Report of the

AAAS Advisory Panel

on

A Review of the Chemical Engineering Bio Initiative at Montana State University

Thomas R. Hanley
Edgar A. O'Rear, III
Gregory N. Stephanopoulos
J. Scott Hauger

December 2, 2002

Conducted by

The Research Competitiveness Service of The American Association for the Advancement of Science

Research Competitiveness Service

A. Introduction

This is a report of findings and recommendations for a review of the Chemical Engineering Bio Initiative of the Department of Chemical Engineering of Montana State University (MSU), conducted by the Research Competitiveness Service of the American Association for the Advancement of Science (AAAS). The review was requested by the Dean of the College of Engineering, Dr. Robert Marley, the Associate Dean, Dr. Anne Camper, and the Head of the Department, Dr. Ron Larsen

Since 1996, the AAAS Research Competitiveness Service has provided expert peer review and guidance to institutions around the country that are engaged in research, development and innovation. The development of the process for this review was collaborative between AAAS staff and Dr. Larsen, with the participation of the faculty of the department. The statement of work may be found at Appendix A. Dr. Larsen prepared the necessary background materials provided to the committee and arranged the schedule for the site visit which took place on October 27 – 29, 2002. The agenda for the visit may be found at Appendix B. AAAS recruited the review panel members, participated in the site visit as part of the panel, and managed the panel's work in preparing this report.

The review panel members were:

> Thomas R. Hanley, Ph.D., Dean of Engineering and Professor of Chemical Engineering, Speed Scientific School, University of Louisville
>
> Edgar A. O'Rear, III, Ph.D., Director, Oklahoma Bioengineering Center and Francis W. Winn Professor of Chemical Engineering and Materials Science, University of Oklahoma
>
> Gregory N. Stephanopoulos, Ph.D., Bayer Professor of Chemical Engineering and Biotechnology, Massachusetts Institute of Technology
>
> J. Scott Hauger, Ph.D., Director, Science and Engineering Policy and Practice Group, American Association for the Advancement of Science

The following report is organized into three parts. Part I provides a contextual overview of the findings of the panel in the form of an analysis of the strengths, weaknesses, opportunities and threats (SWOT) which the department must manage as it addresses the issues involved in undertaking a bio initiative. Part II addresses the specific questions asked by the department in the statement of work. Part III addresses certain general findings and recommendations developed by the panel that may not be fully addressed by our answers to the questions articulated by the faculty.

The panel would like to thank Dr. Larsen, Dr. Camper, Dr. Marley, and all of the faculty members and students with whom we met during our site visit. Their help and cooperation was enthusiastic. This was, in fact, one of the best-organized and best-attended programmatic views of the many we have conducted. Our appreciation also goes to the Provost, Dr. David Dooley and the Vice President for Research, Dr. Tom McCoy, whose concern for, and interest in, the review and its outcomes was manifest. As will be detailed in the following report, it was clear to the panel that the Chemical Engineering program at Montana State is well situated to undertake the challenges involved in lifting its programs to the next level, by the expansion of its research, education, and outreach missions through the adoption of a bio initiative.

B. An Overview of the Environment for a Bio Initiative

This section presents the panel's assessment of the strengths and weaknesses that the department brings to the proposed bio initiative as well as a consideration of the special opportunities of which the department can take advantage as it plans for a new undertaking. Finally it identifies several potential threats to programmatic success that should be considered as planning progresses.

1. Strengths

The Chemical Engineering Department has a history of success in attracting strong faculty and students. Its faculty played a vital role in the development of the Center for Biofilm Engineering and in advancing other research areas. There is a strong tradition of research among the faculty, that is being continued by some faculty members, although the research mission has been under-emphasized in recent years. The panel found both the undergraduate and graduate students with whom it met to be highly competent and highly motivated, and especially appreciative of the faculty's dedication to their education. The faculty are dedicated to this purpose and are recognized by the students for the personal attention given to them, both in the classroom and in the laboratory. These are strong assets with which to begin an undertaking to revitalize the research mission of the department and to undertake curriculum development.

The panel also finds a positive university environment for interdisciplinary research collaboration. The existence of strong research institutes in thermal biology, computational biology, veterinary molecular biology and biofilms provide a unique asset to the bio initiative. All of these institutes expressed a willingness, even an eagerness, to collaborate in building departmental capabilities and to draw upon the new resources to advance their own missions. The initiative has the positive interest of the Dean of the College, the Vice President for Research and the Provost, all of whom will support a well-crafted initiative.

