Department of Bioengineering

10th Anniversary Celebraton

August 14, 2004

UCSD Jacobs

The Department of Bioengineering

The UCSD Bioengineering Program was initiated in 1966 by Drs. Y.C. Fung, Marcos Intaglietta, and Benjamin Zweifach within the Department of Aeronautical Mechanics and Engineering Science. In August 1994 the UC Office of the President approved our request to form a Department of Bioengineering, the first in the UC System. It is wonderful that our Department is celebrating the tenth anniversary of its establishment. While an age of 10 years is young, we had a gestation period of 28 years, which are covered in this book together with the last 10 years. At this momentous occasion, I wish to express my sincere thanks to all my colleagues: faculty, research scientists, staff and students, for their wonderful work as a team in making the Department such a marvelous place to be, both scientifically and interpersonally. On behalf of the Department, I also wish to take this opportunity to thank the generous support and strong encouragement by our friends everywhere in the country and our administration at UCSD and the UC system. Our friends and colleagues are extremely precious, much more than the diamond on the cover of this book*, which is a symbol that represents the tenth anniversary.

Sincerely,

Shu Chien
Chair, Department of Bioengineering

* The preparations for this book and the celebration on August 14, 2004, have been made possible by the outstanding work by the following members of UCSD central administration, Jacobs School External Relations Office, and Department of Bioengineering (listed alphabetically): Kelly Briggs, Suzie Dandos, Chandra Ewell. Jennifer Griffin, Denine Hagen, Irene Jacobo, Paul Laperruque, Beth Maples, Carolyn Post-Ladd, Jeff Sanchez, and Loretta Smith. Their marvelous contributions are gratefully acknowledged.

Tributes

A Foundation for Excellence

David Miller
University of California, San Diego
Acting Senior Vice Chancellor, Academic Affairs

It is hard to believe that it has been ten years since a small group of distinguished faculty in bioengineering split off from the then AMES department and formed one of the few Departments of Bioengineering in the country. I was serving as chair of AMES at the time when much of the discussion occurred. The bioengineering section of our department was always one of the most focused and visionary groups, zealous about the quality of faculty and researchers recruited to join them. At the time there were only six ladder rank faculty, and only the quality of the program could overcome the traditional 'critical mass' arguments about the minimum size of a viable department. We had mixed emotions about their separation because they added strength to our broader programs in engineering science, interacted with colleagues in several areas of mechanics, and attracted large numbers of outstanding students at both the graduate and undergraduate levels. However, it was clear that they would bring even more stature and viability to the School of Engineering and to UCSD if they became an independent department. Of course one of the principal issues was resources, new faculty positions and space. I believe the final approval waited for the arrival of Dean Robert Conn who quickly understood how important such a development would be to the growth and stature of the school. After reviewing their well-developed growth plans involving expansion into biomolecular and biochemical areas, with themes such as "tissue engineering", he endorsed the new department and allocated sufficient faculty positions to ensure its success. I do recall that the space and operational budgets were quite modest but the enthusiasm of the faculty made it all work. At that time it was envisioned that the bioengineering department would mature at something like 15 faculty, while the latest plans call for them to grow to about 25 faculty. Any leader at UCSD would be proud of what this young department has accomplished, and I surely am. They are ranked as one of the top three departments in the country, they enroll more than 200 undergraduates and 30 graduate students each year, their research funding exceeds $800K per faculty, they have been received private funding to build their own building, the Powell-Focht Bioengineering Hall, and they have continually been leaders and/or contributed to several interdisciplinary initiatives on the campus which have involved the natural sciences, the School of Medicine, and other engineering departments. On this 10th anniversary, I offer my congratulations and appreciation to the department, its faculty, staff, and students.

The Department of Bioengineering: A Former Dean's Perspective

Robert W. Conn, Ph.D.
Former Dean,
Jacobs School of Engineering (1994-2002)

The first major decision I faced during my tenure as Dean of Engineering at UCSD was whether or not to support the formation of a Department of Bioengineering within the School of Engineering. After accepting the appointment as Dean in mid-1993, the Chancellor and Vice Chancellor informed me that the campus was considering a proposal to form a new Department of Bioengineering, and that they felt it important to have my recommendation before proceeding. That was very considerate of them, but it also meant that I had to become informed very quickly about an area I knew relatively little about.

So I spent that Fall of 1993, while still formally at UCLA, getting introduced to bioengineering as a field, and meeting with the faculty who were supporting the formation of this new department. Two things became immediately apparent - 1) this was an extraordinary group of faculty, and 2) this was the only area of engineering at the time at UCSD that was ranked among the top 5 programs in the country.

But something else emerged equally clearly, something deeper, namely, that Bioengineering would emerge as the new engineering field for the 21st century. It would for the first time map an engineering field to the science of biology - something that amazingly had never happened before, at least not in a formal way. It was immediately clear that the potential to lead in this new area would represent, on UCSD's part, an opportunity for vision and leadership - and the time for this had come. Approval of the faculty's proposal followed in short order.

The department's success in its first decade has proven the rightness of the faculty's vision and the campus's decision to move ahead. I wish the department and its faculty, staff and students all the best in the decades to come - and I know that they will continue to provide vision and leadership to this critical field.

Bioengineering as a Catalyst for New Engineering Initiatives

Frieder Seible. Ph.D.
Dean, Jacobs School of Engineering

As we celebrate the 10-year anniversary of our great Department of Bioengineering and the many accomplishments of our faculty and students, it is also a time to look forward to all that is to come.

Since taking on the responsibilities of Dean of the Jacobs School in 2003, some of my most exciting interactions have been with the biomedical community, discussing how we as engineers can contribute to improving health care and medical sciences. It is not just an opportunity, but an obligation, for engineering to explore new ways in which advances in technology can provide better monitoring, diagnosis, and treatment of medical conditions. These complex challenges can only be solved through a truly interdisciplinary approach, and this will be the focus of many of the new initiatives involving our bioengineering department, as well as all the departments of the Jacobs School in the next decade and beyond.

The sequencing of the human genome is spawning a new field dedicated to understanding living systems as a whole in a quantitative and integrative perspective. Systems biology not only has the potential to revolutionize drug development, but could also help advance medical care through personalized diagnosis and treatment. Our Bioengineering Department, working together with many others on campus, launched one of the first educational programs in bioinformatics, now considered a model for the country. And in 2004, our bioengineering faculty developed a new course sequence in systems biology. With our incredible depth of faculty in this field, UCSD is and will lead this emerging field.

It is one of our declared goals to lead research on the life sciences with engineering solutions for medical innovation. Breakthroughs in these areas are driven by ever smaller sensors and actuators, frequently referred to as nanotechnology, and our engineering work now starts with smaller and smaller building blocks (at the cell or atomic level) to develop new materials with new mechanical, biological, and chemical processes, for the design and shaping of the final product. With UCSD's strength in the biological, physical, and health sciences, it is imperative for UCSD to not just contribute to, but lead this general area of biotechnology and medical devices. Our Bioengineering Department is positioned to be a leader in this area as we move forward.

UCSD is one of the youngest, yet fastest rising, research universities in the world, and bioengineering at UCSD has not just contributed to, but led this advancement. Faculty luminaries such as Y.C. Fung and Shu Chien have inspired and motivated young minds on this campus and well beyond, and have truly defined the field of bioengineering. With our incredible faculty expertise across the campus, our wonderful neighboring scientific institutions, and with our regional biotechnology industry, now described as the strongest in the nation, biomedical engineering will be the cornerstone to some of the most exciting and significant contributions that UCSD will make in the years ahead.

The Beginning and Early Years of Bioengineering at UCSD

Y.C. Fung

The bioengineering adventure in UCSD began in 1965. Thirty years later, in an evaluation of all Ph.D programs in the United States by the U.S. National Academy of Engineering published in 1996, the UCSD Bioengineering was rated as number 1 in Program and number 2 in Faculty in the category of Bioengineering. We are proud of this evaluation because it gives a nod to our hard work. To explain our experience, however, is a little complicated, because the UCSD experience was a bit unconventional, and some explanations are needed.

The Birth of the Program

The beginning of bioengineering at UCSD was thus: One day in June1965, Ben Zweifach, after visiting Harold Wayland and me at the California Institute of Technology for a year, was ready to go back to New York. Before leaving, I wanted to show him around Southern California. We decided to come to La Jolla to visit our friend Pete Scholander, a legendary naturalist at the Scripps Institute of Oceanography. Macos Intaglietta,who was a postdoc Fellow at Caltech at the time, and had worked with Pete in one of his expeditions, met us at Scripps. After a pleasant visit with Pete in the afternoon, we dropped in on Sol Penner, the Chair of the Department of AMES. Dr. Penner was a former colleague at Caltech. He asked us what we were doing. We said Bioengineering. Penner immediately called Joe Stokes, the Dean of the School of Medicine. Dr Stokes said:"Don't let them go home. Ask them to give a seminar." I could not, because I must begin my trip to Michigan the next morning. Ben and Marcos did stay, gave a seminar, and Sol started the recruitment process.

I went to Ann Arbor, Michigan to search my heart for an answer to the question whether I wanted to devote 100% of my time to bioengineering or not. If my answer was yes, then I should give up my career at Caltech and my interest in aeroelasticity and aerospace. By Christmas time my mind was made up. I wanted bioengineering 100% of my time. In January 1966 I returned to California and told Dr. Penner. Three weeks later Dr Penner gave me an appointment letter signed by Chancellor John Galbraith. I was named explicitly a professor of bioengineering. Ben, Marcos, and I came to UCSD in July, 1966.

The Unique System of Early UCSD

The University of California allows each campus to develop its own approach. In 1966, bioengineering was what the Dean of the School of Medicine Joseph Stokes wanted. He made 3 FTE's available to the Department of Ames, in which the bioengineering students and faculty were located. At that time, Chancellor Galbraith of UCSD has a Dean of the School of Medicine, but no other deans. There were two engineering Departments, the APIS (Applied Physics and Information Science), and the AMES(Applied Mechanics and Engineering Science). Bioengineering belonged to AMES. The Ph.D certificates of our students would read as "Doctor of Philosophy in Engineering Science with Specialization in Bioengineering." The first dean of Engineering was appointed in 1982. Thereafter other deans appeared in UCSD. This system lasted until 1994, when Bioengineering was separated out as a Department. Soon APIS and AMES were reorganized into many Departments, and the frontiers' days were gone.

