Report of the Harvard University Task Force on Science and Technology
April 2005

The Task Force on Science and Technology was convened by President Summers to identify needs and opportunities in scientific research at Harvard. Such an assessment would have two uses. First, it would ensure that in a rapidly changing world Harvard would continue to engage in the most promising areas of science and engineering. Second, the assessment would provide advice on the allocation of resources—both physical and financial—and how to organize scientific activities geographically given the new opportunities in Allston.

The Task Force comprised faculty members from the three faculties principally involved in scientific research, Arts and Sciences—including the Division of Engineering and Applied Sciences—Medicine, and Public Health. Its membership included representatives of the major areas of natural sciences and engineering: biological sciences, physical sciences, engineering and applied sciences, and medical sciences. In addition the committee heard from social sciences engaged in the population sciences and in health policy.

The Task Force found extraordinary variety in the subject, scale, and organization of research being conducted at the University. From astronomy and physics to clinical investigation, from nanotechnology to analysis of complex systems, from individual hypothesis-driven science to large-scale team based projects requiring shared tools and infrastructure (such as the Center for Nanoscale Systems): Harvard's research endeavor is enormously creative, varied, and successful.

Despite current success, the University faces significant challenges as it looks forward into this new century of scientific research. First, the landscape of science is changing: new technologies, emerging fields, the ability to collect, manipulate, and analyze large amounts of data, the requirement for costly new tools, and the blurring of disciplinary boundaries are creating new opportunities that could be missed if we are not alert and adaptable. Second, the University has begun what may be the final phase of its ability to develop new science facilities in Cambridge, and the Longwood area is developed almost to capacity; Harvard might find itself badly constrained in future years were it not for the new land to be developed in Allston. Harvard must make the most effective use of each of these discrete precincts but also ensure that they function together as a unit.

There is, of course, uncertainty in all of this. We do not yet know precisely where and when buildings will be placed in Allston. Many departments and divisions are in the midst of planning for faculty growth. Several new centers and initiatives are still defining their precise scope and needs. In other words, there is a multitude of moving parts, the motion of any one of which could cause us to delay setting priorities and making recommendations. But delay also perpetuates uncertainty. Therefore, we have reached certain conclusions that we state here, recognizing that, as circumstances change, our conclusions will surely evolve.

This report describes the process followed by the Task Force and the conclusions the Task Force reached. The Task Force's recommendations address two issues: first, areas of inquiry that the University should consider to be priorities in the coming years; second, the placement of initiatives in these areas in relation to other scientific activities in Cambridge, Longwood, MGH and Allston campuses—with a particular focus on the largely unprogrammed Allston campus.

Process overview

The Task Force on Science and Technology began its work in the fall of 2003. (See Appendix A for membership.) The Task Force explicitly wanted to maximize opportunities for input from faculty members, but was aware that this University-wide process could have unintended consequences for planning by Deans and their staffs within schools. Thus the Task Force employed several methods to engage diverse faculty members across the University, while including as members the Divisional Deans of the Life Sciences and Physical Sciences of Faculty of Arts and Sciences and welcomed as *ex officio* members the executive deans of the three relevant faculties to participate in meetings. In addition the Provost briefed the Deans of the three involved faculties at a regular monthly meeting.

In the autumn of 2003, the committee conducted a large number of interviews with Harvard faculty. In January 2004, the Task Force issued a "call for ideas" to all Harvard faculty members for visionary, collaborative, interdisciplinary science and engineering initiatives that either built on existing strengths at Harvard or addressed lacunae in the University's scientific portfolio. The call for ideas focused on new science initiatives that could be sited in Allston, but, as the Task Force deliberated, it also considered the implications for Cambridge and Longwood, and the MGH campuses. Authors were asked for the most exciting ideas, not capital plans.

Together the interviews and the call for proposals yielded 70 proposals. The caliber of these submissions was, in the main, extremely high, and remarkable for being highly responsive to the request. The submissions were remarkable too for the consensus they seemed to represent among the University's scientists about the most important areas to develop in the coming years. Many of the proposals were complementary with several other proposals. When grouped together, these proposals pointed toward larger, ambitious concepts that were then evaluated by the Task Force.