The panel also found good camaraderie and interest across the college. The other department heads with whom we met expressed encouragement and support for the bio initiative within Chemical Engineering, and some suggested that the initiative should be a broader one across the college, drawing on the expertise in the Chemical Engineering Department. This encouragement and good will represent a valuable asset to the initiative.

Finally, the panel found that the department has access to good research facilities and space, especially through the on-campus research institutes. There also appears to be some capability to expand the department's research space through renovation of existing facilities. In summary, the panel finds that the department can draw upon significant resources and strengths that will support the success of the proposed bio initiative.

2. Weaknesses

Faculty size in chemical engineering, as in the rest of the college, is too small for sustained research activity. In the opinion of the Advisory Group, seven FTE is at or near the minimum number of faculty to cover the teaching requirements in chemical engineering. To put this in context, the average size of all Ph.D.-granting chemical engineering departments from an NRC report was 11-12. For top research rated departments, the size was 15-16. Although MSU should not try to grow to these numbers, it is clear that the addition of even one faculty member to the department, thus reducing the average teaching load by 14%, would go a long way toward gaining faculty "buy-in" to a bio emphasis and the expansion of the department's research mission that commitment will require.

Partly as a consequence of faculty size, faculty teaching loads are currently too high to adequately support the initiative. Moreover, they appear to be inconsistent with teaching loads in peer departments in engineering and with those in the College of Letters and Sciences. This problem can be partly addressed by adding one or more faculty members. It can also be addressed by curriculum reform. Both approaches are indicated.

As a related issue, there is currently a lack of a critical mass of faculty who are interested and qualified to undertake the proposed initiative. As described in more detail below, the panel believes that this weakness can be overcome by augmenting current faculty in the bio chemical engineering field with one new hire and three replacement hires in appropriate fields.

Finally, the panel finds a need for bioengineering leadership to reduce the risk and enhance the likelihood of success in a bio initiative. The department needs an entrepreneurial faculty member with the vision, drive, the charter, and the time to lead the initiative. Although the department is home to a number of talented and capable individuals, they all appear to have prior commitments and interests. A champion with the time and the urge to lead the bio initiative has not clearly emerged from the faculty at this time. Finding the right person to lead this effort is necessary to overcome this critical weakness.

3. Opportunities

The timing seems right for the proposed bio initiative in several ways. The department enjoys the support of the Provost, the Vice President for Research, the Dean of the College, the Head of the Department, and the Montana NSF EPSCoR Project Director for a viable research-oriented initiative in bio and chemical engineering. The time window is open to include this initiative as a thrust area in Montana's next NSF Infrastructure Grant proposal, due in July 2003.

Moreover, the timing seems right for Montana State University to define and develop a particular niche of excellence within the general area of life sciences and bioengineering, exploiting a national trend of interests in these fields. The panel foresees a limited time window for the initiative in this context as well, while there are still opportunities to establish a leadership position through early entry into the competition and through creative nichemanship in defining a center of excellence for the department and the university. Three existing research institutes, the Center for Biofilm Engineering, the Thermal Biology Institute, and the Center of Computational Biology, seem highly interested in expanding their own capabilities with a chemical engineering competence. If the Chemical Engineering Department can meet some of those needs in a timely fashion, MSU as a whole can benefit from the synergies involved, while staking out a claim to an interesting and fruitful research niche. At this point there are several viable paths open. For example, a bio initiative with a microbiology emphasis would readily tie into the biofilm and thermal biology institutes. Alternatively, an emphasis on bio imaging could promote ties to computer science, physics and computational biology, as well as the biofilm center. Other opportunities exist. The time is ripe for the department to identify, select, and pursue one or two of those alternatives.

4. Threats

The panel foresees three potential threats to the success of the proposed bio initiative which must be considered in planning for the program. The first is the need for a long-term commitment from the university to provide faculty lines in support of the initiative. The panel recommends that one new faculty line be provided as an investment and an incentive at the start of the program. Additional lines will likely become necessary as the result of a successful initiative. Specifically, as more faculty time is devoted to and funded by research in the bio area, it will be necessary to add additional lines to maintain the teaching mission of the department. Overall, this places the department and the college at an

additional risk, as some faculty lines will be dependent on a continuous flow of "soft money." In the opinion of the panel a certain level of risk is acceptable and appropriate within the context of a research university. We recognize that such a shift in perspective represents a cultural change for the department but it is an appropriate one to its growth and development as a research community.

