# TABLE OF CONTENTS

- **Acknowledgments**
- **Introduction**
  - Benchmarking Interdisciplinary Research in the Sciences
  - Benchmarking Study
  - Some Comparative Background
- **Analysis**
  - Key Data Points
  - Case Studies
  - What We Need:
    - In the Faculty’s Words
- **Assessment**
  - How Much and What Kind of Space Do We Have Now?
  - Looking Ahead
  - Where Might We Start?
  - A Rough Model
- **Appendix**
The planning of a new research and teaching facility is intertwined with a new strategy for developing graduate programs, a comprehensive hiring strategy that cannot be governed on the basis of single departments and a greater focus on research priorities that cut across the entire university and offer new levels of collaboration with the School of Engineering and Applied Science and the School of Medicine.

Gary Wihl, Dean, Faculty of Arts & Sciences
I am pleased to submit the results of a benchmarking study undertaken by the Faculty of Arts & Sciences at the request of the Chancellor. This study is the culmination of a two-year planning effort in Arts & Sciences, beginning with the work of the Academic Planning Committee in fall 2009, the deans of Arts & Sciences at their spring 2010 retreat and in-depth consultations with faculty working groups in spring 2011. The focus of the benchmarking study is a comparative analysis of the critical mass of research activity and infrastructure support in six interdisciplinary scientific fields where Washington University currently excels or could excel in the next ten years. Excel in this context means producing path-breaking research, increasing our sponsored research, and moving into the highest cluster of graduate program rankings by the NRC.

The benchmarking study has a primary focus on a major capital investment, a so-called science corridor, along the north side of the Danforth Campus, beginning with a new facility of 260,000 gross square feet. But the case for the construction of this facility includes equally complex, strategic initiatives within Arts & Sciences. Our benchmarking study concludes that new infrastructure goes hand in hand with the state of research in new scientific fields. These new fields cannot be classified under the traditional structure of teaching departments in the STEM disciplines. The planning of a new research and teaching facility is intertwined with a new strategy for developing graduate programs, a comprehensive hiring strategy that cannot be governed on the basis of single departments and a greater focus on research priorities that cut across the entire university and offer new levels of collaboration with the School of Engineering and Applied Science and the School of Medicine. The launch of a major infrastructure project will animate and advance all of these strategic goals.

The benchmarking study is the work of many hands. A full list of the faculty participants is appended to this study. I am particularly grateful to the following faculty for their time, effort and contributions: Barbara Schaal, Kathy Miller and Tiffany Knight from Biology; Ray Arvidson, Brad Jolliff and Jen Smith from Earth and Planetary Sciences; Bill Buhro from Chemistry; Ken Kellon, Marty Israel and Jim Buckley from Physics. In addition, Bill Buhro and Ken Kellon along with Stuart Solin, Don Elbert and Phil Bayly were instrumental in the analysis of Materials Science. Hank Webber provided the catalyst for this entire initiative at the outset by challenging Arts & Sciences to develop a compelling case for scientific excellence. Generous thanks are due to Evan Kharasch, Ed Macias, Ralph Quatran, Larry Shapiro and Erik Herzog from Biology for participating in the selection of the consulting firm and for their recognition of this project's potential to better the entire university. Laurie Sperling and her colleagues at HERA conducted the benchmarking study and provided the case studies. Dick Roloff provided valuable guidance at several key stages of this study's development. His enthusiasm and support has been an encouragement all along. Bill Darby's expertise in data analysis and organization created light where there was darkness. The elegant charts and tables throughout reflect his hard work. Dennis Martin deserves special mention. He has kept this project on track every step of the way, coordinating input from the consultants, the faculty, and the deans. He is the principal author of the report.

As is the custom in acknowledging the important work of all the contributors, any imperfections that remain are the responsibility of the Dean of the Faculty.
With guidance from the Academic Planning Committee and rooted in a faculty-driven planning process that began in fall 2009, Arts & Sciences aspires to excel in a highly focused way. We have identified specific areas of collaborative research as our priorities, and we see the need for new models in interdisciplinary research and teaching.

Though some elements of the sciences within Arts & Sciences have attained world-class stature, we lag behind the competition in many key respects. We need to close the gap. We must do so with significant investment in our faculty, including a net gain of at least 20 new positions in the natural sciences, and with a major investment in infrastructure. This is essential if we are to recruit and retain the best faculty and students in areas where we can make an impact in research and teaching.

Arts & Sciences anticipates that over the next 10 years, between $230M and $275M will be required to maintain academic buildings in their current configuration. While necessary improvements, these renovations represent a simple continuation of the status quo. The majority of this, on the order of $140M to $175M, will be required to maintain science buildings, many of which are in deficient condition today.

**Benchmarking Interdisciplinary Research in the Sciences**

At the request of Chancellor Wrighton, Arts & Sciences conducted a benchmarking study over the spring 2011 semester. This study examined six research areas with the potential for excellence in faculty research, graduate education and cross-school collaboration. These areas grew from over two years of planning and faculty
consultation. The appendix includes a list of faculty work groups who have contributed ideas and leadership in identifying the following priorities:

1. **Evolutionary Biology**
   At Washington University, Evolutionary Biology includes population genetics, genomics, phylogenetics, and evolutionary and ecological genetic perspectives combined with technological advances of molecular genetics, bioinformatics and theory to understand evolutionary history and processes that lead to the diversity of life on Earth. The Missouri Botanical Garden is an important resource for research collaboration.

2. **Plant Biology**
   Plant Biology at Washington University and elsewhere is a broad, highly interdisciplinary field. Plants play a critical role on this planet as they provide food, fuel and many important natural chemicals and metabolites. A fundamental understanding of their biology is essential. We focus on several important research areas in Plant Biology, including plant growth and development, photosynthesis and energy production, biochemistry and metabolism, and responses of plants to their environment, using cellular, molecular, developmental, genetic, genomic and computational approaches. Since these studies combine many areas of biological research, collaborations both within and outside the university are very important for progress, discovery and the development of new knowledge. Our strength in Plant Biology is complemented by our association with the Donald Danforth Plant Sciences Center and Monsanto.

3. **Materials Science**
   Faculty in Chemistry, Physics, and Earth and Planetary Sciences (Arts & Sciences), all five departments in the School of Engineering and Applied Science, and the School of Medicine share interests in Materials Science. The current research foci include nanoscience, such as studies of semiconductor quantum nanostructures, biomedical and biological materials, amorphous materials and magnetic materials. Much of this research focuses on materials synthesis, properties and applications. A considerable effort aims to develop a deeper understanding of the fundamental processes underlying materials production, including phase transition control and microstructural refinement. The Center for Materials Innovation (CMI) provides shared instrumentation and very useful collaborative space in the Earth and Planetary Sciences building. Many faculty have ties with I-CARES (the International Center for Advanced Renewable Energy and Sustainability).
4. Environmental Science
At Washington University, Environmental Science includes Biology, Earth and Planetary Sciences, Environmental Engineering, and I-CARES. Close ties also exist to Anthropology, Architecture and Political Science, but more so on the curricular front than in terms of scientific research. Research collaborations seek greater understanding of ecology, habitat restoration, climate change and the effects of natural and human phenomena on environmental systems. There are also ties between faculty from the medical school and Arts & Sciences. For example, collaborations on a biofuels project include genomic techniques to understand environmental perturbations on the selection and enrichment of inhibitor tolerance genes encoded by soil microbial communities. Important university resources include the Center for Geographic Information Systems (GIS), genomic facilities and the Tyson Research Center.