Task Force members asked of each concept whether it was primarily intradepartmental or cut across several schools or departments. (Meritorious proposals with a scope no greater than a single existing department were referred back to the relevant school.) Did it engage multiple disciplines, methodologies, and/or levels of analysis? Would the concept have the potential to engage existing faculty and take advantage of Harvard's strengths? Would it extend Harvard into important new areas of knowledge? Would the proposal have significant impact—either on basic understanding of the world or on our ability to address specific problems in the world?

Finally, the Task Force asked whether investing in a particular field would create educational opportunities for our undergraduate and graduate students. While Harvard's research agenda reflects the aspirations of its scientists, Harvard is not a research institute but a university. It is essential that Harvard's scientific enterprise be an educational enterprise as well as one dedicated to discovery.

In the end, the Task Force selected a set of concepts that met these criteria for further development. Many of these involved the grouping of complementary proposals from the original 70. These were described in detail in the May 2004 report of the Task Force.

The Task Force invited teams of faculty and senior scientific staff that had made the selected proposals to further develop their concepts into "white papers." Specifically, authors were asked to provide an overview of the initiative including rationale, current stage of development, relevance to the University's educational enterprise, potential organizational structure and timing, risk factors, and definition of success. Staff from the Provost's office and the University Development Office offered counsel and support to the teams as they worked over the summer months to elaborate the proposed initiatives.

The papers were submitted to the Task Force in the fall of 2004, and formally presented by the authors to the Task Force over the course of three retreats in September, October and November. (A brief overview of each white paper is provided in Appendix B.) Prior to each retreat, white papers were assigned to two Task Force members for a preliminary review; their integrated feedback was shared with the proponents to help in preparing for the retreat discussion. At the retreats, each white paper team was given ten minutes to present an overview of its proposal, followed by twenty minutes of discussion. Authors were encouraged to revise their white papers after the meetings, incorporating any feedback from these discussions. The Task Force met separately to evaluate, prioritize, and make a final determination about all of the white papers in November and December.

White paper evaluation

The Task Force began by seeking to identify those white papers that should be considered priorities for the University as a whole. The white papers were categorized according to their stage of development into two clusters. The first cluster consisted of immediate and high priority initiatives, including *Chemical Biology, Engineering, Environment, Global Health, Stem Cells, Systems Biology,* and *Systems Neuroscience*. This is not to say that all of these initiatives had detailed strategic plans, budgets, and staffing plans but rather that they were intellectually well-defined, with clear aspirations, goals, and understandings of their scope and boundaries.

The second cluster of initiatives included *Global Neglected Diseases, Health Policy, Innovative Computing, Microbial Sciences, Origins of Life, Quantitative Health and Social Science, Quantum Science and Engineering, Translational Biomedicine,* and *Translational Immunology*. These initiatives have the potential to be high priorities for the University, but because they are in an earlier stage of development than the first

group, they will require additional work by the faculty involved. The Task Force believes that these initiatives are not yet ready for large scale funding or space from the University. In these cases, faculty will be invited to apply for smaller scale development funds in order to further develop and test their proposal.

Finally, the Task Force considered the possible campus locations for these new initiatives. This is a task that will require significantly more work. The Task Force worked with proposing faculty to determine which projects needed additional space and where. A very important issue at this stage was for faculty to define their desired intellectual contiguities and their concepts of intellectual critical mass and cohesion. In making its recommendations, the Task Force kept two goals in mind: first, it sought to ensure that existing concentrations of scientific research were strengthened, not weakened by possible moves. Second, the Task Force aimed to create a vibrant science presence in Allston, which also has the greatest capacity to accommodate new, large science buildings built on new models.

Siting Recommendations

The proposals reflected, and the Task Force recognized, that scientific research today and in the foreseeable future will require significantly more collaboration among the physical sciences, the life sciences, mathematics, and engineering than ever before. Therefore, while particular initiatives will continue to be housed in discrete spaces, proximities between certain initiatives will be essential and, in some cases, scientists from one initiative may even be marbled throughout the space of another (e.g. individual chemical biologists or engineers may choose to be contiguous to biologists so long as their discipline has adequate critical mass nearby). For the purpose of the physical planning process, the Task Force proceeded to consider the siting of the immediate, as well as potential, high-priority initiatives.

