optimistic in light of the challenging funding environment.

The "endowment equivalent" figures convert the net annual cost required (or run rate) into the amount of endowment that would be required to fully fund these costs in perpetuity at current endowment payout rates (excluding one-time startup costs). While it is clearly desirable to fully endow new *permanent* annual costs to avoid creating new unfunded obligations to the operating budget of the University, that is a decision of academic and financial priorities. Very importantly, the addition of so many new faculty will itself be challenging, although a scientific critical mass in new areas of research is essential. The task of managing these investments over the coming decade and more will require the full engagement and unprecedented cooperation of HUSEC, faculty leadership, Deans and University administrators.

6.3 HARVARD'S OPTIONS IN ADDRESSING THIS FINANCIAL CHALLENGE

At this time, we have no master financial plan for meeting obligations on this scale and duration, although we recognize that University governing bodies would be ill-advised to proceed without one. We have begun working with financial officers to create this model. This analysis must continue and must engage the attention of faculty, students and administrators across the University community. It is clear that the scale of science expansion suggested in this report requires the University to draw from all available sources of revenue, and potentially find new sources of funding.

Central University Resources

In 2001, Harvard's faculties approved an assessment on all University endowments to fund administrative expenses. This new source of funds enables the University to redirect resources to support the development of strategic initiatives, like infrastructure in Allston. In FY06, this assessment yielded approximately $130M for the Strategic Infrastructure Fund, or SIF. Harvard's ability to create such a financing instrument is a unique and extremely advantageous by-product of our sizeable endowment and its substantial growth over the past years.

Although there is as yet no comprehensive calculation of the costs of the physical infrastructure (or academic programs) of the new Allston campus, it is understood that the cost of the infrastructure alone will exceed the capacity of the SIF and will require new philanthropy and other revenues. The SIF was never intended or planned to support the programmatic and academic costs of Allston – ranging from science to arts and culture to undergraduate life and new professional schools – which will also be substantial.

In addition to the SIF, the President and Provost are also able to support new academic initiatives both within individual schools and across the University in interdisciplinary activities. These funds are intended to serve as seed funding and are always a small fraction of what will be necessary for these new initiatives to reach their full potential, but they have been important. A significant number of new science activities recommended by our Committee have or will receive startup assistance from these discretionary funds.

The Central Administration does not have in hand the funds needed to realize a major expansion in Allston, to support existing programs adequately, and to fund the recommendations of this report for innovation in science and engineering. Doing so will require substantial analysis, creativity, new revenues, and hard choices among competing priorities.

New Philanthropy

We think that the intellectual excitement of new science, the expansion of science capacity in Cambridge and Longwood and the development of the Allston campus will generate philanthropic giving opportunities. The physical plant and program costs of new faculty will be unsustainable without unprecedented giving. Although plans for a University-wide capital campaign have been put on hold during the current leadership transition, new research, new faculty, new facilities and innovation and leadership in emerging areas of scientific inquiry will challenge alumni and friends of the University on a scale which we have not yet seen.

New Revenues

Consistent with the need to maintain the University's academic values, we will have to do better in the generation of subsidiary income from the commercialization of technology and intellectual property, from co-development and real estate activities undertaken with the private sector, from grants, gifts, contracts and other forms of partnership with the private sector, and from aggressive pursuit of sponsored funding. All of these avenues have challenges; all can be misused to the detriment of the scholarly University mission; all have the potential to support innovation and speed the transition of new scientific knowledge into public good, new therapeutics, and economic development for this region.

Existing Endowments

As a result of the performance of the Harvard endowment over the last three years alone, the University is some $7 to $8B richer than what we had expected based on reasonable and prudent expectations about the growth of the endowment, which in the aggregate will shortly exceed $30B. The redirection of some fraction of the past and future appreciation of those endowments currently supporting University science in the various faculties seems both appropriate and necessary. We have been the beneficiaries of enormous generosity by past generations of University alumni and friends, and an extraordinary period of market growth and prudent stewardship. Now is the time to invest a portion of our good fortune in the future of science at Harvard.

7.0 CONCLUDING THOUGHTS

Our intensive deliberations over the past six months are the prelude to a long-term, University-wide effort to coordinate new initiatives across the several faculties in science and engineering. Through dialog and discussion, the participants educated themselves about the breadth and scale of the research and educational portfolio on the Cambridge, Longwood and MGH campuses

Our proposals aim to make the University more than the sum of its parts. To achieve this aim, Harvard needs more transparent faculty governance, new organizational structures that give intellectual agility to individuals and small collections of faculty, and the institutional agility to seize opportunities in new areas of science and engineering.

The call for cross-school departments and inter-departmental committees with faculty appointment powers are two concrete proposals to stimulate and integrate inter-disciplinary research across Harvard. They will draw Harvard's campuses together, set the stage for a more rational and integrated approach to science and engineering planning, and transform the planning of the Allston campus.

We have proposed HUSEC as a university-wide standing committee involving the deans and faculty representatives from FAS, HEAS, HMS, HSPH, and the affiliated hospitals. It will have executive and advisory powers for starting and evaluating new initiatives on the existing campuses and at Allston. We believe that HUSEC will provide an impartial and long-term vision that will help to build a successful and intellectually coherent Allston campus and keep the Cambridge and Longwood campuses strong and vibrant.

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APPENDIX A: Charge to University Planning Committee for Science and Engineering

January 9, 2006

Dear Colleagues:

This is a time of extraordinary promise for science and engineering at Harvard. New facilities are under construction in Cambridge, and Allston planning is in high gear. The University also has the resources to make unprecedented investments in science and engineering. As a result, we have an opportunity to position Harvard to be at the forefront of these areas for years to come. In that spirit, I am writing to ask you to serve on a University Planning Committee for Science and Engineering. This committee should engage in an intensive, open-minded effort to advise the Deans, the Provost, and me on the most forward-looking uses of our science facilities and of our substantial resources. Recent plans that emerged from the Task Force on Science and Technology focused on cross-school, interdisciplinary science. We must now integrate those ideas with school and department-based planning. We should strive to create the most attractive long-term environment for our faculty – those already here, and those we will wish to recruit in the years ahead – and the best educational opportunities for our students.

The aim of this process is to advise on the future of science and engineering at Harvard across the University, irrespective of physical location, seeking again to ask, "what can we do best?" before answering the question, "where can we best do it?" While striving to look comprehensively at the future direction of University science and engineering in the broadest possible way, please be assured that we will honor our existing commitments to faculty colleagues.

These include:

- The commitments made to faculty for space and support in facilities currently under construction, such as the Northwest Laboratory and the Laboratory for Interface Science and Engineering (LISE).
- The decision we have made as a University to commence in the near future the design and construction of a major new science facility in Allston.
- Our commitment to the Harvard Stem Cell Institute, to see it permanently housed in the new Allston facility. We will see this facility built and opened at the earliest practical date, and HSCI will be among its first occupants.
- Our commitment to the substantial enhancement of Harvard's efforts in Engineering and Applied Science.
- Commitments to HMS basic science departments in accordance with their 5 year plans and to working more closely with the Harvard affiliated hospitals.
- Our collective commitment to our educational mission, for undergraduate and graduate education in the sciences.
- The affirmations by Deans Kirby and Martin of their joint determination to locate in Allston important nodes of research currently housed within the FAS and Medical School.

At the same time, if there are ways to strengthen science research and education, to deepen our expertise in an important field, or to more successfully launch a new area of departmental or interdisciplinary inquiry by realigning current efforts, contiguities, and resources, we should not fail to discuss them. I will look to this committee for recommendations that take an encompassing view of our science and engineering enterprise. This is an ambitious goal, as challenging as it is important, and will require intense effort over the next several months that will culminate in a report by late spring. The first organizational meeting will be held on January 20 from 11:00am-1:00pm at a location to be determined shortly. I will attend that meeting to charge the committee and will be joined by the Provost and Deans. Three members of the faculty, Chris Walsh (HMS), Andrew Murray (FAS), and Chris Stubbs (FAS), will chair the committee. They will work closely with David Fubini, who comes from outside the University but knows Harvard well and will act as facilitator at the meetings. The committee will find a regular time for weekly meetings and will be asked to prepare a report to the Harvard Corporation and me by May 1, 2006. The Provost will attend these meetings and his office will provide staffing. Likewise, the Provost's Office is happy to provide appropriate support to free your time for this important service to the Science and Engineering community and to the entire University.

I will give this effort my strongest support, as it is vital to the future of Harvard. I look forward to hearing from you and sincerely hope that you will be willing to serve.

Many thanks,

Lawrence H. Summers

APPENDIX B: Co-Chair Meetings with Stakeholders.

11 FAS departments

- Physics
- OEB
- Psychology
- EPS
- Math
- Astronomy
- MCB
- Bio Anthropology
- CCB
- Statistics
- DEAS

School of Public Health

- Entire faculty

8 HMS departments

- BCMP
- Genetics
- Health Care Policy
- Pathology
- Social Medicine Neurobiology
- Cell Biology
- Microbiology and Molecular Genetics
- Systems*

Harvard Leaders

- President Bok
- Dean of HMS
- Dean of HSPH
- Dean of FAS

5 major Harvard-affiliated hospitals' Executive Research Committees

- MGH/ECOR
- BIDMC
- Brigham & Women's Hospital/ROC
- Dana Farber Cancer Institute
- Children's RSG*

* Pending

APPENDIX C: Background and Fact Sheets for Harvard Science and Engineering:

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HSPH Overview

Main research and education foci

Since its founding 83 years ago, the faculty of the Harvard School of Public Health have made fundamental contributions to public health in widely diverse settings, including : developing the iron lung, paving the way for vaccines for polio and chickenpox, creating occupational health as a field of public health, establishing that the virus which causes AIDS is in the retrovirus family, and launching the "Designated Driver" campaign in the United States to curb alcohol-related traffic crashes.

The Harvard School of Public Health may be the most broadly interdisciplinary of any graduate faculty in the university. The interests and expertise of the School's faculty and students extend across the biological, quantitative, social, and policy sciences. Indeed, the field of public health is inherently multi-disciplinary. Its focus is on the health of populations, particularly of the poor and underserved. A wide variety of scholarly approaches is needed to understand and to effect changes in the health of large numbers of people in this country and abroad. With its roots in biology, HSPH is able to confront the most pressing diseases of the day—such as AIDS, obesity and diabetes, cancer, and heart disease—through research into their underlying structure and function. Core quantitative disciplines like epidemiology and biostatistics are needed to analyze the risks for, and broad impact of, health problems, allowing the School to look beyond individuals to entire populations. And, because prevention of disease is at the heart of public health, the School also pursues the policy and social sciences to understand how these factors shape individual health-related behaviors as well as societal influences on health.