5. Space Sciences: Astrophysics
Our Astrophysics and Astroparticle Physics area includes experimental work in high-energy astrophysics (observation of gamma-rays, x-rays, cosmic-rays, neutrinos and detection of dark matter), in astrophysics of pre-solar grains (laboratory study of refractory grains found in meteorites) and solar wind, and in the exploration of gravity at short distances. We have theoretical work in general relativity and gravitational-wave detection, and at the intersection of particle physics with astrophysics and cosmology.

Planetary Sciences is the study of the origin and evolution of the planets, moons, and small bodies (e.g., asteroids) in the solar system. Washington University focuses on two areas within this discipline. The first is cosmochemistry, which uses analyses of meteorites, lunar samples and cosmic dust or other materials returned to Earth by spacecraft for analysis to understand the early evolution of the solar system and the chemical fingerprints that tell us how planetary bodies evolve over time. Cosmochemistry also involves modeling and experiments that provide insight into the formation of the solar system from an initial gas and dust cloud. Planetary geology and geophysics is a second area of focus and uses modeling, experiments and space-borne data (e.g., collected by the Mars Exploration Rovers) to understand how planets and moons evolve over time, including their internal tectonic evolution and their surface environments and histories.

Benchmarking Study
Benchmarking is a key dimension of strategic planning in that it tells us about the competition and gives a sense of where we stand. Our objective was to measure the distance between where we are now and where we want to be over a 10-15 year horizon.

In a competitive review process, Health Education and Research Associates (HERA) was selected as project consultant for a bench-
marking study of key research priorities in the sciences. HERA, working closely with Arts & Sciences, organized the benchmarking data collection by gathering information from peer and leading institutions identified by our faculty in these areas. HERA also prepared a set of case studies that offer compelling evidence of the kind of science buildings necessary to carry out research in the areas of excellence we plan to advance, buildings that will allow us to collaborate more effectively, to hire new faculty who will make the most of new interdisciplinary collaborations and to train new scientists, in new ways, for an evolving future.

In this study we have learned the following:

■ In the priority areas we have identified, the competition is not standing still.
  ▲ Where we are highly ranked we are challenged to maintain our top standing;
  ▲ Where we can see the opportunity for excellence, we need to improve with strategic investments.

■ This is not and cannot be simply about a need for more space; nor can it be simply about a need for more faculty.
  ▲ We need modest growth in the number of faculty, graduate students, postdocs, technicians, all in targeted areas;
  ▲ We need the right kind of faculty;
  ▲ We need the right kind of space to conduct research and train future scientists.

We need to encourage our faculty to organize in interdisciplinary research teams and support them with improved infrastructure to achieve the following objectives:

▲ Location and proximity, the physical disconnection of our current science departments – and in many cases, disjunction within departments – severely limits academic connections and impedes interdisciplinary research;

▲ Collaboration, the opportunity for new, cross-disciplinary graduate programs, for sponsored research with co-PIs from multiple departments and schools must be promoted with new infrastructure and new ways of organizing the work of the faculty;

▲ Integration, outdated buildings where many of our faculty conduct their work were not designed to be flexible, to allow sharing of equipment and lab space, to enable easy and effective commerce of people, equipment, chemicals and technology;

▲ Flexible lab planning strategies. Architects have discovered the advantages of flexible design and new approaches allow multi-use buildings not conceivable until recently. We need to design labs for flexible reconfiguration, with generic labs for shared use, with sufficient space for easy expansion, growth and retraction, as necessary;

▲ Core labs and shared equipment, which establish the appropriate balance between dedicated and shared labs, between teaching and research labs, and providing matching funds for cutting-edge equipment that can help achieve our priorities, is key.
To address these challenges, Arts & Sciences proposes a phased plan to revitalize the configuration of Arts & Sciences on the Danforth Campus. The starting point will be a transformative structure, designed to reflect what we have learned in our benchmarking of the sciences. The first phase will provide a new way to organize the faculty and the research effort with a greater interdisciplinary emphasis, thus opening opportunities for new research collaborations, new sponsored research and new graduate programs. All these opportunities will require close ties between Arts & Sciences, the School of Engineering and Applied Science and the School of Medicine. The initial focus will be on Evolutionary Biology, Plant Biology and Materials Science. Subsequent phases will address the needs in Space Sciences (both Astrophysics and Planetary Sciences) and Environmental Science. Along the way, improvements will be made to benefit not only the core science departments, but the humanities and social sciences as well.

Some Comparative Background
Before delving into a comparative analysis of interdisciplinary research in the sciences, a review of recent infrastructure development is useful. The National Science Foundation’s (NSF) biennial survey of science and engineering research facilities provides a useful context for the benchmarking study. Among the data collected is the amount of new research space recently constructed or planned to begin. Working with the NSF data, we were able to exclude engineering and medical school disciplines and focus on the biological and physical sciences pertinent to Arts & Sciences. We further refined our analysis to examine 23 specific institutions identified by our own faculty as peer or leading institutions in the six research areas we’ve identified as our priorities. The following chart provides a graphic illustration of how we are lagging in infrastructure investment in the core sciences.

This graph shows that over 1.1 million of net assignable square feet (NASF) of research space for the biological and physical science was added by institutions with which we compete. During this time frame, only 825 NASF in new construction was reported by Washington University (a lab renovation of Busch Lab). This and other evidence indicates we have lagged in our investment in the core sciences found in Arts & Sciences at Washington University. For instance, while we have hired 45 new faculty in the natural sciences and mathematics over the last decade there has been essentially no net growth in the number of science faculty. This contrasts with almost 20% net growth in faculty in the humanities and social sciences over the last decade. Arts & Sciences must plan for growth in the number of science faculty if we are to compete; and we must plan to upgrade our infrastructure to support these faculty if they are to generate sponsored funding, publish findings on new discoveries, establish new graduate programs and work across the boundaries of traditional academic disciplines.

Washington University already has a strong investment in materials science. … many of these scientists and engineers are recognized as the best in the world. … However, a lack of integration and breadth prevents Washington University from capitalizing on this investment. The faculty members are isolated in different buildings spread across all of the Danforth and Medical Campuses.

Ken Kelton, Arthur Holly Compton Professor of Arts & Sciences, Professor and Chair, Physics
Net assignable square feet (NASF) is the sum of all areas on all floors of a building assigned to, or available to be assigned to, an occupant for a specific use, such as research or instruction. NASF is measured from the inside faces of walls. (Definition from National Science Foundation, National Institutes of Health, FY 2009 Survey of Science and Engineering Research Facilities.)
2. ANALYSIS

Key Data Points

The following table summarizes the highlights of the benchmarking survey conducted by HERA. (The online appendices include complete sets of benchmarking tables in the six areas examined for participating institutions in these areas, along with the Washington University data.) This summary table introduces the relationship between faculty, research space and research profile/stature, here reflected by the latest National Research Council’s rankings. See the appendix for a more in-depth analysis of NRC rankings.

