November 25, 2013

MEMORANDUM

TO: The Steering Committee

FROM: June Pierce Youatt, Acting Provost

RE: Request to Establish a New Academic Department: Department of Biomedical Engineering

I seek the advice of Academic Governance on the request to establish a Department of Biomedical Engineering. The proposed department would provide an identity for the biomedical research which is being conducted across numerous departments, within various colleges, and provide a possible academic home to faculty recruited to Michigan State University as part of the Institute for Engineering, Science and Health (IESH). Please note that faculty recruited to the IESH may choose to be housed in any number of academic departments; this simply provides an additional, relevant option.

In addition to increasing the visibility of the research in this area, "a BME department may have a positive impact on recruiting women to engineering at MSU. According to the American Society for Engineering Education (ASEE), women earned 21.8% of the doctoral degrees awarded in engineering in 2011. Biomedical Engineering had the greatest percentage of women earning doctoral degrees with 36.7%.

Michigan State University's lack of a BME department marks us as an exception with respect to our aspirational peers. Each of the top 50 engineering programs, according to US News and World Report, have a biomedical engineering program, department, or school. Of the twenty (20) "Big Ten Plus" engineering colleges, only the University of Nebraska and Michigan State University lack a BME department.

I would appreciate the advice of relevant standing committees – particularly the University Committee on Faculty Affairs and the University Committee on Graduate Studies.

Thank you.
Opportunities Attributed to a Department of Biomedical Engineering on the Faculty and Students
22 November 2013

Background: The College of Engineering at Michigan State University is requesting the establishment of a Department of Biomedical Engineering (BME) within the college. This document describes the challenges associated with the lack of such a department and its anticipated impact. It should be noted that the majority of the Big Ten universities have such a department, or similar; many have had such units for over 20 years.

Challenges: Currently, we have research active faculty spread throughout the college who are engaged in biomedical engineering research. Their work is primarily supported by the National Institutes of Health (NIH) – see Appendix A regarding current biomedical research activities by Engineering faculty. In addition, they enjoy support from the National Science Foundation and other federal and private sponsors. The Department of Biomedical Engineering will grow from strong research programs and make the university as a whole stronger in this important area of scholarship while also maximizing the impact of their work on the community.

Although there are institutes dedicated to translational research such as the Clinical and Translational Sciences Institute (CTSI) and the Institute for International Health (IIH) led by the College of Osteopathic Medicine, none provides an academic home for faculty and students. A planned Institute for Engineering, Science and Health (IESH) will provide a research venue for faculty with interests aligned with the IESH foci; however, the number of foci will be limited to provide maximum research impact through its programs. The proposed Biomedical Engineering department will provide a venue for academic programs related to IESH and neuroengineering, among others, in addition to serving as a venue for collaboration distinct from the various institutes.

Challenges in growing the research enterprise for biomedical discovery within the College of Engineering include:

1. Graduate students interested in studying biomedical engineering have no "home" at Michigan State University. None of the existing departments has MS or PhD degree programs in biomedical engineering. Such degree programs are typically much different from other engineering programs (such as mechanical engineering, electrical engineering, computer science and so on). Biomedical engineering degrees have significantly greater biology and physiology content compared to other programs in the college. Graduate student recruiting is a major bottleneck for faculty without a formal biomedical engineering graduate program. A companion request for establishing such programs is following the academic governance process.
2. Faculty research opportunities have been hindered by the lack of a formal biomedical engineering presence. Proposers to programs at NIH, such as some of those in the National Institute of Biomedical Imaging and Bioengineering, have a competitive advantage if the engineering faculty member has an affiliation with a focused biomedical (or bioengineering) department. Some mid-career faculty have reported that they had difficulty in securing support from NIH prior to having an affiliation with one of the medical colleges.

