Report of the
University Boulevard and Main Street
Faculty Committee
May 1, 2003

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Executive Summary

Scientific initiatives of the 21st century will focus on understanding how biological systems function and using this information to ameliorate human disease. The convergence of interests from physical and computational sciences and engineering into the biological realm requires developing completely novel ways to do science and technology. The advances in diverse fields ranging from cellular and molecular biology to engineering and nanoscale science will transform our understanding of fundamental life processes and revolutionize medical science with a direct impact on education of our students, our health, the economy, and the future of mankind.

We are at a critical juncture both at Rice University and in the development of modern science. Rice University is uniquely positioned to assume a leadership role in creating and disseminating research at the interface of biology, medicine, and engineering. Success in this endeavor would provide Rice an unparalleled level of national and international recognition, significantly enhancing our ability to attract top faculty and students. Why is Rice particularly well qualified to lead this multidisciplinary research? Four characteristics stand out. First, no other university in the world can claim direct access to the world's largest medical center. Moreover, Rice and the Texas Medical Center (TMC) already have a long history of productive collaboration, providing a strong foundation for more extensive educational and research interactions. Second, Rice's strategic investments over the past decade in the areas of biological sciences, biotechnology, nanoscale science, information technology, and environmental sciences have developed a critical mass of faculty in complementary research areas crucial to success. In recognizing these areas at an early stage, Rice has a significant advantage over many of its competitors on the East and West Coasts. Indeed, we have already been a major force in developing the interactions on which future endeavors can build (for example, Gulf Coast Consortia). In addition, in cutting edge research fields, including both nanoscale science and bioengineering, Rice has the legitimate opportunity to be recognized not as a leading institution but as *the* leading institution in the country, perhaps the world. Such recognition benefits not only the individual areas but also all of Rice. Third, unlike so many other research universities that preserve nearly inviolable disciplinary boundaries, Rice maintains an environment which, by design, fosters interdisciplinary and inter-institutional research and educational efforts. A truly major interdisciplinary initiative will be highly likely to succeed at Rice. Finally, Rice's strength in the humanities and social sciences provides an important opportunity to critically assess the societal impact of new technologies and related ethical issues from a variety of perspectives. This opportunity does not exist for many competing initiatives based on combining only medical and engineering research.

For Rice to achieve its true potential in biological research, contiguous research and teaching spaces *are essential* to allow the level of communication and types of interaction required to promote projects that would otherwise languish. Success requires placing students, biological and physical scientists, engineers, and clinicians in facilities strategically designed to promote multidisciplinary interactions. Such facilities would

serve not only as a bridge between Rice and the Texas Medical Center but more largely as a bridge between Rice and the outside world. Ideally, the facility would bring together researchers from multiple institutions, industrial collaborators, Rice students, and the Houston community to promote synergistic interactions at a myriad of levels. This facility would be the anchor for the proposed master plan for Rice's next fifty years providing the southern basis of new academic building development and becoming the focal point for the university's face to the world.

Rice is widely recognized for its willingness to undertake significant new interdisciplinary research initiatives—initiatives that have yielded some of Rice's greatest achievements. The University and Main facility would be without doubt the most ambitious interdisciplinary research undertaking in the history of Rice. This project also offers most significant possibilities—the possibility for Rice to be recognized for creating some of the most exciting research advances of the next decades, the possibility for Rice to be known as *the* leading institution for multidisciplinary research, the possibility for Rice to significantly enhance its ability to recruit top faculty and students, the possibility for Rice to achieve a new level of excellence in the 21st century.

The Committee chartered by the Provost in June of 2002 to consider possible development of the property at University Boulevard and Main Street at the southern vertex of the campus strongly endorses further serious consideration of this project. Enhancements of current interactions, both educational and in research, and creation of new collaborations not yet conceived will be enabled by this building—with space to attract new people, ideas, and funding to take advantage of a modern facility with educational, laboratory, office administrative, and support functions designed for the future. This building could include a conference center, classrooms and small conference rooms, various support facilities, possible space for Continuing Studies, a quality bookstore, food facilities, amenities for support of students and the community, and ample parking. This joint educational and research center will focus on the intersection of life sciences and biomedicine, connecting work in the biological and physical sciences, computation, engineering, biotechnology, and nanoscale science as well as many humanities and social science programs and initiatives from the Jones School and the Baker Institute. Rice University already has more than seventy individual collaborations that span the departments and programs at Rice with the TMC as well as major organizational collaborations. These efforts face geographical challenges and would be enhanced by this focused facility. The collection of 42 organizations, 60,000 employees, and approximately 30,000 physicians and researchers in the TMC provides multiple opportunities for new and exciting initiatives. Bold proposals for interdisciplinary research and education programs are being sought by funding agencies and foundations, and this facility will be the catalyst for Rice to be the leader in such endeavors.

The Committee identified a significant number of potential Rice occupants of this facility as summarized in this report. The actual programs and facilities to be housed will require an on-going evaluation beyond the scope of this group and will need input from partners in the Texas Medical Center and other entities. Some basic parameters for occupancy were developed: a need for proximity to the medical center, ability to build new

communities at that site, and programs of an interactive nature. Given current Rice research space of approximately 400,000 square feet, the new building must be at least 200,000 net square feet of research space in order to realize a significant increase in research activity and income and to provide sufficient space for the enterprise envisioned. In addition, a similar amount of space will be needed for the other proposed activities. A major benefit of this expansion is that other space on campus will be made available for enhancement of all Rice programs. A key consequence of this facility is that the amount of indirect costs should significantly increase as funding from the National Institutes of Health along with other agencies will provide a significant proportion of the support for this effort. Rice already receives about one-quarter of its external research funding in biological areas, and the endeavors that would be facilitated by the University/Main building would be anticipated to significantly enhance this fraction. The bold step of developing University/Main into a dynamic research center provides a unique opportunity for Rice University and its surrounding community—without this step we risk remaining a second tier research university. As Winston Churchill said in 1943, “We shape our buildings, and afterwards our buildings shape us.” This facility at the intersection of University Boulevard and Main Street will be a transforming event for Rice University. Furthermore, the bold step of developing University/Main into a dynamic research center provides a unique opportunity for Rice University and its surrounding community—without this step we risk remaining a second tier research university. This faculty committee strongly endorses this project, and recommends highly that the university proceed with further planning.

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Introduction

Charge to the Committee

- Develop the intellectual rationale for a new facility at the south end of the campus—the "University and Main Streets" building.
    - A new building is not only a physical or financial asset, it is an ***intellectual*** asset, which for a university, is a much longer-valued intangible. Can we develop a shared vision for this facility?

- Determine how Rice could occupy the space, physically and intellectually, along with possible collaborators from the TMC and elsewhere.
    - How will the ***faculty*** make use of the space? List the current and possible future collaborations that would be appropriate in a new facility at this location. What other occupants can be foreseen?

- Examine the possible benefits as well as the pitfalls, and look closely at how each component could work.
    - What is the value in galvanizing outside interest in Rice University and our research activities? What can be done in this facility that can't be done elsewhere? Would the movement of a significant fraction of research and people to this corner of the campus produce a strong negative impact on our culture? How could this work?

Summary of Deliberations

The University & Main project is complex, spanning many departments within and outside Rice. Due to the complexity, the definition of the purpose of U&M needs to evolve over time and with many more parameters than currently available. However, the U&M project would be a transforming event for the university that could move Rice to the next level among research universities. The facility would establish Rice as a leader in integrated research, particularly in biological and medically related technology. Based on collaborations at other universities such as Stanford and the University of Illinois at Urbana-Champaign it is clear that most major future research and educational initiatives will require integration of many disciplines. Rice has already established various research-focused institutes on campus so an intellectual paradigm shift is not required for this initiative. In addition, the potential to provide the cornerstone for a new campus plan and develop significant ties to the community are all attractive aspects of this proposal. The committee has defined many possible occupants and agreed there are many attributes in the role the facility could assume for the university, the Main Street community including the Texas Medical Center, the Greater Houston area, and the world.

Dr. Malcolm Gillis, President Rice University, outlined the following existing relationships between Rice and TMC (http://www.ruf.rice.edu/~opa/tmc/index.html):

- In 1964 researchers from Rice worked with Dr. Michael E. DeBakey of Baylor College of Medicine to develop an implantable artificial heart. Those efforts continued into 90 productive partnerships in education, research, and outreach.
- Almost all of Rice's academic divisions and several of centers, institutes, and offices are involved with 20 institutions at TMC.
- The Center for Neuroscience, a joint undergraduate/graduate program with Baylor, was established to explore the neural basis of human behavior.
- The Houston Area Molecular Biophysics Predoctoral Training Program is a collaborative graduate program involving biophysics faculty from four major universities to offer advanced course work in molecular biophysics, structural biology, and other areas of biomedical research.

The combination of TMC and Rice will break new ground in bio-related fields, propelling Rice's research efforts into a nationally-recognized program. In order for the project to be successful the entire Rice community will need to share in the vision. To accomplish this goal the next phase of analysis will need to be diverse, including support from the faculty, administration, and staff. The U&M facility has the potential to be a major unifying part of the south campus and a significant signal to the outside world that Rice is reaching out to the world.

Building Design

Since the impact of the U&M project is so large, it was a difficult task to define the physical size of the building and the occupants it would contain. Yet, the facility would serve many constituencies in a manner that promotes interactions and collaboration. On the current Rice campus there are few areas that promote communities (communities defined as interactive groups which provide for the needs of members of each group and afford continual mixing or expansion). The residential colleges certainly are the major focus for undergraduate communities at Rice but academic space and facilities do not exist that fulfill this need. The student center provides some social space, Duncan Hall was designed to provide some interactive space for faculty and students, and the library provides study space. But there is not one central location where faculty, students, staff, and other interested individuals can interact easily in a meaningful way. The U&M facility would provide a collaborative space for all of the individuals to interact on an intellectual level. It would require a mix of amenities: bookstore, coffee house, casual restaurant(s), formal and informal meeting spaces, various retail services, state-of-the-art electronic access, access to the rest of campus by shuttle service and new sidewalks, and parking. It should be designed for easy access from the TMC and the new light rail station. There are many possibilities for building design and further investigation into architecture firms should be reviewed.

Significant buildings like this joint research center need to present a welcoming and inviting face to the public. Examples of this public face may include fundraising and social functions, but will even more likely be structured as opportunities to gather and build the intellectual community, to create opportunities for open discussion and generate excitement for the work. For example, Biogen in Cambridge, MA opened a 1,110 sq. ft. teaching facility. The Community Laboratory was designed to serve public school students. The space is within one Biogen's R&D buildings and is outfitted with the latest equipment and technology. In 2002 50 Cambridge 11^{th} and 12^{th} grade students enrolled in two one-week sessions on molecular genetics. While the facility will need to be inviting to the public, it must also be secure. Sensitive research and valuable equipment will require security within certain parts of the building to be high.

More than any other single characteristic, the spaces within the building must be an asset to the research. Collaborative space must provide an environment that allows the investigators to pursue the must important questions and most critical research. The facility will have to grow with the demanding and varying needs of research. The laboratory space must be modular and flexible. The infrastructure must be easily accessible and easily modified. The difficulties and expense of modifying a lab must be minimized.

The goal of the U&M building is to provide a space where research is nurtured and encouraged. The facility will require a variety of attributes ranging from laboratory space to social areas. The perception by the public must be accessible and accepting. A well designed facility will serve the goals of the researchers and public.

Size

The size of the facility will have to aid research space but not hinder interactions and isolate groups in a remote facility. The importance of collaboration and multi-institutional interactions should be the significant factor in making the decisions concerning space. Issues concerning how to divide space between Rice and TMC will have to be addressed in the future. Providing a sense of community should guide the design of space allocations. Development of the plan for the facility should carefully consider how to organize around central common areas that could act as town squares allowing interactions to develop naturally.

The need for significant new interactive space requires this facility to be of sufficient size to support the program that is developed. In the discussions concerning the specifics of the facility, the issue of whether it should be more than one building spanning University was discussed, but that level of detail was left for further deliberations. It may be easier to place some research intensive, equipment specific space in a separate building. It was felt that to have a major impact the facility should provide at least a 50% increase in assignable research space. Given that currently about 400,000 square feet are available this would suggest at least 200,000 square feet be provided for enhancement of Rice research. Collaborative space would require a significant amount of additional space. A conference center, classrooms, conference rooms, retail and food establishments would all require significant space as well as facilities and engineering support.

The impact of this newly available space on the rest of the campus would be very significant. Further deliberations to discuss how to assign vacated space on campus will need to be addressed to avoid future ramifications.

Facility Occupants

A new state-of-the-art research center will be very appealing to many departments and centers at Rice as well as TMC. The two major concerns included the effect of being separated from the rest of the campus at that site and Rice staffing. Some groups were very interested in having new, increased space regardless of the need to be closer to the medical center. Others were quite concerned about division of programs, departments, or schools. The issue of whether to place programs that currently have significant interactions with the medical center versus programs that one could envision as being capable of developing new interactions was also examined. No clear definition of criteria evolved, but it would be difficult to develop *de novo* interactions in all cases. The committee began the discussion of logical occupants for the facility which include some of the following:

- The Bioengineering Department is the prototypical group that currently has extensive interactions with the medical center, industry, and other organizations. It would also benefit greatly with better access and more integrated facilities with medical center programs. The department has many joint and adjunct faculty, a

number of MD/PhD students from the medical schools who pursue their PhD in bioengineering, and significant joint grants and programs. The interactions with other engineering departments and nanotechnology efforts at Rice would provide a basis for expansion of those efforts into this facility. There is concern about moving the program away from the other engineering departments, but that deficit would be generally outweighed by the enhanced interactions and research efforts that would develop.

- Biochemistry & Cell Biology also has many interactions with the medical center. A number of joint grants exist, several faculty members have joint appointments in the medical schools, and there is strong interest across the department in enhanced interactions with the medical center.
- Development of the various Gulf Coast Consortia would be significantly enhanced with a central location, which could provide meeting space, specialized shared instrumentation facilities, and other support for these programs. This effort has become an international prototype for inter-institutional collaborative research and education and is the major unifying effort among the area research institutions.
- The Institute for Biosciences and Bioengineering (IBB) has existed since 1986 and functions to provide cross-disciplinary educational and research programs in bioscience and bioengineering. Again, it is a recognized model for integration of science and engineering research and education activities and is experienced in promoting such efforts. The various laboratories that would benefit under the institute umbrella include the Center for Excellence in Tissue Engineering and the Center for Plant Science. A number of new groups are developing based on interdisciplinary research efforts in science and engineering including the Rice Bioinformatics Group (joint with CITI), and a number of newly proposed centers such as the Center for Biocomplexity and Biosystems Engineering and the Center for Analysis and Modeling of Metabolic Pathways. These programs would be a significant basis for expanding joint efforts, possibly leading to new initiatives under the Gulf Coast Consortia. Under the proposal most faculty associated with the IBB would be housed in this facility. A number of other groups including a membrane program, biophysics efforts, and others may be part of IBB or other entities associated with the facility.
- A bookstore, coffee house, restaurants, and various retail groups would provide a basis for building community relations, particularly with faculty, students, TMC, and other Houston groups. How extensive these activities will be will require a more intensive discussion.
- A major component of the facility should be to support education and interaction through conferences and learning centers. A significant portion of Rice courses could be offered in the building. The location is closer to many of the colleges than current classrooms and efficient shuttle service would provide easy access. Many graduate level courses are taken jointly by students from Rice and TMC, making this location ideal. A number of the joint training programs under the Gulf Coast Consortia utilize these courses currently. We envision establishment of a learning center with classrooms, conference rooms, and facilities for conferences. There are not sufficient facilities for conferences either at Rice or in TMC and

establishment of space that would allow conferences with up to 1000 or so participants would be a significant step in developing interactions with the community. The proximity to the light rail stop would be an important part of the conference development.

- The Continuing Studies program represents a major community outreach activity. Access to parking and the light rail would be a significant benefit for the programs. Sharing teaching spaces with this group could maximize the use of classrooms and other facilities.
- CBEN would benefit significantly from the ability to expand interactions further into the biological arena.
- Many other departments would have some of their activities in this facility even if their faculty were not housed in the building. Examples include statistics (which has significant joint efforts in the medical center), computer science, and applied mathematics, for example. The ethics programs, Baker Institute programs, and various efforts from the Jones School would benefit greatly with interactions at this site.

Collaborative Research

Development of collaborative research initiatives would be the hallmark of this facility. The committee discussed many possibilities summarized in the appendices to this document, and many more will emerge as further discussions with potential partners proceed.

Industrial Research and Development

A major limitation in the development of a viable biotechnology industry in Texas has been the lack of major pharmaceutical partners who could provide a focus for new efforts in drug or related developments. The recent partnership between Novartis and MIT is an example of this type of interaction (http://www.sciencemag.org/cgi/content/full/299/5605/330). Novartis, facing a slumping economy, is moving to old-fashioned contracts with individual scientists or making research deals with small companies. However, many big agreements are still in effect and MIT alone has partnerships valued at $173 million. The possible connecting of this facility with efforts like BioHouston need to be considered, and the role of industry, startup, and incubator facilities in the development and long-term operation of the facility will need to be explored carefully.

Management

How to manage the facility is a topic that will require careful consideration as the project develops and was not fully resolved by the committee. Rice should have a unit that oversees the day-to-day operation of the facility. The IBB is an option since it has experience in grant management, program development, purchasing, and scheduling that will be necessary for the facility. It is clear that an organization with the goals of IBB or a new entity would be appropriate for this.

Infrastructure Considerations

As the concepts for a new facility at the corner of University and Main develop, certain infrastructure and staff support matters are important to consider during the early stages of the planning process. Infrastructure must be mapped onto the design criteria in support of the program. Although the term infrastructure encompasses a board range of program and design elements, three issues need consideration.

