



Michael Kaufman Dean, College of Applied Science and Engineering

August 18, 2015

Charge

Develop a proposal for the Bioscience and Bioengineering program across Mines – vision for the next 10 years

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Task	Description	Status				
T1: Form group	Form working group	Completed				
T2: Establish current status of biology at Mines	 Share past reports with working group Identify changes in personnel and expertise since reports were completed. Look at job market/placement of our students pursuing bio-focus. 	1 and 2 completed; 3 in process				
T3: Proposal development	Brainstorm possibilities within constraints of what is possible and impossible resource-wise. Bring ideas to meetings and flesh them out collectively.	Underway				
T4: Faculty engagement	Determine how best to engage the biology faculty across campus in discussion.	Breakout sessions at faculty conference				
T5: Develop proposal	 Develop recommendation that appears strategic to the institution. Identify resource needs that support recommendation. Determine if resource needs make proposal a pipedream or something that we can get traction. 	In process				
T6: Recommendation report	Produce formal recommendation report.	Preliminary draft completed				

Relationship to Goal 1 – Enhance distinctive identity and reputation of Mines Strategic Plan Create new and enhance existing large research initiatives focused on the global challenges related to the earth, energy and environment. Goal 2 – Build upon a student-centered campus culture of excellence, inclusion, diversity and community Enhance opportunities for students to develop effective communication skills as a complement to strong content expertise Goal 3 - Build and diversify revenue streams and auxiliary enterprises Establish new or expand continuing education and executive education • enterprises that enhance the reputation, global reach and financial security of Mines. Diversify federal research funding across multiple agencies while ٠ increasing corporate and private research support. Membership Michael Kaufman (Chair), Joel Bach (ME), Cecilia Diniz Behn (AMS), Chris Higgins (CEE), Keith Neeves (CBE) and Brian Trewyn (CH) 1500 Illinois Street Golden, CO 80401



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Context

Bioengineering and related disciplines are becoming increasingly significant in fulfilling the role and mission of the Colorado School of Mines (CSM). Many intellectual frontiers related to the environment, energy, materials, healthcare and their associated fields of science and engineering are being and will continue to be driven by advances in the biosciences and the application of engineering to living systems. In an effort to address the need for engineers and scientists trained in these areas, many departments across campus have hired faculty who concentrate in this increasingly important area. The failure of CSM to manage this effort institutionally has resulted in a somewhat eclectic collection of excellent faculty working in disparate areas. As the CASE Visiting Committee emphasized in their evaluative report in 2014: "CSM needs to incorporate biology and bioengineering into its historic academic strengths and build on those accordingly. It cannot attain a national reputation in broad based biological research, where the competition is already decades ahead."

CSM finds itself in a situation of having a number of outstanding faculty (Table 1) who are teaching and/or conducting research in the bioscience and bioengineering areas but without an institution-wide policy for how bio should be incorporated into the strategic plan. This is not a new issue. There have been at least four previous "bio-strategy" committees on campus and these committees have made several proposals including (1) a 2006 recommendation to form "a departmentlevel entity housing basic bioscience and bioengineering faculty to deliver life science courses, to conduct research and graduate training, and to enhance applied activities in other departments", (2) a 2010 recommendation to "create a Department or Division of Biotechnology or Bioengineering", (3) a 2012 recommendation to "recruit 15 tenure track faculty over 3-5 years to build up a critical mass in areas of prior success and significant expected growth, specifically in bioenvironmental and biomedical engineering", and (4) a 2013 recommendation to "create four Biology Minors" that would be administered by a "Biology Administrator". The full reports from the 2006, 2010, 2012, and 2013 committees can be viewed online by selecting each year. Outside the creation of minors, these recommendations were never acted on, presumably because of the resources required.

In order to provide a bit of the history of bio at Mines, it is noted that, during the first 120+ years of its existence, Mines was not really known for anything with "bio" in the title. There was, however, pent up demand in the student body. In July 2001 a group of faculty (mostly Department Heads and Division Directors) submitted a proposal to the administration to establish the Bioengineering and Life Sciences (BELS) program.

BELS was officially established in 2002. The founding Departments/Divisions included Chemical Engineering and Petroleum Refining, Chemistry & Geochemistry, Engineering, Environmental Science & Engineering, Geology & Geological Engineering, Liberal Arts & International Studies, Mathematical and



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Computer Sciences, Metallurgical & Materials Engineering and Physics. The heads of these Departments/Divisions served as the BELS Board of Directors. Day-to-day administration was the responsibility of the BELS Director and Associate Directors.

