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June 4, 2019

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COMMITTEE REPORT FOR UC 10-YEAR RESEARCH PLAN

"Innovation is born when disciplines collide." These six words encapsulate much of the essence of this document. The Committee was charged with formulating ideas about where STEM research at University of Cincinnati (UC) should be in 10 years and how best to achieve that goal. This is a difficult task since the rates of scientific advances and unanticipated discoveries are so rapid that they defy prediction. Nevertheless, in order to be at the forefront of, or keep pace with, the academic research community, UC must be positioned to rapidly take advantage of the unpredicted and to embrace and develop new discoveries as they emerge. To be competitive in this arena, UC must become nimble and rapidly adaptable to new research paradigms and new ideas that may require the melding of very different disciplines. This will require the University to change its culture and its architecture from one in which siloed intramural units compete for funds, based on numbers of undergraduates enrolled, to a culture that fosters interdisciplinary collaboration and synergy.

The Committee invited three individuals to speak with the Committee to share their various perspectives. Professor Pat Limbach, UC Vice President for Research and an Ohio Eminent Scholar, confirmed the need for greater synergy within the UC research community and described the ongoing efforts to enhance research innovation. Professor Marshal "Chip" Montrose, UC Vice Provost and Dean of the Graduate School spoke with the Committee and, among other issues, discussed the need to recruit ever better graduate students in the STEM fields, and some of the hurdles to achieve that end. The third invitee was Professor Steven Goodman, Vice Chancellor for Research at the University of Tennessee Health Sciences Center (UTHSC) involving four campuses across the state. Professor Goodman had been charged with developing and implementing a five-year research plan for the institution and was currently in the fourth year of his tenure at UTHSC. His approach and ideas were thoughtful and his implementation plan seemed to be highly successful. He shared with the Committee a 90-page document describing in detail his rationale and strategy. He was adamant that for any plan to succeed, its formulation and implementation must involve and have buy-in from the faculty. This means that there must be trust between the faculty and the administration. There must be interactions plus incentives for interactions between disciplines and campuses. He emphasized the need for entrepreneurship and collaborations with small and large companies and the need to convince state legislators that financial support of the research enterprise brings benefits to the state in the form of jobs. To that end, he has brought to Memphis a start-up company that focuses on 3-D printing of blood vessels for transplantation. The draw for Memphis was the presence of FedEx for rapid worldwide delivery of newly minted blood vessels. He is now negotiating a multi-hundred million dollar relationship with FedEx to support other research projects.

Before embarking on methodology, one should define the actual ten-year goal and what metrics one should use as a measure of success, or lack thereof. An aspirational goal is for UC to be in the top 50 universities in the STEM disciplines. This would entail bypassing schools like Brandeis University and the University

of Iowa. A less aspirational objective would be a ranking in the top 80 universities where UC would be competing with the likes of Baylor University and Boston University. A more realistic goal, perhaps, would be a ranking in the top 40 public universities where UC would be competing with the likes of Rutgers University and the University of Massachusetts. A metric of success could include research funding from federal sources and/or foundations plus contracts for research with industry. In recognition of the fact that UC is smaller than some of its competitors, one might consider dollars secured per researcher as a metric. Alternatively, it could be reputational as is reported annually by U.S. News and World Report. Regardless of ranking or metric, UC must retain Carnegie Research 1 status. Carnegie Research 1 status represents doctoral universities that engage in very high research activities There are 131 Carnegie Research 1 universities in the United States, of which 96 are public universities. In Ohio, there are only three Carnegie Research 1 universities including UC. It is imperative that UC retain Carnegie Research 1 status to retain credibility with the Ohio state legislature to remain competitive for research funding from the State.

An analogy for a successful research program is a three legged stool where loss of integrity of one leg causes instability or collapse of the stool. In this scenario the three legs for research would be 1) outstanding research programs and faculty; 2) outstanding graduate, undergraduate and postdoctoral education; and 3) an administration and business model that financially and emotionally support the long term vision of UC as a leading research institution nationally and internationally. Without all three legs working in harmony and to the same end, the vision of UC as a leading research institution will fail or, if initially achieved, will collapse.