It was fortunate that the bioengineering faculty was one of the earliest faculties recruited by the School of Medicine. By luck we participated in the recruitment of the School of Medicine faculty. This gave us an advantage to know the new medical faculty naturally, and no barrier between clinical faculty and bioengineers got in the way. Thus Professor Eugene Bernstein, M.D., a famous cardiovascular surgeon and artificial heart researcher, became our best friend. Professor Richard Peters, M.D., a famous thoracic surgeon, cooperated with us intimately. One day I got a phone call from a neurologist Profesor Robert Tschirgi, telling me that NIH was entertaining a surgery-bioengineering training grant. I called Gene Bernstein, and together we wrote and obtained a surgery-bioengineering pre- and post-doctoral training grant in 1971. This grant was renewed again and again, and is still being funded in 2004. It must have set a record of longevity!

Our Students and Faculty

As soon as the Bioengineering Program started at UCSD, we sent out flyers to recruitstudents. The first three graduate students arrived were Elliot Flicker, Frank Yin, and Evan Evans. Elliott was Dr Zweifach's student at NYU. Frank Yin came from MIT with a master's degree in mechanical engineering. Evan Evans was an aerospace engineer in San Diego who wanted to change. The first post-doc was Jen-Shih Lee, who got his Ph.D. from Caltech. Could anybody wish for better students anywhere? Today, Frank Yin is the Chair of the Bioengineering Department of the Washington University at Saint Louis, Missouri. Evan Evans is a world famous cell membrane mechanics authority, a professor at the University of British Columbia, Vancouver, and the Boston University. Jen-Shih Lee was the Chair of the Department of Biomedical Engineering of the University of Virginia, in Charlottesville, VA for more than twenty years, and has retired to La Jolla to market and manufacture some of his inventions. They shine bright!

Many graduate students succeeding them are outstanding too. And we have many outstanding and successful undergraduate students. Year after year, we got the best students.

Bright students need outstanding teachers. Let me describe briefly how did we gather the stars.

The first new faculty we recruited was Professor Arnost Fronek, who got his M.D. from Charles University in Prague and Ph D from the Institute of Physiology of the Czechoslovakian Academy of Science. He is well known for his research on non-invasive diagnosis, especially famous for his establishing the use of post-occlusive reactive hyperemia and pulse-reappearance time as the gold standard for the diagnosis of arterial diseases.

We recruited Dr Kitty Fronek, MD, PhD. as a Research Physiologist. Her extensive knowledge about in vivo experiments was a great resource for our students and faculty.

The next faculty member we recruited was Professor David Gough, who got his PhD from University of Utah. Dr Gough is interested in the implantable glucose sensors for diabetes. Because his research was more basic than others, he was uniquely successful in his invention and manufacturing of his devices.

Then we attracted Dr Geert Schmid-Schonbein, our own Ph. D, to come back to our faculty from Columbia University. Geert is a bright star in research on inflammation.

The next star we enticed was Dr Andrew D. McCulloch from Aukland, New Zealand. We knew his teacher and read his thesis on the mechanical properties of heart muscle. In his thesis we recognized a genius.

In 1988, we were fortunate to have succeeded in persuading two stars to join us. Professor Shu Chien and Richard Skalak of Columbia University agreed to come to La Jolla. This legendary success gave us confidence in our future.

Then Professors Lanping Amy Sung, Kuo-Li Paul Sung, Robert L. Sah, John Frangos, Bernhard O. Palsson, Shankar Subramaniam, Sangeeta Bhatia, Gary A. Huber, Wayne Giles, Jeff Hasty, Michael Heller, Xiaohua Huang, Trey Ideker, Gabriel Silva, and John Watson joined our faculty. Our faculty is now truly star-studded.

Our faculty is further amplified by Adjunct Professors Michael Berns, Charles Cantor, Paul C. Johnson, Deidre A. MacKenna, Lou K. Waldman, and Affliated Faculty Professors Pao C. Chau, Kenneth R. Chien, Jim W. Covell, Mark H. Ellisman, Anne Hoger, Rick L. Lieber, Jeff H. Omens, Peter D. Wagner, and John B. West.

In addition , we have Professional Research Staff Doctors Dale Baker, Peter C. Chen, Y.L.Hu, Wei Huang, Julie Y.H. Li, Jeff Price, Amy Tsai, Shunichi Usami, and Yihua Zhao.

Such strength! It must be an envy of any institution of the world.

The Big Help of the Whitaker Foundation

In the late 1980's, when the need for our bioengineering group to grow was the greatest, the State of California was in a severe financial crisis. It was at this juncture that the generous help of the Whitaker Foundation enabled us to survive, to grow and to develop exactly as we wanted. The rigorous evaluation process of the Whitaker Foundation was

an inspiration. The astute advices we received from the Whitaker Foundation told us always to aim high, to pursue perfection, and to have confidence in ultimate success. The Whitaker Foundation helped us building up the faculty. When we found an ideal faculty candidate, the Whitaker Foundation was willing to pay his/her salary until the State of California can take over. It is fortunate that the State is always optimistic toward the future, and has never failed to take over any promised burden.

The Whitaker Foundation Helped Us to Establish our Department

The separation of the bioengineering group out of the AMES Department was based on the approval of all members of the AMES Department. Everybody in AMES recognized the support of the Whitaker Foundation, and decided that it was good.

Our Academic Program

Our academic program followed the Caltech model. On courses, we put emphasis on fundamentals and rigor. On research, we put emphasis on excellence. The undergraduate curriculum emphasizes applied mathematics, continuum mechanics, electronics, and design. Graduate courses had two objectives: to emphasize the basics, and to air the specialties of the instructor. Since bioengineering renews itself rapidly, graduate courses are renewed frequently.

Reaching Out to the National and International Community

We thought that it was good to expose our students to the national and international community. So we organized a number of national and international meetings on campus. At the meeting time, Gene Mead, our technician, was the marshal. He organized the students to meet the participants at the airport, delivered them to the hotels or the residential halls on campus. Every meeting included a picnic and a fireside entertainment at our famous La Jolla beach. Participants soon became a big family.

Thus we held a Symposium on Biomechanics on campus on July 29-31, 1970, the proceedings of which were published as a book by Prentice Hall under the title Biomechanics: Its Foundations and Objectives. We held the Third International Congress on Biorheology on campus on Aug 28-Sept 1, 1978. We held the Second World Congress on Microcirculation on campus on July 25-27 1979.

A glorious meeting was held on campus in July 1984. This was the Frontiers in Biomechanics meeting organized by Professors Geert Schmid-Schonbein, Savio L-Y Woo, and Benjamin W. Zweifach. The proceedings were published in a book of 395 pages by Springer Verlag, New York.

In 1990,the First World Congress on Biomechanics was held at UCSD for 5 days from Aug.30 to Sept 4. In this meeting, the World Council was formed, giving a permanent structure to that organization.

Our faculty members and students had also organized meetings off campus. Examples are: The 1966 ASME Biomechanics Symposium at the Winter Annual, New York. The July 1972 meeting on Thin Shell Structures: Theory, Experiment, and Design, (Prentice- Hall, 615pp, 1974),held on the campus of Caltech, Pasadena. The October 1973 ASME Biomechanics Symposium held in Georgia Tech. The May 9-13 1983 China-Japan-USA Symposium on Biomechanics held in Wuhan, China (Biomechanics in China, Japan, USA Science Press 1984, 526pp). The Sept 28-Oct 2, 1987 Japan-China-USA meeting in Osaka (Progress and New Directions of Biomechanics, Mita Press,Tokyo, 444pp.) and the October 1997 Biomedical Engineering Society Fall Meeting. On the horizon, the 35th Congress of the International Union of Physiological Sciences, March 31-April 5, 2005, San Diego, and the 12th World Congress of the International Society of Biorheology, Chongqing, China, May 30-June 3, 2005, both with Shu Chien as the Chair.

Getting Ready for the Future

This article is meant to sketch a bit of our past history. The entire past history of the UCSD Bioengineering is about looking toward the future. At this 10th Anniversary of the formation of our Department, we are looking further, and wider, and thinking of the next 10 years, 100 years, and 1000 years.

Past, Present and Future of Bioengineering at UCSD: Celebration of the Department's 10th Anniversary

Shu Chien

I feel very fortunate to be a part of Bioengineering at UCSD. At this wonderful occasion of the Tenth Anniversary of the establishment of the Department, it is my great pleasure to recall many marvelous memories, appreciate the wonderful present, and look forward to the exciting future. Yuan-cheng (Bert) Fung, one of the founders of our UCSD Bioengineering Program in 1966, has written an excellent article dating back to the inception of the Program. What I write here covers mainly the period starting from 1988 when I came from Columbia University to join UCSD.

The Move to UCSD in 1988

In 1986, I was asked by Ben Zweifach and Bert to join UCSD as a faculty in Bioengineering in the Department of Aeronautical (later changed to Applied) Mechanics and Engineering Science (AMES). Because I had a large research group at Columbia, my wife K.C. had a full-time job as a pediatrician, and our children were in New York, we had difficulty deciding even after several visits to La Jolla. In the summer of 1987, when I was on sabbatical leave at the Institute of Biomedical Sciences (IBMS) in Academia Sinica in Taiwan, Ben phoned me at 6 AM Taipei time and asked whether I would come to La Jolla. Half asleep, I answered "Yes". I am glad that I had the right mind to accept the position even though only half awake. I did express my concern about my collaboration with long-time colleagues – particularly Dick Skalak. UCSD responded by also recruiting Dick to San Diego. Amy and Paul Sung, Jerry Norwich, and later Shunichi Usami also joined us in La Jolla from Columbia.

The move to UCSD made it possible for us to incorporate molecular biology into our research program and led to our current research on the molecular basis of the modulation of signal transduction and gene expression by mechanical forces.

Now, sixteen years later, it is clear that the move was a great decision. I am very grateful to UCSD for giving me the opportunity and privilege to work with such wonderful colleagues, including faculty, research scientists, staff and students.