- Redundant supply feeds from the public utilities are important parts to service quality and reliability, particularly in research facilities. Specifically, the U&M facility could benefit from service provided by two electrical power substations, as is the case for many of the Texas Medical Center institutions. Since providing redundant public utility service often has a long lead-time, it is valuable to execute this initiative early in the planning process.
- University founders showed both vision and wisdom when the Rice Central Plant was built some distance away from the first building, Lovett Hall, in anticipation of future growth and to realize economies of scale. Presuming the U&M facility is developed as envisioned in the master plan, a second central plant affords the same opportunities and advantages for providing new utility services. Besides the economy of scale benefits, this infrastructure offers a more environmentally and architecturally desirable campus.
- Rather than be driven by the existing staff structure on the main campus, considering alternative methods for support services for south campus development may be customized to best fit the specific program needs. Regardless of whether contractor leveraged or “in-sourced,” these services are most efficient and responsive with the means of on site facility spaces. Hence, space allocation for maintenance, operators, custodial, and grounds services could maximize building services as well as become the genesis for a south campus service center.

Conclusion

Despite the fact the University and Main project is still in early discussions, it is abundantly clear the benefits of such a facility outweigh the risks. Rice would benefit from a research perspective as well as from a community–relations perspective. Rice has an opportunity to embrace its immediate vicinity to TMC, and it is important to welcome that opportunity before it is seized by another institution or industry.

Summary of the Types of Occupancies
(From Ideas in Appendix 6)

Current Departments/Labs/Groups:

- Bioengineering Department
- Biochemistry and Cell Biology
- Biophysics Research Group
- Biostatistics Research Group

Current Collaborations:

- Institute of Biosciences and Bioengineering
- Center for Biological and Environmental Nanotechnology
- NASA/National Space Biomedical Research Institute
- Gulf Coast Consortia
- Center for Excellence in Tissue Engineering
- Center for Neuroscience
- Institute for Nanoscale Science and Technology
- Nano-Energy Center
- Texas/United Kingdom Collaborative Research Initiative

New Collaborations:

- Center for Biomembrane Research/Gulf Coast Consortium for Biomembranes
- Visualization Center
- Howard Hughes Medical Institute
- Bio Ethics
- Joint Institute with TMC
- Biophotonics
- The Gates Center for Nanotechnology and Global Development
- Toxicology Nano Center
- Plant Science Center
- Institute for Computational Mathematics in Biology and Medicine
- Texas Heart Institute-Rice Center for Nano Research on Vulnerable Plaque
- Center for Fullerene Bionanoconjugate Research
- Texas Nano-Vivo Center
- Institute for Molecular Medicine-Rice Center for Nano-Bio Research

Support Facilities:

- SEA
- Animal Facility
- Genomics, Proteomics, and Metabolics

Services:

- Bookstore/Coffee Shop
- Restaurant
- Cafeteria
- Student Health Center
- Library/Access Point
- Transportation Center (Walk, Segway, Bike, Rail, Shuttle, Bus)
- Retail

Educational, Meeting Space, and Administrative

- Learning Center
- Conference Center
- Administrative Space
- Visiting Institute
- Incubator Space/Pharmaceutical

Recommendations

The committee has consensus agreement that the building of a major new facility at the south end of the campus has significant intellectual merit. It is much more than a building, a physical and financial asset for Rice University—it is a gateway for potentially vast expansion of the university's impact on humanity. This collaborative facility will enable Rice and our collaborative researchers to literally cure cancer, to stop heart attacks, to diagnose disease earlier, and to replace worn-out or injured tissue and organs. These miracles will occur through expanding the vistas of collaborative research among much of the Rice faculty, and enabling facile collaborations bridging Rice to the Texas Medical Center and many other external activities. Much of the research needed to perform these miracles is already occurring at Rice and with TMC. For example, nanoparticles are being used in cancer therapy. Jennifer West, Naomi Halas, and John Hazle have taken advantage of the fact that near infrared light, specifically between 800-1300 nm, penetrates deeply into tissue due to the lack of absorption of these wavelengths by tissue chromophores or water. The tissue can be irradiated externally or through fiber optic systems, and light passing through normal tissue will not induce damage. However, when this light interacts with nanoshells within the tumor tissue, which are easily linked to specific antibodies for the cancer, it is absorbed by the particles and converted to heat. Heating the cancerous tissue above 55 ºC results in destruction of the tumor, while the localization of the nanoshells minimizes damage to surrounding normal tissues. Cancer therapy is not the only area showing promise in research development.

For many years doctors believed that heart attacks were caused by the buildup of fatty plaque within an artery, decreasing the amount of oxygen-rich blood to the heart. Now researchers believe that more than half of all heart attacks are not caused by the build up of the fatty plaque, but rather by an inflammation caused by vulnerable plaque. Researchers such as Dr. Morteza Naghavi, Dr. James Willerson, and Dr. Ward Casscells, in conjunction with CNST members Smalley, Hauge, Billups, and Weisman are working to identify ways vulnerable plaque can be detected and how heart attacks can be prevented through the detection of vulnerable plaque.

Like the advances in heart disease, tissue engineering research is showing great promise. At Rice University, Antonios Mikos along with Dr. Michael Miller and Dr. Alan Yasko from M.D. Anderson Cancer Center have been developing a degradable, polymeric composite biomaterial for treating skeletal defects with guided bone regenerations. The research goals include making the biomaterial moldable, able to harden in a short time period, to have the same mechanical properties of the bone it is replacing, degradable, replaceable by new bone, and maintain a specified mechanical strength during the period of degradation and new bone growth. This research is important since there is a renewed concern for the safety of nondegradable implants in the human body.

Medical procedures are often invasive and expensive, but at Rice faculty members are exploring new ways to design these procedures. Dr. Rebekah Drezek has been focusing her research on the development of optical imaging technologies for in vivo assessment

of tissue pathology. Her projects emphasize design, prototyping, and clinical testing of optical tools for the detection, diagnosis, and monitoring of the molecular signatures of precancerous conditions and early malignancies. Emerging photonics provide the opportunity to see subtle biophysical changes in tissue to provide real-time, minimally invasive detection and diagnosis of disease that is not possible through current histopathologic analysis.

It is at the boundaries of our conventional academic disciplines that breakthrough discoveries will occur, most certainly in biology, medicine, and nanotechnology, and probably extending throughout science and engineering. A facility designed for fostering close contacts among diverse intellects will be the catalyst that is today present only in scattered parts of Rice. This vision has driven the committee, and will ultimately drive the Rice faculty at large. The idea is so compelling it merits examination throughout Rice University, and we trust that it will become the shared vision of Rice University.

The first recommendation is that the Provost should aggressively pursue approval of the concept with the President and the Board of Trustees, because of its high intrinsic merit.

The committee has identified the principal categories of activities which this proposed facility will enable. The committee found significant rationale for movement of entire departments into the facility, and for movement of research groups and clusters of research groups smaller than departments into the facility. Also identified were current active collaborations already existent with the Texas Medical Center and elsewhere that would benefit from location at the University and Main site. Even more significant are numerous new collaborations that could expand greatly the scope of research at Rice and, we think, at the Texas Medical Center and beyond. Including an infrastructure with various services, both for research and for education, would greatly enhance the ability for Rice and the TMC to attract people as well as funding. The possible extension of the facility to accommodate commercial entities, both entrepreneurial and industrial (especially large pharma), adds a dimension that is now missing at Rice. These potential occupancies are listed in detail in this report, but many more are possible, especially over the period of a few years while planning and construction are underway.

The second recommendation is that the Provost should commission a further study, to include possible partners from the TMC and elsewhere, to both expand and prioritize potential occupants of the facility, and to place a timeline on the feasibility of establishing each of these occupants.

The committee has examined the benefits and the pitfalls of this proposed new facility. The benefits are significant and numerous, as detailed in the deliberations section, primarily focused on greatly expanded collaborative research both inside and outside Rice. There is simply no way a piecemeal approach can accomplish the expansion of Rice research that will allow us to participate, much less, lead the burgeoning bio-nano revolution. Rice would benefit substantially from expanded research funding, from expanded research faculty and students, and from enhanced infrastructure, and the value-

added to Rice's reputation as a major research institution will also enhance our ability to attract the top undergraduates, which will facilitate maintaining our top rankings nationally and internationally. The facility will also be a magnet for support from the biotech community, as well as other donors who are attracted to research that solves medical problems. A serious challenge Rice may face would be potential polarization of the campus, which could be mitigated by facile transportation modes and by hosting classes and events at U&M to ensure regular usage by all the Rice community. Another pitfall might be the organizational infrastructure issues of managing and sustaining a mixed occupancy facility "owned" by Rice University. The committee feels strongly that the benefits significantly outweigh the pitfalls. If Rice does not invest in this opportunity, we doom ourselves to back-row seats for the research and technology show of the century, and we will lose the significant, intangible value of that small piece of property at the corner of University Boulevard and Main Street.

The third recommendation is that the Provost should commission funded studies of the architecture of collaborative spaces, especially high-rise laboratories. Green architecture should also be considered. The committee has listed comparative facilities in the appendices.

Appendix 1
The Rice University Vision and Culture

Through the years Rice has striven to keep the standards and quality of research, faculty, and undergraduates superior. Taking direction from this standard, the U&M Committee examined the vision and goals of the university in broad terms.

Since its inception Rice's vision has been innovative. Edgar Odell Lovett, the university's first president stated the following vision:

Rice University is an academic institution of international prominence.

Lovett shaped what Rice would become. His vision was lofty and enabled future change. The committee recognized the need to expand on excellence and examined the approaches for achieving the vision, as expressed in the 1990's campaign approved by President Gillis and the Board of Trustees.

Rice: The Next Century was developed and President Gillis and the Board shaped the following objectives for implementing the new campaign:

Enhance the quality and value of education and scholarship at Rice
Strengthen the faculty
Expand and strengthen our interactions "beyond the hedges"

These objectives allowed the board to have a more specific vision for the university, seeking to enhance Rice's quality and value by strengthening our faculty and increasing our interactions, in a collaborative research mode. Realizing Rice is too small to compete in absolute numbers with the top east and west coast schools, the university will focus on becoming the prominent research university between the coasts and will continue to work toward achieving that absolute goal.

Therefore, after analyzing the initial vision set forth by the first president of Rice, Edgar Odell Lovett, and the current vision established by President Gillis and the board, the U&M Committee established the following vision:

Rice University is the premier research university between the coasts.

Appendix 2
Committee Mission, Barriers, and Aspects to Consider

With the guidance of the charge to the committee from the Provost, the U&M Committee agreed upon the following mission statement for the committee's activities for the duration of the appointment:

To lead an initiative to create a place where Science and Engineering can take leadership in new emerging technologies through collaboration with outside entities.

Although the building of a major new facility at Rice University will be led by the Board of Trustees, the President, and the Provost, the faculty, as represented by this committee, can take the initiative to aid in the development of the project. The faculty propels emerging technologies through research, and collaboration among researchers, especially across interdisciplinary boundaries, is key to the most revolutionary advances in science and technology.

The U&M Committee identified a number of elements of the vision that will be critical, and not currently being met, in order to sustain and grow as a university:

<u>Critical Elements of the Vision</u>

- Provide lab space to meet current research space needs
- Provide space to house new research initiatives
- Transform Rice's science and engineering activity by expanding collaborations to interact strongly with the external technical community
- Enable more effective and facile interactions with the TMC

<u>Barriers to the Rice Vision</u>

- Inadequate space for research
- Inadequate funding
- Limited leadership—too few, too small centers/institutes
- Lack of sufficient numbers of faculty to enable growth
- Current building plan inadequate/inconsistent with vision
- Inability to keep and attract best new faculty/staff
- Lack of knowledge of Rice's effective patent and ownership processes/policies

Aspects of U&M Project

The committee's work will be directed toward preserving positive aspects of Rice University's culture, generating new opportunities, providing enablers for the future, and mitigating our problems. The committee has identified the following ways it can preserve, generate, provide, and mitigate problems or concerns to help Rice obtain its vision:

- Preserve
    - Pastoral sense of main campus
    - Spirit of collegiality
    - Interdisciplinary environment
    - Strong engagement of students (undergrad and graduate)
    - Enthusiasm and energy
- Generate
    - A more vital research enterprise with higher impact on technology, professions, economy, and humanity
    - Geographical and structural transition to urban environment
    - Effective new links to TMC and individual colleagues and technical problems
    - Facile interface for collaboration
- Provide
    - Extended space for research and collaboration, with flexibility to evolve
    - Increased engagement across disciplines
    - Enhanced shared equipment facilities
    - Expanded opportunities for visitors
- Mitigate
    - Isolation "behind the hedges"
    - Attitude of space and resource entitlement
    - Malaise and laziness

In order to understand difficulties faculty members face, the committee polled several professors for their reactions and comments about current Rice facilities.

I am an Assistant Professor in the Department of Bioengineering. I conduct translational interdisciplinary research leveraging advances in imaging technologies and molecular biology to develop novel strategies for minimally invasive cancer diagnosis and treatment. I teach a core course in quantitative physiology and will be developing a new elective in biophotonics.

I chose Rice both for the strength in bioengineering and in complementary areas such as nanoscience and because of the proximity of the Texas Medical Center. There is nothing which would have a more positive effect on my professional career and my ability to advance my research program than a building which would bring me together with other scientists and clinicians interested in interdisciplinary research.

Professor Rebekah Drezek

The lack of modern facilities is the greatest single institutional impediment to the success of the newly formed Department of Civil and Environmental Engineering. My Department has a substantial fraction of its research square footage that is decades behind the needs to be competitive for research support, but more importantly we are constrained to hiring faculty whose research can be carried out in antiquated surroundings.

Professor Joe Hughes

Rice should be not just the BEST BUY in university education, but in our focused areas, the BEST in university education and research.

Professor Larry McIntire

Appendix 3
Approach

Since the committee's inception in June 2002 more than thirty meetings have been held to discuss the U&M project. The committee established a good working relationship with the Rice University planning group in Facilities and Engineering. Diane Levi, the Rice planning and programming contractor, provided support for the meetings and took detailed minutes.

The initial task of the committee was to define its mission, using the Rice Vision as a foundation. Once the mission was defined, the committee identified its stakeholders (who have needs) for the project. From there the committee discussed the intellectual rationale for the building (current research needs, new research, current collaborations, and new collaborations). Specifically we identified the type of space and facilities we could conceive in the building:

Research—Groups, departments
Collaboration—Centers, institutes, TMC, industry
Clinical—Patient, research, student
Facilities—Instrumentation
Services—Community, support, transportation
Educational—Classroom, auditorium
Meeting—Conference
Administration
Other—Entrepreneurial organizations, community
Infrastructure—Support for building and potentially other Rice buildings

The diversity of the committee and the backgrounds of its members was helpful in examining the potential interactions with the biotechnology industry, to identify and clarify commercialization issues, and to identify issues in remodeling, such as current conditions of lab space, renovating up to standard vs. moving to new space, and conversion into conference rooms and labs with less expensive remodeling.

The committee identified over 30 ideas for further study and placed those ideas into the following categories:

- Research Space
- Collaboration Space
- Clinical Space
- Facilities & Instrumentation
- Service Space
- Educational Space
- Meeting Space
- Administrative Space
- Other

Each idea was assigned a committee member to draft the idea. Further details were developed through committee discussions. These ideas were project sheets as shown in Appendix 5, and they consist of

- New ideas from the committee
- New ideas from department chairs and faculty
- New ideas from or involving outside collaborators

CNST maintained the ideas on their Web site for easy access and to prevent multiple versions of ideas. The complete list of ideas is contained in Appendix 5, and a short summary of the physical attributes is found in Appendix 4.

Appendix 4
Summary Table

	Number of People	Square Footage Required	Likely Research Funding (extramural, not including 9 month salary)	
			FY '03	FY '08
Current Departments Lab Groups	237	166,000	$24M	$38M
Current Collaboration	610	108,500	$21.7M	$52M
Future Collaboration	668	249,000	$5.3M	$70M
Support Facilities	40	70,000	$2M	$9M
Services Facilities	193	83,000	$0.5M	$1M
Educational, Meeting, Administration, and Other	605	150,000	$0M	$2M
Total	**2353**	**826,500**	**$53.5M**	**$172M**

Appendix 5
Spreadsheet of Ideas

A Research Space

A1	Bioengineering Department	Larry McIntire
A2	Biochemistry and Cell Biology Department	Janet Braam
A3	Bio Physics Research Group	Jason Hafner
A4	Biostatistics Research Group	Kathy Ensor/Fred Rudolph

B Collaboration Space

B1	Center for Biomembrane Research/Gulf Coast Consortium for Biomembranes	Jason Hafner
B2	Center for Neuroscience	Steve Cox
B3	Visualization Center (Imaging Center/Core Imaging Facility)	Jan Odegard
B4	Institute of Biosciences and Bioengineering	Fred Rudolph
B5	Center for Biological and Environmental Nanotechnology	Vicki Colvin
B6	NASA	Wade Adams
B7	Howard Hughes Medical Institute Center	Wade Adams
B8	Gulf Coast Consortium	Vardi/Dean Matthews
B9	Center For Excellence in Tissue	Larry McIntire
B10	Institute for Computational Mathematics in Biology and Medicine	Zygourakis
B11	Bio Ethics Center	Andrew Lustig
B12	Joint Institute with TMC	Rudolph
B13	Bio Photonics	Rebekah Drezek
B14	Texas Heart Institute-Rice Center for Nano Research on Vulnerable Plaque	Wade
B15	The Gates Center for Nanotechnology and Global Development	Andy Lustig
B16	Toxicology Nano Center	Vicki Colvin
B17	Plant Science Center	Janet Braam
B18	Texas Nano-Vivo Center	Wade Adams
B19	Center for Fullerene Bionanoconjugate Research	Wade Adams
B20	Institute for Molecular Medicine-Rice Center for Nano-Bio Research	Wade Adams
B21	Institute for Nanoscale Science and Technology	Wade Adams
B22	Texas/United Kingdom Collaborative Research Initiative	Wade Adams

C	**Clinical Space**		
	C1	Patient Clinic	
	C2	Research Clinic	
D	**Facilities and Instrumentation**		
	D1	SEA	Jason Hafner
	D2	Animal Facility	Rudolph/Tony Mikos
	D3	Genomics, Proteomics, and Metabolics	Rudolph
E	**Service Space**		
	E1	Bookstore/Coffee Shop	Rebekah Drezek
	E2	Restaurant	Rebekah Drezek
	E3	Cafeteria	Rebekah Drezek
	E4	Student Health Center	Wade Adams
	E5	Library/Access Point	Janet Braam
	E6	Transportation Center (Walk, Segway, Bike, Rail, Shuttle, Bus)	Wade Adams
	E7	Retail	Wade Adams
F	**Educational Space**		
	F1	Learning Center	Fred Rudolph
G	**Meeting Space**		
	G1	Conference Ctr.	Jan Odegard
H	**Administrative Space**		
	H1	Administrative Space	Rudolph
I	**Other**		
	I1	Visiting Institute	Jan Odegard
	I2	Incubator Space/Pharmaceutical	Fred Rudolph

Key for Idea Sheets

Category:

1. Current Research Need
2. Current Collaboration
3. New Research Need
4. New Collaboration

Type of Activity:

A. Research
B. Collaboration
C. Clinical
D. Facilities and Instrumentation
E. Education
F. Meeting
G. Administrative
H. Other

Appendix 6
Ideas

A1: Bioengineering Department

Responsible committee member: Larry McIntire

Category: 2—Current Collaboration

Type of activity: A—Research, E—Education

Description: The bioengineering graduate program at Rice educates its students so that they can directly interact with physicians and cell and molecular biologists, while still excelling in the quantitative capabilities so important for engineering applications. Our approach is based on Rice's tradition of excellence in cross-disciplinary research and education, as well as on our long standing record of productive research and training collaborations with institutions in the adjacent Texas Medical Center, the NASA Johnson Space Center and other academic and industrial research centers around the country. Future bioengineers will need to build on recent advances in molecular and cell biology in order to translate scientific aspects of biotechnology into new cost effective products and processes. To be successful in this effort, bioengineers will need interdisciplinary skills that reach from the biological sciences to modern materials science, systems modeling, computer science, and bioprocess design.

