A Program on . . .

BIOCHEMICAL AND BIOMEDICAL ENGINEERING

KA-YIU SAN, LARRY V. McINTIRE
Rice University
Houston, TX 77251-1892

WE HAVE WITNESSED a gradual change in the chemical engineering profession in the last decade. Chemical engineers have branched out and have found new and exciting career opportunities in a number of emerging areas, such as bioengineering, advanced materials processing, and electronic and photonic materials. However, nearly all of these newly emerging, high-technology areas require not only training in the fundamentals of chemical engineering, but also demand a good basic knowledge of the science in the area concerned. This is particularly true in the field of bioengineering, where much of the science was not even known ten years ago. It is our belief that if chemical engineers are to play an active and important role at the frontier of this exciting area, they must be trained to be proficient in engineering fundamentals as well as in biochemistry, cell biology, and molecular biology. Here at Rice University we are working toward this goal by forming three comprehensive research and education programs in a Biosciences/Bioengineering Institute. The Institute will be located in a new 110,000 ft^2 building designed for crossdisciplinary laboratory investigations involving biochemical and biomedical engineers and life scientists (see Figure 1).

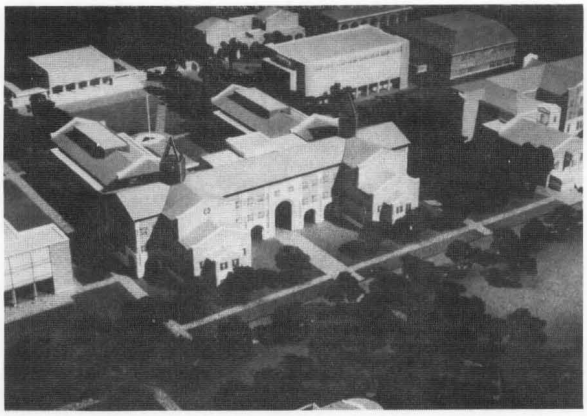

FIGURE 1. Architectural model of the new Biosciences/ Bioengineering Institute at Rice.

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ACADEMIC PROGRAM

Rice University has been at the forefront of biomedical engineering research for more than twenty years. The Biomedical Engineering Laboratory was first established in 1964 to provide engineering design and development support for Dr. DeBakey's Baylor-Rice total artificial heart. Dr. David Hellums, the current A. J. Hartsook Professor of Chemical Engineering, was a founding member. Since then the effort has greatly expanded, but the research has remained centered on problems related to the cardiovascular system. Beginning in 1979, the chemical engineering department decided to enlarge its efforts in bioengineering to include biochemical engineering. New faculty with different, yet complementary, interests were recruited to enlarge the scope of our existing biomedical research activities. Currently, our program has six faculty members and is expected to increase to a total of nine over the next five to ten years. Over the past four years, we have averaged four graduating PhDs in biochemical and biomedical engineering, which is approximately half of our total department PhD graduates (40 for the four-year period). Six of the recent graduates currently hold Assistant Professor positions in chemical engineering departments around the country. Approximately half of our total chemical engineering department graduate students are working on bioengineering thesis topics.

The philosophy of our program is to create an environment which will provide basic training in engineering principles and life sciences, and to prepare our students to meet new challenges in the process aspects of biotechnology. Three engineering options are currently offered: one is a five year undergraduate program, leading to a degree of Master of Engineering with emphasis in bioengineering; the second program leads to a PhD degree in chemical engineering; the

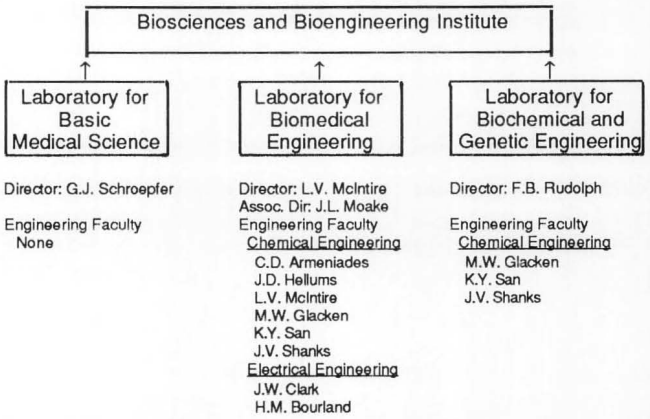
third is a joint program with the Baylor College of Medicine which leads to a MD/MS or MD/PhD degree.