Washington University has distributed strengths in the chemical, physical and biological properties of plants and soils, but a common space would allow those fields to truly integrate. Shared space would allow faculty to share cutting-edge equipment for interdisciplinary studies, including mass spectrometry, chemical and stable isotope analyses, and genomic facilities for microbial and plant studies.

Tiffany Knight, Associate Professor, Biology
This table compresses a great deal of information. Six complex stories emerge as we consider the patterns and implications of these data. For example, in the column detailing research output, “Research expenditures/Tenured or tenure-track faculty (FTE),” we see that Washington University lags behind competitors in Materials Science, Environmental Science, Astrophysics, and Planetary Sciences. In these cases, we generally report less assigned NASF per FTE. Our stronger showing in Plant Biology and Evolutionary Biology reflects our excellence in these areas, but whether or not we can maintain our top rankings is an important question.
How can we organize this information as we consider both where we are now and where we hope to be? What is our relative position today in comparison with leading institutions in these research areas, and what realistic expectations should we set for ourselves? These questions are at the root of our benchmarking study, and the two charts on this page and the next synthesize what we have learned in this comparative analysis of faculty and research output in these six areas.

Though the benchmarking analysis per se cannot reflect such underlying complexities as the importance of individual faculty, academic leadership and the successful recruitment and retention of world-class scholars, the patterns that emerge in examining the data we collected are instructive.

The first chart (above) in this sequence illustrates where we are today, in a continuum defined by four quadrants depicting high and low metrics for research space (net assignable square feet, NASF) and research expenditures, both normalized by tenured and tenure-track faculty FTE.

Our relatively strong positions in Evolutionary Biology, Plant Biology and Planetary Sciences in the right-hand quadrants contrast with the less favorable positions of Environmental Science, Materials Science and Astrophysics in the left quadrants (tending toward lower research output and less research space per FTE). The pattern emerging in this analysis is important and helps us assess our relative position.
As we consider where we want to be over the next 10-15 years, the second chart (above) in this sequence illustrates our aspirations for greater research impact defined in terms of significantly higher output, gains in net assignable square feet and a reconfiguration of research space to enable a flexible, adaptable, collaborative and modern environment. The projected growth will clearly depend upon our ability to recruit and retain outstanding faculty. Similarly, new and reconfigured facilities, and investments in technology (instrumentation, networking, data archives) and people (not only faculty, but technicians, postdocs, graduate students) are necessary to attract and retain the best faculty as well as top-notch graduate students. Neither alone is sufficient to move us forward; but together, faculty and infrastructure are known to be mutually reinforcing as we strive for academic excellence. The recruitment of Professors Roddy Roediger and Frank Yin, coupled with new facilities (the Psychology Building and Whitaker Hall) and revitalized departments brought us unparalleled gains in research and teaching in Psychology and Biomedical Engineering. New faculty leaders, recruiting new faculty colleagues, in new facilities, result in new excellence in teaching and research. We believe that strategic investments in faculty and facilities in the areas we identify as priorities in the sciences will result in similar success.
Understanding each of these areas is more complex than these data alone can demonstrate. For instance, the challenge in Evolutionary Biology, where we are now ranked at the top by NRC, is to maintain this top position with a revitalized faculty who will further research output. The implication of this analysis is that an increase in research space itself (NASF per FTE) is not essential; indeed, the NASF available to our faculty in this area seems, on the face of it, just fine. But it will become clear that Evolutionary Biology requires a new kind of space and infrastructure if it is to maintain its top ranking.

At the opposite end of the spectrum, Materials Science will require more coordination and new infrastructure if we are to improve our competitive position and develop a research program that has greater impact and contributes to our research and teaching missions.

But in the workings of faculty, collaborating with colleagues in other disciplines, with postdocs and graduate students, securing sponsored research in a highly competitive environment, a powerful, common theme is clear:

> The qualities and capabilities of the faculty, the human and technological infrastructure to support their work, and the amount and kind of space in which they work can make all the difference.
CASE STUDIES

The following materials were assembled by HERA based upon their knowledge of scientific research construction at universities, medical schools and research institutes. The buildings described in the following pages graphically illustrate advances being made at other institutions to enable teams of faculty, postdocs, graduate students and research technicians to work in highly collaborative ways, ways that cut across the traditional boundaries of academic disciplines.

The case studies are formatted to provide quick facts about the buildings featured, a review of “success factors” that highlight what was to be accomplished and how these facilities have achieved these objectives, and specific insights on research collaborations, core labs and shared instrumentation. In addition, photographs, architectural drawings and floor plans are included to give a greater sense of how these buildings are designed and how they work.
Case Study – Intentional Collaborations

The University of Chicago
William Eckhardt Research Center
Chicago, Illinois

Building Facts
• 274,000 GSF
• 136,700 NSF (49.85% net to gross)
• 7 floors, including 2 below ground
• Sep 2011 construction start
• Feb 2015 construction complete

Success Factors
• Astronomy & Astrophysics faculty currently work out of five campus buildings; the Eckhardt Center will bring the faculty under one roof.
• Areas for formal and informal interactions are especially important for fostering collaboration among the experimentalists and theorists in physical sciences.

"We are bringing together researchers who previously were in five different buildings spread across campus. Our new facility will house programs in astrophysics, astronomy, chemistry and physics in addition to fostering trailblazing work in molecular engineering. We have spent a great deal of time optimizing the connectivity of our various research areas both horizontally and vertically in our space planning. Our collaboration, seminar, conference rooms and dining are strategically placed to connect and strengthen collaboration." – Faculty

"Not only will we have modern lab space with good connection to faculty and research offices, the building will provide well thought-out space for meetings, seminars and informal collaboration. We have a lot to look forward to when the building is complete." – Administrator

Science Disciplines/Collaborations
• Astronomy and astrophysics, chemistry, physics, molecular engineering, biology, cosmology, and geophysical sciences.
• Institute for Molecular Engineering, Kavli Institute for Cosmological Physics, the theoretical physics group of the Enrico Fermi Institute, and part of the James Franck Institute.
• Partnership with Argonne National Laboratory for Nanoscale Research.

Core Labs/Shared Equipment
• Vibration-dampening space for Class 10, 100, and 1,000 clean rooms.
• Molecular imaging suite.
• E-beam lithography.

Space Program Highlights
• New space requirements were developed by auditing the existing space for each department and adding 20% for each, treating each equally.
• Laboratories, offices, conference rooms for Division of Physical Sciences plus a clean room, and specialized laboratory and imaging facilities.