Structure, departments and divisions

- The School has nine departments:

    - Laboratory sciences: Genetics and Complex Diseases, Immunology and Infectious Diseases
    - Quantitative sciences: Biostatistics, Epidemiology
    - Lab/Quantitative: Environmental Health, Nutrition.
    - Social and Policy sciences: Health Policy and Management, Population and International Health, and Society, Human Development and Health

  The departments are responsible for teaching and academic programs, and for the recruitment, appointment, promotion and retention of faculty.

- In addition it has two divisions: Division of Biological Science (DBS) and Division of Public Health Practice (DPHP). The divisions integrate the School's efforts in two important areas. The DBS oversees the PhD program in biological science and provides a forum for priority setting and critical decisions in laboratory science, an area of the School's work that requires considerable investments in space and financial resources. The DPHP was created in 1997 in response to the national call by the Institute of Medicine for dedication to public health practice to strengthen service, education and research opportunities for the School's students, faculty and practitioners. The Division also helps prepare students for leadership positions and nurtures community partnerships to meet health challenges

- Several centers provide a focus for interdisciplinary work on major public health issues: cancer prevention, injury control, society and health, health communications, health and human rights, population and development studies. These centers are reviewed every five years to ensure that they continue as vibrant contributors to the intellectual life of the School and University.

Table with department names, sizes

Department	Faculty Primary	Faculty Secondary	Faculty Adjuncts	Faculty Total	Post Docs	Other Acad Appts	Students PHD	Students DPH	Students DS	Students MPH	Students MS1	MS2	Total
Biostatistics	32	15	8	55	16	40	69		4.5		4	6	83.5
Environmental Health	31	15	12	58	59	145	6	1	53		1	16	92
Epidemiology	19	28	15	62	23	18	0	10.5	77		53	28	168.5
Genetics and Complex Diseases	9	0	4	13	30	13	16		1				13
Health Policy and Management	27	16	24	67	4	66	71*		13.5		36	48	97.5
Immunology and Infectious Diseases	14	6	5	25	40	66	28		3				20
Nutrition	10	4	1	15	18	26	0	1.5	25				26.5
Population and International Health	24	3	7	34	35	39		2	28			37	67
Society, Human Development, and Health	25	11	13	49	23	24		4	57		1	41	103
Master of Public Health Program										297**			297
Totals	191	98	89	378	248	437	190	19	262	297	95	176	

* MPH concentrations are not based in specific departments

- HSPH faculty have been honored with many of the highest scientific awards: 3 MacArthur Awards, Charles Mott Prize, 2 Nobel Laureates, Albert Lasker Clinical Medical Research Award, 2 Heinz Awards, FASEB Excellence in Science Award, ACS Medal of Honor, 20 members of the national Academies (NAS and IOM), 3 of the top 10 most cited scientists in clinical medicine for the last decade.

Educational roles and successes

HSPH offers graduate programs in the disciplines associated with public health and in public health as a profession. Of our approximately 1000 students, roughly half pursue education leading to a career in academic research and the other half will go on to careers as public health practitioners, spanning the range from clinical research to management of health care organizations to heads of local, state and country health departments.

The major professional degree program is the Master of Public Health program, a one-year course of study for students who hold or are earning a doctoral degree. More than 95% of the students in the MPH program are physicians. The School also offers five two-year professional degree programs leading to the M.Sc. degree. In addition, academic departments offer doctoral programs that lead to the D.Sc., or Dr.P.H. degree and, through GSAS, the PhD.

- The School offers four degree programs: Master of Science (M.S.), Master of Public Health (M.P.H.), Doctor of Science (Sc.D.), Doctor of Public Health (Dr.P.H.).
- HSPH-based PhD programs: Biology in Public Health and Biostatistics
- PhD in Health Policy
- Joint degrees: MD/MPH; JD/MPH

Successes:

- As HSPH offers the only MPH degree targeted to post-doctoral training, a high percentage of MPH graduates go on the senior leadership positions.
- Gro Harlem Brundtland, MPH '65, was Director-General of the World Health Organization from 1998-2003.
- Since 1962, six directors of the Centers for Disease Control and Prevention have been Harvard School of Public Health graduates.

Governance structure and internal resource allocation

The dean, with his senior management team, provides the administrative and academic leadership of the School. An elected Faculty Council prepares the agenda for faculty meetings, devises procedures for faculty action, and develops other mechanisms to communicate and enrich faculty involvement in the School. Several committees are delegated authority in specific areas of the academic program: Committee on Admissions and Degrees; Standing Committee on Appointments, Reappointments, and Promotions; and Committee on Educational Policy.

The School's budget is comprised primarily of sponsored research funding (70%) plus 30% from tuition, endowment and gifts. Funds available for allocation are returned to departments based on an allocation model which credits departments for the grant overhead and tuition dollars they earn.

Priorities for the future

Through recent planning activities, we have developed a matrix of multidisciplinary agendas and cross-cutting approaches that set priorities for future activities:

DETERMINANTS OF POPULATION HEALTH				
PUBLIC HEALTH AGENDAS	Environmental	Biological	Social	Health Policies
Infectious Diseases				
Chronic Diseases				
Unnecessary Epidemic of Violence/Injuries				
Disparities in Health				
Health Systems				

This matrix, with some minor changes, provides the framework for academic, strategic and business planning for the School. The shading indicates academic emphasis for each of the major public health agendas (darker shading indicates greater activity). In setting priorities and direction for the future, several factors are considered: public health importance, areas where the School has unique strengths, areas of impact, and areas that address disparities. To illustrate, areas of focus include:

- AIDS, tuberculosis, and malaria, which combined kill an estimated 7 million people worldwide each year, primarily in the developing world,
- Overweight and obesity, a skyrocketing health problem globally, and linked to a host of health problems that have been coined "metabolic syndrome": high blood pressure, high cholesterol and blood fat levels, type 2 diabetes and cardiovascular disease; and even risks of asthma, some cancers, and susceptibility to the effects of environmental toxins,
- Major trends affecting population health in the coming decades (aging, greater diversity and disparities, changed family and workforce structures, and continuing globalization) and requiring the full range of public health approaches to understand their impact on health, and implement and evaluate policies calculated to achieve the highest attainable standard of health,
- Leveraging our existing population resources and expanding them to include understudied groups worldwide, including most of Asia, Latin America, and Africa.

Three other factors will have significant impact on the School's future directions. One is the explosion of data across the spectrum from biological data (genes, proteins, small molecules) to cohort studies of increasing size to more complex approaches to measurement of exposure and geographic location and the challenge of capturing and interpreting these data. The second is increasing globalization and its impact on health. And third is the challenge of allocating limited health resources to reduce gaps and inequalities in access to health and health care.

HMS Overview:

The mission of Harvard Medical School is "to create and nurture a community of the best people committed to leadership in alleviating human suffering caused by disease." While educating leading physicians has always been a central part of this mission, the reputation and contributions of HMS derive from a much broader spectrum of activity. By numbers and philosophy, HMS is as much a graduate school as it is a professional school. There are approximately 700 M.D. students and 600 Ph.D. students, including 150 students who simultaneously earn both M.D. and Ph.D. degrees. 70% of all life sciences Ph.D. students at Harvard University carry out their thesis work in laboratories at HMS and its affiliated hospitals. The M.D. and M.D.-Ph.D. programs are considered the best in the nation. The Ph.D. programs share top ranking with several competitors, including MIT, Stanford and the University of California San Francisco.

Over the past 25 years the HMS M.D. programs (*New Pathway* and *Health Sciences and Technology*) have set the standard for top medical schools worldwide. Ongoing medical education reform will help maintain our leadership position. Our Ph.D. programs have been similarly innovative, responding both to changes in core scientific knowledge and continuous student feedback. However, it is unlikely that trainees choose to come to HMS solely because of the quality of medical or graduate education. There are two other important factors. First, we are affiliated with 15 teaching hospitals, many of which are ranked at or near the top nationally. This wealth of clinical expertise vastly exceeds that of our nearest competitors. Second, our biomedical research enterprise, considered as a whole, is unsurpassed. Our predecessors had the wisdom to cultivate scientific discovery across the entire spectrum of inquiry, from meticulous studies of individual molecules to large, multi-institutional clinical trials. The diversity of our research portfolio has ensured that a disproportionate number of unpredictable, transforming breakthroughs happen here.

By its very nature, the biomedical landscape is always changing. This presents both challenges and opportunities. We would argue that HMS has an enormous advantage in dealing with change. The faculty in our clinical departments would not be here if they were not continually transforming the standards of medical practice to create and take advantage of new knowledge. Our scientists are natural academic entrepreneurs – none can stay at the top of his or her field without continuously reinventing himself or herself and breeching the boundaries of what we know. We embrace change, because our preeminence depends upon our ability to discover and break new ground.

HMS Quad Main Research and Education Foci

(areas of current strength are shaded)

Area/Approach	BCMP	Cell Biol	Genetics	Micro & Mol Gen	Neuro	Pathology	Syst Biol
Aging						X	X
Bacteriology				X			
Biochemistry	X						
Cancer biology	X	X				X	
Cell cycle		X	X				X
Cell death	X	X					
Cell physiology	X	X		X	X		X
Chemical biology	X	X		X			X
Cell/tissue architecture	X	X			X	X	
Developmental biology		X	X				
Emerging diseases	X			X			
Evolution	X		X				
Genetics – model organisms			X	X	X		X
Genomics			X				
Human disease	X	X	X	X		X	
Human genetics			X				
Imaging (all levels)	X	X		X	X	X	X
Immunology				X		X	
Microbial pathogenesis				X		X	
Neurobiology		X			X	X	
Neurodevelopment / degeneration		X			X	X	
Neurophysiology					X		
Nucleic acid: protein interactions	X	X	X	X			
Organ development	X	X	X		X	X	
Pharmacology/drug discovery	X	X		X	X		X
Proteomics		X				X	
Stem cells	X	X	X				
Structural biology	X	X		X			

Area/Approach	BCMP	Cell Biol	Genetics	Micro & Mol Gen	Neuro	Pathology	Syst Biol
Systems biology							X
Systems neuroscience					X		
Vaccine development	X			X		X	
M.D. EDUCATION	X	X	X	X	X	X	
D.M.D. EDUCATION	X	X	X	X	X	X	
Ph.D. EDUCATION	X	X	X	X	X	X	X
POSTDOCTORAL EDUCATION	X	X	X	X	X	X	X

Harvard Medical School Basic Science Departments

Department	Jr. Faculty (Women)	Sr. Faculty (Women)	Dept Totals (Women)	Off-Quad Primary Appointees (Women)
Biological Chemistry & Molecular Pharmacology	6 (1)	16 (0)	22 (1)	11 (1)
Cell Biology	7 (0)	13 (4)	20 (4)	6 (0)
Genetics	4 (2)	7 (1)	11 (3)	21 (4)
Health Care Policy	8 (4)	10 (2)	18 (6)	N/A
Microbiology & Molecular Genetics	8 (1)*	13 (2)*	21 (3)*	3 (0)
Neurobiology	6 (3)	12 (2)	18 (5)	6 (1)
Pathology	5 (1)	8 (2)	13 (3)	N/A**
Social Medicine (SM)	***	***	***	***
Systems Biology	3 (1)	4 (1)	7 (2)	4 (0)
Totals (excluding SM):	**47 (13)**	**83 (14)**	**130 (27)**	**51 (6)**

\# HMS has no financial responsibility for off-quad primary appointees

* Microbiology and Molecular Genetics quad faculty counts include investigators at the New England Primate Research Center in Southborough

** All hospital Pathology faculty are considered off-quad members of the department

*** Nearly all faculty have multiple appointments; some are only peripherally affiliated with the Department of Social Medicine.