The bioengineering undergraduate program will prepare students for careers in rapidly developing areas of biomedical engineering and bioprocessing. Our unified and comprehensive program leading to the B.S. degree in Bioengineering will:

- Provide students with a fundamental understanding of the life and medical sciences
- Teach students to apply engineering principles in the life and medical sciences
- Develop their critical problem solving skills in bioengineering
- Develop their ability to communicate effectively and participate in interdisciplinary teams
- Expose students to a broad education that prepares them for diverse careers

Undergraduates in bioengineering will then have the training to pursue further education in graduate school, medical school and have strong preparation for a career in the biotechnology industry.

Location requirement: Administrative offices, faculty offices, undergraduate laboratories, faculty research laboratories, receiving, and storage

Size: 50,000-60,000 asf

Research funding per year: $10 million ‘03, $15 million ‘08

Number of people: 25 faculty members, 40 Postdocs, and 100 Grad Students

Special attributes: Primarily wet laboratory space but significant computer laboratories—for both research and education.

Justification: Highly desirable to have entire department in one location.

Advantages of U&M location: Bioengineering with benefit from an integration with TMC—both for education and research.

Disadvantages of U&M location: Problems with communication with rest of Rice campus.

Comparable facilities or projects elsewhere: Several campuses are building large facilities for Bioengineering. For example, UCSD, UCB, Georgia Tech/Emory, Penn, Washington University, and Rutgers have all undertaken this type of project.

Issues: University decision on how to delegate space.

Questions yet to answer: **None**

A2: Biochemistry and Cell Biology Department

Responsible committee member: Janet Braam

Category: 1—Current Research Need

Type of activity: A—Research, E—Education, D—Facilities and Instrumentation

Description: The Department of Biochemistry and Cell Biology has strong research in the areas of biochemistry, biophysics, and cell and developmental biology. The department is well supported with faculty positions, research and instructional laboratories, auxiliary staff, scientific equipment, fellowships for graduate students, and general operating funds. Fifty graduate students are currently enrolled, with an additional complement of twenty-five post-doctoral research scientists and visiting scientists.

Location requirement: The physical structure should be designed for increasing interdisciplinary and Texas Medical Center interactions. Based on our experiences with different biological science research buildings, we strongly recommend the design include large lobby areas, open staircases and atria, and convergent spaces containing seating for informal and formal scientific discussions.

Size: 80,000 sq. ft of laboratory space and an additional 10,000 sq. ft of shared equipment/facilities space and animal/plant care facilities. We suggest that TMC facilities for mammal care be used when possible because of expense.

Research funding per year: $10 million '03, $15 million '08

Number of people: Currently 19, future 25

Special attributes: NMR equipment and other sensitive equipment must be located at ground or basement level.

Justification: The research interests of the faculty in the Department of Biochemistry and Cell Biology (BCB) extend from cell biology, genetics, and development to biochemistry, structural biology, and biophysics. Instead of focusing on human systems, most laboratories in the department use model organisms whose traits facilitate the exploration and analysis of various aspects of fundamental biology. This choice has historically represented an intellectual divide between basic biological research and the biomedical research that has traditionally been housed in medical schools. Advances in modern biology and the advent of genomics, proteomics, and metabolomics have blurred the distinction between these two enterprises: medical schools are hiring researchers who work with model organisms, the results of basic research are having immediate impact on medicine, and findings in model organisms have clear implications for human health.

Advantages of U&M location: The University and Main project represents an opportunity for Biochemistry and Cell Biology to increase its research presence at the

interface between basic and medical research by increasing our contact with medical school faculty and by providing an environment conducive to new hires at this interface. BCB has a close and strong relationship with the Texas Medical Center, demonstrated by numerous ongoing collaborations. The proximity of University and Main will facilitate the current and future interactions. Connections to be fostered between BCB and TMC include collaborative research, course offerings, shared core facilities (computing, microscopy, spectroscopy, imaging, genomics, proteomics, and transgenic organisms), shared seminar series, and conferences.

As biological research attracts an increased number of investigators from outside areas, it will be essential for resident biologists to integrate the various disciplines. BCB has been historically successful in this role. The faculty of BCB already participates in many of the collaborative consortia, such as CBEN, Gulf Coast Consortium, and Center for Neuroscience and the Baylor College of Medicine Program in Developmental Biology. The presence of the BCB faculty in the University and Main facility will enable these collaborations to continue in an effective way. In addition, the many collaborations already existing between BCB faculty and laboratories in the Texas Medical Center will facilitate interactions between laboratories in TMC and University and Main.

Disadvantages of U&M location: None

Comparable facilities or projects elsewhere: All major universities have large facilities for modern biological research because of the current and growing importance of this research area.

Issues: No forseen disadvantages of moving the department in its entirety to the Medical Center proximal area.

Questions yet to answer: None

A3: Biophysics Research Group

Responsible committee member: Jason Hafner

Category: 3—New Research Need

Type of activity: A—Research

Description: The three (eventually four) biophysics research groups in the Department of Physics and Astronomy would move into contiguous lab space in the new building at University and Main.

Location requirement: Ground or basement floors, no higher than third (for scanning probe microscopy).

Size: 10,000 sq. ft.

Research funding per year: $3 million ’03, $6 million‘08

Number of people: Four research groups, ca. 25 people total

Special attributes: Low vibration for scanning probe microscopy, safe space for X-ray diffractometers.

Justification: The current biophysics groups (Huang, Hafner, Kiang) in the Department of Physics and Astronomy are spread across campus, and closer labs would facilitate more productive interactions. This move would free up space in the MD Anderson Biolabs third floor, and Herzstein Hall basement.

Advantages of U&M location: Proximity to medical center will facility future and already existing collaborations.

Disadvantages of U&M location: Distance from the main campus, but all faculty members agree the benefits outweigh this inconvenience.

Comparable facilities or projects elsewhere: None known

Issues: None

Questions yet to answer: In order for the biophysics research program to benefit from this project more faculty and staff members would have to be added.

A4: Biostatistics Research Group

Responsible committee member: Fred Rudolph

Category: 2—Current collaboration

Type of activity: B—Collaboration

Description: The Rice Bioinformatics Group is the Rice component of the Gulf-Coast Consortium for Bioinformatics, whose members, besides Rice, are Baylor College of Medicine, MD Anderson Cancer Center, University of Texas - Health Science Center, University of Texas - Medical Branch, and the University of Houston. The educational activities of the Rice Bioinformatics Group will be integrated with the training activities of the Keck Center for Computational Biology. It is a joint Ph.D. program between two Departments: Statistics at Rice and Biostatistics at M.D. Anderson Cancer Center. Following a qualifying exam at Rice, students can pursue degree programs in one of the participating Departments.

Location requirement: No specific requirement

Size: 6000 asf

Research funding per year: $1 million ’03, $2 million ‘08

Number of people: 6 faculty, 4 postdocs, and 12 students

Special attributes: Will to be connected by networks. There will also be a need for educational space.

Justification: Clearly the TMC location would benefit the activities of this group, which is a strong collaboration in research and in education

Advantages of U&M location: The proximity to partners in TMC and access to Gulf Coast Consortia participants.

Disadvantages of U&M location: None

Comparable facilities or projects elsewhere: None known

Issues: None

Questions yet to answer: None

B1: Center for Biomembrane Research/Gulf Coast Consortium for Biomembranes

Responsible committee member: Jason Hafner

Category: 2—Current Collaboration

Type of activity: B—Collaboration

Description: This group of approximately 15 PIs (and expanding), studies the fundamental properties and biological function of biomembranes. William Brownell formed the Baylor College of Medicine (BCM) and has been trying to get space to bring the PIs together in one floor of a building at BCM. The group has submitted a large collaborative, multi million dollar grant to NIH that will likely be funded.

Location requirement: No particular location requirements.

Size: 20,000 sq. ft.

Research funding per year: $3 million ’03, $6 million ‘08

Number of people: 15–20 investigators

Special attributes: Lab space will be needed.

Justification: The extensive, existing collaboration will likely be heavily funded by National Institute of Health (NIH), and the GCC for Biomembranes will likely expand the possibilities for funding. A central location for the research groups would enhance collaborations.

Advantages of U&M location: Proximity to Rice and Med Center.

Disadvantages of U&M location: None

Comparable facilities or projects elsewhere: None known

Issues: BCM currently dominates the principal investigator list, but this composition is changing so a decision must be agreed upon concerning the allocation and costing of space.

Questions yet to answer: None

B2: Center for Neuroscience

Responsible committee member: Steve Cox

Category: 2—Current Collaboration

Type of Activity: A—Research, E—Education

Description: Work on the brain is carried out at multiple locations and in a number of departments at BCM, UTHSC, and Rice. There are sizable clusters in the Neuroscience department at BCM, in the Neurobiology department at UTHSC, and in the Psychology department at Rice. This work stretches from molecules to mind, and, although most focus on phenomena relevant to one or two orders of magnitude in space and/or time, there is general acceptance that the true advances will require a wider scope. This need has motivated a shift in training at BCM. So, in 1999 BCM developed a full year introductory graduate course in Integrative Neuroscience that has been offered at Rice, by Baylor faculty, to a mix of Rice/TMC students for the past three years. This shift has spurred the development of several other courses, created and fostered new research collaborations, and served as a catalyst for the development of a Center for Neuroscience at Rice. The center currently has 18 Rice Faculty from six departments. For more details, refer to http://www.ruf.rice.edu/~neurosci/.

Location requirement: None

Size: Access to public seminar/conference room for 200. Two classrooms, each with a 30 student capacity and office space for one coordinator and one assistant. Total 2500 sq. ft.

Research funding per year: $0.5 million ’03, $5 million ‘08

Number of people: 20

Special attributes: None

Justification: The challenge faced by a field as large and as interdisciplinary as Neuroscience is one of synthesis. How do we assemble the painstakingly achieved elements into a coherent and quantitative, and therefore predictive, understanding of the brain? A centrally located Center for Neuroscience that spans departments and institutions and focuses on training, dissemination and integration would make considerable strides toward the desired synthesis.

Advantages of U&M location: We have no immediate need for equipment or lab space—as we envision considerable overlap with other proposed entities at University & Main, for example, the departments of Biochemistry & Cell Biology and Bioengineering, the Centers for Biomembrane Research and Imaging, and the Gulf Coast Consortia. Rather we envision bringing Rice and TMC students, postdocs, and faculty together for seminars, courses, and conferences. A key advantage, independent of which institution

owns what, is that the location will lend an air of neutrality to all activities and so reduce the barriers that workers often perceive/place between departments and schools.

Disadvantages of U&M location: Need to provide links back to TMC and Rice. Comparable facilities or projects elsewhere: The Salk Institute integrates nine laboratories in its pursuit of the molecule-mind synthesis (http://www.salk.edu/faculty/laboratories/). The Stanford Brain Research Institute, (http://www-med.stanford.edu/sbrc/) lists "Building a Neuroscience Community" as its first major initiative.

Comparable facilities or projects elsewhere: The Salk Institute (http://www.salk.edu/faculty/laboratories/) and The Stanford Brain Research Institute (http://www-med.stanford.edu/sbrc/)

Issues: While the U&M facility will bring researchers together it will also be a major operational undertaking, raising the question of what group will manage the day-to-day activities of the facility.

Questions yet to answer: None

B3: Visualization Center (Imaging Center /Core Imaging Facility)

Responsible committee member: Jan E. Odegard

Category: 2—Current Collaboration

Type of activity: A—Research, D—Facilities and Instrumentation

Description: Several research groups at Rice are continually faced with a need for interpreting and understanding large datasets provided by a variety of methods, whether it be from a large scale simulation and modeling or from collecting data from a variety of sensor/imaging systems. The insight gained by visualization, in particular for multidisciplinary collaborations, is invaluable and a "3D picture is worth a lot more then several gigabytes of raw data." Rice does not have a facility for visualizing such complex datasets to give researchers much needed insight. Based on the fact that images provide avenues to new insight, the Rice community would greatly benefit form gaining access to a professionally run state-of-the-art visualization facility. Furthermore, Rice and TMC (as well as other natural collaborators) are uniquely positioned to utilize such an advanced visualization facility. In fact, such a center would promote new and far-reaching collaborations.

Location requirement: If the Houston Museum of Natural Science would benefit from use of the space, then the possibility for theater style seating with high ceilings would be beneficial.

Size: For such a facility to be a real success and a draw on faculty and collaborators, it needs to be both large and provide flexibility (new technology with demanding space requirements that includes the need to re-configure space potentially at frequent intervals). Some space would also require significant ceiling height. At this stage, we should however focus on conceptualizing a world-class facility (the kind of research, number of people, types of specialized, shared equipment, etc.), and explore the space requirements at similar facilities. Estimated 20,000 asf lab and 6000 asf office.

Research funding per year: $0 '03, $10 million '08

Number of people: 20 faculty, 40 postdocs, and 100 students in '08

Special attributes: The center should have an array of special high-end visualization equipment. The facility needs a very high capacity network connectivity and adjacent computer machine room facilities, high capacity cooling, and significant power distribution capacity and backup.

Justification: Rice has a number of research areas across departments that have various overlapping visualization and imaging elements/needs. The same holds true in relation to the medical centers/institutions. Research conducted at Rice in a new visualization and

imaging facility would certainly work as a catalyst for collaboration and provide a more effective problem solving environment that would help break barriers.

Advantages of U&M location: Proximity to the medical center would connect Rice into one of the most important centers of activity in Houston and in the world. It would also connect the university to the city in new ways.

Disadvantages of U&M location: Difficulty in maintaining communication with/within the engineering research community. This is particularly true with regards to the Duncan Hall community—the most likely driving force of any major visualization effort at Rice.

Comparable facilities or projects elsewhere: There are a number of visualization and imaging centers across the US and globe. An extensive list needs to be created and a few key facilities more carefully investigated.

Issues: Unknown at this time.

Questions yet to answer: How will Rice and TMC work together for administrative purposes?

B4: Institute of Biosciences and Bioengineering (IBB)

Responsible committee member: Fred Rudolph

Category: 2—Current Collaboration

Type of activity: A—Research

Description: The Institute of Biosciences and Bioengineering (IBB) was founded to foster interdisciplinary studies among the biological, chemical, and engineering faculty and to encourage interaction with faculty and scientists at neighboring institutions. In order to solve many of the problems of modern bioscience, it is necessary not only to deal with the complexities of a particular subdiscipline, but also to incorporate and employ the tools and information of a variety of other fields of research. The Institute is designed to provide an environment for stimulating the cross-interactions that facilitate discovery and insight across disciplinary boundaries. The Institute provides not only an intellectual setting, but also an organizational framework to connect between departments within the university as well as with organizations outside the university including the Johnson Space Center and the Texas Medical Center. The various activities of the Institute, including short courses, and major conferences, foster positive interactions and have a significant impact on educational programs.

The Institute currently consists of several thematic laboratories that draw on faculty from different departments and schools with currently 50 Rice faculty and 25 adjunct faculty from the Texas Medical Center along with over 120 graduate students and 100 other researchers. The Institute and the Laboratories are housed in the George R. Brown Hall for Biosciences and Bioengineering (completed in 1991) and Keck Hall, which was completely remodeled in 2000. The IBB was the first interdisciplinary institute combining science and engineering faculty in pursuit of biological problems and has been a model for the establishment of a number of other such organizations, both nationally and internationally.

Location requirement: IBB will serve as a major operational unit in the U&M project. It could provide the administrative and logistical support required for the research and education programs which it currently does from the George R. Brown Hall location. This would include purchasing, receiving, safety, administration, conferences, and other basic functions. The IBB has significant experience in all of these areas.

Size: Approximately 3000 sq. ft., consisting of a large conference room, two executive offices (300 sq. ft.), six to eight staff offices (at 150 sq. ft.), and two work rooms (200 sq. ft.).

Research funding per year: $10 million ‘03, $10 million ‘08

Number of people: 300

Special attributes: The IBB would function with other entities in the facility to promote research and education efforts.

Justification: The experience of the unit, its visibility both locally and nationally, and the focus of the organization, all suggest IBB should move to U&M.

Advantages of U&M location: The location of U&M facilitates collaboration with other bio centers.

Disadvantages of U&M location: Possible separation from other centers and research activities on the central campus of Rice could pose communication problems.

Comparable facilities or projects elsewhere: There are a number of similar centers that have developed recently including Georgia Tech and Stanford (http://biox.stanford.edu/). IBB serves as a national model as to how to integrate science and engineering in the biological areas.

Issues: How will the infrastructure be developed within the various groups involved?

Questions yet to answer: What groups (particularly departments) are in the building and are associated with IBB, and how do they interact?