A second threat is the existence of a highly competitive market for faculty in the area of bio and chemical engineering. This is the flip side of the opportunity and limited time window to make an effective entry into the field. MSU has some natural advantages in the competitive market place, for example, its attractive location and the intellectual strength and resources of the existing research centers. The panel has confidence that with a commitment to competitive salaries and start-up packages, MSU can compete effectively to build up its critical mass of expertise to support this initiative, though there are likely to be a series of disappointing losses along the way.

Finally, the panel notes that the professional context for chemical engineering seems to be characterized by a declining importance of traditional chemical engineering industries, a phenomenon that is combined with the uncertainties associated with evolving new opportunities in emerging bio-oriented industries. This presents an inherent but inescapable risk to program planning. In the opinion of the panel, however, it is a riskier strategy not to change, one that threatens obsolescence or declining relevance. Nonetheless, a certain agility is indicated as one approaches the challenges of strategic planning for a bio initiative. In practice, this means that any plan should be recognized as contingent on its assumptions about the environment. Evaluation mechanisms should be built in and periodically applied. The plan should be understood to be a living document, open to change and amendment as warranted by changing assessments of the environment and of progress in that environment.

C. Answers to Questions

This section is organized according to the statement of work found in Appendix A.

1. Opportunities

a. What will a "bio" emphasis in the chemical engineering program (or new "bio" program) allow us to accomplish?

The panel believes that adding a bioemphasis to the Chemical Engineering program has a high potential to increase enrollments at both the undergraduate and graduate levels. A significant number of entering freshmen indicate an interest in this area but are typically uncertain with respect to the path to follow in engineering. Through its opportunities for student research within MSU's attractive research centers in related areas, the department should have a high appeal to graduate students nationwide. This emphasis can provide the department with a presence in a strong and growing area that should be attractive to students at all levels.

A number of the industries which traditionally hire chemical engineers are moving into biotechnology. This change will allow the department to match graduate skills and knowledge to industry's needs in the bio area. An expanded emphasis here should also generate additional resources for the department and assist the department in adding new, junior faculty. In short, the panel believes the department can be rejuvenated to enhance research and enliven instruction by the successful adoption of a bio emphasis.

b.	*What funding opportunities would open up?*	Over half of all federal funding for research goes into medical and biological research areas. Many government funding opportunities are growing in biotechnology. At the National Science Foundation approximately two-thirds of the funding in the chemical engineering program areas are linked to bioengineering. Department of Defense basic sciences research (e.g., DARPA and ARO) is approximately one-third bio-oriented. NIH funding, including NIBIB (National Institute for Biomedical Imaging and Bioengineering) has had sustained growth in recent years, and offers funding opportunities previously untapped by most chemical engineering researchers. New federal initiatives related to homeland security and bioterrorism should also provide additional funding in the bioarea. In the industrial sector the next wave of research investment in the United States is anticipated to be bio-based, with companies including Cargill, ADM, Dow-Cargill, Monsanto, duPont, Dow, Abbott, Merck, and Lilly likely to be looking for academic partners. Health-related bio-research also attracts funding from foundations and general public, leading to gifts and endowments in support of this area.
c.	*What would the impact be on our ability to continue to attract highly qualified undergraduate students?*	Bioengineering is the only field of engineering that has seen real growth nationally in recent years. At most institutions, this is a high enrollment field with outstanding undergraduate students and with excellent opportunities to enhance diversity. Bioengineering also has a track record of enhancing diversity, usually attracting larger percentages of women.
d.	*…Qualified graduate students?*	A strong niche program associated with MSU's research institutes should be highly attractive to graduate students in chemical engineering. The panel recommends that the department develop a strong niche research program in collaboration with selected research institutes around campus. Currently many students conduct research under the auspices of the Center for Biofilm Engineering, but chemical engineering graduate students expressed a need for research opportunities beyond those in biofilm research. MSU's very successful programs including the Thermal Biology, Computational Biology, and Veterinary Molecular Biology Institutes offer research in exciting areas that match well with the skills of chemical engineers, and that have staff eager to work with engineers. By exploiting the opportunity to work with these centers, the department has a very high potential to attract highly qualified graduate students from around the nation and the world.
e.	*How would a bio emphasis impact placement of our graduates?*	A biothrust should allow the department to maintain its current relationships in an economy evolving away from traditional career paths of chemical engineers. The panel believes some industries will continue to shift to a bio emphasis with new expectations for graduates. The department has the ability to meet these expectations without threat to those seeking careers in traditional fields. A bioemphasis will also make those students interested in graduate

school better able to compete. On the other hand, a failure to include a bioemphasis may reduce the department's ability to place students five years from now.

f. *How significant is the "bio" wave that is sweeping through chemical engineering departments?*