Educational roles and successes

Medical Education

Twenty years ago, the HMS New Pathway curriculum and its emphasis on problem-based learning set the standard for medical education around the world. In the past two decades the medical profession has changed dramatically. Since 2001, the Medical School has engaged in a comprehensive review of all four years of its standard M.D. curriculum, resulting in a new program, scheduled to begin in AY07. The new curriculum extracts the best features of the New Pathway—problem-based, self-directed learning—and remodels them taking advantage of experience gained from the first twenty years. In its new form, the curriculum prioritizes four principles:

1. Meaningful and intensive faculty–student interactions must be re-established
2. The teaching of basic science and clinical medicine must be integrated throughout classroom and clinical activities
3. Clinical education must be redesigned to allow for longitudinal faculty mentoring, longitudinal patient experiences and longitudinal student assessment
4. A scholarly, in-depth experience—with a substantive written product—should be required of all students

The changes envisioned for Harvard's M.D. curriculum are ambitious and will require significantly more involvement of faculty as teachers and role models. The Academy at Harvard Medical School, established in 2001, has provided greater recognition for teaching efforts, supported curricular innovation and helped to enhance the skills of our teachers. To expand its mission, the Academy has established a Center for Teaching Excellence focused on the development of faculty as effective, innovative teachers and engaging role models.

Twenty percent of HMS medical students choose an alternative curriculum for their first two years. The Health Sciences and Technology (HST) Program, hosted jointly by Harvard and MIT, has a directed mission to educate physician-scientists and physician-engineers. HST has been extraordinarily successful, with distinguished national leaders among its alumni. It has served as a model for similar programs across the country and around the world. While HST was not specifically examined in the review of New Pathway medical education, we recognized that it, too, has been impacted by changes in the medical profession. We conducted a careful internal review of HST in 2005. The review reaffirmed the value of HST, but also identified areas that need improvement. We have taken the recommendations seriously, and are working to make important, though less dramatic, changes to this program.

PhD education

HMS faculty participate in 10 of the 12 Harvard Integrated Life Sciences (HILS) Ph.D. programs (see table). Four of these programs (Biological and Biomedical Sciences, Immunology, Neuroscience, Virology) share an administrative umbrella structure (the Division of Medical Sciences) for admissions, funding and other functions. Three are based in other schools (Chemistry and Chemical Biology, Biological Sciences in Dental Medicine, Biological Sciences in Public Health) and four have balanced participation from HMS and FAS (Biophysics, Chemical Biology, Neuroscience, and Systems Biology). All degrees are awarded by GSAS.

HMS participation in PhD programs
(Programs with major HMS quad participation are shaded)

Program	BCMP	Cell Biol	Genetics	Micro & Mol Gen	Neuro	Pathology	Syst Biol
Biological and Biomedical Sciences (Division of Medical Sciences)	X	X	X	X	X	X	X
Immunology (Division of Medical Sciences)			X	X		X	
Neuroscience (Division of Medical Sciences)		X	X		X	X	
Virology (Division of Medical Sciences)	X		X	X		X	
Biological Sciences in Dental Medicine	X	X	X				
Biological Sciences in Public Health		X		X			
Biophysics	X	X	X	X	X	X	X
Chemical Biology	X	X		X			X
Chemistry and Chemical Biology	X			X			
Systems Biology	X	X	X				X

Medical education for Ph.D. students

The Leder Medical Sciences (LMS) Program for Ph.D. students, launched in 2006, takes advantage of the opportunities afforded by proximity to superb teaching hospitals. It is funded by a portion of a Merck gift for graduate education and the Howard Hughes Medical Institute. The LMS Program has two goals. First, it provides Ph.D. students with a working knowledge of human biology and disease, enriching their basic science training and broadening their research interests. Although these students do not receive a degree for their work in LMS, they are better prepared for research related to human diseases. Second, the program demystifies the culture and practice of medicine. We believe that this will facilitate future collaborations with clinicians and physician-scientists.

Students are admitted to the LMS Program from any HILS program. The LMS curriculum stretches over a year and a half, interspersed with other Ph.D. program requirements. We anticipate that LMS Ph.D. graduates will be more likely to choose research questions relating to human diseases and better equipped to interact with physician collaborators. They will have the benefits of rigorous training in basic science and fluency in clinical medicine, allowing them to populate an important niche that, we believe, cannot currently be filled by physician-scientists alone.

M.D./Ph.D. Programs

The M.D./Ph.D. Program has an international reputation as the best program for educating physician-scientists who will become leaders in American medicine and biomedical research. Students combine medical studies at HMS with graduate studies at Harvard or MIT. The Program's basic science track offers the largest collection of academic laboratories in the world for research training, complemented by teaching hospitals that are poised to rapidly translate basic discoveries into new clinical applications. Its social science track enables students to pursue Ph.D. studies in premier Harvard social sciences departments, including, Health Care Policy, Economics, Anthropology, History of Science and others. Students can choose either the standard medical curriculum (formerly the New Pathway), or HST. Both curricula include rigorous clinical clerkships at the Harvard teaching hospitals.

Governance structure and internal resource allocation

Each of the seven HMS basic science departments (and two HMS social science departments) is led by a faculty chair. The chair is selected through an international search process, and is usually (though not always) recruited from outside HMS. In the past, there was no defined term of service for department chairs, but more recently chairs have been invited to serve five-year, renewable terms. Department chairs control departmental funds (amounts vary widely, largely dictated by past accumulation and income from intellectual property) and departmental space. Chairs report directly to the Dean of the Faculty of Medicine.

The Dean for Basic Sciences and Graduate Studies (Nancy Andrews M.D., Ph.D.) and the Executive Dean for Administration (Cynthia Walker) work coordinately to deal with issues and requests that extend beyond the departments. They determine allocation of school space and financial resources and work with the chairs on recruitment, retention and other faculty issues. They allocate startup funds for school-wide core facilities and new technologies. They work with a faculty advisory committee (of chairs and non-chair faculty members) to develop new school-wide policies. They coordinate strategic and academic planning efforts for HMS. Both report to the Dean of the Faculty of Medicine.

Priorities for the future

Programmatic collaborations with other Harvard Schools

Because of our dependence upon our affiliated hospitals for clinical education and research, collaboration has always been a strong part of the HMS culture. Our faculty has developed formal and informal collaborations with scientists at FAS and HSPH.

We have been enthusiastic participants in the Harvard Integrated Life Sciences (HILS) confederation of graduate programs. HMS has hosted several activities open to all HILS students and the newly inaugurated Leder Medical Science program. HMS collaborates with FAS in nearly all of our existing graduate programs, particularly the two newest life sciences graduate programs (Systems Biology and Chemical Biology) and the older Biophysics program and Neurosciences programs.

Two joint degree programs, the M.D.-Ph.D. program and the M.D.-M.B.A. program, forge direct links between HMS and FAS, HMS and HBS, respectively.

The HMS Departments of Health Care Policy and Social Medicine have had strong collaborations with HSPH, FAS and KSG for much of their existence and have actively participated in undergraduate education. The program in Medical Ethics, based in Social Medicine, is a provostial interfaculty initiative. It also interfaces with HLS.

Academic priorities

Five interdisciplinary initiatives were deemed school priorities during an AY03 strategic planning process. These include a new department (Systems Biology) and four interdepartmental initiatives – structural biology, chemical biology, systems neuroscience and biodefense/emerging infectious diseases. More recently, a new initiative in Aging has been developed with startup funding from a philanthropic gift. The Department of Genetics is slated to expand in size and scope with the recruitment of a new chair (pending).

In addition to these quad-based initiatives, HMS hosts school-wide collaborative efforts aimed at understanding and curing prevalent human diseases. These include the Dana-Farber/Harvard Cancer Center (900 faculty members) and the Harvard Center for Neurodegeneration and Repair (700 members). HMS is the home base for the NIH-funded New England Regional Center of Excellence in Biodefense and Emerging Infectious Diseases (NERCE/BEID). With Duke University, it is also a major participant in the Center for HIV/AIDS Vaccine Immunology.

Educational priorities include enhancement of financial aid for medical students, identification of new resources to support international Ph.D. students and expansion of the M.D.-Ph.D. program.

FAS Overview[1]

Science and Engineering Departments: Astronomy, Biological Anthropology (a wing of Anthropology), Chemistry and Chemical Biology (CCB), Division of Engineering and Applied Science (DEAS), Earth and Planetary Science (EPS), Mathematics, Molecular and Cellular Biology (MCB), Organismic and Evolutionary Biology (OEB), Physics, Psychology (jointly in the Social Sciences), Statistics

Centers and Institutes: Center for Astrophysics (CFA), The Center for Brain Science (CBS), Center for Nanoscale Systems (CNS), FAS Center for Systems Biology (incorporating the Bauer Center), Center for Ultracold Atoms (CUA), Energy and the Environment initiative, Harvard University Center for the Environment (HUCE), Institute for Innovative Computing (IIC), Institute for Quantum Science and Engineering (IQSE), Institute for Space, Time, and Matter (IST+M), Institute for Theoretical Atomic, Molecular, and Optical Physics (ITAMP), Materials Research Science and Engineering Center (MRSEC), Microbial Sciences Initiative (jointly with HMS) (MSI), Nanoscale Science and Engineering Center (NSEC), Origins of Life

SECTION 1: **Engineering and the Physical Sciences**

The DEAS and Departments in the Physical Sciences have been engaged in a year-long planning process that crosses Departmental boundaries and examines both the core programs of the Departments and unique interdisciplinary activities that are either ongoing or new initiatives. This process is not complete, yet there is much that has already been done. This document should be taken as a snapshot of the planning process that encompasses five major areas: Departmental aspirations, creation of institutes and centers, interdisciplinary graduate programs and scientific computing.