At establishment, BELS offered Minors and Areas of Special Interest in Biomaterials Engineering, Biomathematics, Biomedical Engineering, Biophysics, Environmental Biotechnology, and Pre-medical & Life Sciences. Two subcommittees were established to focus on curricular and research issues, respectively. These committees typically met twice a year.

In late 2002/early 2003 a survey was conducted of students and Department Heads/Division Directors with 100% of those surveyed wanting to see a Bio-Engineering degree established at CSM.

While General Biology had been offered since at least 2001, we did not have facilities on campus to offer a corresponding lab. In 2008, with support from the administration, we created and equipped such a facility and the first Biology Labs were offered on campus.

Prior to the establishment of BELS, Mines had a small number of graduates who would go on to pursue careers in medical fields. Increasing interest in medical school was evident by the time BELS was being formed, so one of the Minors created was Pre-Medical & Life Sciences. The BELS faculty offered the courses relevant to medical school preparation and application, and advised and mentored students through the process of applying to med school. The Medical Sciences Advisory Committee was formally established by BELS in 2006. Two student organizations, the Pre-medical Society (2004) and Beta Beta Beta (Biology Honor Society, 2008) were also established during BELS existence and both continue to thrive.

In 2013, the BELS minor was terminated and replaced with departmentadministered minors. Individual minors were (or are in the process of being) rolled out in Biomedical Engineering (Chemical and Biological Engineering), Biomechanical Engineering (Mechanical Engineering), and Biophysics (Engineering Physics). This change has led to the current situation in which there is no campus-wide coordination of efforts between the departments offering the minors. In addition, there is no formal educational replacement for students interested in pursuing professional medical education. This change has also resulted in a situation in which there has been a slight drop in both the number of bio-related minors (Figure 1) and in enrollment in the biology-themed courses (Figure 2) after several years of steady growth. At the same time, there has been a continued increase in research projects that are bio-based (Figure 3). Students continue to seek opportunities in the bio areas on campus in order for them to satisfy course requirements for medical, veterinary, and graduate schools and obtain jobs in the biotechnology industry. Importantly, the enrollment at CSM and



Biology at Mines: Defining Our Strategic Intent

Strategic Planning Summer Working Group Report

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Figure 1. Number of Mines students (a) who who graduated with BELS or Biomechanical Engineering minors and (b) who have enrolled in BELS, Biomechanical or Biomedical minors since BELS was initiated in 2002.



Figure 2. Enrollment in bio-themed courses at the undergraduate level.



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Figure 3. Bio-related funding at Mines since 2006.

nationwide in bioengineering is on average \sim 50% female suggesting that developing a cogent bioengineering program would increase diversity in the student body.

Other indicators of the increasing importance of bio to Mines students includes the fact that about two-thirds of the undergraduates now enroll in the bio core courses and the "studio bio", which was developed to emulate "studio physics" has become a showcase classroom and is a leader in pedagogical delivery.

Clearly, it is imperative for Mines to determine how best to position the institution in order to (1) provide appropriate educational opportunities for our students at the undergraduate and graduate levels, (2) support our "bio-focused" faculty, and (3) become more competitive for the significant federal and industry funding available in the areas of biotechnology and biomedical research. This will not be an overnight operation, but one in which we need to have both short and longterm strategies for the campus.

It is also important to emphasize that bioscience and bioengineering programs and departments are very common at small to medium sized engineering and physical science focused universities not associated with a medical school. Indeed, most of our peer institutions have a department of biomedical engineering or bioengineering including Carnegie Mellon, Rose Hulman, RPI, WPI, Lehigh, Stevens, Michigan Tech, IIT, and NJIT.

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Recommendations

August 18, 2015 The Bioscience and Bioengineering Strategy Committee has been convening over the summer of 2015 to examine biosciences at Mines and create a plan to better coordinate bio-related educational and research goals at CSM now and into the

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future. The discussion has centered on ensuring that our recommendations (a) are visionary yet viable, (b) create programs of distinction important to the campus, (c) support our current and future students, (d) support our current and future "bio" faculty, and (e) are sustainable.

