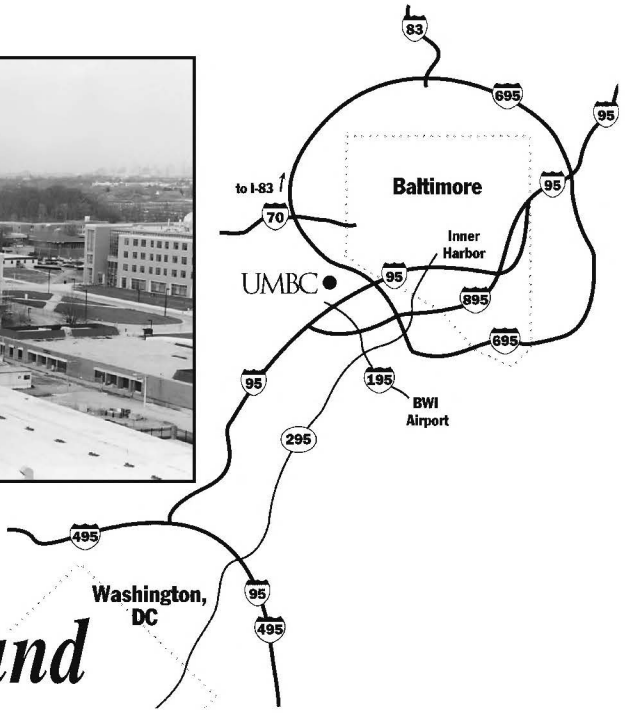



*ChE at*

# *University of Maryland Baltimore County*

TARYN BAYLES, DOUGLAS FREY, THERESA GOOD, MARK MARTEN, ANTONIO MOREIRA, GREGORY PAYNE, GOVIND RAO, AND JULIA ROSS
*University of Maryland Baltimore County • Baltimore, MD 21250*

It all began twenty years ago. An MOU (Memorandum of Understanding) was signed in 1983 that created a satellite program in engineering at the University of Maryland Baltimore County (UMBC) campus. There was only one state-supported College of Engineering in Maryland at that time, at the University of Maryland College Park (UMCP), but in the late seventies and early eighties, sufficient economic development had taken place in the Baltimore region to draw legislative attention to the educational needs of the Baltimore region.

The original program created in 1983 envisaged the UMBC operation as a satellite campus, with an Associate Dean reporting to the Dean of Engineering at UMCP. Programs were set up in mechanical, chemical, and electrical engineering, with program directors in charge who would report to the respective department chairs at UMCP. The BS degree was approved in 1985 and the MS/PhD degree in 1986.

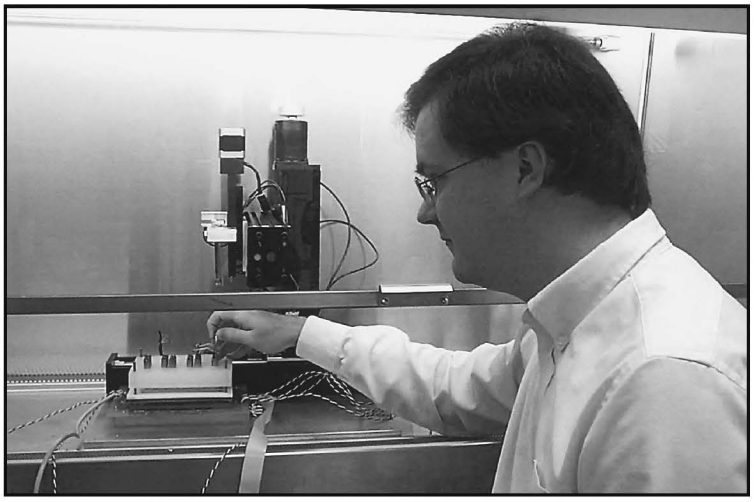
The founding fathers in chemical engineering wisely decided to call the UMBC program "Chemical and Biochemical Engineering" and made a strategic early decision to focus the graduate program exclusively on biochemical engineering, while offering the undergraduate degree in traditional chemical engineering. In 1986, Greg Payne joined the faculty as the first "bio" hire, followed in 1987 by Govind Rao. The program subsequently grew rapidly, with several additional hires joining the faculty (due to space limitations, only current faculty are mentioned). By 1991, engineering at UMBC had grown sufficiently to necessitate the creation of a freestanding college with its own dean, and the programs were renamed as "Departments" with corresponding "Chairs."