The Program Project Grant (PPG)

Based on the excellent foundation established by founders of UCSD Bioengineering, I organized a research team, as I did at Columbia and IBMS, and submitted a PPG application on "Biomechanics of Blood cells, Vessels and the Microcirculation" to the NIH. This was funded in 1990. The project leaders were Bert, Amy, Geert, Schmid-Schönbein and myself at UCSD and Larry Sklar at the Scripps Research Institute (Now Jeff Omens). We had Core Facilities on administration, ultrastructure (Geert), computation (Andrew McCulloch), instrumentation (Shunichi) and cell culture (Bob Hoffman, later Bob Sah). Bioengineering at UCSD had always been very strong, but this PPG was the first time a team effort succeeded in receiving research funding after peer review. That was a big breakthrough, and it positioned us for later developments. We succeeded because of the strong scientific foundation at UCSD, the cooperative efforts of all participants, and the experiences at Columbia and IBMS. I am very pleased that Geert is doing an excellent job after taking over as the P.I. for the PPG in 2000.

The Institute for Biomedical Engineering

After receiving the PPG and subsequently renewing the NIH training grant, which had been started by Bert with Eugene Bernstein of Surgery in 1971, we began to address the identity of our Bioengineering program, which had been a part of AMES since its inception in 1966. AMES was helpful in fostering activities related to bioengineering, but as one of six

groups in a large department we had limited resources and did not have a clear identity to the outside. It took more than one year for the idea of having a separate department to be unanimously accepted by all Bioengineering faculty, and this provided the driving force for the initiative.

Because of the time required to form a department, we worked first to establish the Institute for Biomedical Engineering (IBME) as an Organization Research Unit (ORU). More than thirty faculty members from schools of medicine, biology, and engineering, and the Scripps Institution of Oceanography, joined in this effort. At a retreat in September 1991, we adopted Tissue Engineering Science as a common research theme. Tissue engineering is a term coined by Bert in the early 1980s.

After the establishment of IBME in November 1991, we prepared a brochure that summarized all the Institute members and their research activities, including an index based on research topics. This brochure received considerable publicity in and outside the university. The U.S. News and World Report annual survey ranked us number 5 for the first time in 1993, and this has risen to number 2 in 2004. The comprehensive survey done every decade by the National Research Council ranked us number 1 in graduate education and number 2 in faculty quality in their most recent survey published in 1995.

In 1993 we established an Industrial Advisory Board (IAB), with 20 industrial members. The Board has worked effectively with the Institute to foster research collaboration, hold symposia and workshops, facilitate student internship placement, provide advice and consultation on curriculum of educational programs relevant to industry, and sponsor Bioengineering graduate student activities such as Breakfast with Industry, Annual Symposium, etc.

The Whitaker Foundation Development Award

Shortly after the formation of the IBME in 1991, the Whitaker Foundation announced the request for proposals for the Development Award ($5 million for six years) to develop biomedical engineering. The formation of IBME and our identification of the theme on Tissue Engineering Science prepared us to submit a pre-proposal, together with 62 other submissions. Our pre-proposal was selected for the submission of a full proposal and we were one of five chosen for site visit. In September 1993, we were one of three institutions (together with Georgia Institute of Technology and University of Utah) that received the Award, which allowed us to recruit four outstanding faculty (John Frangos, Bernhard Palsson, Amy Sung, and Sangeeta Bhatia) and set up excellent core facilities. The Award was also valuable in helping us to form the Department.

The Formation of the Department of Bioengineering

The UCSD administration, including Chancellor Richard Atkinson, Vice Chancellor Marjorie Caserio, and Deans of Engineering (Lea Rudee and Robert Conn), Medicine (Gerard Burrows and George Palade) and Office of Graduate Studies and Research (Richard Attiyeh), was strongly supportive for the formation of the Department. I had many group meetings and individual discussions with our colleagues in AMES (then Chaired by David Miller), the AMES faculty voted to allow Bioengineering to form a new department. Following thorough evaluations and positive recommendation by the Academic Senate, the University of California formally approved the formation of the Department of Bioengineering at UCSD on August 20, 1994, and appointed me as the Chair effective July 1, 1994.

The governing of the Department of Bioengineering has always been by consensus of faculty members. The term of our Chair is three years, with the possibility of a two-year extension. After serving my full 5-year term after the extension, I was pleased that David Gough agreed to accept the Chairship in July 1999. Dave did an excellent job from 1999 to 2002. When he did not wish to continue, my colleagues elected me to be the Chair again in July 2002.

The Whitaker Foundation Leadership Award and The Powell-Focht Bioengineering Hall

In spring 1997, the Whitaker Foundation announced the availability of a new Leadership Award program to support Biomedical Engineering infrastructure at a level higher than the Development Award. Our

application was site visited on September 23-24, 1998 by Foundation's Governing Committee (Chair Burtt Holmes, Past Chair Ruth Whitaker Holmes, Portia Whitaker Shumaker and James Kelley), Executives (President Miles Gibbons, Jr., Executive Vice President Peter Katona, and Vice President Jack Linehan), and scientific consultants (Allen Cowley, Jr., Dominique Durand, Don Gibbons, Howard Morgan, and Buddy Ratner). We made thorough preparations and extensive rehearsals for the visit. The presentations involved Bioengineering faculty and graduate students, faculty from the School of Medicine, the San Diego Supercomputer Center (SDSC) and the Salk Institute, alumni, and industrial colleagues, as well as leaders from UCSD administration. We did extremely well as a group during the site visit. This particular event was unbelievably successful; everything just clicked. It was obvious that the Whitaker Foundation's site visitors were very impressed and got involved in the exciting and electrifying atmosphere.

In our written application we requested $13.8 million, including $0.8 million for faculty recruitment. We arrived at this amount because (a) we did not want to risk losing it by asking for too much, and (b) we were limited by the amount we can raise for 1 to 1 matching. Dean Conn obtained a gift of $3 million from the Powell Foundation, which later decided to give us an additional $5 million because of our high ranking in various surveys. Without being asked, Chairman of the Board Herbert Kunzel called Bob Conn to tell him that the gift was raised to $8 million. (Herb unfortunately passed away in 1999 and was succeeded by Joel Holiday, who has continued the wonderful support by the Powell Foundation). The remainder of the matching required was provided by the Jacobs School of Engineering (JSOE) and UCSD. The $13.8 million we requested from the Whitaker Foundation, together with the matching funds, would allow us to construct a building to accommodate about 3/4 of the Department, with 1/4 remaining in the EBU1 building. When the site visitors asked why we did not include everyone in the new building, I replied that we were concerned that the amount to be requested would be too large. The committee asked me to submit a supplemental proposal based on an estimate for constructing a building that would include the entire Department. After consulting with Chancellor Dynes, Vice Chancellor for Development Jim Langley, and Dean Conn, I submitted a request to the Foundation for an additional $4.2 million, with university matching of another $4.2 million. A month later, the Governing Committee of the Foundation approved the Leadership Award in the amount of $18 million. It was fantastic that the Foundation increased the funding amount above our initial request.

The Whitaker Foundation is magnanimous in the support of bioengineering. Despite its large share of support for the new bioengineering building at UCSD, the Foundation agreed to name it the Powell-Focht Bioengineering Hall, in recognition of the Powell Foundation gift and the late Judge Focht who played a major role in the Powell Foundation. To recognize the tremendous contributions by the Whitaker Foundation, UCSD changed the name of IBME to "Whitaker Institute of Biomedical Engineering (WIBE)".

During the period of the Leadership Award, we recruited additional outstanding faculty to the Department. They include Gary Huber and Shankar Subramaniam in 1999; Michael Heller in 2001 (joint appointment with ECE Department); Wayne Giles (joint with Medicine-Cardiology), Jeff Hasty, and Xiaohua Huang in 2002; and Trey Ideker, John Watson, and Gabriel Silva (Joint with Ophthalmology) in 2003. Thus, Bioengineering core faculty has tripled during the ten years since the establishment of the Department.

In addition to the core faculty, the Department has eleven affiliated appointments with other departments on campus, 12 Adjunct faculty from Academia and Industry, 15 [??] research scientists (Table I). Together, the faculty and scientists in UCSD Bioengineering form a marvelous team for research and education at the forefront of Bioengineering.

In early 2002, JSOE received a generous gift of $10 million (including $2 million for the

construction of the PFBH) from the von Liebig Foundation to establish the William J. von Liebig Center for Entrepreneurism and Technology Advancement. Through John Watson's suggestion, Linda Hamilton and Jean Goggins of the Foundation had visited UCSD, and Bob Conn and Joe Bear (current Director of the von Liebig Center) had visited the Foundation in Naples, FL to plan for these initiatives.

The construction of the PFBH began in early 1999, with Anshen and Allen Los Angeles (AALA) as the architect and was completed in November 2002. The Department moved in during the next month. Every one in the Department is extremely pleased with the wonderful facilities and resources in this state-of-the-art building.

The Current State of the Department of Bioengineering

The theme for research and education for our Department is Integrative Bioengineering, This includes the integration of research activities at all levels of the biological hierarchy (from genes and molecules to the whole organism), the collaboration of engineering and biomedical sciences, the coordination of research and education, the building of partnerships between academia and industry, and interaction between UCSD and its neighboring institutions. Under the overarching theme of Integrative Bioengineering, we have major areas of genomic bioengineering, molecular biomechanics, cell and tissue engineering, and systems biology/ bioengineering. The completion of the new Powell-Focht Bioengineering Hall has allowed integrated development of these frontier areas and five core facilities, viz. Biofabrication, Biotechnology, Information Technology, Instrumentation (Nanotechnology and Imaging, and In Vivo Technology. These cores provide important infrastructure to support the research activities and hands-on training for student education (Fig. 1).

Research activities under Genomic Engineering include genomic research on the regulation of signal transduction and gene expression in the heart, blood vessels, blood, liver and other organs/tissues with the use of bioengineering approaches and with the aid of the information technology and in vivo technology cores, The novel concepts of genetic circuitry and in silico biology have been developed to treat genes and signaling molecules as interacting elements in a network, with the aim of modeling and predicting their interactions on the bases of experimental data. This approach provides an important link with the research in Systems Biology.