The science campus in the North Yard area of the Cambridge campus, which in the coming years will see the addition of two new significant facilities in the Northwest Building and the Laboratory for Integrated Science and Engineering, could house two initiatives described in the white papers and part of two others. These include: the *Environment* initiative, drawing on earth science, chemistry, engineering, and biology and reaching out as well to public health, political science, and law and business; and the *Quantum Science and Engineering* effort, involving physics, engineering, and computer science. *Systems Neuroscience*, which is based in the life sciences but also draws upon physics and engineering, will have two components. One of these is the neurobiology department in the Medical School; the other will be rooted in FAS's Center for Brain Sciences (CBS) with ties to the departments of molecular and cellular biology, organismic and evolutionary biology, and psychology as well as the Division of Engineering and Applied Sciences. The CBS will be physically located in the Northwest Building but will work in close coordination with neurobiology at HMS. The Task Force welcomes plans for interactions across the Charles River within this community. Some parts of the *Engineering* initiative will be located in the North Yard area to maintain

connections and close proximity to other DEAS faculty, while also enhancing suitable adjacencies with these other initiatives as well as relevant parts of the Physical Sciences.

None of the first three initiatives is likely in the near- to mid-term to require space beyond what will be available in the North Yard in the coming years. The Task Force recommends continued institutional support for these initiatives, and would suggest that the matter of their location be reconsidered in the future, in light of their evolving space needs as well as the value of adjacencies to initiatives elsewhere at the University.

Allston, of course, represents an extraordinary opportunity because it is undeveloped and unprogrammed. The Task Force recommended that a group of initiatives be clustered together in Allston, within two complexes of approximately 500,000 square feet each. All of these initiatives were seen to exemplify the kind of interdisciplinary activity that would benefit from new space in Allston. Insofar as is possible, the Task Force desired to create intellectual coherence for this new space while recognizing the need to be attentive to forces extrinsic to our planning processes (such as the pressure created by current federal funding rules to create new, segregated space for work on human embryonic stem cells).

These initiatives can be divided into two groups. The initiatives within each group would generate new connections and synergies and would therefore profit from proximity to one another. The first group includes initiatives on *Chemical Biology, Innovative Computing, Stem Cells* and *Systems Biology*, as well as relevant parts of the *Engineering* initiative. Faculty members within these initiatives are already collaborating with each other and are expected to benefit significantly from being located together. For instance, the Stem Cell Institute has launched a small-molecule screening program in conjunction with Harvard chemical biologists to identify small molecules that direct human stem cell differentiation, while the Systems Biology Department is using multidimensional screening to investigate cell circuitry. DEAS, meanwhile, has been establishing connections to the other four initiatives; for example, applied mathematicians from the Division are collaborating with faculty from the Department of Systems Biology on quantitative and theory-driven approaches to biology, and computer scientists and computational experts are participating in the Innovative Computing initiative.

The precise arrangement of these initiatives, of course, is not yet clear. It is clear that engineers and computer scientists will require a discrete headquarters; however, it is also clear that side-by-side placement with biologists and chemists in many cases will also be highly productive. How to achieve the right balance between independence and interdependence will be an important challenge for the University's scientists and planners in the next few years.

The second group comprises initiatives on *Global Neglected Diseases, Microbial Sciences,* and *The Origins of Life*. *Global Neglected Diseases* and *Microbial Sciences* have obvious connections; *Microbial Sciences* and *Origins* share an interest in probing the earth's biological and environmental history. *Innovative Computing*, referred to above, must also work closely with these initiatives. *Innovative Computing* is expected

to establish new tools and approaches for addressing the kinds of computational challenges – such as the management and analysis of large, complex data sets – that will likely characterize all of these initiatives. These three initiatives are not as far along in their planning as those described above. The Task Force therefore recommends that these initiatives be given sufficient seed funding to continue to develop their plans. Temporary expansion space should be provided to these three initiatives as needed, with a view toward moving them to Allston as soon as it is feasible. It is important to note that these three initiatives would create powerful synergies with additional efforts in microbiology and vaccine development that are in early planning stages at the School of Public Health; hence, these specific efforts may eventually share space with this second cluster.