B5: Center for Biological and Environmental Nanotechnology (CBEN)

Responsible committee member: Vicki Colvin

Category: 2—Current Collaboration

Type of activity: B—Collaboration

Description: A physical space to house center leaders, core research projects, and people. The space would provide a tangible link between TMC and CBEN, and provide a research "hotel" available for competitively chosen collaborations.

Location requirement: Assuming shared equipment of a sensitive nature is available on the ground floor, none.

Size: Office space: 2000 sq ft., 2000 sq. ft. conference area, 8000 sq. ft. laboratory space—12,000sq. ft. total.

Research funding per year: $3.2 million '03, $4 million '08

Number of people: Center administration and 3–4 faculty members

Special attributes: The laboratory space would be designed around modular research efforts including hoods, walk-in cold rooms, computation facilities, and standard wet chemical space.

Justification: Interdepartmental centers would be available to allow efforts to grow and multiply that otherwise have difficulties thriving at Rice. The research lab space would become a resource that the center could grant to highly interdisciplinary, new, or industrial collaborations. The idea is not unlike an 'extended stay' research hotel. This space would provide four bays to house specific projects. Interested parties would compete to acquire access to the space, plus modest budgets for equipment and supplies as well as a technician to outfit the space and maintain the lab. Typical time for assignment would be two years, with an option for one renewal, depending on the projects.

Advantages of U&M location: The advantages for collaborations with the medical school is great, and this opportunity would provide a tangible goal for exploratory collaborative work (that is, to acquire space and a lab) and give the center an additional flexibility in the type of resources it can provide to its members.

Disadvantages of U&M location: Distance from the primary buildings of most Rice faculty. The incentive would have to be large in order to motivate faculty to relocate part of their research group.

Comparable facilities or projects elsewhere: Bio-X at Stanford has a similar concept (refer to Appendix 9).

Issues: This concept challenges the traditional notion of space as a permanent fixed asset of a faculty member and could be met with resistance. The expense with outfitting a new lab distant from an existing one is large; permanent technical staff, familiar with the equipment and materials which build up in these areas, would offset this problem. The space alone is not valuable—it would have to come with some kind of money to provide for outfitting costs as well as some permanent staff to facilitate transitions.

Questions yet to answer: Would industrial affiliates who send a researcher to the center want/need to keep intellectual property separate or secure? Rice researchers will need a home lab outside of U&M, will departments allow or encourage double labs for faculty?

B6: NASA/National Space Biomedical Research Institute

Responsible committee member: Wade Adams

Category: 4—New Collaboration

Type of activity: A—Research, E—Education

Description: This collaborative research facility will allow NASA engineers and scientists to work closely with researchers at TMC and Rice University in the pursuit of advanced human spaceflight concepts. Advanced concepts related to the physical, space, and life sciences would be proposed and investigated jointly, with the aim of focusing the best minds at Rice, TMC, and NASA on the future challenges of human spaceflight and exploration (advanced materials, energy and power, astronaut health, etc.).

Location requirement: No special requirements

Size: 20,000 sq. ft. total laboratory space, two conference rooms, and offices for researchers and students.

Research funding per year: $0 million '03, $5 million '08

Number of people: 50 (20 Rice/TMC, 30 NASA)

Justification: This research facility would provide a location for NASA scientists and engineers to actively collaborate with Rice and TMC on joint projects and would significantly strengthen joint proposals for federal funding.

Advantages of U&M location: NASA personnel would be principal investigators (PIs) or Co-PIs with Rice/Med Center researchers on joint projects, and would be able to direct the work of post-docs, graduate students, and undergraduate researchers. This interaction with students would further NASA's education and future workforce goals.

Disadvantages of U&M location: NASA engineers and scientists will have to travel to this location (25 miles).

Comparable facilities or projects elsewhere:

- Institute for Soldier Nanotechnologies (http://www.aro.army.mil/soldiernano/)
- Massachusetts Institute of Technology
- NSBRI: Rice was one of the six founding institutions in this biomedical research consortium which focuses on long-duration space flight and countermeasures for the effects of prolonged weightlessness and other space related problems (http://www.nsbri.org/).

- Ames Research Center (http://www.sciencemag.org/cgi/content/full/291/5511/2073)
- Proposed NASA and BioScience and Engineering Institute

Issues: An institutional framework between NASA and Rice/Med Center will need to be created.

Questions yet to answer: Would NASA Civil Servants need to have Rice/TMC status or credentials in order to write joint proposals for the full range of federal funding sources (that is, NSF, NASA, etc.)?

B7: Howard Hughes Medical Institute Interdisciplinary Research Center

Responsible committee member: Wade Adams

Category: 4—New Collaboration

Type of activity: B—Collaboration

Description: Collaborative research space sponsored by HHMI for short to mid-term projects, utilizing the resources of the Texas Medical Center, Rice University, and the U&M facility. This space could be an international center for biotechnology/nanotechnology/information technology integration, focusing on multidisciplinary research on medical issues arising from ongoing activities in the TMC.

Location requirement: No specific requirements, but will require access to other facilities in the complex.

Size: Perhaps 20 "labs" comprising 1000 sq ft. each, administration offices, 60 offices for permanent staff and visiting members, and possibly residence space for visiting scientists (refer to idea sheet I1)—30,000 sq. ft.

Research funding per year: $ 0 '03, $10 '08

Number of people: 75 total (15 staff, 10 visitors from Rice, TMC, outside)

Special attributes: All-purpose lab space, offices, and visitors' quarters.

Justification: Brings the HHMI into the complex, physically tying TMC and Rice to the second largest funding agency in medical research. It will leverage the HHMI's Janelia Farm center to bring state-of-the-art equipment to U&M.

Advantages of U&M location: Critical location for this collaborative center.

Disadvantages of U&M location: None

Comparable facilities or projects elsewhere: Could be patterned after HHMI's recently announced Janelia Farm project (refer to Appendix 12), a 281 acre complex in Virginia. HHMI plans to spend $500M over the next ten years constructing and operating the "Bell Labs of Biology," designed to bring physical scientists together with biologists to attack multiple medical diseases or sets of biological problems. Their focus is providing (and developing) state-of-the-art equipment to a small staff (200-300) and to visiting researchers who would stay for weeks or perhaps several years. Plans call for 750,000 sq ft of total new space for labs, conference center, and housing for 100 guests (refer to, www.hhmi.org).

Issues: Will HHMI be interested in funding a new center? Does this idea merit a special committee to investigate further?

Questions yet to answer: Who should be the primary contact with HHMI?

B8: Gulf Coast Consortia

Responsible committee member: Moshe Vardi/Kathy Matthews

Category: 2—Current Collaboration

Type of activity: B—Collaboration

Description: The Gulf Coast Consortia (GCC) engage six Houston-area institutions (Baylor College of Medicine, Rice University, University of Houston, University of Texas Health Science Center at Houston, University of Texas Medical Branch Galveston, and University of Texas M. D. Anderson Cancer Center). The training arm of the GCC is the Keck Center for Computational and Structural Biology, which has diversified training programs spanning the institutions within the GCC. The research arm comprises multiple Consortia in different areas, from magnetic resonance to proteomics to bioinformatics, and the number is expanding. Applications for NIH Centers of Excellence, program projects, and other collaborative research efforts are the goals of these research consortia.

Location requirement: Vibrational stability for specialized equipment may require a ground floor location or special engineering.

Size: Approximately 15,000 sq. ft. of instrumental space and 20,000 sq. ft. of laboratory space, offices for staff and visitors (~40-60), and residence space for visiting scientists. Also, a seminar room (seating for ~100-120), classrooms (~20-30 students), and consultation office (~3) will be needed. Instrumentation space and research space [(~15000 sq. ft. of instrumental space and 20000 sq. ft. of laboratory space), offices for staff and visitors (~40-60)] would be similar to HHMI Center and could be the same space or overlapping space.

Research funding per year: $2 million ‘03, $10 million ‘08

Number of people: 60

Special attributes: A special location or engineering for specialized equipment and modular laboratories for research spaces.

Justification: The GCC does not have a tangible location for activities, with the exception of the administration of the Keck Center training program through staff administrative offices located on the Rice campus. The facility at U&M would provide an ideal setting to develop a physical presence for the GCC/Keck Center with a potential site for placement of shared equipment (already acquired through the Keck Foundation), classrooms, seminar rooms, and meeting spaces for the on-going and anticipated collaborations across the institutions. In addition, laboratory spaces for cross-institutional collaborations would provide impetus to develop novel interactions to address problems of importance in this area. Space would be predicated on collaborative (and interdisciplinary) research endeavors.

Advantages of U&M location: The physical proximity to 4 of the 6 components of the GCC and the ability to develop an instantiated presence for the Consortia.

Disadvantages of U&M location: None

Comparable facilities or projects elsewhere: A donor in the Chicago area has offered the University of Chicago, Northwestern, and UI-Chicago funds to develop a similar collaborative training and research effort. Since the early reports, no further information has been forthcoming. Within Stanford, Bio-X (refer to Appendix 9) was developed as an interdisciplinary effort, with mixed results thus far. UCSF was developing an interdisciplinary effort with UCSF, Stanford, and UC Berkeley at its new Mission Bay Campus, but again no clear results thus far have emerged. Unlike these efforts, the GCC arose from an existing, on-going interdisciplinary effort, and the space is motivated by the needs of present programs not as a mechanism for generating non-existent interactions. However, other efforts have the distinct potential advantage of start-of-the-art facilities for collaborative activity that the GCC does not currently enjoy.

Issues: How to allocate space once constructed?

Questions yet to answer: What is the tie-in between this space and HHMI (refer to idea sheet B7)?

B9: Center of Excellence in Tissue Engineering

Responsible committee member: Larry McIntire

Category: 3—New Research Need

Type of activity: B—Collaboration

Description: Teams could be organized in various ways by tissue site (orthopedic tissue engineering, cardiovascular tissue engineering, etc.) or by cross cutting technologies and unresolved questions (interactive biomaterials, angiogenesis, sensor technology, drug delivery methodologies).

Location requirement: Principally wet lab space, including an animal facility. It will also require a need for core facilities (polymer characterization, imaging—for example small animal MRI), microscopy (light and electron, etc.).

Size: 30,000–40,000 asf

Research funding per year: $0 ‘03, $5 million ‘08

Number of people: 60

Special attributes: Must be able to sometimes include proprietary research

Justification: The U&M location will designate Houston as a leader in Regenerative Medicine.

Advantages of U&M location: There is a need for integration with TMC and also conference space for collaborations.

Disadvantages of U&M location: Student communication with facility may be weakened or strained.

Comparable facilities or projects elsewhere: The following organizations and universities are considering similar programs:

- Pittsburgh Tissue Engineering Initiative (http://www.pittsburgh-tissue.net/) received DOD funding
- Georgia Tech/Emory (http://www.gtec.gatech.edu/)
- UCSD(http://www-bioeng.ucsd.edu/research/research_groups/cte/)
- MIT/Harvard (http://hst.mit.edu/)

Issues: None

Questions yet to answer: None

B10: Institute for Computational Mathematics in Biology and Medicine (ICMBM)

Responsible committee member: Kyriocos Zygourakis

Category: 4—New Collaboration

Type of activity: B—Collaboration

Description: The primary mission of the ICMBM will be to increase the impact of applied and computational mathematics on biology and medicine by fostering research of a truly interdisciplinary nature. The ICMBM is envisioned as an information hub in the life sciences.
It will:

- Identify important research areas and problems in need of new mathematics or computational methods and communicate them to high quality mathematicians
- Inform and instruct life scientists about new developments in applied mathematics and computer science
- Bring together biologists, mathematicians, computer scientists, and clinicians to discuss important problems that can only be solved through an interdisciplinary, collaborative approach

The ICMBM will aim to educate scientists both at the start of their career (graduate or medical students) and after they have been well established.

Location requirement: Non specific requirement, but central location might be desirable for computer clusters.

Size: The ICMBM expects the following size parameters:

- Office space for a permanent core of faculty/researchers and staff
- Office space for visitors (100-200 at any given time)
- Conference facilities
- Seminar rooms, smaller classrooms
- Computational labs with large, shared computer facilities (move big Rice clusters there and make them accessible to all researchers)

Ideally, the office and conference facilities should be located on adjoining floors connected with internal staircases or dedicated elevators to create a sense of community (house-within-a-house concept). Estimated 40,000 asf total, 20,000 labs, and 20,000 office/conference.

Research funding per year: $0 ‘03, $10 million ‘08

Number of people: 130

Special attributes: The ICMBM will create an environment, which is highly conducive to research, collaboration, and communication. This can be achieved through the following mechanisms:

- Annual thematic programs lasting from nine months to a year and involving a large number of participants. The participants will be long-term, medium-term and short-term visitors, coming from academia, industry, and government. Each program will have a number of periods of intense activity (workshops, tutorials, panel discussions, public lectures, etc.) separated by periods for less structured interaction and research.
- Summer programs typically lasting a few weeks and involving small numbers of participants.
- Special workshops and hot topics workshops that can be launched quickly and responsive to areas of particular interest or opportunity.
- Courses for graduate and medical students (short and regular).
- Participating institution conferences and graduate student summer programs.
- Postdoctoral program and industrial postdoctoral internships.
- A series of focused ICMBM publications.
- A variety of seminars and seminar series.
- A corporate affiliates program.

Justification: The nature of this Institute clearly dictates a location near the TMC and its mission will be enabled by placement in the U&M facility.

Advantages of U&M location: Primarily symbolic (confluence of Rice and TMC where science meets medical applications). Furthermore, interdisciplinary research in one of the hottest fields of biology and medicine which Rice and TMC should invest in.

Disadvantages of U&M location: None

Comparable facilities or projects elsewhere: Institute of Mathematics and its Applications (IMA) at the University of Minnesota (http://www.ima.umn.edu/).

Issues: None

Questions yet to answer: None

B11: Bio Ethics Center

Responsible committee member: Andrew Lustig

Category: 3—New Research Need

Type of activity: A—Research, E—Education

Description: The primary mission of the Center is to pursue collaborative research on major interrelated ethical and social issues raised by biotechnology and nanotechnology (including intellectual property issues; religious, philosophical, and scientific concerns about altering nature; and public attitudes about the development and application of new bio- and nanotechnologies). Such collaborative research would enhance Rice's interface with researchers in the Texas Medical Center.

Location requirement: Administrative office, faculty offices, library space, conference room

Size: 6,000 square feet

Research funding per year: $400,000 ’03, $400,000 ‘08

Number of people: 10 scholars from several Rice departments, 10 visiting scholars

Special attributes: 20 offices (15'x 15'), located on the same floor as B16

Justification:

- Faculty space for 10 scholars from Nanotechnology and relevant Basic Sciences, Philosophy, Religious Studies, History, Social and Policy Studies, and Economics
- Space for 10 visiting scholars and/or post-doctoral fellows
- Large combination conference room (600 square feet) for meetings and library space (900 square feet) with carrels for study

The above 6000 square foot space would allow collaborative research on major interrelated ethical and social issues raised by biotechnology and nanotechnology (including intellectual property issues; religious, philosophical, and scientific concerns about altering nature; and public attitudes about the development and application of new bio- and nanotechnologies). Such collaborative research would enhance Rice's interface with researchers in the Texas Medical Center.

Advantages of U&M location: Integration with the TMC for both education and research.

Disadvantages of U&M location: Distance from the main campus, but the possibility of close interactions with TMC colleagues outweighs this inconvenience.

Comparable facilities or projects elsewhere: There are a number of renowned bioethics centers elsewhere (including the Center for Medical Ethics and Health Policy at BCM). The Center for Science, Society, and Ethics would work in close collaboration with the BCM Center and others to pursue interdisciplinary research at the interface of biotechnology and nanotechnology applications.

Issues: How to develop an effective partnership among the institutions, departments, and individuals that will participate.

Questions yet to answer: None

B12: Joint Institutes with TMC

Responsible committee member: Fred Rudolph

Category: 4—New Collaboration

Type of activity: A joint collaboration with TMC would encompass all of the activities.

Description: As a part of the general development it will be important to have multiple organizations that foster growth and interaction. The Gulf Coast Consortia is a good model to follow.

Location requirement: There are no specific requirements, but the institutes would span the facility.

Size: Difficult to define, but estimated 5000 asf per institute, and estimate five institutes in ’08.

Research funding per year: Could be expected to generate significant new collaborative funding. $0 ‘03, $10 million ‘08

Number of people: 100 in ‘08 for 5 institutes

Special attributes: Broad and interactive.

Justification: Important to guide development of collaborative efforts.

Advantages of U&M location: The proximity to TMC and Rice would develop the natural growth of the institutes.

Disadvantages of U&M location: None

Comparable facilities or projects elsewhere: None

Issues: None

Questions yet to answer: What is the potential size of the institute? How would a joint institute be organized for administrative and maintenance purposes?

B13: Biophotonics

Responsible committee member: Rebekah Drezek

Category: 4—New Collaboration

Type of activity: D—Facilities and Instrumentation

Description: Given appropriate space and sufficient investment in new faculty (that is, senior leadership) in biophotonics, Rice's proximity to the Texas Medical Center and established excellence in bioengineering should make it a strong contender for significant funding for a Center for Biophotonics. Current biophotonics faculty in the department of bioengineering (Drezek, Anvari) are already actively collaborating with Texas Medical Center researchers as are other researchers (West, Halas) whose work has a significant photonics components. These types of interdisciplinary collaborations are absolutely essential in biomedical optics. Research funding in biophotonics is growing at a very rapid pace, and investment in this area is likely to result in significant returns for Rice. The recent establishment of the new NIH institute for biomedical imaging and bioengineering should result in continued significant investment in the field over the next decade and beyond. It should be noted that a large proportion of the very top bioengineering programs have designated biophotonics as an area for strategic development over the next decade.

Location requirement: Photonics work is often extremely sensitive to vibrations. Space would likely need to be positioned on the ground level (or perhaps a low floor) to be affordable. It may be prohibitively expensive for biophotonics laboratory space to be located on a high floor. Space needs to be positioned such that it is possible to achieve complete darkness.

Size: 10,000 asf total, 80% lab space

Research funding per year: $0 '03, $8 million '08

Number of people: 60

Special attributes: Labs in this field require both wet lab space and instrumentation space. Small animal facilities are also required.