In Molecular Biomechanics, a combination of experimental and theoretical approaches are used to establish the molecular basis of mechanical behaviors of cells and tissues, e.g., the determination of stress-strain relationships of cells and molecules, the use of surface molecular characteristics to manipulate and characterize cells, dynamic tracking of cell cycle, experimental and theoretical studies on cytoskeleton dynamics, etc. The facilities in the Instrumentation Core are particularly valuable for these studies.

Cell and Tissue Engineering encompasses studies on the mechanisms of control of tissue growth, adaptation and repair, and the development of biological substitutes to restore or improve tissue functions by controlling cell phenotype. Research is directed at tissue engineering of the liver, pancreas, cartilage, cardiac tissues, blood vessels, and blood to provide a solid foundation for the translation to practical application of regenerative medicine. The facilities in the biotechnology and biofabrication cores are especially important for these investigations.

To meet the grand challenge of elucidating the functional roles of genes interacting as a network posed by the sequencing of the human genome, the Department has taken the lead to foster interdisciplinary research and education in the new frontier of Bioinformatics, Systems Biology and Systems Bioengineering. The recruitment of outstanding faculty in this area has created the nucleating force to synergize the activities in the Department and the whole campus. This approach has provided the intellectual framework for investigating living systems as whole entities and forms an important element of Integrative Bioengineering.

Since the establishment of the Department, Bioengineering has processed its own graduate admission and charting its graduate curriculum, and we have made excellent progresses in both graduate and undergraduate education (see article by Irene Jacobo and Andrew McCulloch). The quality of the entering students is superb, and their performance has been outstanding. In addition to their excellent academic accomplishments, the student bodies have been very active in promoting many valuable group activities organized by the UCSD Chapter of the Biomedical Engineering Society (BMES) for undergraduates and the Bioengineering Graduate Student Group (BEGS).

The Industrial Advisory Board of the WIBE has worked closely with the Institute and the Department in the implementation of the very successful internship program for the junior and senior undergraduates and the M.Eng. students, with the support of the Internship Award from the Whitaker Foundation.

A list of the Ph.D. graduates from UCSD Bioengineering is given in Table II. These graduates have made outstanding contributions to biomedical engineering, and many of them have assumed leadership positions in academia and industry. The superb accomplishments by our graduate and undergraduate students are most rewarding. The education of the next generation of bioengineering leaders is one of the most important missions of our Department. Our graduates' contributions play a major role in the outside recognition of the strength of our Department.

The faculty of the Department has received many outstanding awards and honors (See Table III). Dr. Fung has written the most definitive textbooks on biomechanics, as well as editing a book on Introduction to Bioengineering. Drs. Palsson and Bhatia wrote the first textbook on Tissue Engineering, with a Teaching Materials Award from the Whitaker Foundation, and Dr. Palsson is embarking on a textbook on Systems Biology.

The Department has a long history of fruitful collaboration with the Department of Medicine in cardiovascular and other areas and with the Department of Orthopaedic Surgery on orthopaedic bioengineering. There have been many joint research projects and research grants and collaborative education programs. Most recently, there have been several new interdisciplinary initiatives being developed with the School of Medicine.

The Departments of Bioengineering and Radiology have initiated collaboration in several ways in the past two years, including cooperation in the Functional Magnetic Resonance Imaging (fMRI) Center, holding of joint annual symposia on Biomedical Imaging and Bioengineering, and initiation of collaborative research and education.

The Department has worked with the Institute of Nonlinear Sciences, the Division of Biological Sciences and the Department of Neuroscience to initiate a joint education program in Neurotechnology/Neuroengineering. There will also be increased research collaboration between Bioengineering and Neurosciences.

Nanotechnology involves the creation and use of materials and devices at the level of molecules and atoms. Bioengineering faculty collaborate with colleagues in Electrical and Computer Engineering, Mechanical and Aerospace Engineering, Physics, Chemistry & Biochemistry, and School of Medicine in research on nanoscience, nanotechnology and Nanomedicine. Examples are manufacture of small biosensors, design and fabrication of nano-structures, electric field assisted self-assembly for nanofabrication, and biomimetic catalytic chemo-mechanical nanostructure, microelectronic DNA arrays and lab-on-a-chip devices for research studies and clinical diagnosis high accuracy and reliability. In cooperation with other departments in JSOE, Bioengineering is pursuing an initiative to recruit faculty in the field of Biochemical Engineering. Nanoscience and nanotechnology is one of the major emphases in this recruitment.

The Department of Bioengineering has initiated interdisciplinary collaborations with several other

units in the School of Medicine, including the Departments of Surgery and the Cancer Center, and the newly established School of Pharmacy and Pharmaceutical Sciences,

The Department of Bioengineering will also enhance it collaboration with other departments in JSOE and Divisions of Natural Sciences and Biological Sciences, as well as other units on campus, e.g., the California Institute of Telecommunication and Information Technology [Cal-$(IT)^2$] and SDSC.

UCSD Bioengineering took the lead in coordinating the ten campuses in the UC system to form a Multi-campus Research Unit (MRU) on bioengineering entitled "Bioengineering Institute of California (BIC)", which was formally approved by the UC Office of the President in August 2003. BIC has organized Annual System-wide Bioengineering Symposia that rotate among the ten campuses and has initiated the cooperative teaching program through the development of web-based teaching materials in various aspects of bioengineering.

Future Plans

We will endeavor to fully achieve the goals and mission of conducting high-quality interdisciplinary research at the forefront of bioengineering and educating the next generation of leaders in bioengineering. The specific plans include the following:

- Recruitment of new faculty to strengthen our current fields and to initiate new areas such as nano-science/technology/medicine, neural engineering, and cancer bioengineering, under the overarching theme of integrative bioengineering.

- Enhancement of the educational programs at graduate and undergraduate levels. Increase of hands-on experience for students by using the laboratory facilities and resources in PFBH.

- Strengthening the collaborations and interactions with the School of Medicine, Division of Natural Sciences, Division of Biology, other Departments in JSOE, SDSC, Cal(IT)2 and other units on campus, as well as neighboring institutions and other campuses in the UC system through the multi-campus Bioengineering Institute of California.

- Enhancement of collaboration with industry, with the goal of recruiting industrial affiliates not only in San Diego area, but also nation-wide and amplifying the internship program. Fostering technology transfer and entrepreneurship in collaboration with the Industrial Advisory Board and the von Liebig Center.

- Establishment of endowment for the Department for uses as student fellowship, faculty start-up supplement, special equipment required for timely new initiatives, and other important needs for education and research not met by regular state and federal funding mechanisms. Establishment of endowed chairs for the recruitment and retention of outstanding faculty.

- Construction of a new Bioengineering Building to house the new faculty to be recruited, as the PFBH is already almost fully occupied.

- Full utilization of our facilities and resources to advance bioengineering research and education with a cooperative and integrative approach.

At this wonderful occasion of our 10th Anniversary I wish to express our most sincere thanks, on behalf of the Department, to all our friends and colleagues everywhere for their marvelous support and cooperation which has made it possible for us to achieve our goals during the first decade of the Department. We pledge to redouble our effort to fully accomplish our missions of excellence in education, research and translation in biomedical engineering, with the ultimate aim of benefiting the health and well being of our people. The future is bright for Bioengineering at UCSD and for Bioengineering as a discipline!

10 Years of Design and Development of Artificial Blood Based on Studies in the Microcirculation

Amy G. Tsai, Pedro Cabrales and Marcos Intaglietta

Design and development of oxygen carrying blood substitutes coincided with the establishment of the Department of Bioengineering at UCSD, as our group joined forces with Prof. Robert M. Winslow of the UCSD School of Medicine, Department of Medicine. The principal joint academic activity was a course in the form of an international symposium dealing with blood substitutes under the auspices of the NIH, the Medical School and our Department. This activity took place during the years 1995, 1996, and 1997. Faculty, scientists and clinicians from UCSD, NIH, FDA, the Army, the Navy, industry and Universities throughout the world were active participants. The courses were attended on the average by 250 participants, and were freely accessible to our faculty and students. Three tutorial books were published, and this course has since 1997 been merged with the meetings of the International Society for Blood Substitutes.

Microcirculation and blood substitutes

Development of blood substitutes at UCSD has focused on understanding the biology and physics of the microcirculation, a system at the interface between the environment and each cellular component of the organism, and the location of critical mechanical and energy interactions. At the time of the formation of the UCSD Bioengineering Department, the Microhemodynamic Laboratory had already acquired world status, being recognized for having developed the principal tools for analyzing transport at the microvascular level and in particular for the optical measurement of the partial pressure of oxygen at microscopic localities of the tissue.

Research at UCSD Bioengineering led to the revision of many of the functions that had been attributed to the microcirculation and established the operational premise that the priority in capillary function is that of maintaining flow, or "functional capillary density". This realization had profound implications in designing a blood substitute, because it means that it is necessary to know if the properties of blood are related to open capillaries, and if this is the case the substitute product must be designed to posses this property. All previously designed blood substitutes focused on the capacity of delivering oxygen, and ignored their potential for insuring a mechanically open microcirculation. The efficacy of the UCSD designed artificial blood resides in the recognition of this necessity.

The contribution of Paul C. Johnson

Professor P.C. Johnson joined our Department and our laboratory and was fully operational, carrying out basic physiological research at the time of the foundation of our Department after his retirement from the Chairmanship of the Department of Physiology at the University of Arizona, Tucson.

Prof. Johnson was and is for our group the key reference point in cardiovascular physiology, and vascular and microvascular regulation. His deep and encyclopedic understanding of circulatory physiology, manifested by being in charge of the cardiovascular portion of our major graduate physiology course, culminated by co-authoring in our group a chapter in Physiological Reviews titled "Oxygen gradients in the microcirculation", where the concept of blood vessels being major oxygen sink was systematized. This hypothesis had again major repercussions in the design of artificial blood.

The UCSD connection with Sangart Inc.

Prof. R.M. Winslow capitalizing on the UCSD discoveries and related patents translated the academic achievements from his and our laboratories into a science based company, Sangart Inc., which pursues the commercial development of the UCSD generated "artificial blood".