Due to the constraints of length, the Departmental plans are not presented here. Since the interdisciplinary work is probably the most challenging insomuch as mechanisms for collaboration are identified, this document highlights that work. This emphasis should not be taken as a de-emphasis of the core missions of departments, which is viewed as primary by the majority of faculty, but rather to highly opportunities at interfaces.

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[1] The following represents the abbreviated version of the FAS overview. A fuller version is available.

DEAS and Physical Sciences Unit[2]	Funding ($M)	Sources	Faculty heads	Faculty FTEs	Staff	Under grads.	Grad.	Sq. Ft. (k)
Departments								
Astronomy	3.7	NSF	20	17	2	27	49	3
DEAS	34	NSF, DOE, DARPA	80	66		289	306	375
EPS	4.1	NSF, NASA, DOE,P	26	15.5	32	44	53	66
Math	1.9	NSF,P	18	18	10	150	54	21.5
Physics	14.4	NSF, DOE, Private	38	30		189	194	107.4
Statistics	1	NSF, NIH, P	14	9	5	8	48	9
Centers, Institutes[3]								
CFA	94	Harvard/Smithsonian	2		800			250
CNS	1	NNIN	1	0	17		201	25
CUA		NSF	5					
Energy-Environment								
HUCE	1.2	NSF, P	90					4
IIC		NSF, DOE, P	11		90			
IQSE	6.1	NSF, DTO, DARPA	10		2		20	
ISTM	10	NSF, DOE, NASA	12		6			20
ITAMP		NSF, Smithsonian	4		6			
MRSEC		NSF	24					
NSEC	2	NSF	15					
Origins of Life	2	P, NSF	10	5			12	40
Graduate Programs								
Biophysics		NIGMS, GSAS	70	0	2	0	50	
Eng. and Phys Bio (EPB)	8.3	NSF, NIH	26				35	
Scientific Computing								
Crimson Grid								
LISE								38.1
Totals				155.5		707	789	870

[2] FAS Life Science departments, centers, and institutes listed separately in Section 2 of the FAS Overview

[3] Full names of centers and institutes and detailed descriptions are found in the text following the table

Centers and Institutes

CfA – The Harvard-Smithsonian Center for Astrophysics combines the resources and research facilities of the Harvard College Observatory (HCO) and the Smithsonian Astrophysical Observatory (SAO) under a single director to pursue studies of those basic physical processes that determine the nature and evolution of the universe. Some 300 Smithsonian and Harvard scientists cooperate in broad programs of astrophysical research.

CNS - The Center for Nanoscale Systems serves students, educators, researchers, and technology companies by providing laboratory access, equipment access, supplies, expert training and support. CNS acquires and operates key fabrication and imaging equipment with nanoscale resolution, makes laboratory space available for research of numerous material systems, and develops and trains users to follow critical fabrication recipes. CNS compliments experimental work with computation simulation of nanosystems. Departments involved in the CNS include CCB, DEAS, MCB, and Physics, with connections to medical imaging work done at the MGH Charleston campus.

CUA – The Center for Ultracold Atoms (CUA) brings together a community of scientists from MIT and Harvard to pursue research in the new fields that that have been opened by the creation of ultracold atoms and quantum gases. The CUA is supported by the NSF.

The core research program in the CUA consists of four collaborative experimental projects whose goals are to provide new sources of ultracold atoms and quantum gases, and new types of atom-wave devices. These projects will enable new research on topics such as quantum fluids, atom/photon optics, coherence, spectroscopy, ultracold collisions, and quantum devices. In addition, the CUA has a theoretical program centered on themes of quantum optics, many-body physics, wave physics, and atomic structure and interactions.

Energy and Environment – This is a new initiative that has the goal of working to find secure, safe, clean and reliable sources of energy, while protecting society from extreme environmental impacts. The key areas of inquiry for this initiative are the development of energy technologies, energy science and environmental impact. This initiative would connect FAS (CCB, DEAS, EPS, OEB, MCB, Physics and Statistics) to the HSPH, HMS and KSG. This program would also create interdisciplinary undergrad and grad courses.

HUCE – The Harvard University Center for the Environment (HUCE) encourages research and education about the environment and its many interactions with human society. The Center draws its strength from faculty members and students from diverse fields including chemistry, earth and planetary sciences, engineering and applied sciences, biology, public health and medicine, government, business, economics, religion, and law. The Center seeks to provide the next generation of researchers, policymakers and corporate leaders with a comprehensive interdisciplinary environmental education.

IIC – The Institute for Innovative Computing fosters the creative use of computational resources to address issues at the forefront of data-intensive science. The IIC fosters the flow of ideas and inventions along the continuum from basic science to scientific computation to computational science to computer science.

The IIC will begin with a core staffing level of about 20-25 in 2005 and will expand to 90-100 during construction of its own facility in ~2010. The IIC will be organized into six program areas: (1) Analysis and Simulation; (2) Instrumentation; (3) Visualization; (4) Distributed Computing; (5) Databases, and (6) Education and Outreach (a new Museum, on the grounds of the IIC's Allston facility, will reach out to educate the public).

IQSE – The Institute for Quantum Science and Engineering is a new initiative that focuses on research and educational program aiming at bridging the gap between quantum theory, basic experimental science and practical device engineering. Specific goals include exploring emerging applications of quantum phenomena in information processing, optics anAd electronics. This Institute has participants from Math, Physics, DEAS and CCB.

Programs include: a focused recruitment of key faculty; fostering an interactive community that spans the spectrum from mathematics to device engineering using a seed research funding program; postdoc prize fellowship program, and a visiting students/scientists program. Currently, five faculty members are involved, with a long-term goal of ten.

IST+M – The Institute for Space, Time, and Matter is a new initiative that brings together theorists and experimentalists across Math, Physics and Astronomy who engage in work in particle physics, astrophysics, string theory, cosmology and precision measurements.

The energy scales about to be explored at the Large Hadron Collider will shed light on the origins of mass, and symmetry breaking in the fundamental forces of nature. Much of the excitement in this area has come from the realization that the acceleration of the expansion of the universe may be the result of a "dark energy" that's an intrinsic property of space. On the theoretical side, developments in mathematics, string theory and phenomenology attempt to find the mechanisms that unify quantum mechanics and gravity.

ITAMP – The Institute for Theoretical Atomic, Molecular and Optical Physics' objectives are: 1) Attracting and training grad students of the highest quality in theoretical AMO Physics; 2) Maintaining an active visitors program to bring senior researchers together for varying lengths of time for scientific collaboration; 3) Establishing a strong post-doc fellowship program as a source of potential faculty.

We are in a time of great intellectual excitement in atomic and molecular physics, stimulated in part by the use of lasers, of synchrotron radiation, of neutral and ion traps, and of particle beams in experiments of quite remarkable ingenuity, and by a growing recognition that atomic and molecular physics is a valuable discipline in which general concepts about the existence and nature of structures can be explored quantitatively.

MRSEC – The Materials Research Science and Engineering Center's interdisciplinary research has participants from five departments, including DEAS; Chemistry and Chemical Biology, Physics, Earth and Planetary Sciences; and HMS. The MRSEC also develops research opportunities for undergrads. MRSEC is receiving strong institutional support from the University, particularly from the Center Nanoscale Systems (CNS). A new laboratory, LISE, that will house CNS, and MRSEC-related faculty, is under construction.

There are currently four major focus areas of MRSEC, although these areas are fluid and can seed new inter-disiciplinary scientific endeavors: a) Multiscale Mechanics of Films and Interfaces; b) Engineering Materials and Techniques for Biological Studies at Cellular; c) Interface-Mediated Assembly of Soft Materials; d) Functionalized interfaces.

NSEC – The Nanoscale Science and Engineering Center (NSEC) is a collaboration among Harvard University, the Massachusetts Institute of Technology, the University of California—Santa Barbara, and the Museum of Science—Boston with participation by Delft University of Technology (Netherlands), the University of Basel (Switzerland), the University of Tokyo (Japan), and the Brookhaven, Oak Ridge, and the Sandia National Laboratories. The NSEC also collaborates with the Boston Museum of Science.

The goal of NSEC is to develop tools to understand nanoscale systems that link Physics, Chemistry, and Biology. It plans, builds, images and tests ultra-small quantum devices based on electrons and photons, and, to understand their behavior theoretically. The Center has research in 3 clusters: a) Tools for integrated nanobiology; b) Nanoscale building blocks; c) Imaging at the nanoscale

Origins of Life – The questions of life's origins are now becoming experimentally accessible through combined advances in biology, chemistry, genetics, geology, and astronomy. This highly inter-disciplinary center will encompass the disciplines from planet formation and detection to the origin and early evolution of life. It will present unique opportunities for undergraduate education at Harvard. The center will grow from the synergy among 5 distinct areas (Astronomy, Planetary Sci, Paleobiology, Chem, Mol Bio).

The team already represents faculty from both FAS and HMS, and both HMS (MGH) and Astronomy are geographically separated from the rest on campus. We have close relations and 'shared' team members with the Microbial Sciences Initiative.

Cross-departmental graduate programs

Graduate Program in Biophysics – The Biophysics Program at Harvard has sought to recruit graduate students (~50) with strong backgrounds in physics and mathematics who were interested in problems of biological and biomedical significance.

The program includes 70 faculty, drawn from Physics, Chemistry and Chemical Biology, Molecular and Cellular Biology, DEAS, and OEB on the Cambridge Campus, from Biological Chemistry and Molecular Pharmacology, Cell Biology, Microbiology, Pathology, Genetics, and Systems Biology on the Longwood campus, from most of the affiliated Hospitals, and from the Health Sciences and Technology faculty at MIT.

Engineering and Physical Biology – The goal of EPB is to create a new generation of scientists who will probe biological processes through the lens of engineering and physics. EPB will develop scientists who can investigate how basic physical effects have been brought together in living systems. The EPB Program will be small and selective (~5 /yr). Questions of interest fall into three general categories: (I) *Mechanics and Dynamics*; (II) *Patterns and Collective Phenomena*; (III) *Transport, Signaling and Communication*.