The bio focus has turned out to be a great boon for the department. UMBC was the first chemical engineering department in the country to have such a focus, and it continues to this day to be the country's only chemical engineering department to focus its graduate program exclusively on the bio area. From the beginning, this specialization attracted a great deal of attention, particularly from prominent biochemical engineering faculty at other institutions. One of the most exciting moments in our young history was when Professor

Daniel Wang from MIT spent half of his first (and only!) sabbatical at UMBC (with the other half spent at CalTech). We learned a great deal from him and through similar interaction with Professors Arthur Humphrey and Michael Shuler. Interestingly, a common thread of advice from all of these distinguished visitors during our formative years was to stay the course and keep building the program, and to resist the temptation to move into non-bio areas. Everyone felt that the concentration of faculty in the bio area and the unique location of UMBC in a bio-dense region of the country would eventually result in a strong and vibrant department.

## THE PRESENT

The department's more recent history has proven that the strategy of focusing its graduate program exclusively on the bio area was a sound decision. Although the department went through its share of growing pains and tough times in the beginning, the end result is a strong and stable department with exceptional facilities and equipment and outstanding faculty, staff, and students. For example, all faculty members in the department have active research programs with substantial external funding, and every eligible junior faculty member has received an NSF CAREER award. Table 1 lists the current faculty and staff in the department, along with their interests and responsibilities.



***Peter Harms (NSF Graduate Fellow) adjusts a high throughput microbioreactor.***

A great asset of being a high-profile department at a relatively small institution (see UMBC profile in Table 2) is an unusually close con-

**TABLE 1**
**Current Personnel at UMBC**

■ ***Dr. Taryn Bayles • Lecturer***
*BS, New Mexico State University*
*MS (Petroleum), MS and PhD, University of Pittsburgh*
Undergraduate education and outreach; transport phenomena

■ ***Dr. Douglas Frey • Professor***
*BS, Stanford University*
*MS and PhD, University of California, Berkeley*
Chromatography of biopolymers

■ ***Dr. Theresa Good • Associate Professor***
*BS, Bucknell University*
*MS, Cornell University*
*PhD, University of Wisconsin-Madison*
Cellular engineering; optimization of chemotherapy and other problems in biocomplexity

■ ***Dr. Mark Marten • Assistant Professor***
*BS, State University of New York, Buffalo*
*MS and PhD, Purdue University*
Bioprocessing, proteomics, and genomics; microbial responses to real-life environments

■ ***Dr. Antonio Moreira • Professor and Vice Provost***
*BS, University of Porto, Portugal*
*MS and PhD, University of Pennsylvania*
*Post Doc, University of Waterloo, Canada*
Regulatory/GMP issues, scale-up; downstream processing

■ ***Dr. Gregory Payne • Professor***
*BS and MS, Cornell University*
*PhD, University of Michigan*
Biomolecular engineering; renewable resources

■ ***Dr. Govind Rao • Professor and Chair***
*BS, IIT (Madras)*
*PhD, Drexel University*
Fluorescence-based sensors and instrumentation; fermentation and cell culture

■ ***Dr. Julia Ross • Associate Professor***
*BS, Purdue University*
*PhD, Rice University*
Cell and tissue engineering; cell adhesion in microbial infection and thrombosis

**Support Staff**

***Mary Anderson • IT Support Associate***
***Laurie Botto • Office Assistant***
***Mike Frizzell • Technician***
***Victor Fulda • Technician***
***Denise Kedzierski • Administrative Assistant***

**Research Faculty**

***Dr. Yordan Kostov • Research Assistant Professor***
***Dr. Nandakumar Madayiputhiya • Research Associate***
***Dr. Leah Tolosa • Research Assistant Professor***
***Dr. Pyon Kyun Shin • Research Associate***
***Dr. Haley Kermis • Research Associate***

nection with administration. Everyone from the university President on down is literally at arms reach and is tremendously responsive and supportive of departmental needs.

Another unusual aspect is the close ties our department has with the Biology and Chemistry Departments as a result of many common faculty research interests. At its inception, our department occupied research space and facilities generously loaned to it by the Chemistry Department, and it also received strong support from the Biology Department. All of our faculty members also participate in the Molecular and Cell Biology and in the Chemistry-Biology Interface Programs at UMBC. These two programs have resulted in biology graduate students working in chemical/biochemical engineering laboratories and vice versa, leading to a creative interdisciplinary mix in our laboratories.