Context
• Initially proposed as a renovation of the Research Institutes, the new building occupies the site and replaces the current Research Institutes.
• Building bridges to the Gordon Center for Integrative Science where additional teaching occurs.
Case Study – Open Laboratories

Stanford University
James H. Clark Center
Palo Alto, California

Building Facts
• 245,200 GSF
• 145,073 NSF (59.2% net to gross)
• 4 floors, including 1 below ground
• Jun 2001 construction start
• Sep 2003 construction complete

Science Contact
Sanjiv Sam Gambhir, MD, PhD
Director, Molecular Imaging; Member, Bio-X Program
sgambhir@stanford.edu

Architect
Foster + Partners with MBT Architecture

Success Factors
• Fosters an unprecedented degree of collaboration between scientists from different disciplines to meet the pressing scientific and medical challenges of the coming decades by removing individual isolated research and requiring the combined expertise of multi-disciplinary teams.
• Almost complete flexibility in lab layout allows for rapid reconfiguration.

“
This open lab design is a radical attempt to foster interaction between faculty members and spur research that crosses the traditional barriers. These large lab areas can be broken down and reconfigured to adjust to changing needs of different projects. The ‘hotel spaces’ are temporary benches that allow teams to form easily as needed which gives researchers access to space and ideas that might not be available in their current space.” — Scientist

“
The ‘hotel’ space in Clark is an experiment in itself. Although the benefits are untested, the space enables researchers to have access to space and ideas that might otherwise not be available in their current space.” — Clark website

Science Disciplines/Collaborations
• Bio-computation, biophysics, regenerative medicine, bioengineering, genomics and proteomics, chemical biology and bio-design.
• Bio-X Program (biology and information technology and engineering).

Core Labs/Shared Equipment
• In-vivo imaging, bio-computation collaboratories, central glasswash, media prep, low vibration laser labs, special projects spaces, 2 super computers.
• Shared instrumentation provided in both individual labs and general facilities locations, which range from shakers to microscopes to tissue culture hoods and cold rooms, can be accessed on a case-by-case basis.

Space Program Highlights
• Three wings of open labs with no interior corridors (external balconies instead) overlook courtyard and provide shared and individual wet and dry laboratory space.
• 15% conference and classrooms; 9% shared support facilities.
• Social gathering spaces include LinX, a full-service restaurant (~600 meals/day) with long family-style tables, and a Peet’s Coffee and Tea.

Context
• Exterior massing, envelope and materials fit well with surrounding context while the three wings facing into the interior courtyard allow greater freedom in layout and transparency.
• Clark’s location unites the medical center with the rest of campus, reflecting more programmatic affiliations.

Credit: Richard Centrella
# Case Study – Threading the Campus Needle

## Harvard University Laboratory for Integrated Science and Engineering (LISE)

**Cambridge, Massachusetts**

### Building Facts

- 139,680 GSF
- NSF N/A
- 10 floors, including 3 below ground
- Jun 2004 construction start
- Nov 2007 construction complete

### Science Contact

Charles Marcus, PhD  
Chair, LISE Client Committee  
marcus@harvard.edu

### Architect

Rafael Moneo with Wilson Architects

### Success Factors

- A large amount of new vibration-stable space (38,000 ft²) is underground, accommodating imaging, clean room and materials laboratories.
- LISE is connected floor-by-floor to the Gordon McKay Engineering and Applied Sciences Building; by bridge to the physics and engineering complex and underground to the Science Center, creating an integrated nano-science district.
- Many places for discussion in LISE serve as a catalyst for scientific progress, “making collaboration easy”. LISE third floor is the “social floor”, with conference and seminar space for 5 to 30 people and an expansive seating area with views of the reconstructed quad; first floor contains a two-story café space, open to a second-floor lounge.

> *If you moved this project 500 yards from this location, it would not have been so successful. We have the proximity and the incredible facilities we need to do our research. In fact, I have another lab (in another part of campus) and I no longer use it.*

– Faculty

### Science Disciplines/Collaborations

- Harvard’s Center for Nanoscale Systems.
- LISE hosts scientists from other schools through an NSF grant where about 20 non-Harvard researchers use the facilities at any given time.

### Core Labs/Shared Equipment

- 10,000 ft², 6-bay Class 10 clean room; 10-lab imaging suite; advanced materials science lab; biological prep labs; material synthesis lab; interdivisional research labs.
- Microscopes: scanning electron, tunneling electron, focused ion beam, and near field.
- New truck dock also serves the Science Center, which lacked a service dock.

### Space Program Highlights

- Five primary types of labs: 1) Class 10 clean room; 2) stable suite of imaging labs; 3) biological prep labs (convertible to BSL-2 labs); 4) material synthesis lab with capacity to handle equipment that generates extreme heat; 5) interdivisional research labs (dry) accommodate high power consumption and are vibration, electromagnetic interference, and noise controlled.

### Context

- LISE is carefully fit into an existing courtyard within 5 feet from existing buildings; base of tower preserves existing courtyard pedestrian circulation.
- 67% of the building is underground; tower provides small lab footprint (6,400 ft²).
- A moat for the underground levels allows natural light in, making the space much more versatile; makes it accessible to fire trucks on more than one side and legal to store hazardous materials underground, satisfying the fire safety requirement.

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Health, Education + Research Associates
Section through the clean room and existing McKay building.

Section through the clean room and the laboratory tower.

Typical LISE tower and McKay floor plan with the connecting bridge to Cruft.

Basement floor plans – clean room, mechanical services and McKay building.

Site plan of the Harvard campus with the footprint of LISE tower and its relation to the network of campus pathways.

Images courtesy Rafael Moneo.

1. LISE
2. McKay
3. Science Center
4. Cruft
5. Lyman
6. Jefferson

Health, Education + Research Associates
Case Study – Creating the Link

Duke University
French Family Science Center
Durham, North Carolina

Building Facts
• 280,000 GSF
• 172,125 NSF (61.5% net to gross)
• 6 floors, including 1 below ground
• 2002 construction start
• 2006 construction complete

Success Factors
• The building straddles the existing physics and biological sciences buildings and connects to
  new greenhouses, enhancing the science focus.
• Brings teaching and research together in the same complex of buildings.
• Center gets scientists out of ‘silos’ and into collaboration.

Science Contact
Phil Benfey, PhD
Chair, Biology Department
philip.benfey@duke.edu

Architect
Moore Ruble Yudell and RMJM (Hillier Group)

Science Disciplines/Collaborations
• Genomics, biochemistry, materials science, nanoscience, physical biology and bioinformatics.
• Space for departments of Chemistry, Biology, Biological Anthropology, Anatomy and Physics.

Core Labs/Shared Equipment
• Some dry labs are strategically placed next to experimental labs for integration of computational
  research with biology and chemistry.
• New undergraduate teaching labs are smaller and have more hood space – two design
  specifications that are well suited for undergraduate experimentation.

Space Program Highlights
• Consistent lab modules with flexible support systems to suit future fit-out.
• Majority of chemistry and biology are located in different wings; research labs and support
  spaces and teaching labs and supporting interaction spaces on each floor.
• Lecture hall, conference rooms are shared.
• Research and collections greenhouses are linked by bridge.

Context
• The Center forms a new exterior space called Science Terrace which creates a physical and
  intellectual link on West Campus, while providing a destination lawn and amphitheatre for
  campus activities and an entry into the landscaped-roofed lecture hall.
• A complex structure, the Center was designed to fit its specific location, the site tucked in
  between and designed to serve five surrounding existing buildings in tight proximity.