A third group of initiatives — *Global Health, Quantitative Health and Social Science*, and *Health Policy* — should, logically, be sited in Allston within or immediately adjacent to the newly re-built Harvard School of Public Health. The Task Force recognizes that the HSPH is in the midst of its own planning process, but recommends that its dry lab space incorporate *Global Health* and *Quantitative Health and Social Sciences*, in particular.

In addition, it is essential that the School and the *Global Health* and *Quantitative Health* initiatives have ready pedestrian access to the complex described above that will house the *Global Neglected Diseases* initiative and other relevant efforts. Finally, the Task Force recommends that many bench scientists from HSPH, especially those involved in microbiology and immunology, be housed in the same complex.

The Task Force discussed whether a Longwood location, in space made available by the move of HSPH and other activities to Allston, would be preferable for the *Translational Immunology* and *Translational Biomedicine* initiatives, or whether, instead, they could be located at either the MGH campuses or in Allston. The leadership at Harvard Medical School and within the affiliated hospitals has expressed interest in pursuing these ideas further in collaboration with the Provost.

Finally, the Task Force embraced aspects of the *Collaborative Science Initiative* – in particular, the suggestion that collaborative workspaces and visitor capabilities be developed. The Task Force felt these ideas could be "built into" the planning for the new science and public health complexes, rather than further developed as a stand-alone initiative.

Going forward

For the initiatives deemed to be new University priorities, the next step will be to refine academic plans and specify the associated resource requirements in greater detail. Resource plans will define anticipated levels of faculty and other staff, and overall space and funding needs. Those initiatives that require additional faculty appointments are expected to work closely with the leadership of the schools involved, both to determine whether and how these appointments may be integrated with department and school-

based planning and to ensure that proper policies and procedures for faculty appointments are followed. The Task Force, recognizing the potential for significant expansion in the numbers of faculty, researchers and staff in the development of these initiatives, strongly recommends that the University take all possible steps to ensure the recruitment of minority and women candidates to these positions.

Each of these activities is also expected to follow the University's "Principles and guidelines for the establishment of centers" approved by the President, Provost and Deans in November 2002. The Provost's office will work closely with the faculty leadership of the initiatives and the deans of the relevant schools to ensure appropriate commitment, cross-school coordination, and effective administration.

For the subset of those immediate, and potential, high-priority initiatives likely to occupy the 500,000 square foot complex in Allston, a small committee has been formed to develop a more detailed program. This group will also ultimately participate in the selection of an architect and will work with the architect to develop the design. The committee will include representatives of the Medical School, the School of Public Health, the Faculty of Arts and Sciences, and the Division of Engineering and Applied Sciences.

Beyond this initial set of proposals, the Task Force believes it would be valuable to solicit and evaluate a second round of ideas from the faculty, possibly through another call for ideas. The Task Force recommends that the University, building on the momentum established by the Task Force planning process, develop an ongoing mechanism to identify, evaluate and implement important avenues of scientific research at Harvard.

While the Task Force focused its efforts on new endeavors, Task Force members, the Deans of FAS, DEAS, HMS, and HSPH, and the Provost all recognize that new science initiatives cannot be successful without a simultaneous commitment to strengthen and see to completion the existing, core science activities throughout the University, a number of which (the Center for Genomics Research and the Center for Nanoscale Science in the FAS, for example) are of very recent origin. Thus, any new planning efforts must now be coordinated and integrated with Harvard's existing activities in the sciences and engineering, including the Radcliffe Institute for Advanced Study, and the academic plans of various departments and centers. Such efforts are well under way in DEAS and in the physical sciences more broadly, for example. The Provost, and the Deans of FAS, DEAS, HMS, HSPH and Radcliffe must work closely together to ensure such integration.