## HIGHLIGHTS

We are fortunate to be at the leading edge of a revolution. Biotechnology has become a dominant aspect of the US economy. Indeed, just as the previous century witnessed enormous strides in chemistry- and physics-based technologies, this century is poised to herald advances based on biology. The human genome has been sequenced, and unprecedented opportunities are opening up in the biotech/pharma world. We plan to exploit these opportunities with a vigorous research and education program that targets its bioprocess aspects, and through bioengineering applications that focus on cellular interactions in disease-causing states.

Our current undergraduate curriculum (see Table 3, Column 1) has little to differentiate it from other departments across the country that offer the chemical engineering major. This is changing, however. Our bio-focused graduate research program, coupled with enormous growth in the pharma/biotech industry, provided the inspiration for a new biotechnology/bioengineering track at the undergraduate level that we began in 2001 (Table 3, Column 2). While we plan to offer both the traditional track and the new track within the chemical engineering major for the next few years, we anticipate that the new track will ultimately emerge as a new major, depending on enrollment and acceptance of its graduates by employers and graduate/medical schools.

An unusual aspect of UMBC's graduate offerings, developed by Tony Moreira, is the four-course sequence in Biochemical Regulatory Engineering.

- *Regulatory Issues in Biotechnology*

**TABLE 2**
**UMBC Facts, 2002-2003**

**President** • Freeman A. Hrabowski, III

**Faculty** • 680 full time and 350 part-time

**Students, Fall 2002**
- 11,711 enrolled
  - Undergraduate, 9,549
  - Graduate, 2,162
  - Full-time, 8,779
  - Part-time, 2,932
- Freshman Class 2002
  - First-time freshmen, 1,370
  - Living on campus (74%), 1,007
  - SAT percentiles
    25th - 1120
    75th - 1290
  - Average SAT
    Top Quartile - 1374

**Chemical and Biochemical Engineering Statistics**
- Undergraduate, 100
- Graduate, 34
- Faculty, 10 FTE

**Academic Programs**

UMBC offers 37 majors and 32 minors or certificate programs in the physical and biological sciences, social and behavioral sciences, engineering, mathematics, information technology, humanities, and visual and performing arts. New degree programs include environmental science, financial economics, and a B.F.A. in acting.

UMBC's Graduate School offers 27 master's degree programs, 21 doctoral degree programs, and seven graduate certificate programs. Programs are offered in education, engineering, imaging and digital arts, information technology, life sciences, psychology, public policy, and a host of other areas of interest. A new gerontology PhD program is one of only six in the United States.

**Achievements**
- Ranked in top tier of nation's research universities—Doctoral/Research Universities-Extensive—by the Carnegie Foundation
- Six-time Pan-American Intercollegiate Team Chess champions
- National Science Foundation ranking for federally funded research in science and engineering jumped by nearly 50 places (from 200 to 153) in less than five years
- Named a "Hot School" by the 2003 *Kaplan/Newsweek College Guide*
- Only Maryland university rated a "Best Value" by the 2001 *Kaplan/Newsweek College Guide*
- Ranked 16th nationwide in NASA funding
- Named "Chess College of the Year" by *Chess Life* magazine in 2000
- Won the NCAA Northeast Conference Commissioner's Cup in 1999, 2000, 2001, and 2002
- Recognized as a college that builds character by *The Templeton Guide*
- Awarded Phi Beta Kappa chapter in 1997
- Only Howard Hughes Medical Institute Investigator at a Maryland public university
- Two-time recipient of U.S. Presidential Award for Excellence in Science, Mathematics, and Engineering Mentoring
- Consistently ranked among the top five research universities nationally in production of bachelor's degrees in Information Technology
- Designated a Center of Academic Excellence in Information Assurance by the National Security Agency

- *Good Manufacturing Processes for Bioprocess*
- *Quality Control and Quality Assurance for Biotechnology Products*
- *Biotechnology GMP Facility Design, Construction, and Validation*

This course sequence is also available as a stand-alone certificate program that is highly sought after by biotechnology industry professionals. Graduate students who complete this certificate program are highly attractive to industry—these issues are of critical importance to industry and programs of this type are not generally available at most institutions.