Photos courtesy RMJM.
### Case Study – Phased Science District

**University of North Carolina-Chapel Hill**  
**Carolina Physical Science Complex Master Plan**

**Chapel Hill, North Carolina**

#### Building Facts
- 720,000 GSF in three phases
- 437,000 NSF (60.7% net to gross)
- 2007 construction start
- 2020 construction complete

#### Science Contact
- Michael T. Crimmins, PhD  
  Senior Associate Dean for Natural Sciences  
  crimmins@email.unc.edu

#### Architect
- Wilson Architects

#### Success Factors
- Executed over 13 years in 3 phases, this master plan gives the university opportunity to apply “lessons learned” from the initial phases.
- Linkages among science neighborhoods foster sharing of special equipment, programs, people; centralized material and service distribution on its own level for entire district.
- Science buildings enhance interaction and engage scientists and students as integral parts of the science community.

> Through careful planning and phasing we have provided cutting-edge facilities which bring together five departments while reinforcing our historic campus based on quadrangles. These facilities have been major assets in recruitment and retention. — Scientist

> Our Master Plan and construction set a precedent for research space on campus, replacing sub-standard labs – both space and equipment. — University Planner

#### Science Disciplines/Collaborations
- Chemistry, computer science, marine science, math, physics and astronomy, science library,
- Institute for Advanced Materials and Carolina Entrepreneurial Initiative.

#### Core Labs/Shared Equipment
- 4,500 ft² fluids lab, including a 120-foot long wave tank.
- 13 telescopes on the roof of Chapman Hall for undergraduate use.
- Wind tunnel, clean room, greenhouse, and observatory.
- High field room with seven nuclear magnetic resonance (NMR) spectrometers.

#### Space Program Highlights
- Caudill Laboratories: analytical chemistry research labs (wet labs, dry labs, computational labs, and shared instrument space); faculty offices and conference; and open student space for interaction and collaboration.
- Chapman Hall: two floors dedicated to marine science, two floors for physics and astronomy, large lecture halls, faculty offices, an astronomy deck, newly created Institute for Advanced Materials, Nanoscience and Technology.
- Venable Hall: additional chemistry space, marine sciences, 225-seat lecture hall, classrooms, new science library.
- Sitterson Hall addition: Computer Science Department, 80-person general-purpose classroom.

#### Context
- Site slopes 80 feet from one end to the other, accommodating 4 levels: service, library, walk connecting old to new, and upper level entry for existing buildings.
- Careful placement of a large footprint on this delicate historic campus creates a sense of openness while strengthening the quadrangles and courtyards already in place.
The plan calls for a 13-year transformation. Chemistry Labs: 146,000 GSF
Synthetic Chemistry & Marine Sciences: 169,000 GSF
Multidisciplinary Facility: 128,000 GSF
Computer Science: 35,000 GSF
Science Library

Four access levels integrate buildings and landscape on a vertically sloping site.
Several important themes emerge in HERA’s analysis and summary of recent construction trends in the support of scientific research at today’s universities. We’ve learned that we have fallen behind, that research at top institutions is being conducted in new ways, with facilities very different from ours. As we go further with our planning, the recently appointed steering committee, co-chaired by Provost Macias and Dean Wihl, will play a key role. Members of this committee include Deans Shapiro and Quatrano (from Medicine and Engineering, respectively), Professor Schaal (from Biology), Executive Vice Chancellor Webber, Vice Chancellor for Finance Feiner, Vice Chancellor for Research Kharasch and Associate Dean Martin. Some potential guiding principles to consider as we go forward:

**Location and Proximity**
The precise location of new facilities on campus and the way they are integrated with existing facilities are perhaps the most important factors for success. The best equipment and lab space must be proximate and accessible to various interdisciplinary teams.

**Collaboration**
Careful attention to co-location of labs, flexibility of arrangement, shared social spaces, stairways, corridors and classrooms are ways to encourage scientific collaboration by design.

**Integration**
Creating subtle opportunity spaces and amenities that encourage interaction and provide opportunities for increased collaboration.

**Flexible Lab Planning Strategies**
Lab-planning strategies respond to institutions’ specific campus standards, their research needs and the degree of future adaptability desired. Some key goals identified include flexibility for reconfiguration, generic labs to accommodate various programs, easy expansion for growth, and size: large lab footprints that allow for equipment and protocols as new research priorities evolve, and even smaller lab footprints customized for the needs of individual principal investigators.

**Core Labs and Shared Labs and Equipment**
Core labs and shared labs and equipment facilitate collaboration, research expansion and aid in recruitment and retention of key scientists. In addition, such facilities are cost effective and can limit unnecessary or redundant expenditures. Core labs provide dedicated research facilities, often shared with affiliated departments, for very specific, specialized purposes. Shared labs and equipment are by definition more flexible and can benefit multiple users in a space that is adaptable to changing requirements.

The appendix includes detailed examples of these principles at work in a number of spaces HERA has identified in the course of this study.
Meeting the major scientific challenges of the present and the future will require interdisciplinary approaches. … For the science departments in Arts & Sciences to play a central role in addressing these and other problems of the 21st century, it is essential that we strengthen existing structures and develop new ones to support interdisciplinary education and research.

Draft statement on an integrated science campus in Arts & Sciences at Washington University, Division of Natural Sciences and Mathematics department chairs, summer 2010
“... We need facilities to sustain the core disciplines while enabling new interdisciplinary research and teaching ... facilities that are flexible, to allow rapid adaptation to new areas of research and to encourage industrial partnering. ... Our vision for an integrated science campus is to provide the infrastructure and environment that fosters collaboration. ... Currently, departments are physically removed from each other, severely limiting the degree of spontaneous interaction. ... As the nature of research questions change, we need to have core facilities where large and expensive multi-user instruments will be housed to provide state-of-the-art, shared instrumentation in computation, imaging, molecular structure and genomics.” 

Barbara Schaal, Mary-Dell Chilton Distinguished Professor, Biology

“... At present, the plant biologists at Washington University are located in a set of seven interconnected buildings with good to excellent lab space. Unfortunately, the interconnectedness and layout of the buildings are not optimal. The opportunities for collaboration among the plant biologists and with other areas of the department are limited by the traditional layout of the labs and the distance between them. Biology is located across the campus from Chemistry, Physics, Math and Engineering. This limits collaborations between researchers who must combine forces to address the most important problems. ...” 

Kathy Miller, Professor and Chair, Biology

“... Washington University already has a strong investment in materials science ... many of these scientists and engineers are recognized as the best in the world. ... However, a lack of integration and breadth prevents Washington University from capitalizing on this investment. The faculty members are isolated in different buildings spread across all of the Danforth and Medical Campuses. ... Fundamental characterization equipment, such as wide and small angle x-ray diffraction facilities, differential thermal analysis, etc. is either lacking, incomplete, or isolated in individual research groups. ... Nanofabrication is at the heart of many of the advances in materials today. While Washington University has recently invested in the construction of several clean rooms, and while we have some expertise and lithographic equipment in the School of Engineering and Applied Science, we lack the broader facilities and expertise to turn these into truly productive nanofabrication centers. Finally, our PhD programs are not coordinated in a way that provides all of our students with an education in the core body of knowledge needed by all engaged in materials-related careers. ...” 