The panel believes that this initiative impacts chemical engineering at its foundation. Biology will join chemistry and physics in forming the underlying sciences on which chemical engineering is based. Bioengineering is an important emerging field and will have a strong and lasting impact on chemical engineering education. The appointment of a biologist as director of NSF, counter to the history of the agency, might be taken as a signal of the perceived importance of biology in a broad sense by the federal research establishment.

g. *Is this something we must do if we are to stay relevant in the foreseeable future?*

The department must respond to diminishing prospects for its graduates in traditional areas of chemical engineering. While it is conceivable that other choices for a new thrust areas might exist, this panel believes MSU chemical engineering should go in this direction because of the local opportunities available for interdisciplinary collaboration. This initiative will have impact on the profession at both the national and international scale. Undergraduate students looking for employment or for graduate programs in engineering will be expected to possess some training in bioengineering, with the impact felt immediately in graduate programs.

h. *How great is the risk that we will be jumping on one bandwagon just as a new band begins playing a new tune?*

The panel feels that there is little or no risk. The greater risk is failure to respond. In the judgment of the panel, bioengineering is here to stay for the foreseeable future. The field has been emerging from within chemical engineering for at least 20 years. It appears as strong today as ever.

i. *Will we miss much if we simply stay the course?*

Bioengineering is different from prior trends in chemical engineering because it is not based on a single industry. It represents the inclusion of a whole new science among the fundamental sciences supporting chemical engineering. It will not disappear because federal support is very high and increasing. The expectations for that national investment in medicine, specialty chemicals, and pharmaceuticals are very high. New industries are already appearing that will make use of the talents of graduates in this area. You need this tool in your kit to maintain the same robust credibility you have enjoyed in the past.

j. *What collaboration opportunities exist on campus and with regional national labs, etc.? (Lists internal and INEEL, PNL, medical institutes in Hamilton & Great Falls).*

Researchers and teachers from other departments, centers and institutes at MSU were open to opportunities for collaboration. Current and future opportunities expected at INEEL, PNL and other labs appear to be growing, with a strong emphasis on biotechnology and multidisciplinary collaboration. PNL, for example, has strong NMR capabilities and health related research programs that offer potential collaborations.

k.	*Based on the experience of the panel, how receptive are individuals at those facilities likely to be collaborative?*	All the people we interviewed were very receptive to collaboration. Many groups on campus recognize the added strengths that engineers can bring to their research projects. Several had specific ideas that chemical engineers could pursue. This included, for example, the study of heat transfer and culture systems appropriate to extremophiles for the Thermal Biology Institute and the investigation of adhesion and signal transduction for Computational Biology and Neuroscience. The National Labs have mechanisms to promote collaboration with universities. In our experience, personnel at these facilities are eager to work with faculty and students. Moreover, the panel notes that MSU has a special channel to INEEL through INRA.

2. Level of Involvement

a.	*What is the appropriate level of involvement for the department? (research emphasis only, bio option in curriculum, a new bio option with complete curriculum).*	The panel recommends that the department first develop a research emphasis and graduate curriculum in the "bio" area, in accordance with the research interests of existing and new faculty. New faculty should strengthen the core undergraduate chemical engineering curriculum, while enhancing the "bio" focus area. The panel strongly recommends reducing the number of focus areas in the department from the current four. This can be done by absorbing certain material that now comprise a focus area into elective courses in the core curriculum.
b.	*Should a new "bio" emphasis be focused at the graduate or undergraduate level?*	Make the initial thrust in the graduate program with research. Elective courses for graduate students and upperclassmen will follow naturally. Let these developments impact and effect changes in the undergraduate program as a vision for a "bio" program takes shape under the circumstances that evolve over time.
c.	*What new courses would likely be required?*	The development of new courses in engineering will follow from the skills and interests of new faculty to be hired. The need for an introductory or survey course can also be anticipated. It is important to appreciate that many courses contributing to the program can and should be taught by other departments (e.g., cell biology, biochemistry, molecular biology, microbiology).

d.	*What number, type, and level of courses would be required for each type of "bio" emphasis?*	The panel does not recommend either an undergraduate bio-option or a new bio program at this time, due to resource constraints. These stronger alternatives should be revisited after several years experience, with new faculty in place.
e.	*What type of emphasis can the department accommodate with existing or expanded personnel?*	In the opinion of the panel, existing personnel are not sufficient to accommodate a bioemphasis. The panel recommends the addition of one additional faculty line (tenure-track) and the rapid hire of three additional faculty members to replace anticipated retirements. These four hires should be strategically made to develop a critical mass for the proposed bioemphasis. A strong research collaboration should be initiated through these new faculty with at least one of the other research centers in addition to the Center for Biofilm Engineering.
f.	*What opportunities exist for graduates of a "bio" program?*	See Section C.1. a, above.