A theme that is consistent in this report and from previous bio-strategy committees is the need for an administrative unit to advocate and coordinate on behalf of biology at CSM. The current and historical ad-hoc approach by individuals, groups of faculty, the BELS program, and individual departments has laid a strong foundation; however, past history has shown that it is difficult to effectively manage and grow biology at CSM using this approach. Thus, our primary recommendation is to create a plan that consists of three stages that will be conducted over an extended period of time as described below.

Stage 1 (1-3 years): Establish a Bioscience and Bioengineering Program Director who will work with a Faculty Advisory Committee from different departments and colleges and have the Director and this committee examine the efficacy of the bio-related curriculum at the undergraduate and graduate levels and the needs and interests of faculty with teaching and research in these areas. This Director should be given the necessary time and resources to address the significant range of issues that are not currently under the purview of any one department or college. A list of issues identified by the current committee is provided in Appendix 1. The milestones that we propose for this 1-3 year period are listed below:

- ٠ Immediate: Identify Program Director and Faculty Advisory Committee and provide a charge that is agreed to by the administration.
- Quarterly: Program Director provides progress reports on the items listed in • Appendix 1 (with agreement of the faculty advisory committee).
- Semi-annually: Program Director and Faculty Advisory Committee will convene an External Advisory Committee (likely composed of members from regional academic and medical institutions and the biotechnology industry) to update them on the progress being made and to work with them in order to determine how best to proceed strategically (next steps). Program director will also meet with the Mines Senate to update them regarding the progress made and to solicit their support.
- Annually: Program Director will provide recommendations as to next steps for the bio-strategy for Mines (with concurrence of the faculty advisory committee).



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Stage 2 (3-5 years): Based on the successes and failures in Stage 1, the Program Director and the Advisory Committee will consider the formation of interdisciplinary undergraduate and/or graduate degrees that leverage existing strengths and possible synergies between faculty in different departments. Importantly, such a degree(s) should be created with the intent to prepare students for employment in the regional biotechnology industry or for their pursuit of professional degrees (medical school, graduate school, etc.). Milestones will be created at the initiation of this stage.

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Stage 3 (5-8 years): Based on (a) the successes and failures of the interdisciplinary degrees initiated in Stage 2, (b) the retention and recruitment of faculty working in bioscience and bioengineering, and (c) the growth in research volume related to bio, it will be appropriate at this juncture to consider the formation of a Bioscience and Bioengineering Graduate Program or some other path that will enable Mines to increase the pool and quality of graduate students and to attract faculty to existing and emerging areas of strength. Again, milestones will be created at the initiation of this stage of the process based on what is learned in Stages 1 and 2.

We feel that this staged approach is the best way to balance short-term issues that need immediate attention with a long-term vision to create a program of distinction in bioscience and bioengineering.



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Table 1. Summary of Bio Faculty at Mines. Note significant increase since 2001.						
Year Hired	CSM Dept.	Rank	Faculty	Current research interest		
1991	CEE	Professor	Linda Figueroa	Env. biotechnology		
1995	CBE	Professor	David Marr	Biomedical microdevices		
1996	CEE	Professor	Junko Munakata Marr	Env. microbiology		
2001	ME	Professor	Joel Bach	Biomechanics		
2002	PH	Professor	Jeff Squier	Biomedical microdevices		
2003	LAIS	Professor	Tina Gianquitto	Evolutionary theory		
2004	СН	Assoc. Professor	Steven Boyes	Polymers, drug delivery		
2004	СН	Professor	Jim Ranville	Environmental colloids & bioavailability		
2004	CBE	Teaching	John Persichetti	Bioprocess engineering		
2005	CEE	Professor	John Spear	Environmental molecular microbiology		
2006	ME	Associate Prof.	Tony Petrella	Comp. biomechanics		
2007	CBE	Teaching AP	Paul Ogg	PhD cell biology, virology		
2008	CBE	Associate Prof.	Keith Neeves	Biomedical microdevices		
2008	СН	Associate Prof.	Matt Posewitz	Algal microbiology, biofuels		
2008	CBE	Teaching AP	Cynthia Norrgran	MD, biology, biophysics		
2009?	СН	Research Faculty	Chris Cox	Bio-detection		
2009	CEE	Assistant Prof.	Josh Sharp	Env. microbiology		
2009	CEE	Associate Prof.	Christopher Higgins	Environ. toxicology & bioaccumulation		
2010	CBE	Assistant Prof.	Mark Maupin	Comp. biochem., biofuels		
2011	ME	Assistant Prof.	Anne Silverman	Amputee biomechanics		
2011	CBE	Teaching AP	Judy Schoonmaker	Biology		
2012	CBE	Assistant Prof.	Melissa Krebs	Tissue engineering		
2012	AMS	Assistant Prof.	Steve Pankavich	Multiscale analysis of bionanosystems		
2012	СН	Assistant Prof.	Brian Trewyn	Biomaterials		
2013	CBE	Assistant Prof.	Nanette Boyle	Metabolic engineering		
2013	AMS	Assistant Prof.	Cecilia Diniz Behn	Mathematical neuroscience & metabolism		
2013	ME	Assistant Prof.	Ozkan Celik	Biomechatronics		
2013	ME	Assistant Prof.	Xiaoli Zhang	Medical robotics		
2014	CBE	Assistant Prof.	Kevin Cash	Biomedical sensors		
2014	AMS	Assistant Prof.	Aaron Porter	Infectious disease modeling		
2014	PH	Assistant Prof.	Susanta Sarkar	Biomedical imaging		
2014	CBE	Teaching aP	Josh Ramey	Biology		
2014	MME	Research Prof.	Terry Lowe	Biomaterials		
2014	СН	Assistant Prof.	Shubham Vyas	Physical biochemistry		
2015	СН	Professor	Mark Jensen	Biological interactions		