Research Programs:
The University and the Board of Trustees must accept that in the short term, support of research, particularly basic research, is not a revenue generator, but in the long term its benefits include financial income in the form of commercial licenses, royalties, patent income and job creation for the local economy. Leading research also generates recognition and prestige for the Institution nationally and internationally, facilitating more effective recruitment of top-notch students. A most recent example in the biomedical field is based on studies of a bacterial immune system which unexpectedly led to the discovery of a new, efficient and inexpensive gene editing system that has the potential of becoming a billion dollar industry. Given the rapid, and often unexpected advances in our knowledge base, UC must decide whether to build on existing strengths, create new programs or develop a hybrid model. Whatever the decision, the institution must recognize that research is ever-increasingly interdisciplinary and that the programs that are developed must promote interdisciplinary interactions.

I. PROGRAMS (INTERDISCIPLINARY):

1. One program that is imperative to build and that bridges all disciplines is **computational and data sciences.** UC must have the ability to handle and take advantage of the enormous datasets and associated data platforms that have been, and continue to be, generated. There are pockets of expertise in foundational data science disciplines (statistics, machine learning and artificial intelligence) and applied data science disciplines (biostatistics, bioinformatics, business analytics), but what UC needs is a program that transcends the University. This is not a proposal to enhance "UC Information technology" (UCit). However, UCit should assist to ensure that the network infrastructure and speed is sufficient to handle efficiently the large banks of data that researchers need to download and mine. In today's world, the current internet speed of UC network is inadequate for the needs of many of our researchers in multiple fields.

2. For recognition and publicity, UC might find it advantageous to align itself with one or more overarching themes which support research that encompasses multiple disciplines and that utilizes technologies from various fields. Such alignment might give recognition and publicity to UC as a leader in addressing major global issues from multiple perspectives. Some of the themes discussed by the Committee include: a) Health, geological and sociological consequences of climate change: This theme might address far-reaching issues such as how to ameliorate (even prevent) severe weather events, improving alternative energy sources, enhancing sustainability, promoting access to fresh water, and how to deal with new diseases and possible pandemics, etc.: b) Global and

local urbanization: There are opportunities to combine architectural expertise and/or city planning with artificial intelligence to optimize the design of living spaces or traffic and commuting patterns, respectively. Of course, new psychosocial and health challenges may arise and will need to be addressed: c) Aging populations and the concomitant economic, health, demographic and sociological consequences. How do we care for an aging population and who will pay for such care?

3. Formation of interdisciplinary research institutes and centers. As defined by our visitor, Dr. Steven Goodman, research institutes would have no boundaries and would operate freely between colleges, and even perhaps in collaboration with other academic institutions or businesses. Centers, in contrast, would be formed by faculty within a college and could be enhanced by joint appointment of faculty from other colleges. Institutes should receive funding directly from the central administration and not from individual colleges. Should UC actively move in a direction that supports "big science", it will be necessary to revise its criteria for tenure. There will be individuals who will never be the lead investigator of a program but whose contributions are indispensable for the success of programs in which they are involved. These individuals are likely never to be the lead or communicating author on published papers or the lead investigator on a grant. However, they should be eligible for tenure based on their value and contributions to the program(s).

   Developing institutes is a challenging proposition and will require participation of faculty from most, if not all, of the colleges. To help identify current areas of excellence will require active participation from UC libraries to do key word analysis on funded grants and publications from the immediate past five years. Using these data, a committee of faculty should select four or five areas that could be formed into research institutes as well as a couple of aspirational institutes based on a sense of where future research opportunities may emerge. The Committee recognizes that formation of research institutes will require changes in the way funds are distributed and will need a change in culture at multiple levels. Such a culture change is addressed in a later section. The Committee also stresses the need for active faculty involvement and participation in all aspects of structural and fiscal change. Faculty participation and buy-in is essential for developing, adopting and implementing strategies to enhance the research status of UC.

Recognizing the rapid pace of scientific advancement, it is important for UC to be positioned to take advantage of opportunities offered by unexpected research advances. One suggestion considered by the Committee was to recruit certain new faculty from disparate disciplines into institutes, but not have their labs reside in a departmental space but rather in a common research space. In other words, a common space may house faculty laboratories from Chemistry, Electrical Engineering, Molecular Medicine, Physics, etc. The concept is that particularly the graduate students and postdoctoral fellows will inevitably bump into each other and talk about their research interests. It is hoped that such a research intensive environment with mixed expertise will generate new ideas that are spawned as a consequence of intersection of two or more disciplines.