The primary intellectual community for EPB, the daVinci Group, are drawn almost entirely from Physics, Chemistry and Chemical Biology (CCB), Molecular and Cellular Biology (MCB), Organismic and Evolutionary Biology (OEB), and DEAS. Science also flourishes on the campus of HMS and HSPH. New links between activities are evolving.

Scientific Computing

The CrimsonGrid – The CrimsonGrid Initiative, started in April, 2004, aims at building the next-generation campus "technology infrastructure" for scientific computing. A major goal of this Harvard-wide project is to provide the ability to transform legacy traditional "computing-cluster silos, large and small" all across the university campus, schools and units, to a more seamless technology eco-system, using a switched or ***"grid"*** framework.

The Harvard initiative plans to demonstrate the application of the complete suite of grid services— ***computing, data, and information***. The project involves testing new models for tech support orgs, building new technical skills, integrating emerging grid tools and technologies, and developing new business & policy models. The CrimsonGrid is designed to support, in a single fabric, a campus-wide research environment.

SECTION 2: FAS Life Science Divisional Overview

LS Division Departments and Centers: Molecular and Cellular Biology, Organismic and Evolutionary Biology, Chemistry and Chemical Biology, Psychology, Biological Anthropology (a wing of the Anthropology Department), Center for Brain Science, FAS Center for Systems Biology (The Bauer CGR Center)

The Life Science Division's primary mission is to integrate analyses of biological problems and to bring together previously separate disciplines in the physical, chemical, biological and psychological sciences. The Life Sciences Council (LSC), chaired by Professor Melton, has set out to integrate and coordinate these sciences to better serve undergraduate and graduate education, facilitate interdisciplinary faculty recruiting, and create shared research facilities to serve the faculty in the life science departments.

To promote the goals of the curricular review, the LSC formed a Life Sciences Education Committee (LSEC) comprised of the head tutors from the five undergraduate life science concentrations. This committee strives to map out a new vision for the life sciences undergraduate curriculum. The first major step in this change was to offer a series of two new introductory courses (Life Sciences 1a/1b) in 2004/2005.

In addition to our departmental based activities, the life sciences have also enjoyed significant success in launching two FAS initiatives. The Center for Brain Science (CBS) has had a particularly successful year recruiting faculty and plans to build on their success in the coming year as they mature their program for occupancy in the North West building when it opens in 2008. CBS will enter a new phase of development this year as they begin their faculty recruiting efforts and also partner with HMS in a new joint graduate program.

The LSC recognizes that our efforts can be further enhanced through the establishment of cutting edge shared research facilities. We can build on the significant strengths and achievements of the Bauer Center for Genetics and Genomics which has created an array of research and computing core facilities that serve all Harvard sciences. Our future challenges will be to expand these facilities to meet evolving needs in coordination with DEAS & Physical Sciences as part of our programming efforts for the NW building.

A brief overview of our departments, centers and core facilities follows.

Department of Molecular and Cellular Biology

Members of The Department of Molecular and Cellular Biology are united by a common interest in understanding fundamental questions in the biological sciences at the level of molecules and cells. On the other hand, we also have strong ties to other departments in FAS (e.g., OEB, CCB, Physics, DEAS, Psychology), and at the Medical School (the basic science departments at HMS), and play major in several new initiatives (e.g., the Bauer Center for Genomics Research, the FAS initiative in Systems Biology, the Center for Brain Science, the Harvard Stem Cell Institute and the Microbial Sciences Initiative). We support an integrated approach to teaching of graduates and undergraduates in biology.

Areas of research:

<u>1) Biochemistry and Physical Biology</u>: A core interest in the molecules and molecular assemblies that underlie biological led to the formation of this precursor to MCB.
<u>2) Developmental Biology:</u> The goal of this community is to understand the properties of cells and how they interact with each other to convert a fertilized egg into a physiologically and morphologically complex adult animal.
<u>3) Cell Biology</u>: Although the research of many MCB faculty address questions of cell biology or uses cell biological methods, cell biology per se is not yet well represented.
<u>4) Neurobiology</u>: The goal of the neurobiology community within FAS is to understand how nervous systems work primarily at the level of individual nerve cells interactions. This community is now closely associated with the Center for Brain Science (CBS).
<u>5) Systems and Computational Biology:</u> Broadly defined, systems biology is the attempt to understand how the overall properties of biological systems arise from the interactions of parts that lack those properties. Efforts in this area include the Bauer Center.

Department of Organismic and Evolutionary Biology

The Department of Organismic and Evolutionary Biology (OEB) seeks to maintain world-leading research that supports innovative undergraduate and graduate teaching in three main areas: 1) Organismal Systems Biology & Ecology; 2) Evolutionary Genetics & Genomics; and 3) Biodiversity & History of Life.

In doing so, OEB contributes to several initiatives, including: Microbial Sciences, Center for Brain Sciences, Plant Sciences, Origins, Systems Biology, and Biodiversity & Evolution. As a department, OEB shares links with HMS/Broad and MCB through its evolutionary genetics/genomics faculty and the Genetics & Genomics Training Grant (GGTG), as well as evolutionary developmental biology; with DEAS and HSPH through the IGERT Biomechanics TG; and with EPS and HSPH through shared interests in the environment and global health & infectious disease.

The department oversees the new OEB undergraduate concentration (~100 students), has ~1135 enrolled undergraduates in its courses, and has 83 graduate students in its graduate training program, graduating ~14 PhD's per year. OEB's organizational structure is unique in that it includes two affiliated institutions – Museum of Comparative Zoology and the Harvard University Herbaria – each of which has its own endowment. It also has strong links to the Arnold Arboretum and the Harvard Forest.

OEB's academic priorities are to: 1) establish a successful new concentration; 2) strengthen bridges with affiliate faculty and departments (BioAnthro, MCB, EPS and Phys Sci) that support broader undergrad and grad training programs; and 3) build broadly upon its strengths in the areas of evolutionary biology and organismal systems biology.

Department of Chemistry and Chemical Biology

The Department of Chemistry and Chemical Biology (CCB) at Harvard sits squarely between the physical and life sciences and, thus, has already built bridges to important disciplines while reinforcing the core strengths in Chemistry. CCB is a strong department overall, built on the distinction of our faculty, and the high quality of our students, postdoctoral researchers, and staff. The central intellectual position of CCB is reflected in both research and teaching.

CCB has strategically developed strengths in specific areas, especially Chemical Biology and Materials Chemistry, needs remain in other key areas of Chemistry. CCB faculty play central roles in existing interdisciplinary efforts at Harvard, including the Broad Institute, the Materials Research Science and Engineering Center (MRSEC), and the Nanoscale Science and Engineering Center (NSEC), and are participants in other interdisciplinary programs, e.g. the Center for Brain Science (CBS). CCB also has strong connections to several proposed University science initiatives, including Chemical Biology, Origins of Life, Energy and the Environment, Materials and Nanoscience, and Computing. The Dept is currently developing a plan for growth in directions that correspond to our priorities for undergraduate and graduate education and in new intellectual directions in research.

There is also a strong tradition of providing excellent undergraduate education in CCB. We foster undergraduate research opportunities, provide excellent advising, and place emphasis on high-quality teaching of undergraduates by senior faculty members.

Department of Psychology

Psychology is the science of mind and behavior. We study how and why people perceive, remember, communicate, and reason -- with the ultimate goal of understanding cognition, emotion, and motivation (in normal people and those with disorders, in young and old people, and in people in different contexts). This understanding, in turn, should lead to applications, such as building better user interfaces for computer systems, reducing intergroup conflict, and developing more effective psychotherapies.

In order to achieve these goals, the investigations in Psychology are necessarily wide-ranging and diverse. We study topics as varied as the hormonal bases of differences in spatial ability, the patterns of brain activity that underlie memory, the reasons why some people do not feel pleasure, and the social bases of attitudes. In addition, we use methods that range from paper-and-pencil tests of problem-solving ability, to functional magnetic brain-imaging, to studying patterns of eye movements in babies and adults, to recording response times. Sophisticated statistical techniques are used in much of the data analysis.

The Psychology department is loosely organized into four (very porous) groups: The Cognition/Brain/Behavior group (9 faculty members) has three foci: Perception, memory, and language. The Social group (9 faculty members) has two foci: Social cognition and group interaction. The Developmental Group (4 faculty members) is focused on understanding the roots of cognitive development. And the Clinical/Psychopathology group (4 faculty members) focuses on the nature of depression, schizophrenia, and related disorders. The department currently has 378 undergrad concentrators and 88 grad students.

FAS Center for Systems Biology (The Bauer Center for Genomics Research)

The Bauer Center is the main home for systems biology research in FAS. Research in the Bauer Center is carried out by the Bauer Fellows. These are young, independent researchers, funded in large part by the center, who are drawn from a wide range of disciplines, and selected on the basis of their willingness to interact with each other, and with the surrounding faculty. The center currently has ten Fellows, including two trained as physicists, a biophysicist, a biochemist, and a computational biologist. The Fellows train postdocs, graduate students (jointly mentored by Harvard faculty) and undergraduates. In addition to its research role, the Bauer Center also has extensive laboratory and computer resources that we make available to scientists in the FAS, and in Systems Biology.

The Center for Brain Science

Realizing the intellectual and biomedical importance of understanding the brain, Harvard and FAS recently decided to invest heavily in this area. A major step was to establish a multi-departmental Center for Brain Science (CBS) with resources to hire neuroscience faculty that span the basic science and clinical departments. Many neuroscientists will be housed in a new building at the Cambridge campus, the Northwest Building, within which neurobiologists will be brought together with physicists, engineers, computational biologists, psychologists, and chemists, to attack fundamental questions about how the brain functions and malfunctions.

The ambitious aims of CBS are nothing less than understanding the structure and function of brain circuits. To do this we will need tools more powerful than those available today, tools that can only be developed in close collaboration with physicists, engineers, chemists, and molecular biologists.

HARVARD-AFFILIATED HOSPITALS OVERVIEW

The Harvard-affiliated hospitals are major institutions of patient care, research and teaching. Although as corporate entities, the teaching hospitals are largely independent institutions from Harvard University and its Medical School, they have strong academic ties to the University through their Harvard-appointed faculty and common educational mission to teach Harvard medical and graduate students.