Ken Kelton, Arthur Holly Compton Professor of Arts & Sciences, Professor and Chair, Physics

“... In order to solve the vast environmental challenges before us, we need a deep understanding of science within disciplines and with interdisciplinary syntheses. This synthesis would be facilitated by shared space allowing both casual and structured interactions across disciplines. For instance, plant-soil interactions is an emerging field
of environmental science. This has become possible only recently with the development of new technologies. Washington University has distributed strengths in the chemical, physical and biological properties of plants and soils, but a common space would allow those fields to truly integrate. Shared space would allow faculty to share cutting-edge equipment for interdisciplinary studies, including mass spectrometry, chemical and stable isotope analyses and genomic facilities for microbial and plant studies. David Fike’s current proposal for a state-of-the-art secondary ion-mass spectrometer exemplifies this concept. If funded, this device would bring new analytical capabilities simply not available with any other instrument currently on campus (and only present at a few institutions, MIT and CalTech, for instance). This analytical technique for the isotopic and trace elemental characterization of soil samples can support core users from Physics, Earth and Planetary Sciences Biology, Engineering and Medicine. In addition, a new integrated science facility would also provide a clearinghouse for analyses of samples taken from the large-scale ecosystem-level research being conducted at Washington University’s Tyson Research Center, as well as other ecosystems both locally and globally.”  

**Tiffany Knight, Associate Professor, Biology**

“... work in astroparticle physics/space sciences might be divided into two areas. ... The first area (detector development) includes facilities with a number of requirements including: clean rooms, dark rooms (or labs with light-blocking shades), proper ventilation, high vacuum equipment, hoods, radiation shielding, RF isolation (e.g., a screen room or special electrical grounding), capacity for handling toxic or caustic chemicals, and good access to a local machine shop and electronics shop, distinct from the central shop. ... While these facilities might be shared within astrophysics and space sciences to a large extent, the requirements for dedicating equipment to specific materials systems (or in some cases samples returned from space) coupled with the strict requirements for delivering working detectors for NASA missions and other experiments makes it difficult to envision that these could be shared. ... For the second area (integration of components into large equipment) we require shared laboratories with large areas and high ceilings, and overhead cranes with good lift capacity (e.g., 10 tons or more). These areas often require direct access to a loading dock and garage doors. Access to machinists and some local equipment (often large milling machines in the high bay area) is also important. A single facility of this type could probably serve all of the physical sciences.”  

**James Buckley, Professor, Physics**

“Planetary Sciences, needs: (1) university support of shared analytical and research laboratory facilities, (2) shared space that fosters collaborative work in a more interdisciplinary way with colleagues in astrophysics and cosmochemistry who are now housed in Physics or on the fourth floor of Compton, and biologists for astrobiology and environmental scientists, (3) routine access to a state-of-the-art, theater-style room for colloquia, workshops and meetings, and perhaps a broader range (in size) of conference rooms. Presumably such facilities will be incorporated in one or more of the new buildings, e.g., Physics.”  

**Brad Jolliff, Scott Rudolph Professor in Earth and Planetary Sciences in Arts & Sciences**
3. ASSESSMENT

How Much and What Kind of Space Do We Have Now?

Today, the departments of Biology, Chemistry, Earth and Planetary Sciences, Physics, Mathematics and such interdisciplinary units as the Center for Materials Innovation and the McDonnell Center for the Space Sciences occupy over 800,000 gross square feet on the Danforth Campus. As shown in the “current” map above, the science departments (in blue) are disconnected, in separate buildings, some of which are in fair to deficient condition.

In 2006, Hastings and Chevetta produced a Master Plan Study for Arts & Sciences in which our buildings were rated qualitatively. This plan has served as a road map for ongoing renovations and investments. We have made a number of improvements since 2006, and in a recent update of the Hastings and Chevetta ratings, we estimate that 53% of the current space designated for the sciences is “excellent” or “good,” but over 80% of the space occupied by Physics is no better than “fair,” and for Chemistry, 20% is “deficient” and another 30% is “fair.” For all the sciences, issues of proximity, collaboration, integration, flexible labs and sufficient core labs and shared equipment abound.

The table on the following page provides detail on current space assigned to science departments, in both GSF and NASF, by use, and by condition.

Looking Ahead

Arts & Sciences’ plans, as presented to the Chancellor and the Provost, the Academic Planning Committee, the Faculty, the A&S National Council and the Buildings and Grounds Committee of the Board of Trustees call for an ambitious transformation of Arts & Sciences and a reorganization of the sciences, humanities and social sciences. (See the “future” map above. Dark blue buildings represent new structures in an integrated science campus.)
**Net assignable square feet (NASF)** is the sum of all areas on all floors of a building assigned to, or available to be assigned to, an occupant for a specific use, such as research or instruction.

NASF is measured from the inside faces of walls. (Definition from National Science Foundation, National Institutes of Health, FY 2009 Survey of Science and Engineering Research Facilities.)

**Gross square feet (GSF)** is the floor area of a structure within the outside faces of the exterior walls. (Definition from National Science Foundation, National Institutes of Health, FY 2009 Survey of Science and Engineering Research Facilities.)

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### NASF on Danforth Campus Assigned to Science Departments

