I. Overview

The College of Engineering proposes the establishment of a Bachelor of Science degree entitled Bioengineering. This degree program will be administered by the Bioengineering Program Committee:

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<th>MEMBER</th>
<th>DEPARTMENT</th>
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<tbody>
<tr>
<td>Jerome Schultz, Chair</td>
<td>Chemical and Environmental Engineering</td>
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<tr>
<td>Guillermo Aguilar</td>
<td>Mechanical Engineering</td>
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<tr>
<td>David Bocian</td>
<td>Chemistry</td>
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<tr>
<td>Jie Chen</td>
<td>Electrical Engineering</td>
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<tr>
<td>Tao Jaing</td>
<td>Computer Science and Engineering</td>
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<tr>
<td>Ashok Mulchandani</td>
<td>Chemical and Environmental Engineering</td>
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<tr>
<td>John Shyy</td>
<td>Biomedical Science</td>
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<tr>
<td>Frances Sladek</td>
<td>Cell Biology</td>
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Initially, the Bioengineering Program Committee will have the responsibility for approval and management of Bioengineering courses within the curriculum. In the early phase of establishing the Bioengineering Curriculum, the teaching faculty for the program will be drawn from the College of Engineering with the approval of the Dean and the Chairs of the respective departments.

II. The Major

Major requirements for the Bachelor of Science in Bioengineering are as follows:

Lower-division requirements (69 units)

a) MATH 009A (4), MATH 009B (4), MATH 009C (4), MATH 010A (4), MATH 010B (4), MATH 046 (4)
b) CHEM 001A (4), CHEM 001B (4), CHEM 001C (4)
c) PHYS 040A (5), PHYS 040B (5), PHYS 040C (5)
d) BIOL 005A (3), BIOL 05LA (1), BIOL 005B (4), BIOL 005C (4)
e) CEE 011 (2)
f) CS 010 (4)

Upper-division requirements (87 units)

a) BCH100 (4), BCH102 (4)
b) BIEN 110 (4), BIEN 120 (4), BIEN 125 (4), BIEN 130 (4), BIEN 130L (2), BIEN 135 (4), BIEN 140A (4), BIEN 140B (4), BIEN 155 (2), BIEN 175A (4), BIEN 175B (4)
c) CHEM 112A (4), CHEM 112B (4), CHEM 112C (4)
d) ENGR 118 (5)
e) ME 138 (4)

f) STAT 105 (2)

g) Technical Electives (16) There is a requirement of 16 units in upper-division courses in engineering, biology and/or substantive courses in a field or fields related to bioengineering. The purpose of these electives is to add strength and breadth to the major and to meet specific requirements for postgraduate study or a chosen career. The substantive courses in fields related to bioengineering usually have science or mathematics prerequisites (e.g. Chem 112C, Phys 40B, Math 046, BCH 100).

III. Justification

The proposed major in Bioengineering will allow students to complete a B.S. degree that will provide them with the basic education to enter the fields of bioengineering and biotechnology. Although the major will be termed “bioengineering” the course requirements will allow students to participate in the biotechnology industry as well. In general the term “bioengineering” is sometimes associated more with the medical industry and the term “biotechnology” is more associated with the pharmaceutical and food industries. (More descriptions of these terms are given below).

Training bioengineers is particularly important in the State of California. As shown in the graphic below from the 2004 Annual Report of the California Healthcare Institute, the biomedical and biotechnology industry is one of the prime employers of technology trained individuals in the State of California.

This report goes on to give the following encouraging statistics for opportunities for students with a bioengineering education.

“Today 2,600 biomedical companies in California—86% of them founded in the last 25 years—and 87 public and private research institutions continue to advance scientific knowledge and develop new treatments for serious diseases such as cancer, and cardiovascular, respiratory, and infectious disease. The pace of progress is accelerating with the expansion of information-based technology approaches—for example, genomics is mining the human genome for biological information to create preventive therapies, and nanotechnology is developing sensor technology and using microchips to diagnose disease. And as the industry matures in California with more
products in advanced clinical trials, it is moving beyond a primarily R&D-based industry, adding more manufacturing to its repertoire.

“California continues to receive more funds from the National Institutes of Health (NIH)—in 2003, approximately $2.9 billion—than any other state. And the total reported private investment in research and development is $15.5 billion, with the average company investing 48% of its revenues back into R&D. The industry employs more than 230,000 Californians in jobs with an estimated average annual salary of $67,000, and total estimated wages and salaries paid of $14 billion. It generates $32.3 billion in worldwide revenue and more than $7 billion for the state in exports. California companies are addressing issues of global health in new ways—developing medicines for diseases in developing countries, and new pricing strategies to balance the industry’s successes with responsibilities to the developing world. They are balancing business risks by building networks of alliances that enable them to integrate virtually, with each member of a network focused on a specific role in bringing high value products to market. In many ways, it is an exciting time for what has always been a vibrant, innovative, and resilient industry.”

The following is a definition of bioengineering that was developed at NIH:

“Bioengineering is rooted in physics, mathematics, chemistry, biology, and the life sciences. It is the application of a systematic, quantitative, and integrative way of thinking about and approaching the solutions of problems important to biology, medical research, clinical proactive, and population studies.