Appendix A. List of Task Force membership

Steven E. Hyman, Chair, Provost; Professor of Neurobiology at Harvard Medical School Harvard University

Edward Harlow, Co-Chair, Professor of Biological Chemistry and Molecular Pharmacology; Head of the Department of Biological Chemistry and Molecular Pharmacology Harvard Medical School

Victor Dzau, Hersey Professor of Theory and Practice of Physic; Head of the Department of Medicine at the Brigham and Women's Hospital Harvard Medical School (as of July 1, 2004, Chancellor for Health Affairs, Duke University; President and CEO, Duke University Health System)

Alyssa Goodman, Professor of Astronomy, Faculty of Arts and Sciences

J. Richard Hackman, Cahners-Rabb Professor of Social and Organizational Psychology, Faculty of Arts and Sciences

Marco Iansiti, David Sarnoff Professor of Business Administration, Harvard Business School

Charles Marcus, Professor of Physics, Faculty of Arts and Sciences

Douglas Melton, Thomas Dudley Cabot Professor of the Natural Sciences Molecular and Cellular Biology, Faculty of Arts and Sciences

Andrew Murray, Professor of Molecular and Cellular Biology; Director, Bauer Center for Genomics Research Faculty of Arts and Sciences

Venkatesh Narayanamurti, John A. and Elizabeth S. Armstrong Professor of Engineering and Applied Sciences, Dean of the Division of Engineering and Applied Sciences and Dean of Physical Sciences Faculty of Arts and Sciences

Daniel Podolsky, Mallinckrodt Professor of Medicine, Massachusetts General Hospital, Harvard Medical School

Stuart L. Schreiber, Morris Loeb Professor of Chemistry, Chemistry and Chemical Biology, Faculty of Arts and Sciences

Samuel O. Thier, Professor of Medicine; Professor of Health Care Policy, Massachusetts General Hospital, Harvard Medical School

Christopher T. Walsh, Hamilton Kuhn Professor of Biological Chemistry and Molecular Pharmacology, Biological Chemistry and Molecular Pharmacology, Harvard Medical School

Dyann Wirth, Professor of Immunology and Infectious Diseases; Director of the Harvard Malaria Initiative Immunology and Infectious Diseases, Harvard School of Public Health

Nancy Maull, Executive Dean, *ex officio,* Faculty of Arts and Sciences

Eric Buehrens, Executive Dean, Administration, *ex officio,* Harvard Medical School

John Lichten, Dean of Finance and Administration, *ex officio,* Harvard School of Public Health

Paul Riccardi, Dean for Administration and Operations, *ex officio,* Harvard School of Public Health

Kathleen Buckley, Assistant Provost for Science Policy, *ex officio,* Harvard University

Donella Rapier, Vice President, Alumni Affairs and Development, *ex officio,* Harvard University

Appendix B. Summary of white papers

Chemical Biology. Chemical biology – the application of small molecule chemistry to systematically probe the complexities of biological systems – has become a most productive, interactive scientific discipline in recent years. Allston represents an opportunity for expanding and coordinating Harvard's efforts, while enabling rich links to other efforts envisioned for Allston, including *Stem Cells*, *Global Neglected Diseases* and *Systems Biology*.

The *Collaborative Science Initiative* envisions scientific facilities (workspace, laboratory facilities, and infrastructure) designed with the explicit goal of enhancing and supporting collaboration. The development of Allston facilities *de novo* offers an opportunity to think creatively about the role of physical facilities in catalyzing collaborative activity.

Engineering has been identified as an important area of growth for the University and is a discipline that is central to many of the interdisciplinary initiatives being proposed. DEAS is currently refining its plans for academic expansion and will finalize plans for Allston based on the nature of the other initiatives sited there.

Environment. Understanding and addressing the environmental challenges that will increasingly confront our society requires a deeply interdisciplinary approach, including the natural and social sciences, public policy, business and law. The Harvard University Center for the Environment (HUCE), established with such a mission and approach in mind, requires more space and funding to achieve its mission. Allston could provide important adjacencies.

Global Health. The Harvard Initiative for Global Health (HIGH) was launched in November 2003 to catalyze and enhance Harvard's contributions and impact in global health through education, research, and global engagement. An Allston location could enable connections with wet lab scientists, health policy scholars, and researchers in the material sciences and the environment.