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Appendix 1

Several specific issues at the institutional, undergraduate, graduate, and faculty levels were identified by the committee and are summarized below.

Institutional needs

- Create an external Advisory Committee for bio on campus consisting of members from regional academic and medical institutions and the biotechnology industry
- Increase visibility of bio at CSM by developing recruiting and marketing strategies targeted at students, parents, industry, academia, and medical centers.

Needs at the undergraduate level

- Develop a webpage and a section in the bulletin with information on bio-related minors, programs on campus, where to get advising, and research opportunities. There needs to be a clear path for students who want to go to bio-focused graduate school (med school, vet school, bioscience/bioengineering/public health, etc.) or find a job in a bio-related industry.
- Involve CASA and faculty given their role in advising undergrads in biology related courses and minors.
- Engage with the Honors program to explore the possibility for a Pre-Health-oriented bio track.
- Engage with CRC and figure out how to better include the typically smaller biotech companies that have trouble getting into career fair.
- Reach out to the Colorado Biosciences Association (CBSA) to engage the biotech industry in Colorado.
- Advertise and transport students to the CBSA Career Fair in downtown Denver.
- Encourage faculty engagement with the Premed Society and Biology Honors Society on campus.
- Raise awareness and engage with the Medical Sciences Advisory Committee for students interested in medical school.
- Organize an annual or a semi-annual Open House for bio on campus and invite companies, other universities, and students to participate
- Generate better statistics on job placement of undergraduate students with bio interest/emphasis in collaboration with CRC
- Look into entrepreneurial opportunities and training that are characteristic of the biotech industry in Colorado
- Engage students more effectively in the undergraduate research fellowships and internships that are bio-related both on- and off-campus

Needs at the graduate and postdoc levels

- Improve the number and quality of graduate students and postdoctoral fellows that apply to Mines' bio-focused departments. Develop a concerted effort to attract individuals outside of our traditional recruiting pools.
- Resurrect the bioscience graduate group (BGG) to facilitate awareness and collaborations between graduate students and postdocs conducting bio-related research.
- Explore the need and feasibility of an interdisciplinary graduate program analogous to Materials Science and Hydrology. Such a program could provide a means to matriculate graduate students



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with biology backgrounds who may not be good candidates to go through existing engineering/physical science departments.

• Reduce barriers to sharing existing research infrastructure and identify the needs of future capital and infrastructure

Faculty needs

- Improve the integration and communication between faculty teaching bio courses from the freshman to the graduate levels
- Provide better resources for new faculty and knowledge among new and existing faculty of biorelated resources (primarily lab equipment) across campus and funding opportunities (e.g. NIH's R15 funding mechanism for schools with small amounts of NIH funding).
- Consider co-localization of bio labs to capitalize on shared infrastructure and promote collaboration.
- Provide seed grants with local hospitals and medical centers based on the successful program with Children's Hospital Colorado (CHC) spearheaded by John Poate and his counterpart at CHC, Fred Suchy.
- Streamline the Institutional Review Board (IRB) process by making the process clearer to faculty.