3. Feasibility

a.	*Does the department have the facilities and staff to make a "bio" emphasis work? (2) If not, is there a reasonable probability of developing the capacity?*	There seems to be adequate space for remodeling and expansion. A viable program will depend on the use of research institute facilities. These should be augmented by equipment in startup packages for new faculty and by investment in undergraduate experiments in the "bio" area, (e.g. units for electrophoresis and membrane separations; and the purchase of bioreactors in addition to chemical reactors). Building a reasonable capability will likely depend on access to EPSCoR support or support from research centers. If these resources can be made available, and if strategic new hires are made, the panel believes that the department stands a very good probability of developing the capacity.
b.	*Early replacement of retiring faculty: Does MSU have the commitment, flexibility, and resources adequate to carry this effort through to completion?*	Yes, the administration appears to have the commitment and ability to partner with the chemical engineering department and with EPSCoR to make this a successful initiative. The need for an additional faculty line will require support from the administration. Importantly, key leaders in both MSU and MSU-EPSCoR appreciate the potential contributions engineers can make to the other "bio"-based research enterprises on and off campus. Faculty "buy-in" for the "bio" initiative will be greatly enhanced with an additional faculty line. Chemical engineering faculty must commit themselves to goals and milestones that will justify an additional line.

4. Compatibility with Existing Programs

a.	*What steps can the department take to ensure that the new program best be made to fit with the existing chemical engineering program?*	The panel sees the "bio" emphasis as an evolution of the existing program to create and disseminate new scientific knowledge rather than a mere add-on to static, accumulated knowledge. The core undergraduate program should be nurtured and further developed as the department grows toward the new model. It is a particular strength of the chemical engineering curriculum that it is well positioned to make such a transition.
b.	*How can the department best utilize existing resources and expand its resource base?*	The panel recommends the department play the lead role in a college-wide "bio" emphasis that seeks to increase capabilities and faculty lines in all departments, in a coordinated college development effort. This strategy can be pursued in conjunction with, or subsequent to, a strategy focused on chemical engineering. In particular, new faculty in (say) imaging might build on existing expertise in electrical engineering (David Dickensheets, Ross Snider, Fred Cady), chemical engineering (Joe Seymour, Sarah Codd), physics, and computer science (Gary Harkin, Denbigh Starkey, Brendan Mumey). This focus area could enrich many research programs and help address expressed needs in the Center for Computational Biology and in CBE.
c.	*How can the department minimize the risk that the new program will be viewed as a competitor by other programs? Or will other programs perceive the new program as a good fit with their own?*	The panel did not see any strong evidence of such concern on the part of other departments. Other departments also have to absorb the impact of the life sciences revolution in their own ways. A strong chemical engineering program can facilitate that growth. The department chairs recognize the potential opportunities. They are ready to participate and support, but not lead, a bioengineering effort.
d.	*What types of "bio" programs are possible, and which seem to fit best with the interests of the faculty and available resources?*	See Section C.2. b and c, above.

5. Interest

a. What is the perceived level of interest in going forward with a "bio" emphasis in chemical engineering?

The panel considered the level of interest of the various constituencies. In the department, the response is mixed, but it is generally positive and will become dramatically more favorable with the addition of new faculty lines. The panel notes that this situation is not unusual in chemical engineering departments. In the panelists' experience, many resistors will become converts as transition occurs. Many traditional engineers become aware of new research opportunities through interaction with new bioengineering colleagues.

In the college, the department chairs are generally supportive, though not in a proactive mode. In other departments, a high level of interest exists with several faculty expressing their interest in seeking an engineering perspective for research collaboration. In the centers, personnel are highly supportive--they stand only to gain. In the administration, definite interest exists. These stakeholders would be highly supportive if a viable plan were to be presented.

D. General Findings and Recommendations

The Chemical Engineering Department at Montana State is a small department. It has a relatively low faculty/student (F/S) ratio, and a small research portfolio compared with other chemical engineering departments nationally of similar history and direction. The other engineering departments of the University also seem to be below critical mass and F/S ratio of their peers. With respect to number of students enrolled in, and graduated from, chemical engineering, however, the department seems to be trailing other departments in the College. The panel believes the department must revitalize itself and expand, or stand at risk, over time, of losing university and college support in its educational and research endeavors.