BACKGROUND FACTS

Institution

There are five major Harvard-affiliated Academic Medical Centers: Massachusetts General Hospital (MGH), Brigham & Women's Hospital (BWH), Beth Israel Deaconess Medical Center (BIDMC), Children's Hospital Medical Center (CHMC), Dana-Farber Cancer Institute (DFCI). In addition, the Joslin Diabetes Center and McLean, a large private psychiatric hospital, are also Harvard-affiliated. There are also a number of other affiliated hospitals in the Harvard system, which includes: The Cambridge Health Alliance; The CBR; The Forsyth Institute; Harvard Pilgrim Health Care; Judge Baker Children's Center; the Massachusetts Eye and Ear Infirmary; Massachusetts Mental Health Center; Mount Auburn Hospital; Schepens Eye Research Hospital; Spaulding Rehabilitation Center; and the VA Boston Healthcare System.

Faculty

All faculty of the affiliated hospitals, including clinicians, educators and researchers, are appointed as faculty of Harvard University through its medical school. The process for Harvard appointment and promotion is initiated within the individual hospitals, but requires a process of search and/or evaluation supervised and managed by Harvard Medical School. The total of over 9,000 hospital-based Harvard faculty includes 3,689 Professors, Associate Professors, and Assistant Professors with voting rights at the University, as well as 5,744 Instructors. A total of 7,099 of these faculty are full time.

Approximately 1,240 of these faculty conduct laboratory-based research as a primary activity, and most of these are externally funded with RO1 support from NIH or equivalent grants. Harvard Medical School is the academic affiliation for all of the research conducted by these faculty.

The Hospital-based Harvard faculty are members of many prestigious scientific organizations: 35 National Academy of Science, 73 American Academy of Arts and Sciences, 55 Institute of Medicine of the National Academy, and 20 Howard Hughes Medical Institute.

Students

739 Medical Students

160 – 180 HST students

140 MD-PhD dual degree students

209 PhD students in AMC labs (includes ~15 from MIT)

3750 estimated post-docs (600 BIDMC, 800 BWH, 450 CHMC, 400 DFCI, 1500 MGH)

2700 estimated residents and fellows

Research space

Harvard affiliated hospitals and research institutes own or lease and conduct research in more than 3 million square feet of total research space across multiple campuses in the Boston area.

The breakdown of space allocated to the largest of these includes: MGH with 1,030,000 sf; CHMC with 590,000 sf; BWH with 560,000 sf; BIDMC with 360,000 sf; DFCI with 290,000 sf; Joslin with 85,000 sf; McLean with 30,000 sf.

Many of the hospitals have plans to build additional space over the next 5-10 years, with 140,000 sf being planned for the BWH and 350,000 sf being built by BIDMC to be occupied in 2008. Among the space utilized by hospital-based faculty is some leased from HMS.

Research funding

The Harvard-affiliated AMCs' total research funding is greater than $1.5 billion for 2005. Of this, more than $1 billion is funded by the NIH.

This includes: $485 million MGH; $370 million BWH; $200 million BIDMC, $160 million DFCI; $130 million CHMC; $45 million Joslin; $40 million McLean as well as additional funding at the other eight hospitals and research institutes.

ADMINISTRATIVE STRUCTURE

The relationship between Academic Medical Centers (AMCs) in the U.S. and their associated universities is highly variable. In some cases the hospitals are owned by the University, in others the hospitals are independent corporations but the research conducted by the hospital faculty is run through the University largely or entirely within research facilities of the University. In contrast, each Harvard-affiliated hospital is an independent corporate entity (501-3c), responsible to its own Board. Each hospital is headed by a President/CEO and run by a management team separate from the administration at Harvard University. The finances and funding structures are largely independent from Harvard. Research proposals by hospital faculty are submitted to outside agencies by each hospital, and grants are issued to the hospitals and managed by administrative structures specific to each institution.

The hospitals are also independent from one another with one exception. MGH and BWH (as well as McLean Hospital) are joined as part of a larger integrated system under Partners Healthcare, a non-profit organization. This system also has a joint venture with DFCI as does CHB. BIDMC has a joint clinical venture with Joslin Diabetes Center.

Research committees

In general, each hospital has an executive research committee that, to a varying degree, makes a range of portfolio allocation decisions.

At MGH, these decisions are made by ECOR, a group responsible for providing strategic guidance to MGH executives and Trustees on future research growth and priorities within MGH, across Partners and with affiliated external institutions. In addition, it is a forum for formulation of policies related to human subjects, research proposal review, animal care, animal studies, and research facilities.

ECOR primarily controls the allocation of research space, establishment and funding of institutional cores and allocation of an annual pool of institutional funding for initiatives arising through ECOR discussions or brought to ECOR by investigators. It also provides some career development support (targeted to women and underrepresented minorities early in their careers) and interim/bridge funding.

The voting members of ECOR include a Chair, Vice-Chair, Past Chair and 5 departmental chiefs (selected by Chiefs' Council). There are also 6 members elected by research faculty, 7 selected by the ECOR leaders (selected after election of chiefs and research faculty, to ensure all types of research perspectives represented), a director of one multidisciplinary thematic center and 8 senior management representatives including the President. Non-voting members include subcommittee chairs and others as determined by ECOR.

At BIDMC, the Research Advisory Committee's (ReAC's) mandate is to be the advisory committee to the Chief Academic Officer for all matters related to research, including: space development and utilization, research investment apart from that directly made by Departments, creation and evaluation of interdepartmental programs/centers, policies, awards/nominations. It also coordinates periodic external scientific reviews, and annual research day.

ReAc controls annual funds made available from several sources for investment/recruitment/retention initiatives. It is also responsible for all institutional research space, and core facilities.

ReAC's membership is comprised of the Chairs of the 5 major research intensive Departments (Medicine, Pathology, Neurology, Radiology, Surgery), plus seven senior research faculty who are not chairs. Additional staff support the committee.

At the BWH, the BRI (Brigham Research Institute) was recently established to foster development of cross-cutting centers and support of the BWH research community's activities generally. Its governance comprises an executive committee and the Research Oversight Committee (ROC) with membership and mandate generally comparable to those of ECOR and ReAc. CHMC's and DFCI have groups analogous to those at the other hospitals, designated RSG and the Executive Committee on Research, respectively.

Funding structures

One of the key differences between the faculty at the hospitals and Harvard schools like FAS is the degree of dependence on soft funding support for both faculty salary and research expenses. Hospital affiliated faculty occupy 217 endowed Harvard Professorships that provide support for their salary and programs. Most of the Harvard Professorships held by hospital faculty are specifically dedicated to hospital-based positions. Those hospital-based Harvard faculty who do not hold Harvard chairs (the vast majority) typically receive support from the hospitals for components of their salary and programs, but these are individual agreements and rarely support more than a small fraction of salary and research costs. Thus, hospital based research faculty rely on competitive external sources to fund their salaries and research. Thus, external competitive grants are critical to the success of these research enterprises.

In 2005, more than $1.5 billion was received in total research funding across these institutions. $1 billion of this funding comes from the NIH. The combined NIH funding to the Harvard hospitals is double that received by Harvard University itself (FAS + HMS + HSPH) and is greater than that received by any other University (which includes their hospital-based faculties). The five major Harvard-affiliated hospitals rank #1-5 for NIH funding among all independent hospitals in the U.S (and McLean is the most well funded independent psychiatric hospital).

RESEARCH AREAS

The Harvard-affiliated hospitals are major loci of biomedical research. The overall aspiration of the hospital's research programs is to bring the most powerful technologies and insights to bear on the goal of improving human health. Thus, the science done at these institutions is designed to understand the physiology of the human organism, to identify the causes of human diseases, and to use this knowledge to improve our capacity to treat and prevent disease. A significant imperative of the research mission within today's hospital is the application of basic insights to the study of specific disease processes. Thus aspirations require robust basic research that might take place outside a hospital or medical context, as well as translational and clinical research that relates directly to human subjects, including epidemiologic and behavioral research.

Basic and translational research

There are major basic and translational research engines in each of the hospitals across a broad range of programs that exist on a continuum from fundamental discovery to efforts focused on disease mechanism and applied discovery. The number of laboratory based research faculty (defined as principal investigators with R01 grants or their equivalents) total over 1240 across the major hospitals.

Scientific programs range from those which are truly fundamental and not directed towards disease mechanism or treatment *per se* to those which are highly disease-focused. In aggregate, there are significant efforts in virtually every area of disease and in many areas (e.g. neurosciences, cancer biology) extensive efforts exist in several of the independent institutions. Among other major areas, programs include study of infectious disease and particularly extensive efforts focused on HIV, obesity, diabetes, and human genetics as well as those focused on cross-cutting mechanisms of signal transduction angiogenesis/vascular biology, thrombosis, inflammatory and immune responses. Laboratory based research faculty include many whose efforts are essentially entirely devoted to research as well as a large cadre of physician-scientists who spend the majority of their efforts in research but also participate in clinical programs.

Clinical research

The hospitals participate in patient-oriented clinical research through clinical trials of new drugs and devices as well as the development of new treatment protocols**.** They have well-developed programs for protection of human subjects through established IRBs. To varying degrees there is institutional-specific infrastructure to facilitate clinical research. This infrastructure includes, in aggregate, four General Clinical Research Centers (at BWH, CHMC, BIDMC and MGH; the latter with a satellite facility at MIT) in order to facilitate clinical research at these hospitals. BWH and MGH have developed significant educational enrichment programs in support of clinical research. All hospitals participate in HMS and HSPH masters programs related to clinical research.

As financially separate institutions, research collaborations, which extend beyond individual hospitals require subcontracts and, in the instance of clinical research, independent IRB review. The coordination and interrelationships between clinical research programs among the major HMS affiliates is likely to change with mandate by the NIH to coalesce clinical research programs (specifically the GCRCs) into a single umbrella structure directly linked to HMS over the next few years (an initiative designated CTSA or Clinical and Translational Science Award).

In addition to patient-oriented research, significant efforts are devoted to health services research ranging from consideration of health policy and outcomes research to assessment of new technology.

Cross-cutting research initiatives

Over the past several years, multiple new programs organizing research efforts on thematic rather than departmental bases have arisen both within and among the institutions. These are exemplified by four large multi-disciplinary centers which occupy the majority of the newly opened research building at MGH (Simches building) in areas of human genetics, computational & integrative biology, regenerative medicine and systems biology. Comparable multi-disciplinary thematic centers are established or being actively developed in each of the other major HMS affiliates. In addition a number of programs have emerged within the past several years that establish collaborations on an inter-institutional basis as exemplified by Dana Farber-Harvard Cancer Center, which comprises more than 900 affiliated scientists and clinicians in all of the major HMS hospitals. Similarly, the Harvard Center for Neurodegeneration and Repair (HCNR), focused on neurodegenerative diseases, includes more than 700 scientists and clinicians from HMS-affiliated hospitals, HMS and FAS.