The professional Master of Engineering Degree in biochemical engineering (non-thesis) is designed to provide chemical engineering students with fundamental training in biochemistry, microbiology, and molecular biology. Students enrolled in this program not only have to fulfill core requirements in chemical engineering, but also have to fulfill certain requirements offered in the Department of Biochemistry and Cell Biology, including extensive laboratory work. The five-year structure appears to be necessary to give sufficient breadth. However, students can obtain a four year Bachelors Degree if they are interested in going directly into graduate research or into a medical school option. Approximately one-third of our current chemical engineering seniors are enrolled in the biochemical engineering option.

The Doctor of Philosophy Degree in chemical engineering under the Biochemical and Biomedical Engineering program follows a philosophy similar to that of the Masters degree. Students enrolled in this program, apart from fulfilling the basic PhD requirements set forward by the Department of Chemical Engineering, are also required to take a sequence of advanced courses from the life science departments, either on campus or from the two medical schools located in the Texas Medical Center, which is adjacent to the Rice campus. Typical examples would include cell biology, molecular biology, and immunology.

The MD/MS or MD/PhD joint programs are designed to provide educational experiences of high quality leading to research careers in medicine. These programs offer a unique combination of professional medical training with rigorous study in science or engineering discipline, and they emphasize an interdisciplinary approach to current problems in biomedicine. Successful completion of a program results in the MD from Baylor College of Medicine and the MS or PhD from Rice.

FIGURE 2
Organizational Structure
Biosciences and Bioengineering Institute

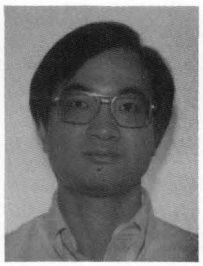


ENHANCEMENT PROGRAM

During the last two years, Rice University has undertaken a series of steps toward the implementation of a new plan of enhancement. This enhancement program was initiated by our president, Dr. George Rupp, in 1986, with the full support of the Board of Trustees and the faculty to "move forward to become, even more than it is today, the university its founders envisaged . . . to become an institution 'of the first rank'." At the research level, President Rupp has decided to focus resources on three cross-disciplinary areas in science and engineering, to move them to national recognition.

One of the three areas, which has a direct positive impact on our existing biochemical and biomedical engineering program, is the formation of a new institute: the Biosciences/Bioengineering Institute. This Institute will pool expertise from a number of engineering departments (primarily from the chemical engineering department) with the Biochemistry and Cell Biology department to solve problems that are multi-disciplinary in nature.

The main goals of the Biosciences/Bioengineering Institute are identified as: 1) to foster and strengthen collaboration among various groups at Rice which are involved in biological sciences and engineering; 2) to provide joint facilities and promote sharing of exper-



Ka-Yiu San is an assistant professor at Rice University. He received his BS degree in chemical engineering from Rice University and his MS and PhD degrees from California Institute of Technology.

Larry V. McIntire is the E.D. Butcher Professor of Chemical and Biomedical Engineering at Rice University. He is also director of the John W. Cox Laboratory for Biomedical Engineering of the Biosciences/Bioengineering Institute of Rice. He received his BChE and MS degrees in chemical engineering from Cornell University and his PhD degree from Princeton University.

tise; and 3) to serve as an interface for expanded interaction and collaboration between Rice University, the Texas Medical Center, NASA Johnson Space Center, private industries, and other research organizations.

The organizational structure of the newly formed Biosciences and Bioengineering Institute is shown in Figure 2. The Institute consists of three major laboratories, each of which pursues a distinct course of research. Faculty from the department of chemical engineering, depending on their research interests, will play an active role in two of these laboratories.