Justification: The equipment needs in this area tend to be quite significant. Research at Rice is currently severely limited by the lack of appropriate shared equipment facilities (for instance, spectrophotometers, fluorimeters, multiphoton/confocal imaging, small animal imaging resources). Centralizing research in this area to one location—close to the medical institutions driving the need for technology development—would improve Rice's ability to become a leader in the field.

Advantages of U&M location: Research in biophotonics is some of the most translational research underway at Rice. Closer proximity to the medical center would certainly facilitate projects from a logistical standpoint. Presuming the space was jointly occupied by Rice faculty and TMC collaborators, the research process itself would be significantly improved due to the increased level of interaction allowed. Dedicated space would allow Rice to compete for large, center-type grants.

Disadvantages of U&M location: A tall, small footprint building would not be typically considered an advantageous space to put a biophotonics lab due to the inherent vibration sensitivity noted above.

Comparable facilities or projects elsewhere: UC Davis Center for Biophotonics (http://biophotonics.ucdavis.edu/index.html)

Issues: Presently, there are only 2 primary biophotonics faculty—both at the assistant professor level. Rice would need more faculty working in biophotonics before establishing a Center for Biophotonics became a realistic possibility. At a minimum, Rice would need to recruit one senior level faculty member to provide leadership.

Questions yet to answer: None

B14: Texas Heart Institute-Rice Center for Nano Research on Vulnerable Plaque

Responsible committee member: Wade Adams

Category: 4—Current Collaboration

Type of activity: B—Collaboration

Description: The Texas Heart Institute, as part of the University of Texas Health Science Center at Houston, operates the Center for Vulnerable Plaque Research (CVPR) in the new THI building in the Texas Medical Center complex. It occupies the top two floors with research laboratories for plaque pathobiology, drug discovery (still under development), bioengineering (photonics, MRI, SQUID, Contrast media, catheter development, and electrocardiography), an animal research facility, IT and Bioinformatics, and clinical epidemiology, and offices for public relations and communications. In 2002, discussions began with the Rice University Center for Nanoscale Science and Technology for a collaboration on how nanotechnology could provide new approaches to detecting and treating the medical condition which is now believed to be responsible for over half the deaths worldwide due to cardiovascular failure (especially sudden heart attacks.) Initial projects include carbon nanotube, nanoshells, and nanocrystals as contrast agents for new detection and imaging schemes, optical spectroscopy and imaging, and image restoration and reconstruction. Ultimate projects might include nanotechnology materials and devices for preventing as well as eradicating plaque formation, and tissue engineering to repair vascular systems.

Location requirement: None, but easy access to shared equipment is important.

Size: Four flexible laboratories of 1000 sq ft each, plus office space for 20 researchers and two administrators. Two administrative offices, conference room (1000 sq ft.)

Research funding per year: $0 ’03, $3 million ‘08

Number of people: 22

Special attributes: Flexible labs, all utilities.

Justification: Needed to provide space and environment for nanotechnology researchers to work with CVPR medical specialists. Current labs in THI do not provide for expansion for this collaboration. Spatially separated labs for the nano work and the medical work are not sufficient to achieve true collaboration.

Advantages of U&M location: It would be central to TMC, close to THI building, and easy access to other Rice CNST laboratories.

Disadvantages of U&M Location: None

Comparable facilities or projects elsewhere: None known

Issues: Can the building provide for growth space?

Questions yet to answer: Will the collaboration succeed in receiving NIH funding for the initial projects?

B15: The Gates Center for Nanotechnology and Global Development

Responsible committee member: Andrew Lustig

Category: 3—New Research Need

Type of activity: A—Research, E—Education

Description: A new center to be funded by the Gates Foundation for studying the problems of global biomedical issues and solutions through integrated research and development of bionanotechnology.

Location Requirement: Administrative office, faculty offices, library space, conference room

Size: 3,000 square feet.

Research funding per year: $0.5 million '03, $0.5 million '08

Number of people: 10 faculty members

Special attributes: 10 offices (15'x15'), located on the same floor as B11

Justification:

- Faculty space for 10 scholars (permanent and visiting) from Nanotechnology and the relevant Basic Sciences (Biological) and Engineering (Bioengineering), Philosophy, Religious Studies, History, Social and Policy Studies, and Economics
- Combined conference room for meetings and library space (750 square feet)

The single space would allow collaborative research on ethical and social issues in bionanotechnology and its applications, especially in the context of developing countries. Major issues include intellectual property concerns, international justice claims about the availability of new technologies, and cross-cultural concerns in the dissemination of new technologies.

Advantages of U&M location: Integration with the TMC for both education and research.

Disadvantages of U&M location: Distance from the main campus, but the possibility of close interactions with TMC colleagues outweighs this inconvenience.

Comparable facilities or projects elsewhere: There are a number of bioethics and nanotechnology centers elsewhere (including the Center for Medical Ethics and Health Policy at BCM). The Gates Center for Nanotechnology and Global Development would work in close collaboration with the BCM Center and others to pursue interdisciplinary

research on the political, economic, social, and ethical issues posed by nanotechnology applications in the context of developing countries.

Issues: How to develop an effective partnership among the institutions, departments, and individuals that will participate.

Questions yet to answer: Will the Center be able effectively to integrate its emphasis on biotechnology and nanotechnology with the current emphases and outreach of the Gates Foundation?

B16: Toxicology Nano Center

Responsible committee member: Vicki Colvin

Category: 4—New Collaboration

Type of activity: B—Collaboration

Description: A national center to support collaborative research in toxicology, nanotechnology, and relevant environmental studies. The center would seek federal funding from the NSF, the EPA, and the DOD, in addition to support from industry including the emerging small business community as well as the major chemical and materials companies. The current activity in nanotoxicology is extremely limited, but this is a field that is expected to grow considerably in the near future as more emphasis comes from the National Nanotechnology Initiative and from public pressure. Rice University, the TMC, and NASA locally are well-placed to pursue such a joint collaborative effort, especially following the lead of the Center for Biological and Environmental Nanotechnology, funded in 2001 for a 5-10 year lifetime.

Location requirement: None, but easy access to shared equipment is useful.

Size: Ten flexible laboratories of 1000 sq ft each, plus office space for 30 researchers and two administrators. Administrative offices, conference room (1000 sq ft.)—15,000 asf total.

Research funding per year: $0 ‘03, $3 million ‘08

Number of people: 32

Special attributes: Flexible labs, all utilities.

Justification: Although Rice University researchers would be included in this center, it would also bring together researchers from the TMC and NASA, as well as industrial and potentially even government scientists.

Advantages of U&M location: Central to TMC, easy access to Rice campus, close to NASA Johnson Space Center.

Disadvantages of U&M location: None

Comparable facilities or projects elsewhere: None at present, but a potential center is being considered at the University of Florida. There are several Tox labs in the DOD, the EPA, and industry (for example, DuPont).

Issues: In-vitro versus in-vivo testing?

Questions yet to answer: What will be the relationship to CBEN?

B17: Plant Science Center (http://www.bioc.rice.edu/plantscience/)

Responsible committee member: Janet Braam

Category: 4—New Collaboration

Type of activity: A—Research, D—Facilities and Instrumentation, E—Education

Description: Plant science research at Rice University could serve as the seed for development of a research institute focused on fundamental discovery and biotechnology research in plants and plant-based products. The plant science research area is a niche in which Rice University has strength; Rice could take the lead in bringing plant biotechnology to Houston.

Location requirement: The physical structure should be designed for increasing interdisciplinary and Texas Medical Center interactions. Based on our experiences with different biological science research buildings, we strongly recommend that the design incorporate include large lobby areas, open staircases and atria, and convergent spaces containing seating for informal and formal scientific discussions

Size: Laboratory and office space to house approximately 10 principal investigators (~30-35,000 sq ft).

Research funding per year: $1.4 million '03, $2.1 million '08

Number of people: Three Rice faculty; one Baylor faculty currently, with plans to increase faculty size both at Rice and through adjunct appointments with Medical Center faculty. The size increase will depend upon the interest of the Rice and Medical Center communities in participating.

Special attributes: Plant growth facilities will be essential, including growth chambers and temperature-, light- and humidity-controlled rooms.

Justification: Undertaking an initiative in plant science research and technology is an exciting proposition. A clear understanding of plant biology is essential for enhancing worldwide agricultural practices that can feed the world. With population increases and greater demands on the environment, improvement of crop production and sustainability will be essential. In addition, there are perceived threats to the security of our food supplies; knowledge of plant–pathogen interactions and generation of disease- and pest-resistant plants are present and future goals for plant scientists. Plants are being developed as a major source of biomass for renewable energy. Wood products, paper and other cellulose-based products are likely to continue to be important plant products. Perhaps of particular interest for Rice University, given its close association with the Texas Medical Center, much of plant science and biotechnology is naturally linked to the biomedical field. For example, nutrition and natural product discovery and/or modification for new drug development are areas of interest for both plant biologists and

biomedical researchers. Plants biosynthesize an astonishing array of defense compounds that affect mammalian processes. Many of these have proven useful pharmaceutical agents, but the drug properties of most plant metabolites have not been explored because of difficulties in obtaining sufficient amounts of material for testing. Significant genomics-based programs in natural product identification and production are now underway at Rice, and this work would be dramatically facilitated by enhanced collaboration with genome sequencing and drug testing initiatives at the medical center. In fact, near the proposed site is the Children's Nutrition Research Center (CNRC) one of only seven USDA funded centers on nutrition. This University and Main location would allow unique interactions between plant scientist and clinicians at the CNRC. Thus we envision great potential for collaboration between a plant science research and technology center and the Texas Medical Center. Indeed, a close juxtaposition of a plant science and technology institute may facilitate a unique partnership that could bring national and international recognition. It is clear that placement of plant biotechnology centers in urban settings near hospitals and medical research centers has not been exploited in the United States.

There are a number of Houston area food and agribusiness companies that may be interested in working with Rice University on such an initiative. Some potential industrial affiliates may include local companies such as Coca-Cola Foods/Minute Maid Co., Imperial Sugar Company, RiceTec, King Ranch, Riviana food, and Randall's/Kroger. In addition, other companies are also potential supporters, such as Cargill, Monsanto, Syngenta, Pioneer Hi-Bred International, Inc., DuPont, Dow AgroScience, and Archer Daniels Midland.

Advantages of U&M location: The current initiatives for biotechnology expansion in Houston, for example, BioHouston, do not include plant biotechnology. Thus, an opportunity is available for Rice to capture this component of science and technology that has high potential for future success.

Disadvantages of U&M location: None

Comparable facilities or projects elsewhere: Danforth Center, St. Louis, MO. although there is no emphasis on a close association with a medical center (http://www.danforthcenter.org/).

Issues: Development of an infrastructure of Medical Center and Rice faculty use of shared facilities and research personnel.

Questions yet to answer: The final size and scope of the center is being planned.

B18: Texas Nano-Vivo Center

Responsible committee member: Wade Adams

Category: 4—New Collaboration

Type of activity: B—Collaboration

Description: A state-wide center to support collaborative research in nanotechnology/ biotechnology/medicine. Available to all Texas universities with nano/bio/medical research programs, will place researchers on-site for 1-4 years to perform collaborative research on competitive grants from the Nanotech Foundation of Texas or other funding agencies (http://www.nanotechfoundation.org/). Including the State of Texas will increase its support for nanotechnology in the coming years. The center would have access to the outstanding research equipment in the U&M complex as well as at the TMC, giving it a huge advantage for locating leading-edge research projects which arise from ideas across the state, but could not be performed in their home institutions due to lack of facilities. Researchers would also take advantage of the entrepreneurship access at U&M and at Rice University to better perform technology transfer. As access expands, the center could evolve into the Southwest Nano-Vivo Center. As stated by the Council on Competitiveness: "The real locus of innovation is at the regional level. . . Commercialization of basic research is a difficult but important ingredient for generating entrepreneurship. . . Universities and specialized research centers are the driving force behind innovation in nearly every region. . . Successful regions leverage unique assets to build specialized clusters. . .Building strong regional economies takes decades." (*Clusters of Innovation: Regional Foundations of U.S. Competitiveness* Council on Competitiveness)

Location requirement: None, but easy access to shared equipment will be useful.

Size: 15,000 sq. ft. consisting of ten flexible laboratories of 1000 sq ft each, plus office space for 80 researchers and four administrators. Four administrative offices, conference room (1000 sq ft.)

Research funding per year: $0 '03, $10 million '08

Number of people: 85

Special attributes: Flexible labs, all utilities. Remote access capability for equipment/labs.

Justification: Although Rice University researchers would be included in this center, it would also bring together researchers from over all the state, not only in nanotechnology fields, but also in bio and medical fields. It would enable these home institutions to also share in the research through remote operation/access of labs and equipment, thereby saving redundancy cost of expensive infrastructure. Excellent attendance (>120) at the

first Nano-Vivo Summit in 2002 gives some credence to the interest such a center would stimulate in Houston-area researchers.

Advantages of U&M location: Central to TMC, easy access to Rice campus, close to Hobby Airport.

Disadvantages of U&M location: None except possible parking issues depending upon how transportation is handled.

Comparable facilities or projects elsewhere: California centers such as the Center for Nanosystems Institute (CNSI), ($100M to be matched by $250M from Feds, foundations and corporations), collaboration between UCLA and Santa Barbara, but not a centralized center (http://www.cnsi.ucsb.edu/). Also QB3, the California Institute for Bioengineering, Biotechnology, and Quantitative Biomedical Research, similarly linking Berkeley, San Francisco and Santa Cruz (but strangely not San Diego), again without a centralized facility.

Issues: Can such a center begin life small, and grow with time? Can the building provide for growth space?

Questions yet to answer: Will the Texas Nanotechnology Foundation succeed in providing funding opportunities? Will the State of Texas invest in Nano-Vivo?

B19: Center for Fullerene Bionanoconjugate Research

Responsible committee member: Wade Adams

Category: 3—New Research Need

Type of activity: A—Research

Description: This group of approximately 5 PI's from BCM, MD Anderson and Rice University (Lon Wilson) investigates new therapies for cancer using C60 (buckminsterfullerene) and derivatives of C60, including some with endohedral metal atoms. Specific projects now include:

- Dr. Vernon Knight (Baylor College of Medicine)—Fullerene-Taxol Conjugates for Cancer Therapy. New C60-Taxol conjugates are being developed as fullerene-based anti-cancer drugs for lung cancer. Administration will be by a liposome aerosol spray technology patented by Dr. Knight. This work is supported by C Sixty, Inc.
- Dr. Charles Dinsmore (BCM)—Fullerene Cations as Vectors for Non-Viral Gene Therapy. Various mono- and dicationic fulleropyrollidines are being developed to deliver DNA fragments and genes to cell nuclei for therapeutic purposes.
- Dr. Michael Rosenblum (M. D. Anderson Cancer Center)—Antibody-fullerene Drug Conjugates for Targeted Cancer Therapy. New antibody-fullerene drug conjugates are being developed to deliver anti-cancer drug cocktails and radiotherapy to cancer cells. This work is supported by C Sixty, Inc.
- Dr. Sidney Wallace (M.D. Anderson Cancer Center)—Gadolinium Fullerenes as MRI Contrast Agents. New Gd@C60 derivatives are under development as MRI contrast agents. Animal imaging and evaluation is performed at M. D. Anderson. This work is also in collaboration with TDA Research, Inc. of Wheatridge, Colorado, and is supported by the NIH under their new Nanotechnology Initiative.

Location requirement: No specific location required.

Size: A total of 4,000 sq. ft. consisting of five PIs, 15 students/postdocs, minimum of five labs, 10 offices, conference room, total 2000 sq ft lab, and 2000 sq ft office/conference room.

Research funding per year: $3 million '03, $3 million '08

Number of people: 20

Special attributes: Bio/nano labs, hoods

Justification: This is an existing collaboration that will likely grow during the next five years and will also likely be receiving increased NIH and corporate funding. This central location for the research groups would greatly enhance collaborations.

Advantages of U&M location: Near Rice and Med Center.

Disadvantages of U&M location: None

Comparable facilities or projects elsewhere: None known

Issues: None

Questions yet to answer: None

B20: Institute for Molecular Medicine-Rice Center for Nano-Bio Research

Responsible committee member: Wade Adams

Category: 4—New Collaboration

Type of activity: B—Collaboration

Description: A small center for conducting collaborative research between the Chemistry Department/CNST at Rice University and the University of Texas Health Science Center's Institute for Molecular Medicine for the Prevention of Human Diseases is proposed. This center will connect the pioneering research of functionalization of C_{60} and other similar nanoparticles for specific biological activity with the Institute for Molecular Medicine's six research centers:

- Cardiovascular diseases (heart disease, stroke, atherosclerosis)
- Cell signaling (range of diseases, including inflammation in the gastrointestinal tract & other tissues. leukemia)
- Human genetics (range of diseases, including heart disease, stroke, hypertension, diabetes, atherosclerosis, stroke, cerebrovascular disorders; supporting research in all other IMM centers)
- Immunology and autoimmune diseases (asthma, infectious lung disease, skin and kidney diseases)
- Protein chemistry (range of diseases, including neurodegenerative diseases; supporting research in all other IMM centers)
- Vascular biology

Location requirement: None, but easy access to shared equipment is important.

Size: A total of 6000 sq. ft. consisting of four flexible laboratories of 1000 sq ft each, plus office space for researchers and administrators, two administrative offices, and a conference room (1000 sq ft.)

Research funding per year: $0 '03, $3 million '08

Number of people: Twenty researchers and two administrators

Special attributes: Flexible labs, all utilities

Justification: Needed to provide space and environment for nanotechnology researchers to work with CVPR medical specialists. Current labs in THI do not provide for expansion for this collaboration. Spatially separated labs for the nano work and the medical work are not sufficient to achieve true collaboration.

Advantages of U&M location: The location is central to TMC, close to THI building, easy access to other Rice CNST laboratories.

Disadvantages of U&M location: None

Comparable facilities or projects elsewhere: Similar to other small collaborations.

Issues: Can the building provide for growth space?

Questions yet to answer: Will the collaboration succeed in receiving NIH funding for the initial projects?