EDUCATIONAL MISSION

In addition to patient care and scientific research, the Harvard-affiliated hospitals have strong educational programs. The faculty within the hospitals teach over 700 Harvard Medical School students, including students in the HST program, over 200 PhD candidates, and approximately 3,750 post-docs. An estimated 2,700 residents and fellows are engaged in post-graduate training at the hospitals every year. In addition to teaching at the bedside and the clinic by physician faculty, hospital-based faculty provide a major fraction of lectures at Harvard Medical School during the preclinical years, and are directors for many of its courses.

The Harvard hospitals continue to fulfill their historical role in being a major training site for physician-scientists who not only reinvigorate the hospital based faculty in Harvard but are a source of key faculty to every leading academic center throughout the country and many medical schools and universities abroad. As noted above, the hospital based faculty plays an integral role in masters programs offered through HMS and HSPH.

ASPIRATIONS FOR THE FUTURE

The hospitals continue to be world leaders in clinical care, clinical and fundamental research, and training of physicians and scientists. An especially important imperative moving into the future is the delineation of the fundamental basis of disease and translation of that knowledge into treatment through applied laboratory and clinical research. It is clear that a particularly powerful nexus is emerging from progress in understanding the genetic basis of human disease and the impact of environmental influences on genetic susceptibility.

Ultimately the hospitals hope to develop treatment (or prevention) strategies that are more effective and safer than current approaches. There are several opportunities to accelerate progress in these efforts to ensure that the Harvard hospitals remain at the cutting edge of science.

Translating discovery into treatment

All of the vectors above are directed towards ultimately improving human health both for those patients seen locally within the Harvard hospitals and for people world-wide. The hospitals aspire to build more robust infrastructure which will allow the extension of laboratory discovery into new therapeutic interventions. These include most especially capabilities to develop new technologies and pharmacological interventions and to be able to pursue initial proof of concept studies in patients particularly where that can be related to disease mechanism. Evolving efforts in chemical biology are one component to support this overall goal, but these will need to be enhanced by capabilities to produce small molecules or biologics as well as all the infrastructure to carry out first in human studies.

Particularly powerful potential exists in developing technology to assess key molecular physiology in man through the application of new imaging approaches and development of these capabilities and facilities will enable direct characterization in man of processes previously only experimentally accessible in model systems.

Patients as partners in research and leveraging IT

Given the large numbers of patients that are treated through Harvard-affiliated institutions, the hospitals are in a unique position to leverage those relationships to strengthen the type of research conducted. By using the human model to incorporate insights into more fundamental molecular genetics, disease and disease mechanisms can be better defined and therapeutic interventions can be better performed.

The amount of clinical data currently captured by the hospitals' research databases is staggering, but much of it is yet untapped. By leveraging IT to mine the data in a confidential way, new types of data sets can be made available and new analyses are enabled that would have previously required costly, time consuming clinical trials to undertake. IT will be a critical enabling component in the incorporation of genetic basis of disease and response to therapy into clinical practice so that it benefits patients, a capability which will be a cornerstone of the hoped for era of personalized medicine.

Improving quality of health care delivery

In addition to aspirations to obtain a more fundamental understanding of disease and to apply that knowledge to allow better treatment and prevention in order to alleviate suffering, the hospitals aspire to develop approaches to understand the process of health care delivery and to enhance its quality and value, i.e. clinical benefit and cost-effectiveness. Developing both a culture and an analytical approach which evaluates the outcomes from medical interventions and, as a corollary, sources of error so that health care can be made safer, are also important components of the research mission.

CHALLENGES

Challenges to the hospital-based research enterprise are myriad, but key among them are the largely soft-money funding mechanisms, rendering them highly vulnerable to changes in the NIH environment or changes in the financial stability of the clinical operations. Second are the competing demands and other pressures which is an implicit challenge to attract young individuals to careers as physician-scientists. Finally, barriers to collaboration across institutional boundaries can encumber programmatic development.

BROAD INSTITUTE OF HARVARD AND MIT

Overview

Broad Institute of Harvard and MIT is a partnership of Harvard, MIT, Whitehead Institute and the Harvard teaching hospitals, announced in June 2003 and launched in May 2004. The Institute's mission is to create powerful new tools for applying genomics to medicine, to make them accessible to the scientific community, and to pioneer their application to the understanding and treatment of human disease.

Broad is governed jointly by the two universities, and administered on their behalf by MIT.

Faculty

The Faculty currently includes five Core Members, whose labs are primarily located within the Broad Institute, and 58 Associate Members, who are deeply involved in Broad research but have their primary labs at one of the universities or hospitals. The five Core Members (of a planned twelve) are David Altshuler (MGH and HMS), Todd Golub (DFCI and HMS), Eric Lander (Whitehead, MIT and HMS), Aviv Regev (MIT), and Stuart Schreiber (FAS). Associate members are drawn from FAS, HMS, HSPH, each of the Harvard hospitals, MIT and Whitehead, and are listed at the following web site:
http://www.broad.mit.edu/about/assoc_members.html

Organization

The Institute is organized around Scientific Programs and Scientific Platforms. ***Programs*** are collectives of faculty, trainees and staff who share an interest in a scientific discipline or disease area relevant to the Broad's mission. Programs include Genome Biology and Cell Circuits, Medical and Population Genetics, Chemical Biology, Cancer, Metabolism, Psychiatric Disease and Infectious Disease. ***Platforms*** are professionally managed, technology-focused organizations whose priorities and activities enable the medical and biological questions arising in the programs. Current platforms include Genome Sequencing, Genetic Analysis, Chemical Biology, Proteomics and Metabolite Profiling, and RNAi. Broad has a major commitment to Computational Biology and Bioinformatics.

Broad has substantial expertise in and commitment to large-scale scientific research projects, with examples including the nation's largest DNA sequencing program (responsible for the largest contribution to the sequencing of the human genome, mouse genome, chimpanzee genome, and many others), the NCRR-funded National Center for Genotyping and Analysis, the National Cancer Institute's Initiative for Chemical Genetics, and others.

Facilities

Broad is housed in two main locations in Kendall Square: a 100,000 sq. ft sequencing center at 320 Charles Street, and a new 230,000 sq. ft. building at 7 Cambridge Center. Approximately 60% of the laboratory space is dedicated to platforms, and the rest scientific programs and faculty laboratories. Connectivity to colleagues in Harvard Square, Longwood and MGH is facilitated by convenient parking with validation, proximity to public transportation, and shuttle buses.

Funding

Broad's current funding is $110M per year, of which 75% is from federal sources. Broad was founded in 2003 with a $100M gift from Eli and Edythe Broad, to be spent over a ten year period in support of Broad's research mission; in November of 2005 the Broads doubled their gift with an additional $100M to be spent over the same 10 year period. These funds make possible the SPARC process in which innovative, collaborative projects can receive one-year seed funds to support novel projects by Broad faculty, trainees and staff. In the first two years over $12M has been committed to investigator-initiated projects through SPARC.

APPENDIX D: Space Overview

SCIENCE AND ENGINEERING RESEARCH SPACE OVERVIEW

SUMMARY

While Allston represents a great opportunity to create additional research and teaching space at the University, Harvard in aggregate is not space constrained in the near term (five year time frame).

However, the individual schools will face differing space constraints over time given current faculty growth plans.

- ¶ HSPH currently does not have space to meet growth needs without new facilities
- ¶ FAS will have, by 2011, space sufficient for 55 net new FTEs with the Northwest and LISE buildings online
- ¶ HMS must reprogram lease space to remain unconstrained past 2009.

AGGREGATE SPACE OVERVIEW

Current space allocation

There are currently 1,761,000 net assignable square feet (NASF) of research lab space at the University. 96% of this space is occupied by 551 faculty members and their associated labs.

The major Harvard-affiliated hospitals, Massachusetts General Hospital (MGH), Brigham and Women's Hospital (BWH), Beth Israel Deaconess Medical Center (BIDMC), Children's Hospital, and Dana-Farber Cancer Institute (DFCI) add an additional 2,945,000 NASF of research lab space.

The research space is divided over three main campuses: Cambridge; Longwood; and the MGH. For the University, 58% is in Cambridge (primarily for the FAS) and 42% is in Longwood (split between HMS and HSPH). The hospitals have 64% of their space in Longwood and 36% at MGH's campuses, including McLean.

Planned growth

By 2012, 435,000 NASF will come online through a combination of building projects and lease expirations (see exhibit 1). Given current school growth plans, at least 118,000 NASF, and potentially more than twice that if growth plateaus at projected levels rather than continues in perpetuity, will be vacant and could accommodate approximately 37 additional research faculty.

In Cambridge, 195,000 NASF is created through the finalization of the Northwest Building (154,000), LISE (11,000), and the planned movement of museum collections (30,000).

In Longwood, 270,000 NASF is potentially vacant, including the current vacancies (66,000) and space liberated if the BIDMC (184,000) and Dana Farber (20,000) do not renegotiate their leases that expire over the next five years.

Exhibit 1

ADDITIONAL SCIENCE SPACE COMING ONLINE IN FAS AND HMS

NASF vs. time, by site (thousands)

FAS	2006	2007	2008	2009	2010	2011	2012
Northwest Building			90*				
LISE			11				
Vacated from FAS bldgs			64				
Museum collections**				10	10	10	
Total	**0**	**0**	**165**	**175**	**185**	**195**	**195**

HMS	2006	2007	2008	2009	2010	2011	2012
Existing space	66						
HIM			146	38			
NRB							20
Total	**66**	**66**	**212**	**250**	**250**	**250**	**270**

* Includes ~33k NASF programmed space and 90k un-programmed split evenly between DEAS and Div. of Life Science

** To be compacted into basement storage space in the NW building

Source: Harvard schools; team analysis

SPACE OVERVIEW BY SCHOOL AND HOSPITAL

Harvard School of Public Health (HSPH)

Summary: HSPH is limited by space considerations. They meet current capacity needs through a variety of leases with entities outside the University and do not have new facilities planned.