While the primary focus of our graduate program is on PhD students, we are also mindful of industry's need for trained Master's students. This, coupled with an attractive integrated BS/MS option available to undergraduates, will result in significantly more MS degrees being granted over the next few years. Ultimately, this is primarily a resource issue, as the majority of the faculty is involved in long-term research

**TABLE 3**

**BS Degree in Chemical Engineering: Traditional (left) and Bio (right) Tracks**

| | |
|---|---|
| ***Freshman Year*** | |
| CHEM 101 Principles of Chemistry I (4) | CHEM 101 Principles of Chemistry I (4) |
| MATH 151 Calculus and Analytic Geometry I (4) | MATH 151 Calculus and Analytic Geometry I (4) |
| ENES 101 Introductory Engineering Science (3) | ENES 101 Introductory Engineering Science (3) |
| GFR electives (6) | GFR electives (6) |
| CHEM 102 Principles of Chemistry II (3) | CHEM 102 Principles of Chemistry II (3) |
| CHEM 102L Introductory Chemistry Lab (2) | CHEM 102L Introductory Chemistry Lab (2) |
| PHYS 121 Introductory Physics I (4) | PHYS 121 Introductory Physics I (4) |
| MATH 152 Calculus and Analytic Geometry II (4) | MATH 152 Calculus and Analytic Geometry II (4) |
| ENES 110 Statics (3) | **BIOL 100 Concepts of Biology (4)** |
| GFR electives (3) | GFR electives (3) |
| ***Sophomore Year*** | |
| CHEM 351 Organic Chemistry I (3) | CHEM 351 Organic Chemistry I (3) |
| ENCH 215 Chemical Engineering Analysis (3) | ENCH 215 Chemical Engineering Analysis (3) |
| MATH 251 Multivariable Calculus (4) | MATH 251 Multivariable Calculus (4) |
| PHYS 122 Introductory Physics II (4) | **BIOL 302 Molecular and General Genetics (4)** |
| CHEM 351L Organic Chemistry Lab I (2) | **BIOL 303 Cell Biology (3)** |
| MATH 225 Introduction to Differential Equations (3) | **BIOL 303L Cell Biology Laboratory (2)** |
| Advanced Science elective (3) | **CHEM 352 Organic Chemistry II (3)** |
| ENES 230 Introduction to Materials (3) | MATH 225 Introduction to Differential Equations (3) |
| GFR electives (6) | GFR electives (6) |
| ***Junior Year*** | |
| CHEM 301 Physical Chemistry I (4) | CHEM 301 Physical Chemistry I (4) |
| CHEM 311 Advanced Laboratory I (3) | **CHEM 437 Comprehensive Biochemistry I (4)** |
| ENCH 300 Chemical Process Thermodynamics (3) | ENCH 300 Chemical Process Thermodynamics (3) |
| ENCH 425 Transport Processes I (3) | ENCH 425 Transport Processes I (3) |
| GFR electives (3) | GFR elective (3) |
| CHEM 302 Physical Chemistry II (3) | **CHEM 438 Comprehensive Biochemistry II (4)** |
| ENCH 427 Transport Processes II (3) | ENCH 427 Transport Processes II (3) |
| ENCH 440 Chemical Engineering Kinetics (3) | ENCH 440 Chemical Engineering Kinetics (3) |
| ENCH 442 Chemical Engineering Systems Analysis (3) | ENCH 442 Chemical Engineering Systems Analysis (3) |
| ENGL 393 Technical Writing (3) | ENGL 393 Technical Writing (3) |
| ***Senior Year*** | |
| ENCH 437 Chemical Engineering Laboratory (3) | ENCH 444 Process Engineering Economics and Design I (3) |
| ENCH 444 Process Engineering Economics and Design I (3) | ENCH 445 Equilibrium Stage Computations (3) |
| ENCH 445 Equilibrium Stage Computations (3) | **ENCH XXX Bioengineering elective (3)** |
| ENCH XXX Chemical Engineering elective (3) | **ENCH XXX Bioengineering elective (3)** |
| GFR electives (3) | GFR elective (3) |
| ENCH 446 Process Engineering Economics and Design II (3) | ENCH 446 Process Engineering Economics and Design II (3) |
| ENCH XXX Chemical Engineering elective (3) | **ECH 485L Bioengineering Laboratory (3)** |
| ENCH XXX Chemical Engineering elective (3) | **ENCH XX Bioengineering elective (3)** |
| GFR electives (6) | GFR electives (6) |

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projects that require the continuity and time investment of longer-term PhD students. At the present time, financial assistance is primarily directed at incoming PhD students (with some exceptions).