Global Neglected Diseases. New scientific approaches, such as comparative genomics, molecular population genetics, proteomics and chemical genetics, present exciting new opportunities for understanding and treating neglected diseases. This initiative would bring together Harvard's relevant expertise, currently dispersed throughout Longwood, Cambridge, and the Harvard hospitals, for education and research in this area.

Health Policy. This initiative seeks to answer the question: how does the U.S. move toward care that is uniformly higher in quality, more efficient and more equitable? The potential move of HSPH and the potential for clinical facilities at Allston present opportunities for domestic health policy in Allston, including an idealized ambulatory practice, an Institute for Health System Design, and the relocation of a hospital.

Innovative Computing. This proposed initiative would identify and address common computing challenges across scientific disciplines, within four broad areas of expertise:

databases and algorithms; hardware and systems integration; visualization; and Internet, web and grid computing. Such an initiative could build important capabilities that would enable the work of other initiatives sited at Allston.

Microbial Sciences Initiative. This initiative, which aims to reach a comprehensive understanding of the microbial world, has existed for over two years as a virtual enterprise, connecting over 50 faculty members across the University. The current focus is on recruiting faculty to strengthen microbial studies research in key departments and developing a postdoctoral fellows program. An Allston location could foster connections with other initiatives under consideration such as *Origins, Global Neglected Diseases,* and the *Environment*.

Origins of Life in the Universe. Understanding the origins of life and its diversity, on earth and beyond, has only recently become a problem that can be tackled by modern scientific methods. A diverse group of faculty spanning multiple Harvard schools and departments has begun to collaborate informally on this topic, and proposes establishing an interdisciplinary center. In the short term, the focus would be to fill gaps in Harvard's current capabilities (e.g., pre-biotic chemistry) and launch a fellows program. Longer term, substantial new physical space, potentially at Allston, could be appropriate.

Quantum Science and Engineering. Quantum Science and Engineering is an important and rapidly-developing field at the intersection of physics, nanoscience, engineering, and information science, with potentially profound implications for security, communication and computation. Additional faculty – not space – is the current constraint for expanding Harvard's efforts in this arena; if this area grows as expected, expanded research facilities will be needed a decade hence.

Quantitative Health and Social Science. Technology is now enabling the collection and storage of unprecedented amounts of data about human populations and institutions; the challenge is translating this information into understanding. This initiative would bring together empirical researchers from a range of fields to engage in collaborative, interdisciplinary quantitative research, and thus could be a good fit for the Allston campus.

Stem Cells. The Harvard Stem Cell Institute will investigate the complex biology and therapeutic aspects of stem cells while attending to the broad societal and ethical implications of this new science. It epitomizes the kind of interdisciplinary activity Allston represents, and will have important linkages with other activities proposed for Allston.

Systems Biology. Systems Biology is a new field that aims to understand the complex physiology that underlies the functioning of cells and organs; it demands the collaboration of biologists with computer scientists, physicists, mathematicians and engineers. An Allston location could provide numerous connections to other initiatives under consideration, including Chemical Biology, Engineering, Innovative Computing, and Stem Cells.

Systems Neuroscience. Systems neuroscience builds on our current understanding of the brain at the molecular and cellular level to an understanding of how these components work together to account for thoughts, perceptions and emotions. This initiative would strengthen connections across existing efforts at FAS and at HMS and the hospitals while fostering new connections with Harvard scholars in the natural, physical, and social sciences. An Allston location might be appropriate once an established community of scientists is in place.

Translational Biomedicine. The accelerating pace of basic discoveries in academic biomedical research offers great promise for human health. This initiative would exploit recent scientific and technological advances to help ease the translation of discoveries to the clinic. Platforms could include developing "humanized" animal models, enabling real-time monitoring of physiologic processes in animals via microengineered devices, and identifying new, validated surrogate disease markers. Substantial financial resources and space would be required to realize this vision.

Translational Immunology. This initiative would bring together expertise throughout the University to perform interdisciplinary research leading to new immunologic prevention and therapies for human disease (in particular, infectious disease, autoimmune diseases and transplantation) and to develop educational programs and career pathways for the translation of the basic biological and physical sciences to clinical practice. Such an approach would necessitate investment in core facilities and a central location.