B21: Institute for Nanoscale Science and Technology

Title: Institute for Nanoscale Science and Technology

Responsible committee member: Wade Adams

Category: 2—Current Collaboration

Type of activity: B—Collaboration

Description: The Institute for Nanoscale Science and Technology (INST, formerly the Center for Nanoscale Science and Technology, CNST) at Rice University is a university-funded organization devoted to nurture science and technology at the nanometer scale. It is equally devoted to the education of future scientist and engineers. Our mission is to provide a venue where researchers from all disciplines of science and engineering can come together to share ideas and discuss their views and prospects of nanoscience, nanoengineering, and nanotechnology. INST provides administrative support to the faculty and to joint projects and programs, supports joint research initiatives, performs fund-raising, sponsors seminars and conferences, encourages entrepreneurism, encourages collaborations both internally and externally, connects to external organizations and supports educational initiatives from Kindergarten to lifelong learning. The main technical thrusts of INST are nanobiotechnology, nano in energy, carbon nanotechnology, social and ethical issues in nanotechnology, and education (K-12 and the public).

Location requirement: None, the space needed will be primarily administrative space.

Size: Eight offices and conference room, general work space (2500 asf)

Research funding per year: No direct research funding now.

Number of people: 8 staff plus 4 students, total of 12 people

Special attributes: None

Justification: The primary offices for the INST should be located near the locus of its main activities, and nano-vivo (nano-bio) and carbon nanotechnology are two of the top three areas of INST focus, both of which will have substantial activities in the facility.

Advantages of U&M location: Proximity to the TMC, but still easily accessible to the rest of the Rice campus.

Disadvantages of U&M location: Slightly farther away from the Deans of Natural Sciences and Engineering.

Comparable facilities or projects elsewhere: Similar to the administrative space required for the IBB.

Issues: None

Questions yet to answer: None

B22: Texas/United Kingdom Collaborative Research Initiative

Title: Texas/United Kingdom Collaborative Research Initiative

Responsible committee member: Wade Adams

Category: 2—Current Collaboration

Type of activity: B—Collaboration

Description: The aim of the program is to foster multi-investigator, inter-institutional collaborative research links between researchers in Texas and the UK, involving universities, medical schools, hospitals, and commercial enterprises. The cross-disciplinary collaborative research efforts will address bioscience research needs, with inputs from the biosciences, nanosciences, and information sciences by fostering inter-institutional and cross disciplinary research to address the needs of society, healthcare and industry. This will be enhanced through encouraging technology transfer, and stimulating and supporting the exploitation of research in novel products and services in health care and other applications of bioscience. Specific goals include the following:

- Initiate collaborative multi-investigator, cross-disciplinary research projects between institutions in the UK and Texas. Identifying up to three major research areas and involving world class research teams synergistically enhancing the research output
- Provide access to funding and other resources for collaborative research, which would not be available to individual research groups working alone
- Develop novel methods and practices to further the research efforts in the biosciences ,and enhance the protection and use of intellectual property
- Stimulate commercialization of technologies in collaborating institutions and, where appropriate, companies resulting in to the more rapid development of technologies
- Establish consortia providing unique access to specialist skills, equipment, and facilities in the UK and Texas

In order to foster high levels of focused collaborative research in a structured way, it is intended to concentrate the program on specific disciplines within the biosciences. The areas that have been selected represent strengths in both locations and provide the greatest opportunity for collaboration and for commercialization:

- Bioengineering, tissue engineering, and regenerative medicine
- Cardiology
- Oncology
- Neurosciences
- Cell signaling
- Computational biology and informatics
- Medical imaging

- Genomics and proteomics (with particular reference to human disease genetics)
- Infectious diseases (including novel vaccines and antibiotics)
- Nanosciences (where relevant to bioscience)
- Structural biology

Other applicable research activities appropriate to these areas of research, for example stem cell research applied to tissue engineering, cardiology, etc, will also be included. Particular emphasis will be given to areas where the research output will lead to intellectual property and/or know-how with the potential for commercialization.

Another element of the program will be to assist researchers in accessing specialist equipment and instruments of research. Areas were collaboration will be supported are:

- Super computing
- Nanofabrication

Support will be available to foster collaborative research on a smaller scale involving a smaller number of disciplines, researchers and institutions than envisioned in the project areas outlined above.

Texas institutions include the following:

- Baylor College of Medicine, Houston
- Rice University
- Texas A&M University
- University of Texas Health Science Center, Houston
- University of Texas M.D. Anderson Cancer Center
- University of Texas Medical Branch Galveston
- University of Houston

UK institutions include the following:

- Imperial College, London
- Kings College, London
- University College London
- University of Cambridge
- University of Manchester
- University of Oxford

Location requirement: None, the space will be primarily administrative space.

Size: Eight offices and conference room, general work space (2500 asf)

Research funding per year: $3 million ’03, $4 million ’08 (approximately $14 M total over several years)

Number of people: 8 staff plus 4 students, total of 12 people

Special attributes: None

Justification: The primary offices for the program should be located near the locus of its main activities, which focus on nanobiotechnology. Although most of the research funding will be distributed to the partner institutions, it is believed that a substantial amount of the funding will be for research which could occur in this facility.

Advantages of U&M location: The proximity to the TMC.

Disadvantages of U&M location: None

Comparable facilities or projects elsewhere: Similar to the administrative space required for the IBB and INST.

Issues: None

Questions yet to answer: Will this collaboration continue after its initial tenure of funding from the US and UK?

D1: Shared Equipment Authority

Responsible committee member: Jason Hafner and Vicki Colvin

Category: 2—Current Collaboration

Type of activity: D—Facilities and Instrumentation

Description: Space for large shared research equipment, defined as equipment used by more than two research groups in more than two departments, similar in concept to the current Shared Equipment Authority (www.ricesea.org) at Rice.

Location requirement: High-resolution electron and scanning probe microscopes require a vibration-free environment, so these instruments need to be on the ground floor, or in the basement if adequate flood control can be ensured.

Size: 10,000 sq.ft.

Research funding per year: $2 million ‘03, $4 million ‘08

Number of people: 10

Special attributes: Low vibration, 220 power, cooling water, one internet connection per instrument, restricted access, dark rooms.

Justification: Our growing research capability requires increasingly expensive equipment that cannot be supported by a single group. The quality of our shared equipment facilities will directly impact our overall research quality.

Advantages of U&M location: Shared equipment is best kept in a neutral location, rather than "owned" by a research group. U&M will represent such a location. In addition, more outside use by medical center researchers would help increase usage hours. Low usage is a problem at a small school like Rice.

Disadvantages of U&M location: Most current shared equipment is used primarily by groups in Dell Butcher Hall, Space Science, Keck, Abercrombie, etc., so the distance to U&M may be an issue.

Comparable facilities or projects elsewhere: Harvard Center for Imaging and Mesoscale Structures (www.cims.harvard.edu), Cornell Nanofabrication Facility (www.nnf.cornell.edu).

Issues: Educational aspects possible—teaching undergrads and grads practical use of high-tech equipment.

Questions yet to answer: What types of equipment would be included? Will all current SEA equipment be included (which will not be possible) or just a certain class of equipment, such as those with bio-slant?

D2: Animal Facility

Responsible committee member: Fred Rudolph

Category: 4—New Collaboration

Type of activity: A—Research, B—Collaboration, D—Facilities and Instrumentation

Description: It will be critical to develop facilities to support the various model systems needed for research activities of the programs. These should include vertebrates up to at least rabbits, facilities for fish and other marine organisms, plants, and others. The facilities need to include extensive surgical and extended care suites. Depending on how the research program of the facility develops there may be a need for extensive mouse or other vertebrate colonies for genetic variants.

Location requirement: It is important to have these facilities near to research activities.

Size: Sufficient to support major new programs. It is difficult to estimate without knowing the program but a facility of at least 20,000-40,000 sq. ft. with ancillary support for vertebrates would be needed. Plant space could be of similar size.

Research funding per year: Would be a part of many individual and collaborative grants and could be the basis of specialized grants. Estimated $0 ‘03, $2 million ‘08.

Number of people: Support staff would include a number of technical staff, possibly 10-20 at least.

Special attributes: State-of-the-art facilities to provide the best environment.

Justification: Needed for development of the programs in the facility.

Advantages of U&M location: Needed for support of collaborative activities.

Disadvantages of U&M location: None

Comparable facilities or projects elsewhere: We have a small, marginally adequate in size facility at Rice. There are facilities at various institutions in TMC but the expanded activities at U&M would be limited without the facility.

Issues: Size and location relative to providing security for animals and avoidance of interference from animal rights advocates.

Questions yet to answer: What is the size and extent of the facility?

D3: Genomics, Proteomics, and Metabolics

Responsible committee member: Fred Rudolph

Category: 4—New collaboration

Type of activity: B—Collaboration

Description: Interactive space and facilities for collaborative research in the computationally intensive, interactive areas of using data to predict function and structure of gene products.

Location requirement: It is important to have these facilities in an area where collaboration is possible.

Size: Would involve shared computational space and equipment for proteomic, expression and metabolic analysis. Likely 10-20,000 sf of laboratories and offices.

Research funding per year: Would support new initiatives in these areas with program grants for a variety of activities. $0 ‘03, $3 million ‘08.

Number of people: Would need a number of support staff (10 maybe) in computational and analytical areas.

Special attributes: Significant equipment requirements.

Justification: A major support group for most of the activities of the program. Critical and possibly inside the Gulf Coast Consortia.

Advantages of U&M location: Would allow collaboration.

Disadvantages of U&M location: None

Comparable facilities or projects elsewhere: None

Issues: How extensive is the program? How will it be funded?

Questions yet to answer: Size, composition, placement.

E1: Bookstore/Coffee Shop

Title: Bookstore/Coffee Shop

Responsible committee member: Rebekah Drezek

Category: 4—New Collaboration

Type of activity: D—Facilities and Instrumentation

Description: A large, combined operation encompassing the Rice U. bookstore and other logo items, supplies, etc. It will serve the medical community, technical community, and university community as well as general public. Model after Oxford's Blackwell's Books—maybe with an open pit arrangement—similar to the Norrington Room at Blackwell's (http://web.comlab.ox.ac.uk/oxinfo/blackwells).

Location requirement: Easy access to public. Ideally located on ground floor.

Size: Norrington Room is 10,000 sq ft, and main store is 160,000 volumes and three miles of shelving. Therefore, the estimated size would be 10,000 asf.

Research funding per year: NA

Number of people: 40

Special attributes: Contains or is joined to a comfortable coffee shop, many chairs, and sofas.

Justification: Stimulate intellectual atmosphere, encourage interaction through being a meeting place. Would replace Rice's current bookstore which is crowded and poor atmosphere. Will provide a bookstore for TMC, patients, families, and public. Furthermore, BCM does not currently have a bookstore, which would be a benefit for BCM.

Advantages of U&M location: Would help bring TMC people/public to Rice.

Disadvantages of U&M location: Students need easy access.

Comparable facilities or projects elsewhere: Many modern bookstores on campuses—Stanford, Cornell, the Harvard Coop are all well-known examples

Issues: Needs to combine Rice student needs, medical center needs, and public needs.

Questions yet to answer: What other bookstores serve TMC institutions?

E2: Restaurant

Title: Restaurant

Responsible committee member: Rebekah Drezek

Category: 4—New Collaboration

Type of activity: D—Facilities and Instrumentation

Description: A high quality restaurant (including bar) to serve Rice and the Texas Medical Center institutions.

Location requirement: Ideally located on highest floor to provide view of the city.

Size: 20,000 asf

Research funding per year: NA

Number of people: 30

Special attributes: A good view of downtown, TMC, and Rice would be a nice attraction to patrons.

Justification: Lack of restaurants in the Texas Medical Center. Faculty club in the medical center closed recently, and a new Italian restaurant for lunch/dinner has recently opened in the TMC and is presently the only restaurant available. Furthermore, a restaurant located in the building would keep people in the building rather than going out for lunch, thereby increasing productivity.

Advantages of U&M location: View from top floor. Need for a restaurant within the medical center.

Disadvantages of U&M location: Parking for public patrons. The restaurant would need to offer validation for events and meetings.

Comparable facilities or projects elsewhere: Trevisio in TMC.

Issues: Could Rice/TMC sustain such a restaurant? If significant public business is necessary as well, ample parking might be an issue. Does Trevisio obviate this need? Can the community support more than one high-quality restaurant?

Questions yet to answer: Necessary size. Identify the competition.

E3: Cafeteria

Title: Cafeteria

Responsible committee member: Rebekah Drezek

Category: 4—New Collaboration

Type of activity: D—Facilities and Instrumentation

Description: A large cafeteria which would serve occupants of the building and others in the Texas Medical Center area. It would facilitate collaborations among building occupants.

Location requirement: Easy access.

Size: Undetermined, but spacious enough to create a pleasant atmosphere. 30,000 asf.

Research funding per year: NA

Number of people: 40

Special attributes: Open atmosphere so occupants of the building who bring their lunches would eat there, too. Healthy food—a good salad bar/healthy sandwiches (like Alonte Café in Smith Towers). It is hard to find a healthy lunch in the medical center.

Justification: Occupants of the building (and visitors) will need a convenient place to eat. This facility is an important potential mechanism to encourage interactions. Food must be of much higher quality than current Rice cafeterias and with more choices.

Advantages of U&M location: Captive audience in building occupants.

Disadvantages of U&M location: None

Comparable facilities or projects elsewhere: Duke University has a cafeteria in the middle of the large interdisciplinary science and engineering building. There is a new cafeteria in the ACES building at UT Austin, and St. Luke's currently has the best cafeteria in the medical center.

Issues: Would the cafeteria be located on the top floor, first floor, or middle floor?

Questions yet to answer: Necessary size.

E4: Student Health Center

Title: Student Health Services Center

Responsible committee member: Wade Adams

Category: 2—Current Collaboration

Type of activity: D—Facilities and Instrumentation

Description: Rice University student health services center, relocated from Hanszen College.

Location requirement: Easy access to students.

Size: 6000 asf

Research funding per year: N/A

Number of people: 10 doctors, nurses, staff

Special attributes: Clinic space, which includes administrative space, waiting room, exam rooms, laboratory, offices.

Justification: Relocation to U&M would encourage students to visit the new research facility. New space could allow design of modern health facility integrated into the research facility concept.

Advantages of U&M location: Easy access to TMC staff for consultation.

Disadvantages of U&M location: Slightly farther away from most student residences than current location in Hanszen College.

Comparable facilities or projects elsewhere: None known or examined.

Issues: Rice is now at point of deciding to remodel current facility.

Questions yet to answer: Could Rice health care costs be decreased by offering a faculty/staff clinic as part of new health plans? What services are needed on-site?

E5: Library and Access Point

Responsible committee member: Janet Braam

Category: 4—New Collaboration

Type of Activity: D—Facilities and Instrumentation

Description: A center is needed for shared access to the Medical Center and Rice University Libraries.

Size: Approximately 2,000 sq. ft. space furnished with computers, printers, and copiers will be required. In addition, three support staff positions will be needed.

Research funding per year: $0.5 million ‘03, $1 million ‘08

Number of people: 3

Special attributes: The library will need to be a state-of-the-art facility with high speed internet connections. Furthermore, there will need to be a shuttle running to and from the current Rice library.

Justification: The occupants of the building will need a library to access research materials. Traveling back to Rice or TMC will not be acceptable or productive.

Advantages of U&M location: This would be an essential part of the U&M facility.

Disadvantages of U&M location: None

Comparable facilities or projects elsewhere: THI Library in TMC.

Issues: None

Questions yet to answer: Should Rice Fondren Library assume responsibility or should it be shared with TMC for operations?

E6: Transportation Center

Title: Transportation Center

Responsible committee member: Wade Adams

Category: 4—New Collaboration

Type of activity: D—Facilities and Instrumentation

Description: Parking for automobiles, Segway, and electric cart parking, access to public transportation (bus and light rail), intra-campus transportation access (bus and Segway), and pedestrian considerations. To encourage pedestrian access, underground or above ground access to the TMC and crossing University Boulevard should be considered. Extension of Rice bus routes into the facility will be necessary. Attractive pedestrian access will also be critical, to encourage walking. If Segways become common, secure parking in a common area or dispersed throughout the facility will be necessary.

Location requirement: Adequate on-site parking or special considerations to encourage minimal automobile parking.

Size: Unknown, but current high-rise construction often includes up to one-third of the gross space allotted to parking. Impact of such space allocations should be carefully considered.

Research funding per year: N/A

Number of people: People assigned to monitor and operate parking/transportation facilities could number from 10-20, depending upon types of transportation options adopted.

Special attributes: Good access to both Rice campus and to the TMC.

Justification: Could be a net positive cash flow for the facility. A transportation center is required for a new, urban research facility.

Advantages of U&M location: Central location for TMC and the new Rice campus concept.

Disadvantages of U&M location: None

Comparable facilities or projects elsewhere: None were identified or studied.

Issues: Needs to combine Rice needs, medical center needs, and public needs.

Questions yet to answer: What transportation services will be needed in five years?

E7: Retail

Title: Retail Space—Shops

Responsible committee member: Wade Adams

Category: 2—Current Collaboration

Type of activity: D—Facilities and Instrumentation

Description: Space for several retail shops to serve the needs of occupants of the facility as well as other visitors to the facility or to the TMC. Examples of retail operations are office supply, lab supply, clothing, drug store, "quick" shop, travel agency, gift and flower shop, and delicatessen take-out.

Location requirement: Easy access to public. Ideally located on ground floor.

Size: Each shop would need to be 1000-2000 sq ft each, for a total of 15,000 sq ft.

Research funding per year: N/A

Number of people: 4-6 per shop, total of 30-50 people

Special attributes: Adjoined to the bookstore/coffee shop.

Justification: Potential to be a net positive cash flow for the facility, if tenants can be maintained. Offers amenities to occupants and the TMC and Rice University communities, saving time for visitors and employees.

Advantages of U&M location: It would help bring together TMC and Rice community, as well as bringing the public to the facility. It would offer the closest shopping available to Rice people.

Disadvantages of U&M location: None

Comparable facilities or projects elsewhere: A few shops are located in the TMC, but none are located at Rice University campus.

Issues: Needs to combine Rice needs, medical center needs, and public needs.