<table>
<thead>
<tr>
<th>Danforth Campus Building</th>
<th>Classrooms</th>
<th>Faculty Offices/ Administration</th>
<th>Greenhouse</th>
<th>Instructional Lab</th>
<th>Research Lab</th>
<th>Other</th>
<th>Total Sciences Departments</th>
<th>POIed Classrooms</th>
<th>POIed Other Departments</th>
<th>Grand Total</th>
<th>GSF**</th>
<th>NASF/GSF</th>
</tr>
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<tbody>
<tr>
<td>Cupples Hall I</td>
<td>1,077</td>
<td>12,693</td>
<td>746</td>
<td>2,851</td>
<td>17,367</td>
<td>4,603</td>
<td>1,971</td>
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<td>44,202</td>
<td>54%</td>
<td>100%</td>
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<tr>
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<td>2,719</td>
<td>12,111</td>
<td>2,402</td>
<td>18,352</td>
<td>3,181</td>
<td>3,333</td>
<td>24,866</td>
<td>39,915</td>
<td>62%</td>
<td>100%</td>
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<td></td>
<td>2,761</td>
<td>75</td>
<td>4,976</td>
<td></td>
<td></td>
<td>4,976</td>
<td>8,640</td>
<td>58%</td>
<td>100%</td>
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</tr>
<tr>
<td>Busch Lab</td>
<td>2,358</td>
<td></td>
<td>4,714</td>
<td></td>
<td>7,072</td>
<td></td>
<td></td>
<td>7,072</td>
<td>11,406</td>
<td>62%</td>
<td>100%</td>
<td></td>
</tr>
<tr>
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<td>14,755</td>
<td>11,525</td>
<td>42,484</td>
<td></td>
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<td>42,484</td>
<td>82,391</td>
<td>52%</td>
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<tr>
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<td>26</td>
<td>8,636</td>
<td>598</td>
<td>17,044</td>
<td>10,058</td>
<td>36,362</td>
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<td>36,362</td>
<td>57,052</td>
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</tr>
<tr>
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<td>4,778</td>
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<td>14,970</td>
<td>1,408</td>
<td>21,152</td>
<td></td>
<td></td>
<td>21,156</td>
<td>37,174</td>
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<tr>
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<td>691</td>
<td>1,321</td>
<td>3,747</td>
<td></td>
<td></td>
<td>7,693</td>
<td>24,176</td>
<td>32%</td>
<td>100%</td>
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<td>6,979</td>
<td>7,541</td>
<td>22,813</td>
<td>2,234</td>
<td></td>
<td>25,047</td>
<td>44,072</td>
<td>57%</td>
<td>100%</td>
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<tr>
<td>Crow Hall</td>
<td>1,283</td>
<td>5,319</td>
<td>7,232</td>
<td>7,558</td>
<td>25,474</td>
<td>4,591</td>
<td></td>
<td>30,065</td>
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<td>65%</td>
<td>50%</td>
<td>50%</td>
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<tr>
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<td>1,571</td>
<td></td>
<td>3,143</td>
<td>2,262</td>
<td>6,976</td>
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<td></td>
<td>6,976</td>
<td>10,506</td>
<td>66%</td>
<td>100%</td>
<td></td>
</tr>
<tr>
<td>Goldfarb Plant Growth Facility</td>
<td>59</td>
<td>231</td>
<td>7,232</td>
<td>2,755</td>
<td>10,277</td>
<td></td>
<td></td>
<td>10,277</td>
<td>14,822</td>
<td>69%</td>
<td>100%</td>
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<tr>
<td>Life Science Bldg.</td>
<td>318</td>
<td>3,298</td>
<td>949</td>
<td>7,321</td>
<td>11,886</td>
<td>704</td>
<td></td>
<td>12,590</td>
<td>20,152</td>
<td>62%</td>
<td>100%</td>
<td></td>
</tr>
<tr>
<td>McDonnell Hall (Hilltop)</td>
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<td>26,570</td>
<td>637</td>
<td>39,972</td>
<td>4,029</td>
<td></td>
<td>44,001</td>
<td>107,097</td>
<td>41%</td>
<td>100%</td>
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</tr>
<tr>
<td>Earth &amp; Planetary Sciences Bldg.</td>
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<td>3,050</td>
<td>37,863</td>
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<td>65,948</td>
<td>2,544</td>
<td>9,376</td>
<td>77,868</td>
<td>162,956</td>
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<tr>
<td>Laboratory Sciences Bldg.</td>
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<td>24,969</td>
<td>6,539</td>
<td>15,133</td>
<td>50,944</td>
<td>8,410</td>
<td></td>
<td>59,354</td>
<td>110,823</td>
<td>54%</td>
<td>100%</td>
<td></td>
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<tr>
<td>Wilson Hall</td>
<td>2,377</td>
<td></td>
<td>7,406</td>
<td>3,230</td>
<td>9,264</td>
<td></td>
<td></td>
<td>19,050</td>
<td>36,408</td>
<td>52%</td>
<td>100%</td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>6,879</strong></td>
<td><strong>105,525</strong></td>
<td><strong>7,232</strong></td>
<td><strong>43,939</strong></td>
<td><strong>159,761</strong></td>
<td><strong>69,876</strong></td>
<td><strong>393,212</strong></td>
<td><strong>435,778</strong></td>
<td><strong>858,059</strong></td>
<td><strong>53%</strong></td>
<td><strong>100%</strong></td>
<td>**</td>
</tr>
</tbody>
</table>

**Percent of Science Departments**

<table>
<thead>
<tr>
<th></th>
<th>Deficient</th>
<th>Fair</th>
<th>Good</th>
<th>Excellent</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Cupples Hall I</strong></td>
<td>2%</td>
<td></td>
<td></td>
<td>100%</td>
</tr>
<tr>
<td><strong>Louderman Hall</strong></td>
<td>27%</td>
<td></td>
<td></td>
<td>100%</td>
</tr>
<tr>
<td><strong>Radiochemistry Bldg.</strong></td>
<td>2%</td>
<td></td>
<td></td>
<td>100%</td>
</tr>
<tr>
<td><strong>Busch Lab</strong></td>
<td>2%</td>
<td></td>
<td></td>
<td>100%</td>
</tr>
<tr>
<td><strong>Compton Hall</strong></td>
<td>2%</td>
<td></td>
<td></td>
<td>100%</td>
</tr>
<tr>
<td><strong>McMillen Lab-Chemistry</strong></td>
<td>11%</td>
<td></td>
<td></td>
<td>100%</td>
</tr>
<tr>
<td><strong>Monsanto Lab Bldg.</strong></td>
<td>41%</td>
<td></td>
<td></td>
<td>100%</td>
</tr>
<tr>
<td><strong>Power Plant-Hilltop</strong></td>
<td>4%</td>
<td>100%</td>
<td></td>
<td>100%</td>
</tr>
<tr>
<td><strong>Rebstock Hall</strong></td>
<td>2%</td>
<td></td>
<td></td>
<td>100%</td>
</tr>
<tr>
<td><strong>Crow Hall</strong></td>
<td>50%</td>
<td></td>
<td>50%</td>
<td>100%</td>
</tr>
<tr>
<td><strong>Cyclotron Bldg-Hilltop</strong></td>
<td>18%</td>
<td></td>
<td></td>
<td>100%</td>
</tr>
<tr>
<td><strong>Goldfarb Plant Growth Facility</strong></td>
<td>6%</td>
<td>100%</td>
<td></td>
<td>100%</td>
</tr>
<tr>
<td><strong>Life Science Bldg.</strong></td>
<td>12%</td>
<td></td>
<td></td>
<td>100%</td>
</tr>
<tr>
<td><strong>McDonnell Hall (Hilltop)</strong></td>
<td>34%</td>
<td></td>
<td></td>
<td>100%</td>
</tr>
<tr>
<td><strong>Earth &amp; Planetary Sciences Bldg.</strong></td>
<td>16%</td>
<td></td>
<td></td>
<td>100%</td>
</tr>
<tr>
<td><strong>Laboratory Sciences Bldg.</strong></td>
<td>38%</td>
<td></td>
<td></td>
<td>100%</td>
</tr>
<tr>
<td><strong>Wilson Hall</strong></td>
<td>38%</td>
<td></td>
<td></td>
<td>100%</td>
</tr>
</tbody>
</table>

**Condition*** of Danforth Campus Building NASF

- Deficient
- Fair
- Good
- Excellent

---

* Net assignable square feet (NASF) is the sum of all areas on all floors of a building assigned to, or available to be assigned to, an occupant for a specific use, such as research or instruction. NASF is measured from the inside faces of walls. (Definition from National Science Foundation, National Institutes of Health, FY 2009 Survey of Science and Engineering Research Facilities.)

** Gross square feet (GSF) is the floor area of a structure within the outside faces of the exterior walls. (Definition from National Science Foundation, National Institutes of Health, FY 2009 Survey of Science and Engineering Research Facilities.)