Expansion will require investing in and hiring new faculty in the department. Such investment and hiring should concentrate on a single key area so as to maximize impact for the department and college. Of the different educational and research areas available to the department, that of *biological engineering* or *bioengineering* stands out as the obvious choice for the following reasons:

(a) Biological engineering is very much related intellectually with chemical engineering. The former can be built on the basic curriculum of chemical engineering by introducing a few courses that add biology as a foundational science of chemical engineering, along with chemistry and physics. It is important to note that the panel is not advocating here a drastic overhaul of the chemical engineering program. The changes recommended above can be accomplished with minimal modifications to the present program, building on the core background of chemistry science fundamentals.

(b) Several aspects of biological engineering can be pursued by the department, (see answers to specific questions provided earlier in the report), that would enhance the present activity in the

Center for Biofilm Engineering and provide further synergies with other strong units in the College and the University. In this regard, the panel recommends the department establish at least one more research cluster in addition to CBE.

(c) Presently there is very strong and growing research activity worldwide, in various areas of bioengineering. This growth has been catalyzed primarily by advances in genomics and genomics-based technologies for the measurement of a vast array of intracellular molecules governing cellular activity, function and physiology. These developments have necessitated more than ever the collaboration of engineers in life sciences research and education in order to assist with the *integration* and *quantification* of biological systems and processes. There are no signs that federal and industrial interest in funding more research in biological engineering may decline in the foreseeable future. On the contrary, all indications are for continued growth as this area provides rich opportunities for discovery and strong intellectual property coverage.

(d) Biological engineering provides a natural platform for broad collaboration with other units across the university. In addition to enhancing the department's research and graduate education mission, further strengthening of this area will also support MSU's goals as a research university.

The recommendations of the panel on how to achieve this move of the chemical engineering department towards biological engineering are summarized below:

1. Prepare a plan for the orderly transition of the department towards enhanced research and educational activity in biological engineering. This should start with the hiring of three faculty members to replace retiring faculty. The specific areas of such new faculty should not be narrowly restricted but be determined, within the general bio initiative area, by the interests of the candidates so as to ensure recruiting high quality individuals. However, some broad guidelines should be followed to also ensure that the new faculty members have skills and interests that overlap sufficiently with the other university units with strong activity in the life sciences (CBE, BTI, etc.). EPSCoR or center funds could be used to support new faculty during a transitional (bridge) period. These appointments would not increase the present allocation of faculty lines of the department.

2. At the same time, seek to increase the size of the chemical engineering faculty by one, in order to maintain the current quality of the educational program in light of the expanded future research mission.

3. The faculty should undertake the development of courses in biological engineering. Such courses should address bioprocessing topics and also provide quantitative treatment of biochemistry and cellular biology. Applications to areas of interest to industry, medicine and the environment (metabolic engineering, bioremediation, drug delivery, biotechnology, tissue engineering, etc.) should be included to demonstrate the role of new biology as enabling science of the pharmaceutical, chemical and biotechnological industries. It is important to note that similar transitions are presently under way in many chemical engineering departments nationally.

4. As the above courses materialize, the department should consider changing its name to that of Chemical and Biological Engineering. Again, this is an action presently considered or already taken by many other chemical engineering departments nationally. The panel believes that a name change should be consistent with a curriculum change, however, it is noted that this does not imply drastic changes in the present curriculum, as the latter is quite relevant in its present form for the above emerging areas. The main benefit of the name change will be the enhanced

visibility of biological engineering and an anticipated increase in enrollments due to the attraction of bioengineering to students, nationally.

These steps will be a positive development for the department, as it will increase its critical mass, lower its F/S ratio and place it in a more competitive position among other engineering departments in the College. The panel did not detect any opposition towards these plans. On the contrary the heads of other engineering departments indicated that there will be several areas for future collaboration with such a department. The panel believes that the above steps should take place over a 3-year period. Longer implementation times pose the risk of a closing window of opportunity.

5. The panel finds that current teaching loads are above average nationally and incompatible with the time demands of faculty members in research universities. The department should make an effort to prioritize its course offerings, focusing on required courses and reducing the number of focus areas. The panel recommends that required undergraduate courses be given top priority in the curriculum, followed by graduate level courses in the focus area(s) such as biological engineering. Teaching loads could be further reduced by maximizing synergies with other departments, and by making more use of adjunct professors.

6. Consider building upon the bio initiative in chemical engineering to explore the possibility of a broader set of activities in bioengineering within the College. This is an ambitious undertaking that would require additional resources and commitment from the college and from higher university administration. However, the arguments set forth in conjunction with the move of chemical engineering to life sciences are valid to a greater or lesser extent for other engineering departments. This expanded vision would provide a framework for the university to invest in the research capabilities of the College of Engineering, paralleling prior investments in Letters and Sciences, and, over time, work to bring teaching loads in line with those in Letters and Sciences.