The Cox Laboratory for Biomedical Engineering, led by Larry McIntire, concentrates on research related to diseases of the cardiovascular system. Currently, the laboratory consists of six faculty members from the department of chemical engineering and a number of adjunct professors from Baylor College of Medicine and the University of Texas Health Sciences Center at Houston (see Table 1). Close working relationships have already been established between the Cox Laboratory and several of those at the Texas Medical Center. Both Professors McIntire and Hellums are Adjunct Professors in the Department of Medicine at the Baylor College of Medicine and the University of Texas Health Sciences Center at Houston. A brief list of current research projects can be found in Table 2.

The Laboratory for Biochemical and Genetic Engineering, headed by biochemistry professor Fred Rudolph, will focus on areas such as genetics, immunology, protein engineering, molecular biology, microbiology, medicine, and agriculture. The membership of this laboratory will include faculty from various departments, including biochemistry and cell biology, chemical engineering, and chemistry (Figure 2).

The Laboratory of Basic Medical Sciences, with director George Schroepfer, has a major continuing research effort on understanding cholesterol metabolism.

As noted above, a significant part of the enhancement effort includes a new $24 million building which is being constructed to house the Biosciences/Bioen-

TABLE 1
Structure of
Rice Biomedical Engineering Laboratory

Staff

Larry V. McIntire, PhD • *Director*
Joel L. Moake, MD • *Associate Director*
Arnez J. Washington • *Administrative Secretary*
Marcella Estrella • *Senior Research Technician*
Nancy Turner • *Research Technician*
Thomas W. Chow, PhD • *Senior Research Associate*
Mattias U. Nollert, PhD • *Research Associate*
Colin B. McKay, PhD • *Research Scientist*

Faculty

C.D. Armeniades • *Professor, Chemical Engineering*
J.D. Hellums • *A.J. Hartsook Professor, Chemical Engineering*
L.V. McIntire • *E.D.Butcher Professor and Chairman, ChE*
M.W. Glacken • *Assistant Professor, Chemical Engineering*
K.Y. San • *Assistant Professor, Chemical Engineering*
J.V. Shanks • *Assistant Professor, Chemical Engineering*
J.W. Clark • *Professor, Electrical Engineering*
H.M. Bourland • *Lecturer, Electrical Engineering*

Adjunct Faculty from the Texas Medical Center

C.P. Alfrey, MD,PhD • *Professor of Medicine, Division of Hematology, Baylor College of Medicine*
S.G. Eskin, PhD • *Associate Professor, Division of Surgery, Baylor College of Medicine*
E.R. Hall, MD • *Assistant Professor, Department of Medicine, University of Texas Medical School*
E.C. Lynch, MD • *Associate Chairman, Division of Medicine, Baylor College of Medicine*
D.A. Sears, MD • *Professor of Medicine, Division of Hematology, Baylor College of Medicine*
R.T. Solis, MD • *Associate Clinical Professor, Department of Medicine Pulmonary Division, Methodist Hospital*
M.M. Udden, MD • *Professor of Medicine, Division of Hematology, Baylor College of Medicine*
K.K. Wu, MD • *Professor and Chairman, Division of Hematology and Oncology, University of Texas Medical School*
F.M. Yatsu, MD • *Professor and Chairman, Division of Neurology, University of Texas Medical School*

TABLE 2
Bioengineering Research at Rice

Principal Investigators	*Biomedical Projects*
J.D. Hellums, L.V. McIntire	• effects of physical forces on vascular cells • vascular wall strain effects on cell metabolism • mass transfer in the microcirculation • video microscopy analysis of blood cell-vessel wall interactions
J.L. Moake, J.D. Hellums, L.V. McIntire	• control of tissue plasminogen activator production by endothelial cells • shear-induced von Willebrand factor aggregation of platelets • new therapeutic strategies for Sickle Cell Anemia
L.V. McIntire	• biochemical control of tumor metastasis
C. Armeniades	• biomechanics of eye tissue and control of healing
J.W. Clark	• cell modeling studies
	Bioreactor Projects
M.W. Glacken	• metabolic control of mammalian cell culture reactors • kinetics of antigen shedding from colon cancer cells • adhesive interaction of mammalian cells
K.Y. San	• construction/characterization of new plasmid vectors • dynamics of bioreactors in transient environments • development of artifical intelligence-based control algorithms • microgravity bioprocessing
J.V. Shanks	• plant cell tissue culture reactors • use of high field NMR for in vivo cell metabolism studies