Questions yet to answer: What other shops currently serve TMC institutions? Would lease rates be competitive? What services are really needed?

F1: Learning Center

Responsible committee member: Fred Rudolph

Category: 4—New Collaboration

Type of activity: D—Facilities and Instrumentation, F—Meetings

Description: Classrooms, support areas, offices, possibly teaching laboratories for nano/bio/enviro subjects.

Location requirement: Can be anywhere in the building but likely better on lower floors with access to food, parking, bookstore etc.

Size: Should have a number of classrooms, both small and large, conference rooms, support areas, offices for faculty to meet with students, and areas for secretarial support. It would be appropriate to have ten small rooms/conference rooms and 2-3 larger rooms.

Research funding per year: NA

Number of people: 5

Special attributes: High quality space with good AV facilities and teleconferencing capability. Each room should be equipped for PowerPoint presentations, and all would need wireless computer access. It is possible that entire areas could share the wireless network with access restricted in some manner. Teaching laboratories would depend on what faculty/departments are in the facility. In addition, it would be important to develop laboratory facilities that could support outreach education by having short courses for teachers, grade 7-12 students, and the public. This activity could be shared with various outreach groups on campus and in the medical center.

Justification: We already have a number of joint educational programs with TMC, including various training programs, the neuroscience effort, and others that would benefit greatly from shared space. In addition, if departments or programs move to the building, it will be important to have undergraduate class space there. The center could also be used for programs sponsored by Continuing Studies, reducing the pressure on the rest of the campus for evening rooms. It would also be useful to provide some community access for meeting space in the building as a way to support the surrounding area.

Advantages of U&M location: The adjacency to TMC would be of central importance to draw from the 60,000 people as well as the Rice community.

Disadvantages of U&M location: Potential reluctance for some faculty and students to have classes there. This problem could be solved by having good shuttle service and provision of other benefits.

Comparable facilities or projects elsewhere: Not known

Issues: How the space would be administered, who would use it, and how?

Questions yet to answer: See above

H1: Administrative Space

Responsible committee member: Fred Rudolph

Category: 4—New collaboration

Type of activity: G—Administrative

Description: The facility will need space for building operations including academic scheduling, facilities and engineering, purchasing and receiving and all aspects of support.

Location requirement: These activities are a natural part of the various programs and will be distributed throughout the facility.

Size: Would need to be 5-10% of total net sf of facility, 25,000-50,000 asf.

Research funding per year: NA

Number of people: Will depend on size and scale of operation, approximately 75 total.

Special attributes: Accessible, loading dock, and storage facilities.

Justification: Administrative support is crucial to the day-to-day operations of facility of this magnitude.

Advantages of U&M location: NA

Disadvantages of U&M location: NA

Comparable facilities or projects elsewhere: NA

Issues: None

Questions yet to answer: What is the scale of the operation?

I 1: Visiting Institute

Responsible committee member: Jan E. Odegard (Richard G. Baraniuk)
This is a short version of a proposal/white paper developed by Richard Baraniuk October 2000. The full document should be consulted for additional insight.

Category: 4—New Collaboration

Type of activity: B—Collaboration

Description: The U&M location should include a new *Visiting Institute* to host top engineering and science researchers and educators from academia and industry. The Institute will bring together Rice faculty and students, a small number of long-term (several months to one year) visitors, a larger number of short-term visitors, and several two-year postdoctoral fellows in a state-of-the-art research and conference center. Regular workshops, panels, and lecture series in emerging areas of science and technology will also be held. This concept provides Rice with exciting opportunities to:

- *Enhance our visibility* by exposing a large number of academic and industrial leaders to the unique Rice environment that has impressed so many previous visitors. More successful faculty and student recruiting, greater public awareness, and higher departmental rankings will result.
- *Enhance our programs* by leveraging our existing strengths into new areas through synergistic collaborations with outside researchers and educators. The Institute will encourage interdisciplinary research and teaching between our current focus areas and, in addition, will allow Rice to explore new potential focus areas for future development.

The Institute will act as an incubator for new scientific, technological, and educational innovations. Our model expands upon the existing and extremely successful TI Visiting Professorship in ECE and incorporates the best aspects of several existing visiting institutes. To keep the scope manageable, the Institute will focus on science and technology; however, once successfully established, this concept can be readily replicated to support Rice's other research disciplines.

Location requirement: No particular limitation or requirement.

Size: Size is difficult to assess, but the facility would require several conference rooms, access to a small number of lecture rooms/halls, collaborative group areas, office space and housing for visitors. One of the key challenges with hosting short to medium term visitors at Rice is housing. Providing housing that can be used by the institute in support of research visitors would be of significant value.

Research funding per year: $0 '03, $2 million '08

Number of people: Five staff, 15-20 visitors

Special attributes: Housing in the U&M facility, or connection to the adjoining Hilton Hotel, with special arrangements.

Justification: First time visitors to Rice often comment on how they didn't know of Rice before and would love to be working in such a stimulating environment. A visiting center would help facilitate increasing Rice's visibility.

Advantages of U&M location: Space is available, both for the required institute space requirements, as well as for potential housing in adjacent lots owned by Rice, limiting major transportation challenges for short and medium term visitors to the institute.

Disadvantages of U&M location: Distance from many of the academic departments and collaborators for visitors.

Comparable facilities or projects elsewhere:

- Isaac Newton Institute, University of Cambridge, UK
- Institute for Mathematics and its Applications, University of Minnesota
- Mathematics Science Research Institute, University of California at Berkeley
- Institute for Pure and Applied Mathematics, University of California at Los Angeles
- Santa Fe Institute, New Mexico
- Institute for Theoretical Physics, University of California at Santa Barbara
- Institute des Hautes Etudes Scientifique, Paris, France
- Hong Kong University of Science & Technology (http://www.ust.hk/en/aa/index.html)

Issues: None

Questions yet to answer: None

I2: Incubator Space/Pharmaceutical

Responsible committee member: Fred Rudolph

Category: 4—New collaboration

Type of activity: A—Research, E—Education, and G—Administrative

Description: The biotechnology industry in the Gulf Coast region has not yet developed any momentum of its own. One limiting factor has been good space for incubators for small, start-up groups and another is the lack of a major pharmaceutical company which could provide infrastructure and credibility to the region. Development of space for support of both small and larger companies would be of great value. BioHouston is an organization that was developed to do many of these aspects but which has scaled back. It may be a good partner for this facility. It would rent space to technology transfer offices from various institutions (one could visualize all the universities having their tech transfer offices in one location), house venture capital groups, provide incubator space and host a variety of activities.

Location requirement: This is the place for these activities. Proximity to all parties will enhance the development of these programs. Collaborative research requires groups to interact.

Size: The BioHouston operation could be as large as 30,000 square feet. A pharmaceutical company operation could occupy 50,000-100,000 sq. ft. of research and support space.

Research funding per year: Lease fees maybe $15-25 per sq ft per year

Number of people: 50-500

Special attributes: Good office and research space, as well as the space for meeting facilities.

Justification: A natural fit for these activities.

Advantages of U&M location: Noted above, a unique opportunity.

Disadvantages of U&M location: Only managing the interaction of commercial with academic use.

Comparable facilities or projects elsewhere: Possible in Boston (Kendall Square)

Issues: Managing interactions with commercial use.

Questions yet to answer: What is the size and who will run the facility? Likely lease rates for a startup company, may be much lower than retail space.

Appendix 7
M+W Zander Study on Collaborative Environments for Scientific Research

M+W Zander focuses on cleanroom technologies, including the production of cleanroom components and technical facility systems for the electronic, pharmaceutical, and food industries. The company is the global leader in the planning and realization of turnkey chip factories. The company is currently examining high-rise research facilities for their collaborative aspects, and will send us their results as soon as possible.

What is collaboration?

Collaboration is a powerful group "systems" strategy with the goal of achieving creative and viable solutions to problems that go beyond an individual team member's limited vision of what is possible in an increasingly interconnected world.

Collaboration depends on a free flow of untested ideas—the kind of interaction that tends to place participants in vulnerable situations. Environmental conditions that foster a sense of emotional safety and control tend to nurture meaningful interaction.

For collaboration to take place team members need to:

- Communicate with each other
- Share an understanding of insights and visions
- Create and discover together
- Self-sustain effective team performance

Architecture can foster collaboration by:

- Creating opportunities to draw people together in a range of productive venues, from the planned symposium to impromptu conversation
- Providing an innovative and flexible environment that communicates and transforms an organization's cultural values
- Providing an inspiring and engaging environment that helps to fuel shared creation and discovery
- Providing a comfortable work atmosphere that offers a wide range of experiential choices from open forums for collaboration to secluded places for reflection

M+W Zander is currently developing integrated architectural design strategies that may be used to foster the vision of the facility as a truly interdisciplinary and collaborative research community. Given the prominent site—adjacent to the Texas Medical Center, characterized by a complex of high-rise structures—and the proposed scale of the project, a high-rise laboratory design solution has been considered by the project development team at Rice as a preliminarily viable and appropriate solution. The recommendations in the study are based on an analysis of the advantages and disadvantages of high-rise research facilities in terms of seven basic design questions, each of which are evaluated based on their influence on collaboration.

- How can formal and informal collaboration be nurtured in a high-rise research environment?
- How can flexibility be optimized in a high-rise research facility where programmatic change is to be expected?
- How can a high-rise research facility accommodate multiple and sometimes unrelated user groups?
- How can sustainable design strategies be optimized in a high-rise facility?
- What are the regulatory (that is, building codes, ES&H policies, etc.) impacts on a high-rise research facility?
- What are the impacts of controlled environment research spaces within high-rise facilities?
- How can a high-rise facility be integrated into the architectural traditions of the Rice Campus?

Collaboration is further explored in the study with a particular focus on providing space within controlled environment laboratories as technically advanced "Collaboratoriums."

Conclusions explore integration of the above concepts to create a state-of-the-art research community.

M+W Zander believes that architecture that achieves the objective of fostering collaboration may be crafted from these basic design concerns:

- Spatial arrangements
- Density and scale
- Degree of enclosure
- Flexibility
- Identity
- Spatial quality
- Process

Appendix 8
Nanotechnology Buildings

Although the report on the first meeting of several planned workshops supported by the National Nanotechnology Initiative is not yet ready, the program for the first meeting held in January 2003 will be useful for the U&M project. It lists the areas of concern for anyone planning to build a new facility with significant experimental facilities involving nanotechnology: acoustic isolation, vibration isolation, temperature and humidity control, air cleanliness, electromagnetic and radio frequency interference, power conditioning and grounding, and system integration. Facilities also need to consider maintaining local experimental environments versus large area environments in order to contain costs.

NANObuildings.com is a Web site intended to provide technical information about advanced technology facilities. It includes relevant information about workshops, projects and other web links covering the design and construction of such projects. For more information on please visit the Web site at http://www.nanobuildings.com/.

As presentations and reports on these meetings become available, they will be sent to CNST for dissemination to Rice's planning teams.

Appendix 9
Stanford University's Bio-X

In 1998, Stanford began to formalize interdisciplinary collaborations in bioscience and engineering and named the concept Bio-X to signify the breadth of multidisciplinary research across the university. Stanford has already made a serious commitment to Bio-X. Much of the energy has come from a groundswell of excitement from the faculty, some of whom initiated the program. The Stanford University Bio-X program brings together engineering, physics, chemistry, and the information sciences with biology and medicine to foster new discoveries and inventions. The Stanford Schools of Engineering, Medicine, Humanities and Sciences, and Earth Sciences teamed up to form the new program.

Bio-X fosters the coming together of leading-edge research in basic, applied and clinical sciences to enable tomorrow's discoveries and technological advances across the full spectrum from molecules to organisms.

The Bio-X Program for Bioengineering, Biomedicine, and Biosciences at Stanford is broad-based and campus-wide. The Program is facilitated by a new Center (The James H. Clark Center for Biomedical Engineering & Sciences), which began construction in June 2001 thanks to the enormous generosity of Jim Clark. A critical mass of ~40 faculty from various disciplines will occupy the Center. Completion of the Center is slated for May 30, 2003.

The Bio-X Program at Stanford University has, as one of its major goals, the enhancement of interdisciplinary programs among the scientific communities at Stanford in computer science and technology, engineering, the basic sciences in Humanities and Sciences, the earth sciences, and the pre-clinical and clinical sciences in the School of Medicine in areas related to bioengineering, biosciences, and biomedicine.

With the support of President Hennessy, Bio-X announced a call for proposals for this new $3M Interdisciplinary Initiatives Program. Faculty members were asked to submit proposals for new interdisciplinary programs in research, undergraduate, and graduate education, and innovative initiatives that relate to these areas of biology.

In October 2000, nineteen proposals were awarded seed grants, averaging $158,000 over a two-year period.

Because the first round was so successful, President Hennessy announced that a further $3M in funds will be available starting in November 2002 to support a second round of funding for the Bio-X Interdisciplinary Initiatives Program.

In October 2002, twenty-one proposals were awarded seed grants, averaging $143,000 over a three-year period.

The research projects for both rounds include interdisciplinary initiatives in new innovative research programs that could best (or only) be performed by faculty from different disciplines, curricular innovations, training grant program augmentation, pre and post doctoral fellowship support, and seminars and symposia.

Please refer to the Stanford University's Web site at http://cmgm.stanford.edu/biochem/biox/ for any additional information.

Appendix 10
Cornell University's New Life Sciences Initiative

Cornell University announced a New Life Sciences Initiative (NLSI) designed to advance discovery in the genomics age. The New Life Sciences Initiative (NLSI) is a university-wide collaboration to develop and launch a multiyear, $500-million campaign that will enhance and support life sciences research and education. President Rawlings and Provost Martin foresee hiring at least 50 new faculty into life science-related areas as part of the NLSI.

Cornell will receive funding through private donors and New York State. The New York State Office of Science, Technology and Academic Research, last year designated Cornell as the site for a Strategically Targeted Academic Research center for Genomics Technologies and Information Sciences. Funding is hoped to reach as high as $15 million.

The following Web site is link to an article in the Cornell Chronicle: http://www.news.cornell.edu/Chronicle/02/5.9.02/NLSI.html.

Please visit the Cornell web site at http://lifesciences.cornell.edu/ for more information.

Appendix 11
Harvard's Bauer Center for Genomics Research

A knowledge connection from SCUP and the AAMC's GIP.
Tradeline, Inc.|Leading-edge resources for facilities planning and management
www.TradelineInc.com (can be found in the archived articles).

Harvard University Constructs Bauer Research Center Multi-Disciplinary Initiative Focuses on Genomics

By Tracy Carbasho

Published January 2003

The pioneering design of the new Bauer Laboratory, which houses the Bauer Center for Genomics Research at Harvard University, provides for maximum collaboration between scientific disciplines and a productive work environment by offering flexible laboratory spaces, innovative technology, and the optimal use of resources.

The Center's primary goals are to develop genomics research programs that require collaboration across traditional departmental boundaries, to provide the Harvard research community access to cutting-edge genomics proteomics technologies, and to perform important genomics research.

"The sharing of space and equipment by researchers facilitates interaction that leads to an enhanced interchange of ideas," says George Busby, director of administration for the Center. The Bauer Center for Genomic Research (CGR) represents the first initiative in a new multi-disciplinary approach to science launched by Harvard in 1999. As space is extremely limited on the Cambridge campus, University leaders decided to demolish the 11,000-sf Gibbs Laboratory, no longer a viable research facility, and construct the 62,000-sf, five-story Bauer Laboratory. Restricted by the University's desire to maintain open spaces, the Laboratory is limited to an above-ground footprint that is only slightly larger than the previous structure.

The 14-month design process began in April 1999 with construction getting under way in the fall of 2000. The $26-million Bauer Center, designed to house approximately 90 permanent staff members, also accommodates an additional 30 to 50 researchers from other University schools and departments who receive training or utilize the equipment on a daily basis. The Center is designed to be easily and inexpensively adaptable to meet the ever-changing and diverse needs of a growing number of research Fellows. The upper floors of the building were occupied in March 2002, and the basement areas were ready for occupancy in September.

Making the Most of Available Space

Designers from Ellenzweig Associates in Cambridge, Mass., took into consideration the small above-ground footprint on which they had to build the facility. All available underground space was used to build a 30,000-sf basement, which features core support and mechanical systems, bulk storage spaces, shipping and receiving areas, labs, offices, and specialized instrument rooms. The basement is constrained on the north and east by major utility tunnels and on all sides by other buildings. "We were able to get the maximum value from this space by physically connecting it to both the chemistry and molecular biology buildings with a series of corridors," says Busby. "In the occupied office areas of the basement, which is used primarily for computational biology, we added skylights to bring in the maximum amount of natural light." On the upper floors, glass interior walls allow natural light to enter the work areas and create an open, transparent environment that is conducive to interaction and discussion among researchers. A skylight on the third floor projects down the stairwell, which is also surrounded by glass to obtain an increased amount of natural lighting.

Making the most efficient use of the available square footage meant placing all of the instrument and wet labs in the center of each floor and locating the offices along the exterior walls. Write-up areas and desks for the research staff are typically located along the north perimeter, while offices for the CGR Fellows are along the south perimeter. Other necessary support lab space such as warm rooms, cold rooms, tissue culture rooms, freezer rooms, dark rooms, and instrument rooms are placed along a shared wall with an adjoining building and are readily accessible from the laboratory.

Adaptable Labs for Tomorrow's Needs

"Genomics is a rapidly changing field that requires expertise from many disciplines to solve difficult and complex problems. The Fellows are a diverse group of scientists who stay at the Center for only three to five years. The University administration does not want to pay for lab renovation and construction every time a new Fellow with a new research program joins the Center" explains Busby. "Therefore, flexibility in the laboratory areas is an absolute necessity." The laboratories are designed with movable tables and wet lab benches that can be easily and inexpensively moved on an as-needed basis throughout the Center. Casework is provided in two-foot-wide modular units with lockable casters, and adjustable or removable shelves. Space beneath the tables and benches is flexible to accommodate the individual needs of each researcher. Utilities are fed from overhead service modules, which provide electricity, data connectivity, gas, air, nitrogen, vacuum, cold water, and deionized water. Services accessed frequently are mounted to a removable shelf and are readily available on the bench. The electrical outlets at the modules have twist lock connections and all other utilities have quick lock disconnects. "Another special feature is that the wet labs and instrument labs are totally interchangeable. We've provided the same infrastructure, the same distribution of overhead service modules, and the same distribution of floor drains," says Busby. Floor drains with cover plates, which can easily be exchanged for drain grates, are located below each of the overhead utility service modules.