How does a small department handle so much? Part of the answer is Taryn Bayles, a full-time faculty member devoted to education and outreach. Her infectious enthusiasm and energy are largely responsible for the high profile enjoyed by the department. An example of her creative talents is demonstrated by teaching innovations incorporated into her courses, such as a design project where freshman engineering students had to build and operate a water-balloon-launching trebuchet that featured her as the target! In addition, Taryn's outreach efforts extend to several local schools and have served to increase both UMBC's visibility and the community's awareness of engineering.

In addition, several faculty members are involved in electronic instructional media development. For example, Doug Frey has developed a highly useful separations course web page that is available to anyone (found at <www.research.umbc.edu/~dfrey1/ench445/>), and Julie Ross, in collaboration with faculty in the medical school, is developing innovative XML-based teaching modules.

We have close ties to industry—several faculty members have research interactions with a number of pharmaceutical/biotechnology companies. In addition, UMBC's location puts us within an hour's drive of top-notch Federal facilities including NIH, ONR, NIST, USDA, FDA, and DOD. Several of our faculty members and students have benefitted by using these unique research facilities.

**TABLE 4**
**Former Chemical/Biochemical Engineering Meyerhoff Scholars**

*"*" indicates non-minority student.*

*"( )" indicates currently working on graduate degree requirements*

Stephanie Bates - Clemson University • MS
Christy Butler - Case Western Reserve • (MD/PhD)
Adetokunbo Eniola - Penn • (PhD)
Andre Johnson - Employed
Ray Onley - Georgia Tech • (MS)
Bradley Peterson - MIT • (PhD)*
Lee Pitts - Johns Hopkins • (PhD)
Simone Stalling - Penn • (MD/PhD)
Kendra Sarratt - Penn • (PhD)
Jeremiah Tabb - Georgia Tech (PhD)
Felicia Boone - Employed
Kafui Dzirasa - Duke • (MD/PhD)
Alexis Hillock - Georgia Tech (PhD)
Michael Johnson - UMBC • (PhD)
Camelia Owens - Delaware • (PhD)
Jason Pinnix - Penn • (PhD)
Natasha Powell - Unknown • (MD/PhD)
Marc Price - Employed
Frederick Scott - UMBC • (MD)
Jason Thorpe - Georgia Tech • (PhD)

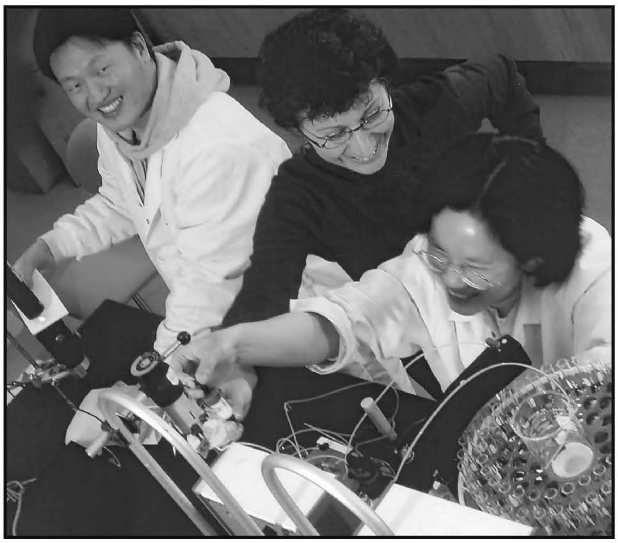
## MEYERHOFF PROGRAM

UMBC is home to the nationally recognized Meyerhoff program, which has a strong track record for graduating minority students and sending them on to top-ranked PhD programs. The program was started in 1994 by President Freeman Hrabowski with a grant from the Meyerhoff Foundation and has since attracted national recognition.

To date, the Meyerhoff Scholarship Program has produced 296 graduates (the first degrees were awarded in 1993). One-hundred and forty-eight students (148) are currently enrolled in PhD, MD/PhD, or other graduate or professional degree programs at institutions ranging from Yale, Harvard, and Stanford to MIT, Johns Hopkins, Carnegie Mellon, and Berkeley. An additional 107 students have already completed graduate-degree requirements and are working as researchers and teachers at some of the finest institutions and companies in the world. Research studies have demonstrated that when compared to a sample of high-achieving non-Meyerhoff African-American students, Meyerhoff scholars have a significantly higher incidence of attending medical school or graduate school in the sciences, engineering, or math. These findings have been substantiated by the fact that the National Science Foundation and the National Institutes of Health have identified UMBC, a predominantly white institution, as having one of the most effective programs contributing to minority-student success in science in the nation. Table 4 lists the Meyerhoff students from Chemical & Biochemical Engineering.