gineering Institute. More than 22,000 square feet have been allocated to accommodate the chemical engineering aspects of bioengineering. This building is expected to be completed and fully operational by the winter of 1990.

CONCLUDING REMARKS

In summary, these are exciting times at Rice University. The implementation of the new enhancement program is another big step toward the goal and commitment of Rice University in striving for excellence in its undergraduate and graduate education. In particular, the formation of the Biosciences/Bioengineering Institute significantly enhances our biochemical and biomedical engineering program. It creates a unique environment which fosters close interactions between life scientists and engineers. The Institute will also serve as an effective administrative body in providing all the necessary logistical support to facilitate interdisciplinary collaboration. More importantly, the potential barriers which often arise from distant physical locations of various departments across the campus will be removed by housing life scientists and engineers under the same roof. As such, it will not only create an atmosphere which promotes interaction between the students and faculty from different disciplines, but will also provide opportunities for the engineering students to work, side by side, with life scientists from other research groups. We therefore firmly believe that our program provides a unique and challenging educational environment. Students graduating from the bioengineering program will be well-equipped with fundamental training and will have had the necessary exposure in both engineering and life sciences for further professional development. □

ChE letters

STATE OF THE UNIVERSITY 1988-1989

To The Editor:

The following is excerpted from a larger document, "Faculty Perceptions of the State of the University, 1988-1989," which was prepared for the Faculty Senate at the University of Cincinnati. I chaired the committee which produced this report.

A university becomes too large when it can no longer provide members of the university community with the services or ambience they expect, without amassing such complicated bureaucracies that they actually end up preventing the very goals they are attempting to achieve. Steven Muller, President of Johns Hopkins has said, "The major research university of today is a radically different institution than its predecessors of three or four decades ago. The most obvious difference is size. There have now evolved in the United States between 50 and 100 major research universities that are megasize–numbering their students in tens of thousands, their faculty and administrative cadres in thousands, their buildings and their acreage in hundreds."

Most educators agree that "multiuniversity" is an apt description of the university of today. Twenty years ago Columbia University had three vice presidents and a budget of $136 million; now it has 12 and a budget of $619 million. The problem in managing such vast institutions has led to what A. Bartlett Giamatti, former President of Yale, called "the corporatization of the American university," and then wrote, "One of the great inventions of 20th century America, the private corporation, has begun to displace, as a formal structure and as a style of management, the older ecclesiastical and academic structures and styles in which universities grew up." He suggests that the "collegial" style of shared decision-making has given way to the hierarchical style of big business. While big institutions need capable administrators, "too many people see themselves as managers first, academics second. They talk about strategy, not vision. Numbers replace rhetoric. An institution that once saw itself as connected to history now prides itself as 'at the cutting edge'. The greatest subtle, unintended effect of these trends has been to split off the managers from the faculty."

If universities are becoming corporate at a time when contemporary corporations are de-layering and decentralizing, then there ought to be a symbolic lesson learned from recent corporate history. American corporate executives often have acted as a privileged class, asking sacrifices of middle management, professionals and other workers, that upper management will not make. While the rhetoric of corporate culture stresses the need to work together, the top executives stress efficiency and impose work rules and cost cutting measures. They vote themselves raises, golden parachutes and bonuses, while workers at all levels are laid off. During the recession years of 1981 to 1983, the compensation of chief executives nearly doubled while national unemployment passed the 11% mark. In symbolic contrast to these American management practices, Japanese executives in

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