Environment Encourages Interaction

University leaders wanted a building where researchers could easily interact with each other and share ideas. The entire facility is built around the goal of maximizing interaction. Designers met this objective by first including a café and lobby area on the ground floor. The west side of the café boasts another gathering area with soft seating. Tables with umbrellas are outside the café for those who want to enjoy their meal outdoors on a warm day. All four levels of the Center feature a tea, or seminar, room, which includes an LCD projector, an overhead projector, and laptop hookups. Each floor also includes a 140-sf interaction room that can be used for small seminars, group meetings, research discussions, interviews, or conference calls. The interaction areas also contain a telephone, data connectivity, and wireless Internet.

Another factor that has promoted interactions is the high density of researchers. In most traditional laboratories, research groups are segregated with each group having its own benches, its own instruments, and its own set of contiguous offices or desks. In the Bauer Lab all the instruments are shared and the desks in the write up area are filled as people arrive, not according to which research group they belong. On the upper floors, each researcher has approximately 117 sf of lab space. This forces individuals to share space and resources, and potentially leads to the sharing of research ideas. The interior glass walls on each floor make it easy to find people and to see what is happening on the floor. "One thing leads to another and pretty soon the researchers know what's going on in each other's group," says Busby. The core resources play a major role in facilitating interaction, and these unique facilities attract many different research groups to the Center. Core technologies include microarray, bioinformatics/ computational biology, robotics, high-throughput screening, and mass spectroscopy. "We're presently providing training, access to our resources, and collaboration to more than 200 different research groups at Harvard University," adds Busby.

Accessibility to the Harvard Research Community

Busby stresses the importance of making the Bauer Center accessible and functional for the entire University research community. The location of the building in the center of the science departments and its physical connection to both the chemistry and molecular biology buildings has made it convenient for researchers to access the Center. The core technologies attract many researchers from Harvard's Medical School, the School of Public Health, and Harvard-affiliated hospitals.

The Center staff trains individuals how to use the various CGR instruments and technologies. When the Center staff determines that a user is qualified to use the equipment, facilities are then made available on a 24-hour basis. Identification card readers are located on the doors to each lab and instrument room. "We're able to program access to specific spaces for certain periods of time for individuals," says Busby. "All of our instrumentation can be scheduled over the Web with each instrument having its own set of protocols for scheduling." The Center maintains computer control of both the activation and operation of every instrument. An identification name and password are

given only to those qualified to run the instruments and to prevent unauthorized individuals from using instruments that can cost as much as $400,000. Visitors can also enjoy the amenities of the tea rooms, interaction areas, the public access computers on each floor, wireless Internet email capabilities, the café, and the lobby which includes plasma screens that show biological visualizations, seminar notices, and other important information.

Special Infrastructure Features

The building has a number of unique infrastructure features, including an oversized HVAC system that currently supports seven fume hoods with the capability of supporting up to 60. The building's utilities are constructed identically to those in the adjoining chemistry building, and are connected to them enabling redundancy and convenient backup for both buildings in the event of a mechanical failure or scheduled preventive maintenance. A large emergency generator located in the basement of the Bauer Laboratory is capable of supplying power to the entire complex of chemistry buildings.

The shipping and receiving operations for five departments are now consolidated into a single operation, allowing an area previously occupied by five loading docks, up to 12 trash dumpsters, and a few parking spaces to be converted into a beautiful courtyard that is enjoyed by researchers and Center visitors.

Lessons Worth Reporting

The key lesson learned by Harvard planners is the importance of flexibility when constructing an interdisciplinary science center. Several CGR Fellows have received research grants and have increased their staffs. In order to accommodate the growth, the University is installing additional wet bench space in what had previously been instrument space. As for the future, Busby would like to see more storage areas at the individual benches, more removable shelves at the wet benches, and more spaces for interaction. "When the environment is conducive to interaction, researchers become interested in looking beyond their own work," says Busby.

Biography

George Busby has served as director of administration for Harvard University's Bauer Center for Genomics Research since 1999. He coordinated the design and construction of the new research facility. Previously, he served as assistant director of Harvard's chemical laboratories from 1973-76 and received his doctorate in synthetic organic chemistry from Harvard University in 1975. Busby was responsible for the operation of the chemistry department of Rice University in Houston from 1976-97 and then moved back to Massachusetts to serve as executive director of administration for the Eisai Research Institute before returning to Harvard.

This article is based upon a presentation Busby gave at the Tradeline Colleges, Universities, and Medical Schools Conference in October 2002.

For more information

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South Courtyard

The new Bauer Laboratory is designed to promote interaction among researchers. The south courtyard, which provides a comfortable environment with cafe tables, is just one design feature that encourages interaction and collaboration.
(Photo courtesy of Ellenzweig Associates © Edward Jacoby, Photographer.)

First Floor Labs

Glass interior walls permit natural lighting to flow into the work areas, creating an open environment that facilitates collaboration. All utilities are supplied by overhead service modules and casework is provided in two-foot-wide modular units.
(Photo courtesy of Ellenzweig Associates © Anton Grassl.)

Design Team

Acoustical: Cambridge Acoustical, Cambridge, Mass.
Architecture/Lab Planning/Furnishings: Ellenzweig Associates Inc., Cambridge, Mass.
Civil Engineer: Bryant Associates, Boston
Contractor: Daniel O'Connell's Sons, Waltham, Mass.
Fume Hoods: Labflex, Brookline, Mass.
Landscape: Reed Hilderbrand, Watertown, Mass.
Lighting: Lam Partners, Cambridge, Mass.
MEP Engineer: BR+A/Bard, Rao + Athanas Consulting Engineers Inc., Boston
Plumbing/Fire Protection: R. W. Sullivan, Boston
Signage: Jon Roll & Associates, Cambridge, Mass.
Structural Engineer: Le Messurier Consultants, Cambridge, Mass.

Appendix 12
Howard Hughes Medical Institute—Janelia Farm

Officially announced on February 1, 2001, Janelia Farm is intended to create a free-ranging environment in which chemists, physicists, computer scientists and other specialists can collaborate with biologists. Janella Farm will occupy 281 acres in Virginia and is expected to cost over $500 million to construct and operate.

Preliminary plans call for at least 750,000 gross square feet of space and construction to begin in 2003. The initial construction will provide laboratories for up to 24 investigators plus their research staffs, a total of 200-to-300 persons.

In 2002, Howard Hughes Medical Institute (HHMI) announced the selection of Rafael Vinoly Architects PC as the architect for Janelia Farm. Vinoly, located in New York, head a 150-member architectural firm. Furthermore, in November 2002 the Loudoun County Board of Supervisors, (location of Janelia Farm), approved the issuance of $550 million in industrial development revenue bonds.

HHMI is one of the largest philanthropies in the world, with an endowment of more than $12 billion and a budget that exceeds $660 million in the current fiscal year. Its headquarters are located in Chevy Chase, Maryland, just outside Washington, D.C. The president of HHMI is Thomas R. Cech.

For more information on Janelia Farm refer to the following Web sites:

- http://www.hhmi.org/bulletin/july2001/janelia/
- http://www.hhmi.org/news/vinoly.html
- http://www.leesburg2day.com/current.cfm?catid=28&newsid=6263
- http://www.bio-itworld.com/archive/081302/firstbase.html

Appendix 13
Texas Healthcare and Bioscience Institute—The 21st Century Life Science Roadmap

The following is the Executive Summary of this document. The full version of this document can be found at http://www.thbi.org/about/roadmap.pdf.

Executive Summary

Texas' life science cluster has reached a pivotal moment in U.S and global competitiveness. Business and economic models are undergoing rapid change, and Texas is facing new trends and changing demographics. States throughout the U.S. are competing for the business revenues, research investment dollars and thousands of life science jobs expected over the next decade. Twenty-six U.S. regions have significant strategies under way to sustain their life science clusters. Examples of their successes include:

- Seattle Hood Center ($150 million in new funds)
- Stanford's BIO-X Project ($210 million in new funds)
- Harvard and MIT ($250 million over two to three years)
- Indianapolis ($1 billion over ten years)
- Yale ($1 billion over five to seven years)

If Texas is going to successfully compete, our life science companies and institutions need to be able to quickly adapt to change, so they can leverage present and future opportunities to sustain research; bring new products to market readily; and leap ahead of competitors. Texas needs a strategic plan for the life science industry. A plan headed by champion—a connector that can turn the many components of the life science industry into long-term economic and societal benefit.

It is time for Texas to leap-frog the competition and take its place at the forefront of next generation regions worldwide. The 21st Century Life Science Roadmap is the strategic plan Texas needs. And creation of the Texas BioInnovation Network – a nonprofit entity – would provide the necessary champion: a dedicated partner for the academic, industrial, entrepreneurial and economic development interests dependent on the success of the life science market in Texas.

The Texas Life Sciences Cluster

In many ways, today, the Texas life sciences cluster is in an enviable position. We have many highly competitive public and private companies and institutions. We have excellent facilities, and research funding is at an all-time high. Moreover, we have the entrepreneurial mindset necessary to visualize this industry's future direction and position ourselves to take the best advantage of the opportunities ahead. Today, the healthcare technology industry in Texas includes:

- 500 companies with $6.5 billion annual sales
- More than 50,000 private jobs with an average annual salary of $48,623
- Average company research and development expenditures of $3.1 million a year
- At least 396 new products in development

In the area of basic and applied research, which feeds this growing industry, Texas also possesses a wealth of resources, including:

- 55 medical academic institutions and research parks
- More than $1 billion in academic research expenditures in the life sciences in 1998

These two areas combine to create a formidable economic driver for Texas' economy, with:

- Total expenditures of $20.15 billion
- Gross State Product of $11.57 billion
- State and local government income of $1.04 billion

Roadblocks to Success

Unfortunately, Texas also faces hurdles in the race to compete in the life sciences. Launching a life science enterprise in Texas is difficult. Our state is challenged with minimal capital and managerial talent, insufficient infrastructure, and processes that impede commercialization of technology by private business. To be globally preeminent, Texas must:

- Spark innovation and discovery by building networks among scientific and research resources and those capable of developing new ideas.
- Attract research and management talent that can drive formation of the next generation of companies.
- Encourage greater commercialization, so society and the state economy can benefit sooner.
- Respond to emerging societal, scientific and economic trends.
- Provide a globally competitive environment and the perspective for collaboration among institutional, scientific, entrepreneurial and public-private institutions.

The Texas Healthcare and Bioscience Institute

As a representative for hundreds of life science concerns across the state, the Texas Healthcare and Bioscience Institute (THBI) is leading the charge to create and promote the 21st Century Life Science Roadmap for Texas.

Created in 1996, THBI is Texas' premier association for the life science industry and the Texas arm of the international Biotechnology Industry Organization (BIO). THBI members include biotechnology, medical device, and pharmaceutical companies, universities and private research institutions, and companies that provide goods and services to core organizations.

THBI promotes the expansion of life science research and manufacturing in Texas by giving these companies an effective voice to pursue issues in their best interest. As such, THBI provides the Texas research and manufacturing community with unparalleled grassroots opportunities to communicate with political leaders, the news media, venture capitalists, investment bankers and the public about the importance of the research and manufacturing community to our state's future success. THBI demonstrates the major contributions research and manufacturing make to Texas' state and local economies — and the great potential for financial growth and job creation. Fostering industry development is an important THBI function, and sustaining a favorable business climate is critical for this development to occur. The 21st Century Life Science Roadmap for Texas provides the framework for building an environment that allows the life sciences to flourish.

Only by setting forth clearly defined steps for all segments of our society can we build a vibrant scientific and technological community for the new century before us—a community capable of delivering once unimaginable health, economic and quality-of-life benefits to all of our families.

Appendix 14
GE Global Research Center

In January 2002 GE announced the investment of more than $100 million in a multi-year project to modernize its research and development headquarters in Niskayuna, NY. The newly renamed GE Global Research Center will be a state-of-the-art research lab and hub for new technology innovations at GE. The Center has been the cornerstone of GE technology for more than 100 years by developing breakthrough innovations in areas such as medical imaging, energy generation technology, jet engines and lighting. The GE Global Research Center has been located in New York State's Capital District since 1900, and has expanded to include facilities in Bangalore, India and Shanghai, China.

The multi-year renovation project will include a new wing of laboratories for biotechnology and nanotechnology as well as state-of-the-art meeting and conferencing facilities. As a result of this investment, GE's Global Research Center will continue to be a focal point of technology in New York State. The Center employs 1,700 people here, including 1,200 technologists (600 of which are PhDs) and people from 45 different countries.

More information can be found at the following Web sites:

- http://www.genewyork.com/CRD.News_Release.PDF
- http://www.ge.com/stories/en/10680.html

Appendix 15
Beckman Institute

The Beckman Institute for Advanced Science and Technology at the University of Illinois at Urbana-Champaign is an inter- and multidisciplinary research institute devoted to basic research in the physical sciences, computation, engineering, biology, behavior, and cognition.

The Beckman Institute was conceived early in 1983, when campus administrators decided to assemble a proposal for a unique new venture in multidisciplinary research at the university. Two faculty committees were subsequently appointed to develop plans for interdisciplinary research thrusts in the engineering and physical sciences, and in the life and behavioral sciences.

The resulting committee reports formed the basis of a proposal submitted to Dr. Arnold O. Beckman in the fall of 1984. Dr. and Mrs. Beckman's gift of $40 million was announced at the annual meeting of the University of Illinois Foundation in October 1985. The Illinois legislature, in its fall 1985 session, appropriated $10 million toward the costs of the project. In addition, the university and the state of Illinois pledged to support the continued operations and maintenance of the Institute.

The Institute consists of 313,000 square feet and makes up six floors, making it the largest single building at the University of Illinois at Urbana-Champaign, other than the University Library. More than 600 researchers from nearly 30 University of Illinois departments as far-ranging as psychology, computer science, and biochemistry, comprising 15 Beckman Institute groups, work within and across these overlapping areas. The building offers more than 200 offices; specialized, state-of-the-art laboratories and other facilities; and meeting areas for lectures, conferences, seminars, and casual interactions.

The Institute's primary mission is to foster interdisciplinary work of the highest quality in an environment that transcends many of the limitations inherent in traditional university organizations and structures. The Institute was founded on the premise that reducing the barriers between traditional scientific and technological disciplines can yield research advances that more conventional approaches cannot

For more information refer to the Beckman Institute Web site at:
http://www.beckman.uiuc.edu/

Appendix 16
Flexible Labs

In the rapidly changing world of bioscience, medical science, and nanotechnology flexible labs have become increasingly more important to keep up with universities' short and long-term needs. The purpose of a flexible lab is to accommodate change over time and to adapt assignments of space to scientists to accommodate the specific needs of each discipline. For example, at Wayne State University in Detroit the need for flexible lab design was driven by overcapacity—the number of applicants exceeded the space by a ration of 4 to 1. To overcome this issue, the facility was designed in two blocks, one for lab space and the other for office space. The labs were created with modules which can be used separately or combined. The classrooms were created with closed circuit television broadcasts to accommodate distance learning.

The key to design a flexible lab that is cost effective and promotes research is interaction between the faculty and the design team. By discussing current research needs and future research needs, the architects can design a lab that will meet the present requirements as well as future requirements. Keep in mind that what may be important today many not be relevant ten or twenty years from now. Some examples of flexible lab space include:

- Bench top height that is adjustable by scientist at the touch of a button
- Mobile instrument carts
- Distinct separation of wet and dry labs
- A generic floor plan that allows for future changes
- Vertical utility services

For the space to be successful, full involvement from information technology, architects, faculty, security, and administration will be necessary, keeping in mind the design will need to relevant and useful for current and future researchers.

More information on flexible lab space can be found at
http://asumag.com/ar/university_designing_flexibility/.

Appendix 17
Green Architecture

The U&M facility will contain state-of-the art equipment, technology, and labs, which will have certain restrictions and exercise constraints on the building itself. Designing a building to withstand the pressures of resource needs will be a great need. A new design concept is called green architecture. Green architecture will lessen the pressures the building will place on the environment and add to the harmony of the space. Areas of green architecture include:

- Light—Light is a large part of the energy equation, often accounting for 40 percent of the building's utility costs. By making better design choices, a building can save 30 percent of the costs, thus resulting in lower maintenance costs and use of conventional lighting. All of this can be achieved through increased use of daylight, light fixtures (rather than direct lighting), and open ceilings.
- Venting—Rather than using conventional venting methods, green architecture focus on using naturally vented systems. With compounding employee health concerns and increases in the amount of health insurance, naturally vented systems have proven to increase the health of the occupants. Productivity increases, and employees are happy.
- Plants—Use of plants inside the building can be visually pleasing as well as cost-effective. Creating an open atrium encourages collaboration. Plants can also be used in the design to save money. For example, at UT's School of Nursing and Student Community Center includes an eco roof of plants to hold water and insulate the building, cylinders to catch and recycle rainwater and runoff from air-conditioning units, and photovoltaic cells to generate solar power.

Green architecture includes many aspects of building design that are not discussed in this appendix (that is, use of recycled materials, waterless urinals, and use of nonpolluting paints). If the contents of the U&M building are going to be considered state-of-the-art, then the design of the building itself should be taken into consideration. Because of continuing energy and health problems, green architecture is becoming more widely accepted. Recently, the U.S. Department of Energy (DOE) launched the Commercial High-Performance Buildings Project as part of its Commercial Whole-Building Roadmapping initiative. The purpose of this project is to raise the awareness of owners, developers, facilities managers, architects, engineers, and contractors regarding innovative concepts using comprehensive systems-engineering approaches that increase the quality and efficiency of commercial buildings while reducing their costs and environmental impacts.

The following Web sites offer more information about green architecture:

- http://sonser4.nur.uth.tmc.edu/sonscc.htm
- http://www.architectureweek.com/topics/green.html
- http://www.energydesignresources.com/enews/PDFedr/EDR-Issue13-August18.pdf