Details

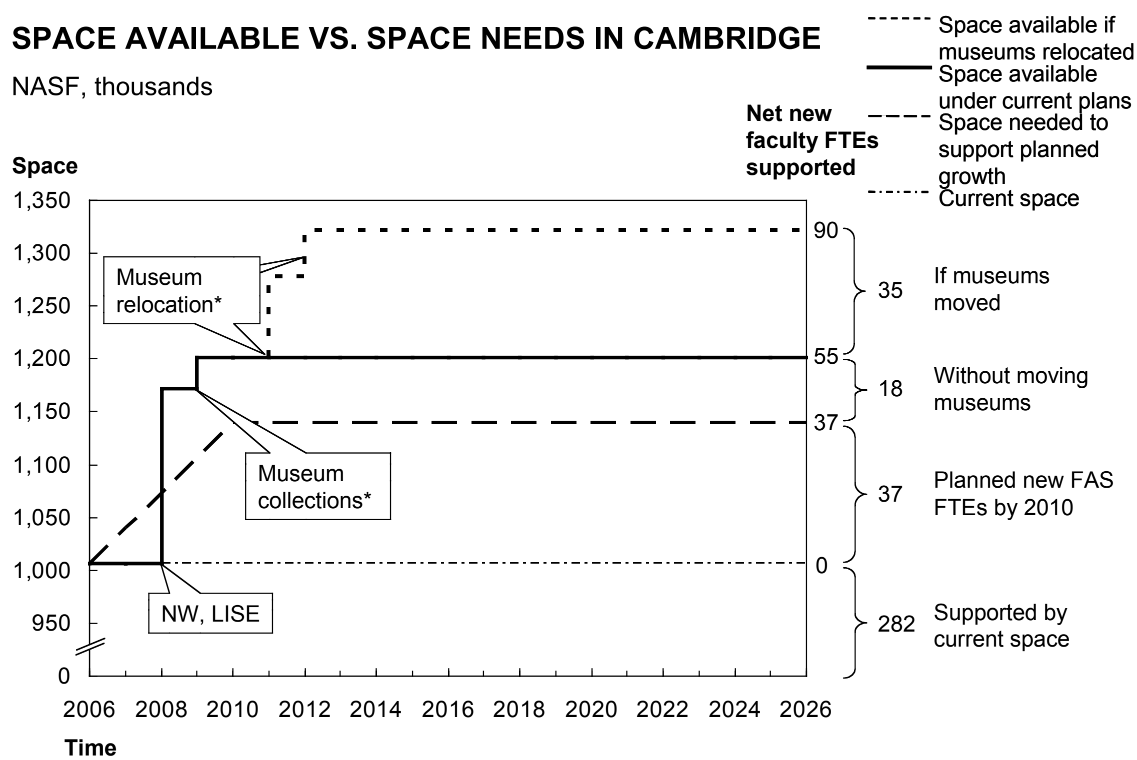
HSPH is located predominantly on or near the Longwood campus. It currently has no vacant space and a considerable portion of their physical plant is near the end of its useful life. In addition to their four core buildings, they currently also lease space in nearly twenty separate buildings to house their faculty and staff.

HSPH plans a faculty compound annual growth rate (CAGR) over the next ten years of approximately two percent, for a total of 37 new faculty across the school. At current average net assignable square feet per faculty, this would lead to a projected shortfall of space of just over fifty-five thousand net square feet, in the absence of any new facilities growth plans. The situation could be compounded by the need to renovate several of their current buildings to adequate standards, further compressing faculty as there is no “swing space” available to temporarily relocate people.

Faculty of Arts and Science: Life Sciences, Physical Sciences, and Division of Engineering and Applied Science (DEAS)

Summary: FAS life and physical science and engineering research space is currently at capacity. However, the Northwest building will come on-line starting in 2008 and several other buildings will contribute vacated space, relieving the near term space deficit. FAS will have sufficient space to meet its current planned 37 net new (i.e., incremental) FTEs in science and engineering, with capacity for an additional 18 FTEs beyond that. Additionally, renovation of the museum complex into lab space and building a new museum facility in Allston would forestall space constraints in Cambridge for a considerable time, allowing an additional 35 FTEs or a total of 90 incremental to current levels (exhibit 2).

Exhibit 2.



* Museum space: either 30 k NASF in 2009 from compacting collections, or 150k in 2011/2012 if museums are relocated
Source: Schools; team analysis

Details

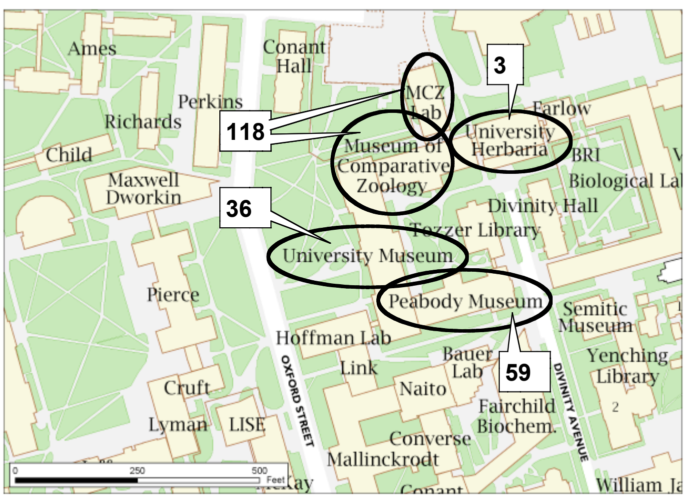
The life, physical and engineering sciences within FAS are currently space constrained (no vacancies) for the next two years in Cambridge. However, in 2008 there will be approximately one-hundred seventy-five thousand net square feet available in Cambridge due to the opening of the NW and LISE buildings, and an additional thirty thousand net square feet by 2012 (possibly earlier) from the moving of museum collections (a total increase of 17%). The sciences within FAS plan to grow by thirty-seven faculty by 2010, with DEAS growing most rapidly (over 5%

CAGR). Beyond this level of growth, there is room for an additional 18 incremental new FTEs in FAS sciences and engineering going forward.

Should FAS continue to grow at the above rate over time, or should Cambridge support significant growth in initiatives of greater than 18 net new FTEs, moving the museum complex to new space in Allston could open between 150 and 190 thousand net square feet in Cambridge (if relocated, the 30 thousand NASF from Museum Collections in exhibit one would no longer be available). This would relieve space constraints for the foreseeable future in Cambridge and support up to an additional 35 FTEs (or a total of approximately 90 more than current levels) at current average FAS lab sizes.

The entire science museum complex is approximately 296,000 NASF (see exhibit 3), of which 80,000 NASF is currently occupied by three academic departments (Organismic and Evolutionary Biology, Earth and Planetary Science, and Anthropology). The 216,000 non-departmental NASF is comprised of: 118,000 (55%) in the Museum of Comparative Zoology; 59,000 (27%) in the Peabody; 36,000 (17%) in the Harvard Museum of Natural History; and 3,000 (1%) in the Harvard University Herbaria.

Exhibit 3
CURRENT HARVARD SCIENCE MUSEUM COMPLEX (~200 K NASF) COULD PROVIDE ~150 K NASF LAB SPACE IF RENOVATED
Thousands, NASF



- Four museums total 216k current NASF
  – MCZ (118)
  – HMNH (36)
  – Peabody (59)
  – Herbaria (3)
- An additional 80k NASF of museum space is occupied by 3 departments:
  – EPS (39)
  – Bioanthropology (24)
  – OEB (17)

Source: Harvard web site; team analysis

An aggressive museum relocation and renovation program could open up approximately 75-80,000 NASF in Cambridge in 2011 and another 75-80,000 in 2012. However, moving the museums and renovating the space for dry or wet biologic (not chemistry) labs would be costly.

Harvard Medical School (HMS)

Summary: HMS currently has an excess of space and, if current leases are not renewed by the hospitals, will continue to have space in excess of their growth plans for the next decade.

Detail

The basic science portion of HMS is also located on the Longwood campus. They currently have approximately sixty-five thousand vacant square feet, with additional space likely to return to HMS in the HIM and NRB from various hospital leases that are set to expire over the next five years. Their faculty growth plans in the basic sciences call for a two and a half percent CAGR, or 17 new faculty by 2010. At that growth rate, they would add 38 new faculty by 2016.

If they do not recapture any of the space leased to the hospitals, they will be space constrained in only three years, beginning in 2009. The hospitals, however, are likely to return most or all of the space to HMS for programming, as there are a number of hospital research buildings and for profit space coming on-line on similar timing and nearby. In the event that HMS regains all the approximately two-hundred thousand net square feet off leases, it will still have an excess of forty-four thousand square feet above what is needed to meet extrapolated (beyond the 17 planned through 2010) faculty growth plans past 2016.

Harvard-affiliated Hospitals

The complex of Harvard affiliated hospitals is large and spans a considerable geography. The majority of bench research, however, occurs at five hospitals in the greater Boston area. These are, with associated research NASF: the MGH (1,030,000); Children's Hospital Medical Center (590,000); the BWH (560,000); BIDMC (360,000); the Dana Farber Cancer Institute (290,000); the Joslin (85,000); and McLean Hospital (30,000).

Additionally, BIDMC is building 350,000 NASF of new research space, and the BWH an additional 140,000. This planned incremental space, along with for profit research space coming online in the Longwood area, increases the likelihood that the hospitals will not renew their leases, with that space coming back to HMS for programming.

APPENDIX E: Draft Criteria for HUSEC Deliberations

Motivation:

Content and Goals

What are the key ideas and goals? Why are they important?

Impact

How might this effort change the world?

What is the likely impact on Harvard as an institution?

Education

What is the likely impact on education (undergraduate, postgraduate, postdoctoral)?

Internal Context and Linkages

What are the relevant existing efforts within Harvard, and how will this initiative both link to and complement them?

External Context and Competitive Posture

What is the competitive landscape and why should we expect to be the best?

Implementation:

Scope, Budget, Leverage and Facilities

How many FTEs, what levels, how much money?

If any new appointments are involved, who will make them?

What facilities are required that we currently lack?

What resources (federal and otherwise) can be leveraged off of this effort?

Pace and startup

What is the rampup strategy? How will we get off to a good start?

Organizational Structure and Management Plan

What are existing impediments to this activity and how will they be addressed?

What is the proposed governance and accountability structure?

What quality control mechanisms (internal and external) will be implemented?

How will junior faculty promotion cases be considered?

Metrics, Expected Longevity and Exit Strategies

What is the expected longevity of this effort? How can we gauge success?

What are the exit strategies and by what criteria should we choose between them?

Space needs and space evolution

What existing space can be used to support this effort?

What new space allocation is required?

What happens to these space allocations once the effort comes to a close?

Site(s) and Geography

How will this activity be distributed across the Harvard complex?

If the effort is distributed, what steps will be taken to ensure cohesion?