The mechanical understanding of what functions are performed by capillaries, and how this functionality is maintained is at the heart of Sangart's development of a form of artificial blood that insures the vital functions of the microcirculation

are maintained or enhanced. The remarkable and counter intuitive discoveries embodied in Sangart's blood substitute were achieved by introducing in the circulation a high molecular viscosity oxygen carrier that also has high oxygen affinity, and therefore targets oxygen delivery to anoxic areas of the tissue.

The new conceptualization of artificial blood emerging from this unique academic-industrial-science based partnership developed a material that is now in clinical trials. This work was generously supported by several NIH R01 grants to R.M.W., M.I. and A.G.T. A Bioengineering Research Partnership also funded this endeavor. Dr. Winslow is currently Adjunct Professor of the Bioengineering faculty.

An interdisciplinary, national and international connection

Medical care, medicine and blood have no national boundaries and our Department has been extraordinarily hospitable to investigators from the international community. Their contribution is amply reflected in publications from our group and all members of the Department. In the field of resuscitation and artificial blood we particularly recognize the direct contribution of the following list of individuals who have and are actively participating in the work and publications from our laboratory:

Marko Turina, 1970-to date, Professor and Chairman, Cardiac Surgery, Universitatspital Zurich

Konrad Messmer, 1978-to date, Former Professor and Head, Experimental Surgery, University of Munich, Germany

Bengt Fagrell, 1980-to date, Former Head of Internal Medicine, Karolinska Institute, Stockholm, Sweden.

Silvia Bertuglia, 1984-to date, Professor, Instituto di Fisiologia Clinica del CNR, Universitá di Pisa, Italy

Rubén Argüero, 1986-to date, Director, Hospital de Cardiología, Instituto Mexicano del Seguro Social, Mexico City

Eishun Tsuchida, 1997-to date, Emeritus Professor, Department of Polymer Chemistry - Advanced Research Institute for Science and Engineering, Waseda University, Tokyo, Japan

Juan Carlos Briceño, Professor of Mechanical Engineering, Universidad de los Andes, Bogotá, Colombia

Barbara Friesenecker, Head of Anesthesiology, University Hospital of Innsbruck, Austria

Heinz Kerger, Head of Anesthesiology, Evangelisches Diakoniekrankenhaus, Freiburg, Germany

Hiromi Sakai, Department of Polymer Chemistry - Advanced Research Institute for Science and Engineering, Waseda University, Tokyo, Japan

Reto Wettstein, Division of Plastic and Reconstructive Surgery, Inselspital University Hospital, Berne, Switzerland.

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The Tenth Anniversary of the Birth of the Department of Bioengineering: A Renaissance

David Gough
Professor of Bioengineering

Bioengineering at UCSD had its birth in 1966 under the direction of its founders, Professors Y. C. Fung, Benjamin Zweifach and Marcos Intaglietta. For the following decades, Bioengineering grew as a Program within the Department of AMES (or Applied Mechanics and Engineering Sciences) and developed an international reputation for excellence. This growth and rise to prominence occurred at a time in which UCSD developed as a campus and grew in national recognition as a leading research university, and at a time in which Bioengineering itself developed into a vigorous and independent engineering discipline. Then in 1994, a new Department of Bioengineering was born at UCSD, for which we celebrate the Tenth Anniversary.

In many ways, the birth of the new Department of Bioengineering at UCSD was actually a rebirth, or renaissance, of Bioengineering. Like the European Renaissance of the 15th Century, the UCSD Bioengineering Renaissance led to a flourishing of science and the arts (i.e., technology), it was brought forth by the creative energies of many contributors and their apprentices, new buildings were erected to sustain the achievements, the efforts were supported by visionary patrons, and advances spread rapidly.

The Faculty. At the time of its founding, the Department had six faculty, two emeritus professors, and a number of associate faculty. The founding faculty included Shu Chien, Y.C. Fung (Emeritus), David Gough, Marcos Intaglietta, Andrew McCulloch, Robert Sah, Geert Schmid-Schoenbein, Richard Skalak and Benjamin Zweifach (Emeritus). Affiliates included: Arnost and Kitty Fronek, Peter Wagner, John West and others. Faculty joining in the subsequent years were: Professors Sangeeta Bhatia, John Frangos, Wayne Giles, Jeff Hasty, Michael Heller, Gary Huber, Xiaohua Huang, Trey Ideker, Bernhard Palsson, Gabriel Silva, Shankar Subramaniam, Amy Sung, and John Watson. Associated faculty and affiliates in the last ten years have included: Michael Albisser, Chris Armour, Dale Baker, Michael Berns, Lars Bjursten, Peter Butler, Charles Cantor, Pao Chau, Albert Chen, Peter Chen, Ken Chien, Paul Citron, John Dobak, Mark Ellisman, David Galas, Anne Holger, Wei Huang, Tony Hugli, Paul Johnson, Jen Shih Lee, Y. Julie Li, Drahoslav Lim, Michael Lutz, Milan Makale, Deidre MacKenna, Hui Miao, Anushka Mihaylova, Jeff Omens, John Pinto, Jeff Price, Erkki Ruoslahti, Sidney Sobin, Paul Sung, Pin Tong, Amy Tsai, Sunichi Usami, Taras Usyk, Dmitri Volfson, Nanping Wang, Robert Winslow, Yihua Zhao and others.

Advances in Education and National Rankings. New undergraduate majors have been initiated during the last ten years to compliment the long-standing Bioengineering and Pre-Medical majors. The new Biotechnology and Bioinformatics majors provide new options for students and represent the diversity of Bioengineering. The undergraduate population grew from under 400 in 1994 to over 950 in 2004. The graduate student population went from 76 in 1994 to 120 in 2004. At both the undergraduate and graduate levels, the academic qualifications of incoming students have soared. As to national reputation, UCSD Bioengineering was tied for first place in graduate education by the National Academy of Sciences study and consistently ranked in the top two or three programs nationally by *US News*.

Powell-Focht Bioengineering Hall. A prominent symbol of Bioengineering at UCSD is Powell-Focht Bioengineering Hall. The first privately supported departmental home on campus, Powell-Focht was funded by a Leadership Award from the Whitaker Foundation and generous gifts from the Powell Foundation, the von Liebig Foundation and many individuals. The building has many novel and innovative features that support the full range of activities of the Department of Bioengineering, including: the Fung Auditorium, named in honor of Professor Y.C. Fung; the Zweifach Library named in

honor of Professor B.W. Zweifach; the novel von Liebig Center for Entrepreneurism and Technology Advancement that fills a unique role in the translation of medical technologies to industry and the public; the Undergraduate Teaching Lab where students can learn in a "hands on" setting; and the Graduate Student Computing Facility. In addition to common research facilities, Powell-Focht Bioengineering Hall contains state-of-the-art research laboratories individually designed to meet the needs of faculty research.

Wide Influence. UCSD Bioengineering has had a wide influence at many levels on the development of Bioengineering as a discipline. The UCSD Whitaker Institute for Biomedical Engineering facilitates collaborations with over one hundred investigators from a variety of departments on campus. The Industrial Associates serve the important functions of providing advice from an industrial perspective, helping to integrate Bioengineering collaborations with the local industrial community, and disseminating the fruits of Bioengineering to the public. During the ten-year period since the inauguration of the Department, a number of other departments of Bioengineering have been founded across the nation, many patterned after UCSD. At the UC Systemwide level, the Bioengineering Institute of California has recently been established with UCSD as the lead campus to coordinate and encourage Bioengineering within the University of California System. At the national level, the National Institute of Biomedical Imaging and Bioengineering was established as one of the National Institutes of Health to further support Bioengineering approaches to advances in human health. At the international level, a number of other nations, particularly in Asia, have become aware of the importance of Bioengineering and have initiated Bioengineering efforts. In each of these many Bioengineering developments, UCSD faculty have played significant roles.

The Future. Many agree that the 21st Century will be the "Century of Biology," much as the 20th Century has been described as the "Century of Physics." Seminal biological discoveries of the recent past will lead to broad innovations in medical sciences that may overcome persistent diseases, point new directions to sustaining health, and alter the very fabric of our society. Bioengineering, with its solid, integrative approach, and in collaboration with specialists from many disciplines, is uniquely situated to provide the tools, conceptual framework and talented workforce to develop these advances.

Like the European Renaissance, the founding of the new Department of Bioengineering and the UCSD Bioengineering Renaissance has set the stage for a bright and exciting future.

10 Years Young and Going Strong

Geert W. Schmid-Schönbein
Professor of Bioengineering

While 32 years old and already enjoying ten years of a formal arrangement as a Department, Bioengineering at UCSD has a remarkable history. As a small program, embedded among aerospace and applied mechanics engineers, it transferred early into the unknowns of a new Medical School to make new friends, encounter new problems and face some of the greatest challenges in science. It was an experiment by our pioneers, Drs. Benjamin Zweifach, Yuan-Cheng Fung, and Marcos Intaglitta, that in the end would exceed the most daring expectations. It was possible on a new campus. In fact UCSD had just about the most ideal growing ground for Bioengineering with a new School of Medicine and a new Engineering Department. This mixture of strong traditional engineering and modern medicine served it well ever since.

Today, Bioengineering's greatest strength is that it embraces all four basic sciences: biology, chemistry, physics and mathematics. Thus bioengineering touches all traditional engineering fields and finds application to virtually all aspects of biology and medicine. We used to be focused on specific areas, like cardiovascular or orthopedic bioengineering. But that rapidly changed and we started on a long expansion of our involvement in medicine. There are no more barriers between engineering and medicine. Engineers like to identify the essence of a problem, a way of thinking that I think is as useful in medicine as it is designing an airplane. Bioengineers are ready to take on the great challenges in human diseases and help to improve and optimize medical practice.

What is it then that makes bioengineering at UCSD so special? Foremost our colleagues and the members of the campus administration, a truly outstanding group of graduate students and undergraduate students, our devoted staff members, and many colleagues, friends and supporters in industry and private institutions, especially the Whitaker and the Powell Foundation. The field has grown in a network of warm collegiality across all parts of the campus, from the School of Medicine, the Jacob School of Engineering, Scripps Institution of Oceanography, to our neighboring Institutions and our industry partners. Their friendship and support encourages us and we thank them.