3. Faculty recruiting with biomedical engineering research interests is significantly hampered by lack of a department. Michigan State University is expanding the research enterprise for translational health care. The institution needs to be able to attract the best and brightest new faculty at all levels to compete with more established biomedical research institutions. Top faculty recruits will not come to MSU if they cannot have a reasonable assurance that they can recruit top graduate students. Having a department that provides an “academic and intellectual home” for faculty with similar and complementary scholarly interests will facilitate such recruiting.

**Opportunities:** Planned faculty hiring related to translational health care includes addition of engineering faculty with complementary scholarly interests. The addition of a Department of Biomedical Engineering will foster an environment to attract top faculty who will in turn attract top-quality students. It will allow MSU to expand its course offering in the area of scholarship (see Appendix B for a current list of BME-related courses offered in the College of Engineering). The end result will be strengthening the College of Engineering’s academic programs and research enterprise, strengthening of collaboration of the college with other colleges on campus, and a strengthening of Michigan State University as a whole.
Appendix A: Select Current Biomedical Research in the College of Engineering

Research experience is the core element of graduate education in STEM fields, and Biomedical Engineering is no exception. Many of the faculty members of the College of Engineering are involved in BME research, some as their main focus and some as part of a collaborative project.

Because BME brings an engineering outlook (e.g., design, analysis, quantification, invention) to solving biomedical challenges and uncovering basic phenomena, talent in computational and laboratory research methods are both needed and complementary between research groups. These research efforts are developing understanding of basic biological, physiological, evolutionary, and biochemical phenomena and developing innovations in diagnostic techniques, tissue engineering, and clinical interventions. Some groups combine computation and experimentation within one laboratory, such as in systems biology.

Promising therapeutic innovations range from development of tissue-engineered patches for spinal cord injuries (a collaborative effort of Sakamoto and Chan, ChEMS and Baek, ME), to robotics for telemedicine (Mukherjee, ME), to administration of poloxamer to prevent the pathogenesis of osteoarthritis following blunt force trauma to the knee. Other innovations include enhancements of highly focused ultrasound (HIFU) for adjuvants to chemo and radiotherapies (McGough, ECE) and novel pharmaceuticals and drug delivery based on nanomedicine (Worden, ChEMS) and nucleic acids (e.g., siRNA) (Walton and Chan, ChEMS) and antibodies (Whitehead BSE/ChEMS, and Chan, ChEMS).

Biosensors (Alocilja, BSE and Mason, ECE) are important for diagnosis, but also for public health and safety for rapid detection of communicable diseases and dangerous pathogens. Recent faculty hires have broadened CoE’s efforts with lab-on-a-chip devices for diagnosis (Lillehoj and Yeom, ME). Other biosensors complement these efforts with allied environmental efforts to invent unique proteomic chips for screening of potential pathogens in ground water sources (Hashsham, CEE). Self-powered implantable biosensors may offer real-time monitoring of surgical interventions and implants (Chakrabarty, ECE). Others are developing protocols for wireless body area sensor networks (Biswas, ECE) related to autism.

Computational efforts include novel advances in digital evolution (Cheng, McKinley, Ofria, Brown, Pennock, and Torng, CSE) and in CoE contributions to BEACON (Goodman, ECE). Biomedical signal processing yields understanding of cardiovascular function (Mukkamala, ECE), central nervous system (Oweiss, ECE) and brain function (Aviyente, ECE), speech (Deller, ECE and Chai, CSE) and control of spinal posture (Choi, ME). Computational efforts extend further, including leading edge efforts in biometrics (Jain and Ross, CSE), development of image processing techniques for automated analysis of biomedical images (Udpa, ECE) and use of large data base searches for protein homology classification or ncRNA identification (Sun, CSE). Many of the CoE faculty members actively contribute to the Quantitative Biology (QB) Graduate program.
Some researchers combine computational expertise with fundamental biochemical and cell biology laboratory work in systems biology and determination of stem cell fate decisions for Alzheimer's and Parkinson's diseases (Chan, ChEMS) or to uncover the basic function of genomics and development (Brown, CSE). Other researchers use experiments combined with analysis to uncover the electrophysiology of the heart (Mukkamala, ECE), the central nervous system (Oweiss, ECE), the response of proteins and cells to high temperature (Wright, ME) or the thermomechanical paths to developing decubitus ulcers (Reid-Bush, ME) or abdominal aortic aneurysms (Baek, ME).