Given the internal competition between colleges for operational funds, a second model was discussed in which the role of deans would be limited to undergraduate educational initiatives while internal allocations for research funding would reside with the Vice President for Research. This model would require that the Vice President for Research have a broad background in basic and entrepreneurial research and that he/she have sufficient financial resources to effectively build and maintain a cutting-edge research enterprise. In this model, it would be important that the Vice President for Research have a co-governing faculty-based advisory committee. Alternative models promoting interdisciplinary research should also be considered. Regardless of the model selected, there needs to be accountability of institute and center performance to both administration and faculty. Metrics of success need to be defined jointly by administration and faculty, and all institutes and centers that are formed as part of the University strategy must be reviewed and reauthorized by faculty and administration committees on a rolling three year basis.

II. FACULTY, GRADUATE STUDENTS AND POSTDOCTORAL FELLOWS:

Integral to successful research programs is the high quality of the faculty and the ability of the faculty to pursue their research in unfettered manner. There should be an emphasis in recruitment and retention of outstanding researchers who embrace collaboration rather operating in a more traditional siloed manner. Currently, in comparison with other Research 1 universities of comparable size, many of the research oriented departments at UC have about one third fewer faculty than similar departments at peer institutions. This puts our research faculty at significant disadvantage due to extraordinarily heavy teaching loads due to a faculty shortage. If UC is serious about increasing its national research status, it must hire significant numbers of faculty at all ranks to replenish faculty size in the basic science departments, particularly in the College of Arts and Sciences and in the College of Engineering and Applied Sciences. While the situation in the College of Medicine and other colleges in the Academic Health Center is not quite as dire, faculty numbers in the College of Medicine basic science departments are significantly diminished and urgently need active recruitment to rebuild the basic science departments. If there is no emphasis on faculty recruitment and retention, the UC aspiration for elevated research status will not be achieved.

Faculty recruitment and retention:

1) The case for faculty recruitment is clear. However, the University must provide sufficient resources for the hiring unit to make competitive offers. To hire the best faculty requires competitive salaries and recruitment packages. Equally important is the retention of outstanding researchers. The best researchers will inevitably receive offers to move elsewhere. UC must recognize that each recruitment represents a very large investment. Thus, if an outstanding faculty member receives an offer from another institution, UC must be willing to counter with an appealing offer to retain that faculty member if the initial investment was a good one. Recruitment and retention are multifactorial. The salary must be competitive. The teaching load, which will vary between disciplines, must be acceptable. The available infrastructure and instrumentation needed for the research must be available to the individual, either in his/her laboratory or as a core facility. The research environment must be collegial and conducive to interaction and collaboration.

2) Graduate students and postdoctoral fellows:
The lifeline of any research program is the graduate students and the postdoctoral fellows. Along with technicians, these are the people who perform the actual experiments and do much of the work. Because they are less constrained in their thinking, students and postdocs often come up with the most innovative and creative research ideas. Therefore, it is critical that the various research programs, departments, colleges recruit and retain the best graduate students and young investigators, particularly given the aspiration of enhanced university research status. Currently the graduate students in the arts and sciences who perform research are gravely underpaid and are obliged to carry a teaching workload that interferes with the efficient pursuit of their research. At the same time, funds allocated to departments for graduate education in the College of Medicine have been stagnant for many years with the number of stipends as well as stipend amounts lagging behind peer programs. To be competitive with our peer institutions, this deficiency must be corrected.

3) Infrastructure:
The explosive growth and exponential rise in the complexity of and dependency on data (including big data), in all scientific disciplines calls for substantial intervention in the digital infrastructure. The current level of investment is insufficient to enable UC to keep pace with the technological developments of today and tomorrow, let alone with peer institutions. If the University wishes to remain a leading research institution, major investments in innovation, capacity, support, security, and researchers are necessary. The quality of scientific research depends on the quality and capacity of the digital infrastructure. Insufficient investment means that network speeds and computing capacity will be outperformed by other Research I universities. The impact will be felt in all areas of research currently active in the University: Natural and Social Sciences, Humanities, Medical Diagnostics, Technology and Engineering, Climate Change, and many others.

A broadly accessible, high-quality digital infrastructure is essential for efficiently and effectively facilitating competitive science. Practically all meaningful scientific and technological developments are dependent on digital infrastructure development and deployment of a high-speed network infrastructure, including a very high speed backbone networking system and the Next-Generation Internet. Providing a robust and sustainable digital infrastructure for competitive scientific research must be part of a UC long-term plan for research.