The students are our most important products. We are extraordinary proud of them. Their achievements have been spectacular and far exceed our highest expectations. Their work touches in numerous ways the life of people across the world and they exceed

the highest expectations. Our students invented and developed elegant treatments for diseases otherwise difficult to treat. They discovered important molecular and biological mechanisms in living tissues. They are developing an amazing array of medical equipment and software for difficult problems in biomechanics, transport processes and systems biology. They have joined other universities, have become leaders and have opened up entire new directions of investigation. They started new companies in bioengineering, created new divisions, and are serving as directors and managers in many companies and in government. Many of our students have become practicing physicians, and they tell us that even a little engineering thinking is helpful in Medical School education and practice. We enjoy their life stories and like to share their triumphs and concerns.

I have never regretted having chosen bioengineering and am most grateful to be a member of the Department. The past ten years have been spectacular. We moved into our own Building that actually says "Bioengineering" over the front entry. We grew and were fortunate to be joined by a number of outstanding colleagues with fascinating research activities. We introduced new academic programs at both the undergraduate and graduate level and we continue to receive support, especially from the National Science Foundation and the National Institute of Health. The only limit is our own time and energy. We are flooded with important problems, far more than we can hope to solve in a lifetime. Basic principles in Biology are emerging and there are still many opportunities for discovery of fundamental mechanisms in many biological processes. Some of our current models have already predictive power, and our understanding of complex processes in Biology is improving. Our models will make more and more predictions. This is when Medicine will benefit most.

Bioengineering at UCSD is here to stay. Its future is bright. Happy Birthday.

UCSD's Bioengineering Graduate Students: A Journey of Excellence

Andrew D. McCulloch
Professor/Vice Chair
Irene Hom Jacobo
Director, Student Affairs

Throughout the history of Bioengineering at UCSD, we have seen impressive and sustained growth in educational opportunities, faculty, research, facilities and resources. In parallel with this growth, has been steady growth in the population of graduate students and their continuously expanding list of groundbreaking academic achievements. In many respects, the history of Bioengineering at UCSD would not have been shaped without the hard work and dedication of all graduate students that have traveled with us in this journey of excellence. Although the road to success for graduate students may have represented many sacrifices, the fruits of their labor have and continue to be evident in their personal and professional accomplishments.

Many have aspired to be part of this vibrant institution and ultimately have gone on to receive educational and research training in our Ph.D., M.D./Ph.D., M.S., M.D./M.S. or M.Eng. degree programs. Since the inception of the Bioengineering Group as part of the Medical School in 1966, we have seen steady growth in graduate student population. In the first year of the program, we had one graduate student, Frank Yin and one post-doctoral student, Jen-Shih Lee. Dr. Frank Yin, who successfully received his M.D./Ph.D. at UCSD, is currently Professor and Chair of Biomedical Engineering at Washington University. Dr. Jen-Shih Lee became the Chair of Biomedical Engineering at the University of Virginia. After a distinguished career, he is now retired and serves as a Visiting Professor of Bioengineering at none other than UCSD.

By the time we became a department in 1994, we had 26 entering graduate students with a total class size of 76. Today, we have a current enrollment of 120 students with an expected new class of 40 in Fall 2004. Along with the growth in student population, we have seen an impressive growth in the number of women students enrolled. From 1990-1999, an average of 26% of the students enrolled were women, a number that has now grown to 38% in 2003. Diversity has also played an important role in the goals of our educational programs, and we continue to seek to expand the diversity of the graduate student body.

Graduate students have had the opportunity to obtain a high quality education in a graduate program that promotes innovative teaching approaches, fosters outreach activities and conducts engineering research at the cutting edge of Bioengineering. This has been made possible by funding from the Whitaker Foundation, the National Institutes of Health, the Jacobs School of Engineering, the Powell Foundation, the Medtronic Foundation, other private donor contributions, numerous faculty research grants and University commitments. The support provided by the Whitaker Foundation has been especially instrumental in allowing graduate students to pursue their studies at UCSD. We are proud to say, that UCSD was one of the first Bioengineering pro-

grams to receive an NIH Training Grant, which has supported students continually during the past twenty years. The training grant from the National Heart, Lung and Blood Institute currently supports 16 graduate students.

In recent years, Bioengineering graduate students have contributed to the department's overarching theme of Integrative Bioengineering. In the new Powell-Focht Bioengineering Hall, focus areas of research in cell and tissue engineering, molecular biomechanics, systems biology and bio-nanotechnology and instrumentation have been reinforced with state-of-the-art core facilities and teaching laboratories. Through the years, graduate students have been guided by faculty leadership in an educational environment that promotes innovative scientific discoveries at the interface of engineering and biomedical sciences that translate to industrial and clinical applications for the benefit of humankind.

The Bioengineering Graduate Student Group, BEGS, was established by graduate students in the Fall of 1994 to coincide with the establishment of the new department. BEGS has been instrumental in organizing Bioengineering graduate students to communicate with industry, faculty, and new graduate students about student life and professional development issues. Most importantly, it has allowed graduate students to contribute actively to faculty governance, by providing valuable input and feedback on many departmental matters. One of their main events is the Annual Bioengineering Graduate Research Symposium, in which graduate students showcase their own innovative research to prospective and continuing students and guests from industry and academia. The Bioengineering graduate students have held 18th annual symposia, most recently in March 2004.

Such innovative research has been recognized nationally with a significant number of awards, such as, National Science Foundation Fellowships, Whitaker Fellowships, and other awards including the American Association of University Women, American Heart Association Predoctoral Fellowship, Arthritis Foundation Fellowship, Beckman Foundation Fellowship, National Consortium for Graduate Degrees for Minorities in Engineering and Science, Inc. (GEM) Fellowship, GATES Millennium Fellowship, and the UC Biotechnology Research and Education Program Fellowship.

Through the years, many students have graduated and pursued a wide array of professional careers. Including Dr. Frank Yin, over 150 Ph.D. degrees have been conferred since 1966. More than 80 M.S. degrees have been conferred since 1994 when the program became a department, and over 30 M.Eng. degrees have been conferred since Fall 1999 when students were first admitted into the Master of Engineering program.

Many of our graduates have taken positions in universities, hospitals and academic research institutes, biomedical, biotechnology and pharmaceutical companies, the private business sector including law and business management, and federal and state government agencies. Some graduates have become chairs and professors of biomedical programs across the nation such as Dr. Thomas Skalak, Professor and Chair of Biomedical Engineering at the University of Virginia and Dr. Karen-May Newman, Professor and Chair of the Mechanical Engineering Department at San Diego State University. Also, Dr. Michael Yen, a professor at Memphis State University, formerly chaired their Biomedical Engineering Department. A significant proportion of Ph.D. graduates have also furthered their studies by receiving postdoctoral training positions for 6 months to 3 years before assuming a career position.

As we move forth in our educational and research training, we look forward to crossing paths with graduate students who continue to travel in this journey of excellence. We also remember those graduate students who have passed away but are remembered for their many contributions to this excellent institution. All have shaped the foundation of the Bioengineering Graduate Program at UCSD, ***"Excellence in research, education, and public service in bioengineering for the betterment of health and quality of human life."***

Molecular Bioengineering in BSB, EBU1 and PFBH

L. Amy Sung
Associate Professor of Bioengineering

When the Department of Bioengineering was established in 1994 I was working in the Basic Science Building (BSB). Back in 1988 when Shu Chien moved from Columbia (College of Physicians and Surgeons) to UCSD, I requested that he have a lab in the School of Medicine. Not being able to get space in the Center of Molecular Genetics (CMG), I set up a Molecular Bioengineering Lab in BSB. Over the years (1988-1996) I neighbored with several well-known laboratories including that of Geoff Rosenfeld, Pamela Mellon, Flossie Wong-Staal and Ken Chien. BSB is immediately next to the Biomedical Library, and only a few steps away from CMG, which I joined as a member in 1989 after Shu. Initially I was preoccupied with setting up the lab, writing the PPG grant, and completing the cloning of human erythrocyte protein 4.2, so by the time I visited Russ Doolittle at CMG, who communicated the 4.2 paper for us, he had been wondering "Where was Amy?" My teaching of molecular biology to bioengineering graduates students then was also interesting as many had mechanical engineering background.

The lab in BSB 5025 was the Microcirculatory Lab Geert Schmid-Schönbein had had before Bioengineering moved to Engineering Building One (EBU1) in 1988, and before then, Ben Zweifach since 1969. In those years, Arnost and Kitty Fronek were my only Bioengineering colleagues close by on a daily basis. I first shared the office with Arnost's administrative assistant Karen, who must have wondered why I mumbled from time to time streams of nonsense A-T-C-G with excitement. Later I moved a few doors down and really enjoyed an (carpeted) office with a view of waving treetops until one day Sam Yen, then Chair of the Reproductive Medicine, stuck his head in. Soon, my office became that of Roger Guillemin, a Nobel laureate in 1977 for his neuroendocrinology studies, and who UCSD was trying to recruit. [I actually did not feel bad because I could joke that a Nobel laureate followed my footsteps. Besides, I had been interviewing for a professorship with several universities including Johns Hopkins.]

Bernhard Palsson, myself, and John Frangos were recruited in 1994/5; Sangeeta Bhatia, who joined the department in 1998, became the 4th faculty recruited under the Whitaker Development Award. I designed laboratories in EBU1 for renovation and equipped them, not only for my own research in 6037 but also for the Molecular Biology Common Facility (MBCF) in 6014 for the department, which has a dual function of research and teaching. Without the Whitaker Foundation and the superb work of every existing Bioengineering faculty then to earn the Award, I would not have been here today and for that I am truly grateful.

During the years in EBU1 (1996-2002) my lab characterized the first tropomodulin genes and created the first E-Tmod knockout mice by targeted disruption of its gene in embryonic stem cells. My postdoc Xin Chu did most of the work. Ju Chen, a junior faculty in the School of Medicine, advised us in the targeting vector and analysis. My graduate student Carlos Vera conducted the mechanical tests on E-Tmod null erythroblasts. The mechanical weakening was revealed by a micropipette aspiration technique guided by Paul Sung, a colleague in Orthopedics and Bioengineering. Integrating single cell mechanics with molecular biology, taking full advantages of the revolutionary recombinant DNA technologies, was a long journey I took, with thousands and thousands of small steps along the way. Eventually we understand much better the molecular basis of cell and membrane mechanics.