“Bioengineering integrates physical, chemical, or mathematical sciences and engineering principles for the study of biology, medicine, behavior, or health. It advances fundamental concepts, creates knowledge for the molecular to the organ systems levels, and develops innovative biologics, materials, processes, implants, devices, and informatics approaches for the prevention, diagnosis, and treatment of disease, for patient rehabilitation, and for improving health.”

The national biotechnology industry trade organization BIO gives the following definition of biotechnology:

"'New’ Biotechnology—the use of cellular and biomolecular processes to solve problems or make useful products. Biotechnology is a collection of technologies that capitalize on the attributes of cells, such as their manufacturing capabilities, and put biological molecules, such as DNA and proteins, to work for us.”

IV. Enrollment Projections

Enrollment projections, like most projections, are always subject to great uncertainty. However, based on national trends one can make a logical estimate. As can be see in the tables below (obtained from the Whitaker Foundation Web Page – www.whitaker.org) the national engineering enrollment has remained fairly stable over the last twenty years. However, bioengineering enrollment is growing at a rate of about 20 percent per year. In 2002,
bioengineering represented about 3% of the undergraduate engineering population. As a conservative estimate we can assume that the Bioengineering enrollment at UCR will be about 3% of the total engineering enrollment. Thus in the year 2010, the Bioengineering student body would be about $0.03 \times 2250$ or about 70 students not counting for any relative growth in bioengineering. If we assume a total growth in bioengineering of about 40% over this five year period, then the estimated total enrollment would be about 100 students or about 25-30 graduating seniors/year.

V. Impact

Over the next five years, the plan is to hire new faculty with bioengineering expertise to carry the major teaching and research thrusts of the program. During this transition period – each of the newly hired bioengineering faculty will be housed in one of the existing departments of the College of Engineering that most closely matches their training. Then a new Department of Bioengineering will be formed, and the existing primary Bioengineering Faculty at that time will transfer their primary appointments to the Department of Bioengineering.
Faculty Positions - 6

Undergraduate Laboratory Space – 2000 sq. ft.

Staff Support – One MSO, one secretary, one technician

**Descriptions of New Bioengineering Courses:**

**BIEN 110 Biomechanics of the Human Body**

Introduces the motion, structure and function of the musculoskeletal system, the cardiovascular system, and the pulmonary system. Topics include applied statics, kinematics, and dynamics of these systems and the mechanics of various tissues (ligament, bone, heart, blood vessels, lung). Emphasis is on the relation between function and material properties of these tissues.

**BIEN 120 Biosystems and Signal Analysis**

Provides basic knowledge for the quantitative analysis of the dynamic behavior of biological systems. Particular applications include neural systems, control of metabolic and hormonal systems, and design of instruments for monitoring and controlling biological systems. Topics include system theory, signal properties, control theory, and transfer functions.

**BIEN 125 Biotechnology and Molecular Bioengineering**

Provides an overview of biochemical processes in cells and their use in developing new products and processes. Presents cellular processes such as metabolism, protein synthesis, enzyme behavior, and cell signaling and control from an engineering viewpoint of modeling and control.

**BIEN 130 Bioinstrumentation**

Introduces basic components of instruments for biological applications. Explores sources of signals and physical principles governing the design and operation of instrumentation systems used in medicine and physiological research. Topics include data acquisition and characterization; signal-to-noise concepts and safety analysis; and interaction of instrument and environment.

**BIEN 130L Bioinstrumentation Lab**

Laboratory experience with instrumental methods of measuring biological systems. Introduces various sensors and transducers to measure physical, chemical, and biological properties. Covers reliability, dynamic behavior, and data analysis.

**BIEN 135 Biophysics and Biothermodynamics.**

An introduction to the application of thermodynamic principles to understanding the behavior of
biological systems. Discusses biophysical properties of biomacromolecules, such as proteins, polynucleotides, carbohydrates, and lipids, and methods of characterizing their properties and interactions.

**BIEN 140A Biomaterials**

Covers the principles of materials science and engineering, with attention to topics in bioengineering. Discusses atomic structures, hard treatment, fundamentals of corrosion, manufacturing processes, and characterization of materials.

**BIEN 140B Biomaterials**

Covers the structure-property relations of metals, ceramics, polymers, and composites, as well as hard and soft tissues such as bone, teeth, cartilage, ligament, skin, muscle, and vasculature. Focuses on behavior of materials in the physiological environment.

**BIEN 155 Bioengineering Laboratory**

Laboratory experience in cell culture, bioreactors, optical techniques, array techniques, and separation and purification methods.

**BIEN 175A & BIEN 175B Senior Design**

Preparation of formal engineering reports and statistical analysis on a series of problems illustrating methodology from various branches of applied bioengineering. Covers the entire design process: design problem definition, generation of a design specification, documentation, design review process, prototype fabrication, testing and calibration, cost estimation, and federal guidelines. Requires a term project and oral presentation.

Approved by the College of Engineering Executive Committee April 13, 2005
Approved by the College of Engineering Faculty April 14, 2005
Approved by the Committee on Educational Policy April 21, 2005