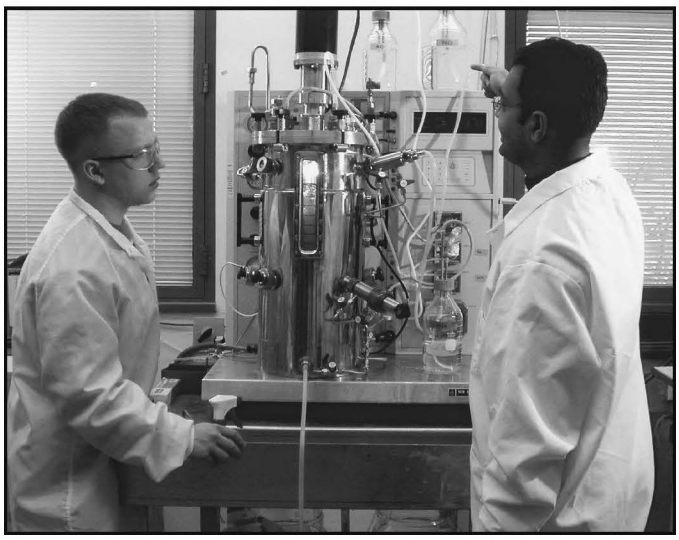
## LUMPKIN MEMORIAL LECTURE

Janice Antoine Lumpkin was one of the first African-American female faculty members in the chemical engineering field in this country. She graduated from MIT and Penn with BS and PhD degrees, respectively, and joined UMBC in 1989, initially as a part-time faculty member. She later converted to a full-time position and brought her catalysis skills to bear on understanding the mechanisms and kinetics of protein



◄ *Sungmun Lee (left), Theresa Good (center), and Wanida Wattanakaroon (right) purifying and testing photoimmuno conjugates for T-cell cancer treatment.*

*Graduate student Swapnil Bhargava (right) instructs undergraduate Seth Miller (left) on the operation of a 20-liter fermentor in Mark Marten's lab.* ▼



oxidation. Tragically, she passed away in 1997 after the birth of her fourth child. The department has honored her memory in the form of a high-profile memorial lecture that is part of UMBC's annual Life Sciences Day celebration. An eminent person is invited to deliver the Lumpkin Memorial Lecture for this celebration. Past Lumpkin lecturers include Arthur Humphrey, Daniel Wang, Douglas Lauffenberger, Sangtae Kim, and Barry Buckland. AIChE has also instituted a travel award in her name for attendance at its annual national meeting.

## THE FUTURE

We share a sense of excitement and anticipation about the future. Biotechnology is transforming life as its early promise is maturing. There is an unusual atmosphere shared by all members of this department—indeed, the feeling one gets is more like being in a small biotech company than in a traditional university setting. Our strengths and the challenges we face as we look into the future are

***Strengths***

- Focus on Biotechnology and Bioengineering: this is a major factor in our ability to achieve excellence. A traditional chemical engineering department faces competition for resources from other subspecialties such as catalysis, polymers, etc. This is never an issue for us.
- Outstanding Faculty: Our faculty members are as productive as those at higher-ranked peer institutions. We are a young group and are aggressive and passionate about both research and teaching. Furthermore, the environment is extremely collegial and friendly.
- Well-Equipped Laboratories: Our research areas are well supported with state-of-the-art equipment, and we truly have unmatched equipment resources compared to our much higher-ranked peers. Again, this is partly due to our focus on one area.
- Outstanding Geographical Location: We are located in an area where biotech-driven growth is inevitable, given our proximity to leading biomedical and biotechnology companies. Maryland ranks third in the nation for the number of biotech companies located in a state.
- Outstanding Foreign Graduate Students: UMBC is just about the only chemical engineering department that can guarantee an incoming graduate student that he or she will work on a bio-related project. This gives us a significant competitive edge in attracting students.

***Challenges***

- Obtaining greater resources for building on our base in a tough budget environment.
- Few domestic graduate students—a situation that is not unique to us and that is slowly changing
- Growth in the number of faculty members. We would like to do more!

## ACKNOWLEDMENTS

We thank Tim Ford for the photographs and Greg Simmons for the Meyerhoff Program statistics. ❒