7. The panel recommends that the department adopt a more entrepreneurial approach to program development, working to leverage research funding into additional faculty lines beyond the new line recommended above. Future IDC funds may be budgeted to reduce the risk by providing bridge salaries for faculty who are between grants. This should stabilize, over time, into a fairly predictable amount. Entrepreneurial approaches, of course, should not be limited to supporting faculty lines only, but should be directed according to a strategic plan to building all of the resources of the department.

   Also, faculty who participate in centers and institutes across the university should be considered as contributors toward meeting departmental goals. In this regard new mechanisms may be necessary that will allow the department to more clearly benefit from the participation of its faculty in research centers. This implies an improved integration of centers and departments, whereby resources flow not only from departments to centers, but also from centers to departments, in accordance with the contribution of faculty time to the center activities. Specifically, departments must be credited for research their faculty do through the centers.

8. The move towards biological engineering will require that a leader be identified for this initiative from within the university or one be recruited from outside. This is a critical position for it will embody the will of the College and University to implement these undertakings.

9. The plan should be revisited after three years and updated and modified based on experience to date.

Appendices

A. Statement of Work

B. Agenda

Appendix A. Statement of Work

We ask that the panel review the Department's situation and assist us in developing strategic goals and objectives in research and graduate education, and offer guidance on how to proceed. Specific topics to be addressed include:

1. Opportunities:
   a. What will a "bio" emphasis in the chemical engineering program (or new "bio" program) allow us to accomplish? What funding opportunities would open up? What would the impact be on our ability to continue to attract highly qualified undergraduate students? Qualified graduate students? How would a "bio" emphasis impact placement of our graduates?
   b. How significant is the "bio" wave that is sweeping through chemical engineering departments? Is this something we must do if we are to stay relevant in the foreseeable future? How great is the risk that we will be jumping on one bandwagon just as a new band begins playing a new tune? Will we miss much if we simply stay the course?
   c. What collaboration opportunities exist on campus and with regional national labs, etc. [Potential collaborators might include: College of Agriculture, Biochemistry, Biology (both branches), Veterinary and Molecular Biology, Center for Biofilm Engineering, Thermal Biology Institute. Regional labs include INEEL, Pacific Northwest Labs, medical institutes in Hamilton and Great Falls.] Based upon the experience of the panel, how receptive are the individuals at those facilities likely to be to collaboration?
2. Level of involvement:
   a. What is the appropriate level of involvement for the department?
      - An increased emphasis in "bio" by hiring faculty with research interests in this area (no curriculum changes)
      - A "bio" option in chemical engineering (chemical engineering curriculum with a "bio" emphasis)
      - A new "bio" program (complete curriculum)
   b. Should a new "bio" emphasis be focused at the graduate or undergraduate level?
   c. What new courses would likely be required? What number, type, and level of courses would be required for each type of "bio" emphasis? What type of emphasis can the department accommodate with existing or expanded personnel?
   d. What opportunities exist for graduates of a "bio" program?
3. Feasibility:
   a. Does the department have the facilities and staff to make a "bio" emphasis work? If not, is there a reasonable probability of developing the capacity?
   b. One approach that has been suggested is to pre-hire individuals to replace retiring faculty before the retirements actually take place. The benefits are that the new faculty can get their research efforts up to speed while the existing faculty carries the bulk of the teaching load. But uncertain retirement dates and delayed retirements could significantly increase the start-up costs. Does MSU have the commitment, flexibility, and resources adequate to carry this effort through to completion?
4. Compatibility with existing programs:
   a. What steps can the department take to ensure that the new program best be made to fit with the existing chemical engineering program?
   b. How can the department best utilize existing resources, and expand its resource base?
   c. How can the department minimize the risk that the new program will be viewed as a competitor by other programs? Or, will other programs perceive the new program as a good fit with their own?
   d. What types of "bio" programs are possible, and which seem to fit best with the interests of the faculty and the available resources?
5. Interest: What is the perceived level of interest in going forward with a "bio" emphasis in chemical engineering?

It is our hope that you can provide a few scenarios with some indication of what would be required for each scenario.

Appendix B. Agenda

Sunday, October 27th

Early afternoon — **Reviewers arrive at Gallatin Field**

Arrange own transportation to Wingate Inn (Scott Hauger will have a rental car.)