The most recent faculty recruit in the TRIFECTA (College of Communication Arts and Sciences, College of Nursing, and College of Engineering) initiative (Zhang, ECE) is developing intelligent embedded sensing and ubiquitous computing technologies with a special focus on healthcare applications in the fast-evolving research field referred to as Mobile Health (mHealth) and patient-centric personalized healthcare.

Appendix B: Current BME-related Courses in Engineering

Our faculty members have already developed a number of biomedical-related courses to meet demand by students. While it is noted that almost all are at the 400-level, this has occurred because 1) this is the only level of course that can be counted in both undergraduate and graduate programs, and 2) our undergraduates who wish to pursue graduate study in BME (here or elsewhere) need such a foundation for acceptance to graduate school. Developing a department and a graduate program should quickly open doors of opportunity that will retain our most qualified BS graduates and lead to an increasing number of 800 level courses.

Some courses currently existing in the College that can support a graduate program in Biomedical Engineering include:

**Mechanical Engineering courses**
- ME 494 Biofluid Mechanics and Heat Transfer (Fall every year)
- ME 495 Tissue Mechanics (Spring every year)
- ME 497 Biomechanical Design in Product Development (Spring of every year)
- ME 8XX Cardiovascular Mechanics – to be planned 2014 Fall

**Chemical Engineering and Material Science courses**
- MSE425 Biomaterials and Biocompatibility (Spring of every year)
- CHE883 Multidisciplinary Bioprocessing Laboratory (Spring even-numbered years)
- CHE891/CMB800/GEN891 Systems Biology Resources (Kris Chan developed and taught in Spring 2012)
- CHE891/CMB800 Recent Topics in Biological Networks, Systems Biology and Modeling (Kris Chan co-taught in Spring 2009, 2010)
- BMB860/CHE891 From Analysis of Metabolism to Systems Biology (Kris Chan taught w/ faculty from other depts in Spring 2006, 2007)
- CHE 8XX Tim Whitehead is developing a new Synthetic Biology Laboratory course to
be taught Spring 2015 (as part of his CAREER Grant)

**Electrical and Computer Engineering courses**

<table>
<thead>
<tr>
<th>Credits/Course</th>
<th>Name</th>
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<tbody>
<tr>
<td>ECE 445</td>
<td>Biomed Instrumentation</td>
</tr>
<tr>
<td>ECE 446</td>
<td>Biomed Signal processing</td>
</tr>
<tr>
<td>ECE 447</td>
<td>Intro Biomed Imaging</td>
</tr>
<tr>
<td>ECE 448</td>
<td>Model &amp; Analysis Bio Systems</td>
</tr>
<tr>
<td>ECE 802 (S14)</td>
<td>Brain Machine Interface, offered previously</td>
</tr>
<tr>
<td>ECE 802 (F13)</td>
<td>Therapeutic and Diagnostic Ultrasound, offered multiple times</td>
</tr>
<tr>
<td>ECE 802 (S13)</td>
<td>BioMEMS and Microfluidics</td>
</tr>
<tr>
<td>ECE 802 (S13)</td>
<td>Neural Engineering</td>
</tr>
<tr>
<td>ECE 802 (S13)</td>
<td>Biomedical Signal Processing offered multiple times</td>
</tr>
</tbody>
</table>

Note: ECE offers a BME undergraduate concentration based on 4 regular courses (ECE445-448). We do not have any official BME grad course, but 3 of our ECE 802 (special topics) courses have been offered multiple times and could (even should) be submitted as new courses for periodic offering.

**Biosystems and Agricultural Engineering courses**

- BE 445 - Biosensors for medical diagnostics
- BE 845 - Biosensor principles and applications