*** Based on Hastings & Chivetta (2006), updated through 2011 with recent Arts & Sciences estimates.
Where Might We Start?
It is obvious that a plan of such scale must be incremental, carefully phased over time. One of the most important decisions is where to begin. What should the first building be? How large a space? Who will occupy it? Where should it be? How can it be transformative and a catalyst for the entire vision for the Danforth Campus of the future?

The identification of specific areas as academic priorities, our internal assessment and the subsequent benchmarking study suggest the following starting point for greatest impact. Two of these areas (Evolutionary Biology and Plant Biology) are top-performing programs that suffer from nonadjacent space. The third area, Material Sciences, is poised for excellence but requires more formal structure and organization, and new space where faculty from Arts & Sciences, Engineering and Medicine can work together. More specifically:

**Evolutionary Biology** is one of our great strengths. But our faculty are small in number and aging. The seven faculty members making up the core group include two new faculty members who arrived this summer. The median age of the group, including our new hires, is 57. Only one faculty member is below 50, while two are 64. If we are to maintain our top standing in Evolutionary Biology, we will need to replenish the faculty with younger scientists. These recruits are likely to expect new research space, along the lines we have articulated. They will require easy collaborations and interactions not only with colleagues in Biology but with those in Chemistry, Physics, Medicine and Engineering and with the Missouri Botanical Garden. They will require modern research facilities and equipment. They will be offered these opportunities by competing institutions.

**Plant Biology** is another important strength at Washington University. Two features stand out, each requiring a rethinking of research space as we plan for the future. First, highly interdisciplinary work, as exemplified by Professor Robert Blankenship, the Lucille P. Markey Distinguished Professor in Arts & Sciences, is likely to be more the norm than the exception. Jointly appointed in Biology and Chemistry, with a secondary appointment in Biochemistry and Molecular Biophysics at the School of Medicine, Professor Blankenship directs an ambitious and successful research program that investigates how light is converted into energy via the process of photosynthesis. Second, we have a number of resources in the area of Plant Biology in the St. Louis region that complement and enhance the environment for plant biology research. One, the Donald Danforth Plant Science Center (DDPSC), is a research institute devoted to enhancing agriculture and biofuels production. The DDPSC contributes world-class research teams, who share knowledge and expertise. This relationship is one that will contribute to our quest for continued and increased excellence and prominence in this field. A second, Monsanto, with world headquarters in St. Louis, presents opportunities for corporate partnerships. New facilities for Plant Biology should be designed to foster collaboration across disciplines and with such regional resources...
to help our faculty compete for research funding as we explore fundamental questions and problems relevant to agriculture, energy production, climate change and other important societal issues.

Materials Science is a different story, one of opportunity yet to be fulfilled, but within reach. Over 50 (34 FTE) faculty members in Arts & Sciences, Engineering and Medicine are working in Materials Science. We estimate approximately 190 PhD students are involved in this work. Unlike Materials Science departments at Northwestern and MIT, at Washington University all of this activity is without a formal organization, without a doctoral-degree program specifically in Materials Science. With greater organization of these considerable, though disjointed, resources, and with an investment in infrastructure for this purpose, we have before us the opportunity for excellence in this important, cross-cutting field. A recently completed review of the Center for Materials Innovation (CMI) paves the way for improvements along these lines.

For these reasons, we propose the first building start with these areas.

A Rough Model

From our benchmarking work we determined the NASF for our research areas. Evolutionary Biology has 54,617 NASF, Plant Biology has 56,173 NASF, and Material Sciences occupies 18,545 NASF (counting only space in Arts & Sciences). The total for these three is 129,335 NASF.

If we were to add 10,000 NASF for a new shared space, and another 5,000 NASF for a large (350-500 seat) auditorium/lecture hall, the total increases to 144,335 NASF.

If we assume that NASF amounts to 55% of the building space required, such a building would require 262,427 in gross square feet (GSF).

It is no coincidence that a building of this scale is precisely what institutions with which we compete have developed. Specifically, from our case studies analysis:

- The Eckhardt Research Center at the University of Chicago is 256,036 GSF;
- Stanford’s Clark Center is 245,000 GSF;
- The French Family Science Center at Duke is 280,000 GSF.

A structure of this scale and with features similar to those we have described would enable Evolutionary Biology, Plant Biology and Materials Science to work in close contact with chemists, physicists, engineers and faculty in the medical school. It would
also provide important opportunities for future growth. Indirect, though important benefits accrue in such a first phase. These include the opportunity to move Anthropology to McDonnell Hall and to identify new swing space for future needs as Biology faculty are realigned.

Phase II would focus on Astrophysics (in need of new, improved space) and Planetary Sciences (in excellent space but requiring more efficient adjacencies), and new space for the rest of Physics and for the Math department.

Phase III would complete the plan for the sciences, with new space for Environmental Science, the rest of Chemistry and the rest of Biology. Along the way, as these moves are made, space would free up for the most overcrowded humanities departments. Our plan calls for English to move to Cupples I when Math moves into new space in the science campus; for German to move into former English space in Duncker; and for Music to come from across the street to new quarters in Rebstock (former Biology space).

A new research building for Evolutionary Biology, Plant Biology and Materials Science:

- Builds on current and future, attainable strengths;
- Requires a new way of operating and organizing academic activities – a more research-driven than department-centric approach;
- Will enable us to recruit the kind of faculty necessary for a high-impact research agenda;
- Will allow us to retain our best faculty;
- Can provide the impetus for the formation of exciting new graduate programs;
- And provide the way for new modes of intra-school collaboration with the Schools of Engineering and Medicine.

The building we envision will itself be transformative and will serve as the catalyst for further changes that will solidify Washington University’s presence among the great universities of the 21st century.

At this stage, we should be flexible and creative in our thinking. Other options for the first building and the phasing of this long-term undertaking, on a scale greater than any since the Danforth Campus was first designed, will surely arise as we go forward.
Appendix

- Faculty Work Groups and other Contributors
- Complete Benchmarking Tables
- Regression Analysis on Faculty, Space, Research Expenditures
- NRC analysis
- Selected Highlights: Departmental Reviews
- Comparative Analysis of Key Trends: Chemistry at Stanford
- A&S Tenured/Tenure-Track Faculty Head Count 2008-09 and Selected Peers
- Summary of Restricted Expenditures from Grant and Contracts FY05-10
- Comparative Analysis: WU Science Departments vs. Peers Research Expenditures (three-year moving average) 2000-2010
  - Biological Sciences
  - Chemistry
  - Earth Science
  - Physics
- Facilities Condition Analysis
- Trends and Concepts Worth Considering — HERA

http://benchmarking.artsci.wustl.edu
username: report
password: benchmarking11
FACULTY WORK GROUPS AND OTHER CONTRIBUTORS

**Evolutionary Biology**
James Cheverud, Professor of Anatomy, School of Medicine
Barbara Schaal, Mary-Dell Chilton Distinguished Professor in Arts & Sciences
Alan Templeton, Charles Rebstock Professor of Biology

**Plant Biology**
Robert Blankenship, Markey Distinguished Professor in Arts & Sciences
Joseph Jez, Associate Professor of Biology
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