Digital infrastructure represents an immediate need and one in which UC is falling behind its peers. Each discipline, however, has instrumentation and infrastructure needs that are required to maintain pace with our peers. Some equipment can be negotiated at the time of faculty recruitment, according to the needs of the recruited individual. In some cases, if there is wider need for certain instrumentation, the equipment can become part of a university core facility and available on a fee for service basis. The University must recognize that today's cutting edge instrumentation can become obsolete within five years. There is also the expense of supporting an individual with appropriate expertise to run and maintain the instrument. An example of such an instrument that would be useful in the material sciences and in the biomedical/molecular biology field is a cryo-electron microscope (cryo-EM) that allows visualization of structural elements at atomic resolution. The lack of such instrumentation impairs the ability of our researchers to be competitive in these fields. There are three Carnegie Research 1 institutions in the State of Ohio, and UC is the only one that lacks such a facility.

III) ADMINISTRATION AND BUSINESS MODEL:

Currently, UC operates on a performance-based budget (PBB) fiscal model. Simplistically, the PBB model rewards those units that bring in the most dollars by increasing their budgets for the following year. Since most of the revenue that is considered in the PBB model is based on the number of undergraduate students taught, this model is antithetical to the successful development of premier research programs. Under a PBB model premier research-intensive programs produce little short-term revenue stream other than funded grants. In short, UC must find an alternative budget model with long-term vision if it is serious about being an academic leader in research.

Whatever budgetary model UC chooses, it must be one that promotes innovation, particularly in knowledge-intensive fields of research. It must be one that promotes our ability to attract and educate the best and most passionate predoctoral and postdoctoral students to new areas of research opportunity. As indicated earlier, it is the graduate students and postdoctoral fellows who form the lifeblood of any research program. They are essential for maintaining progress at the research frontier and in transferring new knowledge to academia and industry by providing trained scientific and engineering personnel. Graduate and postdoctoral stipends must be competitive throughout the University with those of leading institutions in order to attract the best.

The University culture must change to promote a far more collaborative environment that seeks excellence at all levels. This includes the University administrative architecture which needs to be structured to best facilitate research excellence. It must provide incentives, such as increased salaries or salary bonuses for successfully initiating collaborative programs, particularly those that involve very different disciplines. It must provide internal opportunities for bridge funding so that loss of a grant does not irreversibly incapacitate a research program. It needs to have a funding program that is dedicated to recognizing and supporting new research opportunities and directions as they arise. The ability to be nimble and adaptable must characterize not only our researchers, but the University administration.

SUMMARY: (Executive)

The Committee's charge was to present to the Vice President for Research its ideas regarding where UC should stand nationally as a research intensive institution and what is needed to achieve that goal. Several metrics for assessing success or lack thereof, for aspirational and more realistic goals are suggested. The Committee concurred that a 10-year plan might be too long a framework since the pace of discovery is

increasing exponentially, rendering prediction of what the next major scientific advances may occur during that time frame virtually impossible. Given the current nature of science, the Committee agreed that the development of the scientific enterprise at UC must emphasize interdisciplinary approaches and all efforts to retain Carnegie Research 1 status. A priority should be to establish a University-wide umbrella computational and data sciences program that transcends all colleges and departments. Other suggestions and recommendations include:

- Aligning research programs with a major global theme
- Changing the University fiscal model to facilitate and promote research in general and interdisciplinary research in particular
- Creating a research infrastructure throughout the University with instrumentation and core facilities that enable UC researchers to be competitive nationally and internationally.
- Creating a collegial and supportive environment that enables the recruitment and retention of the very best faculty researchers
- Developing outstanding programs with exceptional faculty to attract the best graduate students and postdoctoral fellows
- Changing the administrative architecture so that the research enterprise falls under the aegis of the Vice President for Research, with adequate resources to promote synergy and to minimize intramural competition between colleges for research dollars
- Modifying the University culture at all levels to move away from silo-based research to collaborative interdisciplinary research
- Increasing the engagement of the state legislature by the administration to enhance state funding for research at UC
- Involving the faculty in all aspects of devising changes to the research enterprise at UC and in their implementation

Respectfully submitted on behalf of the Committee for formulating a 10-year STEM research plan

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