4:00 p.m. — **Meeting with Ron Larsen**, Head, Department of Chemical Engineering at Wingate (Bighorn Room)

Focus: Departmental Information, Q&A with review team

6:00 p.m. — **Informal Dinner at Café Internationale**
(207 W. Olive, Bozeman: 586-4242)

With:

- Ron Larsen, Head of Chemical Engineering
- Robert Marley, Dean of Engineering
- Anne Camper, Assoc. Dean of Engineering
- John Sears, MSU Chair for Engr. & C.S. Education
- Shelley Thomas, Administrative Associate, CHE

Focus: Welcome the review team. Begin to consider how a bio emphasis in chemical engineering might fit into the College of Engineering's strategic plan, and the campus research community.

Monday, October 28th

7:00 a.m. **Meet with MSU Administrators** (Berg Conference Room, 330 Cobleigh Hall)

With:

- David Dooley, Provost
- Thomas McCoy, VP Research
- Robert Marley, Dean of Engineering

Focus: Charge to the Review Team

8:00 a.m. **Meet Chemical Engineering Faculty, part 1,** Berg Conference Room

With:

- Ron Larsen, Professor and Head
- Dan Shaffer, Associate Professor (tent.)
- Phil Stewart, Professor
- Joe Seymour, Assistant Professor
- John Sears, Professor and MSU Chair for Engineering and CS Education

Focus: Gather faculty input into proposed bio emphasis

9:00 a.m. **Meet Chemical Engineering Faculty, part 2,** Berg Conference Room

With:

- Max Deibert, Associate Professor
- Jim Duffy, Assistant Professor
- John Mandell, Professor
- Sarah Codd, Research Assistant Professor
- Sue King, Research Assistant Professor
- Giles Cokelet, Research Professor

Focus: Gather faculty input into proposed bio emphasis

10:00 a.m. **Meet Center for Biofilm Engineering Executive Committee,** Berg Conference Room

With:

- Ron Larsen
- Phil Stewart, CBE Research Director
- Anne Camper, Associate Dean for Research
- Al Cunningham, Professor (Civil Engineering)

Focus: How will a bio emphasis in chemical engineering fit with the CBE's future plans?

11:00 a.m. **Break**

11:30 a.m. **Lunch with Chemical Engineering Graduate Students** (SUB 272)

With:

- Joe Menicucci
- Erica Gjersing
- Lee Richards
- Steve Hunt
- Justin Gage (tent.)

Focus: How do current students perceive the proposed increased emphasis on bio in chemical engineering?

12:45 p.m. **Break**

1:10 p.m. **Facilities Tour** (start in Berg Conference Room)

With:

- Ron Larsen
- Anne Camper

Focus: What facilities improvements will be required to support a new bio emphasis in chemical engineering?

2:10 p.m. **Campus Constituencies Meeting, part 1: Thermal Biology Institute, Veterinary Molecular Biology, Computational Biology,** Berg Conference Room

With:

- Ron Larsen
- Mark Young, Director, Thermal Biology Institute
- Gwen Jacobs, Head, Cell Biology and Neuroscience
- Mark Quinn, Assoc. Professor, Veterinary Molecular Biology

Focus: How will a bio emphasis in chemical engineering fit with the campus constituencies' future plans?

3:10 p.m. **Campus Constituencies Meeting, part 2: College of Agriculture, Microbiology, and Biochemistry,** Berg Conference Room

With:

- Ron Larsen
- John Sherwood, Professor, Plant Sciences & Plant Pathology
- Mike Franklin, Microbiology
- Martin Teintze, Assoc. Professor, Biochemistry
- Valerie Copie, Asst. Prof., Biochemistry (tent.)

Focus: How will a bio emphasis in chemical engineering fit with the campus constituencies' future plans?

4:10 p.m. **Meeting with Engineering Department Heads,** Berg Conference Room

With:

- Ron Larsen, Head, Chemical Engineering
- Doug Cairns, Professor, Mechanical Engineering
- Brett Gunnink, Head, Civil Engineering
- James Peterson, Head, Electrical and Computer Engineering
- Rocky Ross, Interim Head, Computer Science

Focus: How might a bio emphasis in chemical engineering fit in with the College's other programs?

Evening **Unscheduled**

Tuesday, October 29th

10:30 a.m. **Exit Meeting**, Berg Conference Room

With:

- Ron Larsen, Head of Chemical Engineering
- Robert Marley, Dean of Engineering

Focus: Debriefing

4:30 p.m. **Exit Interview**, 207 Montana Hall

With:

- David Dooley, Provost
- Thomas McCoy, VP Research

Focus: Debriefing