One day I received a letter from a high school girl. She wanted to know what it takes to develop a career in Bioengineering and how I became a Bioengineering Professor. The letter was only addressed to "A Woman Professor in Bioengineering" at UCSD. It went straight to me, as I was the

only (and the first) woman professor then in the entire Bioengineering Department. I told her the importance of having a solid foundation of math and science. I told her that bioengineering was a young discipline that when I was doing my Ph.D. thesis on the energies involved in cell-cell association and dissociation, I was not aware of this discipline. I also told her that I worked very hard for many years and I competed with male colleagues with my full strength to earn my position as a professor. She replied, so did her teacher, telling me that she was selected to read the letter to her class, and thanking me for telling her my real story.

In December 2002 MBCF was relocated to PFBH and renamed Biotech Core. As the Director, I draw assistance from my own lab and other participating laboratories (14) to train new users and maintain instruments. I have always acknowledged the Whitaker Foundation and wish 40 some current users do the same in future grant applications and publications.

My lab works on the molecular ruler that may meter off actin filaments, and the timing mechanism by which the lifespan of circulating erythrocytes may be defined. For these hypotheses, Carlos Vera worked on the junctional complex (JC) and Edgar Gutierrez the suspension complexes (SC) for their Ph.D. thesis. The addition of Ian Lian, Mike Tyler, and Jeff Blatnik as graduate students and Paul Sche and Weijuan Yao as postdocs has allowed our research to expand.

I have allowed myself to sink deeply into long thinking process. Without it I would not have been able to propose the helix and ruler mechanisms by which actin protofilaments of 37 nm may be generated. Without it, I would not have been able to propose the first 3-D mechanical model for JC, together with Carlos, to address a long-lasting mystery as to why the erythrocyte membrane skeleton consists of "spoked" hexagons.

As we celebrate the 10th anniversary of the Department, I am very hopeful that Bioengineering at UCSD would continue its 38 years of legacy on campus to flourish, and flourish in all possible ways.

A Lifetime at UCSD Bioengineering

Jeffrey Omens, Ph.D.
Associate Adjunct Professor of
Medicine and Bioengineering

After 25 years, I've been involved with Bioengineering at UCSD for more than half of my lifetime: It all started when I was an undergraduate Bioengineering student in the Applied Mechanics and Engineering Sciences Department in 1979. I continued on at UCSD to get my Masters and PhD degrees under the guidance of Professor Fung. After a post-doctoral fellowship in the UCSD Department of Medicine, I have worked toward an independent career in Bioengineering as an Adjunct Faculty Member in the Department of Medicine with a joint appointment in Bioengineering. My research is in cardiac mechanics, and I enjoy all of the collaborations I have with faculty and students in Bioengineering and Medicine.

I have been given the opportunity to teach in the Bioengineering Department, an enjoyable experience for me (and hopefully for the students!) I have taught several of the courses that I actually took as an undergraduate student. Sometimes when I'm teaching I think back to when I was in the class. I know that some of the material was difficult for me and my classmates, and I try to take extra time to explain those concepts now when I teach. With respect to Dr. Fung and his teaching, some of the material was so difficult that now we just skip it! My personal familiarity with these courses has helped me to tailor the lectures and labs to optimize the undergraduate student experience while learning the principles of Bioengineering.

I was lucky to have met my wife, Madonna Maxwell, at UCSD through Bioengineering. She was also a Bioengineer major, and used her education to become a successful engineer at a local medical device company. I suppose there may be some Bioengineering genes passed on to our 2 boys, we'll have to wait and see. I look forward to continuing my research and teaching in Bioengineering, and am thankful to all of the extraordinary people in the Department that have been a part of my life for all of these years.

A Source of Inspiration

Robert Sah, Ph.D.
Professor of Bioengineering

UCSD Bioengineering has been a constant source of inspiration for my research on Cartilage Tissue Engineering. One of the first challenges I was confronted with, when starting as a faculty member at UCSD in 1991 and arriving in La Jolla in July 1992, was choosing a name for my lab. At the time, Professor Chien was leading an effort to apply to the Whitaker Foundation for a Development Award on Tissue Engineering Science. In those days, the core faculty, Shu Chien, Dave Gough, Marcos Intaglietta, Andrew McCulloch, Geert Schmid-Schonbein, and Dick Skalak, together with emeritus faculty Bert Fung and Ben Zweifach, had deep discussions about both the science and engineering foundations for Tissue Engineering. I remember vividly the discussions we had in Engineering Building Unit I about Tissue Engineering, and hearing firsthand from Dick and Bert about the 1st workshop on Tissue Engineering (at Granlibakken, Lake Tahoe, California, February 26-29, 1988) where they and others defined the field, and then reading the proceedings of that seminal workshop [5]. It became clear that Tissue Engineering, as defined by Fung and Skalak at that meeting, was an exciting field--one that had broad scientific and engineering foundations, yet targeted in nature. UCSD's application for a Development Award on Tissue Engineering Science was granted. Cartilage Tissue Engineering was the natural choice for the name of, and research direction for, my lab.

UCSD has provided a fertile environment for development of new ideas in Bioengineering, seeding me with ideas since my startup days as a faculty member. Articular cartilage has remarkable biomechanical properties, and the complexity of these properties and their dependence on cartilage composition and structure continues to present challenges. The ideas for my Biomedical Engineering Research Grant, Cartilage Tissue Engineering: Microscopic Imaging for Electromechanical Analysis (1993-1996) from the Whitaker Foundation, came in part from inspirations at UCSD. I remember becoming acquainted with the classic works of Marcos Intaglietta on video dimensional imaging methods to measure deformation of soft tissues [6], as well as those of Profs. Omens and McCulloch on tracking beads implanted in the heart wall [2]. With our interest in cellularity in cartilage and DNA-binding dyes, it became clear that cell nuclei, tagged with a fluorophore, could be used as intrinsic "beads" within cartilage, and video imaging and analysis methods could be used to measure intra-tissue displacement and to deduce tissue-level strain. The grant from the Whitaker Foundation allowed us to purchase equipment and develop specialized instrumentation for making such measurements. My first PhD student, Rob Schinagl, was able to develop this method and apply it to define at a new

level of detail some of the biomechanical properties of articular cartilage and the remarkable conforming properties of the superficial zone of cartilage [3, 4]. Rob's work has led to more realistic biomechanical models of cartilage [1] and our continuing interests in the biomechanical properties of cartilage—of the lamina splendens at the articular surface, of the superficial, middle, and deep zones of uncalcified cartilage, and of the calcified region of cartilage.

UCSD Bioengineering and the Whitaker Foundation have engaged in a synergistic partnership in Bioengineering education. The Whitaker Foundation has been a source of support for trainees to attend meetings. Many undergraduate and graduate students, and post-doctoral fellows, working in my lab have been fortunate to receive travel funds from the Whitaker Foundation to attend meetings. These types of funds make it possible for trainees at all levels to experience the excitement of meetings at which new concepts are communicated. More recently, being on the organizing end of meetings (2003 California Tissue Engineering Meeting and 2004 Gordon Research Conference on Musculoskeletal Biology & Bioengineering), it was so gratifying to be able to apply and receive funding from the Whitaker Foundation to offer travel awards to encourage trainees and young faculty to attend the meeting. I think the funds were well spent. The poster sessions and receptions at both of these meetings were abuzz with excitement, especially as trainees interacted with more senior investigators to discuss ideas and to develop personal friendships. The Department of Bioengineering has also made substantial regular commitments to train graduate students and post-doctoral fellows, and to help support trainees to attend meetings.

The undergraduate and graduate students in Bioengineering at UCSD are remarkable. These students are quick to embrace new opportunities and challenges. In addition to taking an active role in learning in classes, UCSD students are eager and effective when engaging in research or industry experiences. The Whitaker Foundation sponsorship of the Bioengineering Industrial Internship program at UCSD provided many students with experiences in Bioengineering industry. The annual Research Symposium put on by the Bioengineering Graduate Students is one of the hi-lights of the year for Bioengineering at UCSD. I remember being able to visit UCSD as a prospective faculty member on a weekend of the Symposium, and being treated to uniformly outstanding presentation after presentation. I remember the tremendous contributions that undergraduate students have made to our research efforts. I am amazed at how Bioengineering Undergraduate and Graduate Students worked so effectively to organize the 2003 California Tissue Engineering Meeting. Students, and faculty, have enjoyed utilizing the wonderful new facilities in Powell-Focht Bioengineering Hall. Students and faculty will benefit from the integrated research, educational, and translational activities of the building for many decades to come.

I marvel and treasure how UCSD Bioengineering has created such an outstanding environment, both professionally and personally. The students, fellows, research staff, administrative staff, and faculty in UCSD Bioengineering work in harmony in synergistic interactions to advance the frontiers of Bioengineering, to improve the diagnosis, prevention, and treatment of disease. I look forward to many more decades of pushing forward the frontiers of Bioengineering at UCSD.

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On the Tenth Anniversary of the Department of Bioengineering

Bernhard Palsson, Ph.D.
Professor of Bioengineering

Ten years ago, at the University of Michigan, I knew nearly nothing about UCSD and its Bioengineering Program. As our conversations progressed, my personal interests grew. I ended up joining the Bioengineering Department in fall 1995 as one of the recruitments enabled by the Whitaker Foundation Development Award. While my move to UCSD was enabled by the Development Award, it was the leadership of Shu Chien and Bob Conn that played a key role in my decision. Although space and financial resources would be much smaller at UCSD than what I enjoyed at Michigan, I decided that the human resources and growth potential that the new UCSD Bioengineering Department offered were overriding factors. History has proved my judgment to be correct. I have continued to thoroughly admire my colleagues at UCSD and fully enjoy my interactions with them and the outstanding students in the Department.

I took a Fulbright leave in Denmark in the first half of 1996. This proved to be time well spent intellectually and conceptually. The ideas and priorities that I developed there have formed the basis for my research and educational activities at UCSD. One of them was the first outline to a tissue engineering course. This triggered the writing of the Tissue Engineering book that I was fortunate to be able to write with a much admired colleague, Sangeeta Bhatia. We dedicated this book to Bert Fung and Ed Lightfoot, members of the "greatest generation" that have inspired so many by their leadership and integrity. Bert was one of the founders of the UCSD Bioengineering Program and has stood tall as a symbol of academic and educational leadership and achievement that the rest of us can only dream of achieving.

The first full genome-sequence was published in summer 1995. Having worked on in silico models of cells, I immediately realized the impact that such information would have on building computer models of whole cells and how they would drive biological discovery. Opening the issue of Science where the paper was published was a defining moment in my career and led to the generation of the very productive research program in my laboratory today. Many of the ideas that we are working on were formulated while in Denmark following thorough thinking about the impact of genomics. Taking well timed and placed sabbaticals is recommended.

Following my return to UCSD in fall 1996, I started to build my research group. When I spoke at the annual meeting of the NAE in fall 1997, I outlined what I thought was a cutting edge issue in Bioengineering, i.e., the reconstruction, simulation, and eventual design of what I called "genetic circuits;" i.e., multiple gene products have to come together, function in a coordinated manner according to some predetermined 'script' to produce cellular functions. Today's popular term "systems biology" is essentially synonymous with the "genetic circuits".

The gene circuit idea was articulated in a commentary in Nature Biotechnology in January 1997. In fall 1997, I circulated a document to the Department and JSOE to develop a "Center" or "Program" on genetic circuits, which had most of the elements of what we now recognize as Systems Biology and Bioengineering.

At the BECON meeting at the NIH in February 1998, one of the participants at the discussion panel I ran was Shankar Subramaniam. He proved to be the most productive member of this panel and insisted that we write the summary of the discussion and formulate the recommendation right there and then following the conclusion of our deliberations—which we did. Or which he did, I should say. I was impressed by his vision, determination and eagerness to move the development of bioengineering forward. I thought that UCSD should pursue him as a faculty member, which we did and fortunately successively so. Shankar's move nucleated the formation of Bioinformatics program at UCSD.

Around this time I worked with you and Andrew McCulloch on an application for the Whitaker Foundation Leadership Award that culminated in a vision for the department that consisted of three key elements; biomechanics, tissue engineering, and genetic circuits. I thoroughly enjoyed this process and was very pleased to work intimately with the two of you and the rest of our faculty on this proposal. I felt the vision, the energy, the determination, the collegiality and the

academic quality of our faculty through this process, and it re-confirmed my belief that the human resources of our Department were second to none. A revised version of the proposal, championed by you, was successful and we now enjoy the fruits of your labor every day in the Powell-Focht Bioengineering Hall. The eventual move to the new building in early 2003 was a major milestone in the history of our Department.

Following the establishment of the Bioinformatics program, we continued the development of integrative or systems analysis in cell and molecular biology, along the lines of the 'genetics circuits' theme. Marcos Intaglietta challenged me to give a department seminar to emphasize the 'engineering' component of the effort. The talk was well received and helped me to define the engineering strengths needed to develop systems biology and bioengineering. Marcos has influenced my thinking in more ways than he knows.

After a somewhat slow period in 2000 and 2001, we were successful in recruiting three talented and promising young faculty members in Systems Biology and Bioengineering. Jeff Hasty, Xiaohua Huang and Trey Ideker, giving us the nucleus to build an educational program. In fall 2003 we implemented a three-quarter sequence on Systems Biology and Bioengineering – the first of its kind in the world.
All in all, my stay at UCSD in the Bioengineering Department has been a pleasant one, a scientifically productive one, and an educationally rewarding one. I have had the chance to work with people that I admire, whose collegiality I have enjoyed, and had the environment that has enabled me to grow as a researcher and educator. I am thankful to you and Bob Conn for giving me the opportunity to come here, to the faculty for providing an intellectual environment par none, to the outstanding students that I have had the pleasure of working with, and to the Whitaker Foundation for all the support that they have provided me and the department with. I only hope that through my efforts that I have been able to repay in some small way all these favors and support that I have been so fortunate to enjoy.

A Place to Grow

Sangeeta Bhatia, M.D., Ph.D.
Professor of Bioengineering,
Adjunct Professor of Medicine

As the place that I 'grew up' as an independent scientist, UCSD Bioengineering provided unbound opportunities, an extended family, and an uncompromising value for excellence. Below is a collection of my memories of the department as it celebrates its 10th birthday:

Y.C. Fung: Reading his book as an undergraduate, meeting him for the first time as a graduate student ten years later, celebrating his Presidential Medal of Science, dedicating a textbook to him and his leadership, winning a medal that bears his name and resemblance. What a privilege to have him as a colleague. His grace, intellect, and spirit of service are inspirational.

Shu Chien: Being recruited under his leadership, watching him artfully gather people and resources to culminate in the construction of a Bioengineering building, admiring his boundless energy and commitment both to the department and the field of Bioengineering, respecting his ability to continually innovate in research, getting career advice and always feeling like I had a true advocate, and sharing his love of life and family. My heartfelt thanks to a role model and mentor.

A collection of firsts: first lab, first grant, first paper as senior author, first class, first outreach to San Diego Girl Scouts, first tenure, first baby, first textbook, first hooding of doctoral students.

Colleagues, students, and staff: What an extraordinary group of people. A collegial, warm, brilliant group of individuals. The human capital of our department is, in my opinion, its biggest asset and legacy. I've learned something from each and everyone with whom I've interacted.

Happy 10th Birthday UCSD Bioengineering!

Pushing Ahead And Still Learning

Gary A. Huber, Ph.D.
Assistant Professor of Bioengineering

Often, I jokingly tell my students that I know a lot about engineering and very little about biology. Like several of the other professors, I come from a chemical engineering background (along with a healthy dose of computer science); I first became aquainted with this department while a post-doc in the UCSD Chemistry department. At the time, the department was aiming to continue the tradition of biomechanics established by Prof. Fung, while putting a new emphasis on molecular-level phenomena. I was extremely fortunate to be invited to walk across campus and give a seminar, but I didn't even know until two days before the talk that I was also being interviewed for a faculty position (although I had sent a CV).

To my even greater surprise, they eventually offered me a position.
Since then, my group and I have been developing computer algorithms to simulate molecules at the atomic level and to use that information to predict and understand mechanical properties of larger structures composed of many molecules. Like many new professors, I thought I already knew quite a bit, but in many ways my first day here was like the first day of kindergarten, as I learned about the fascinating variety of research carried out by my colleagues and stayed a step ahead of the students while teaching new courses.

The first big strength of this department, in my experience, is the
freedom to pursue novel and unusual approaches to research, which is vital in a rapidly growing and changing field like bioengineering. The other big strength is presence of faculty, staff, and students from a wide variety of backgrounds; there is no "standard issue" grad student such as one might see in other departments. As someone from a background different from bioengineering, I am truly blessed to have been given an opportunity to contribute to the future of such an important field.

10th Anniversary Celebration

Wayne Giles, Ph.D.
Professor of Bioengineering

Dr. Wayne Giles arrived at UCSD approximately seven months ago. He holds cross appointments in the Departments of Bioengineering and Medicine and is also a member of the Institute for Molecular Medicine. Dr. Giles is a Cardiac Electrophysiologist who studies the basis for excitability and repolarization of the mammalian heart using both experimental (channel biophysics) and theoretical (mathematical modeling) approaches.

Dr. Giles writes:
"I have thoroughly enjoyed my first year in San Diego. This Department now consists of a group of internationally-recognized senior investigators complemented with very impressive junior faculty members, and a truly remarkable cadre of Graduate Students and Postdoctoral Associates. Traditional strengths, and the well-focused common goals for multidisciplinary integrative research and both undergraduate and graduate student training within the Department give confidence that past accomplishments will continue to be sound basis for the required major new developments and changes as this Department evolves and continues to lead the rapidly-growing discipline of Bioengineering. I am very fortunate to be a member of this Department.

At the time of its 10th Anniversary, I sincerely congratulate its founding members - both the academic appointees, and the very effective administrative and support staff".

Looking Towards the Future

Gabriel A. Silva, M.Sc., Ph.D.
Assistant Professor of Bioengineering
and Ophthalmology

In November of 2003 I had the privilege to become the newest tenure track faculty member in the Department of Bioengineering. I was one of a recent rather large group of faculty (in relation to the total number of faculty already in the department) who joined the department within the last few years. When I was searching for faculty positions it was impossible not to send in an application in response to an open faculty search in the Department of Bioengineering at UCSD, regardless of how small I thought my chances were. Here was literally one of the most highly respected departments in the country actively expanding their number of core faculty and openly inviting individuals to apply. (In my case it was particularly enticing since one of the advertised positions was for a joint Bioengineering and Ophthalmology faculty position, the two areas I had done my doctorate in.) So, when I sent in my application in November of 2002 I was fully aware of the department's stature and the quality of their research. Much to my surprise and delight I was invited for an interview and to give a talk in January of 2003, and after everything was said and done officially started as a faculty member in November of that same year. In the short time I have been here it has struck me how forward thinking the department is. For an academic department to be one of the best and remain so it has to constantly re-define itself and continuously evolve. Since I have been here a lot of thought has been put towards the department's future and where it is going, from systems biology, to nanotechnology, to tissue engineering. It will be a true pleasure to witness how the department will change for the better in the next ten years, which if its first ten are any indication will be truly something worth waiting for.

Bioengineering at UCSD My Early BSB Days (1969-1971)

Peter C.Y. Chen, Ph.D.
Project Scientist, Bioengineering,
University of California, San Diego

I came to UCSD in the Fall of 1968 after graduating from high school in Hong Kong. There were 1,700 students including 500 graduate students on this relatively new campus. I enrolled in Revelle College which boasted of a 7 to 1 male to female ratio. Trying to figure out what to major in I went to the provost office and talked with Paul Saltman's lovely assistant Nancy. She suggested I should contact Dr. Zweifach regarding the new Bioengineering major. I went up to the 5th floor of the new Basic Science Building and the first person I met in the department was Perne Whaley. With great difficulty I tried to pronounce Dr. Zweifach's name. Perne smiled and gently said, "Dr. Zweifach is not in but there is a Dr. Fung in the next office and he is just as nice." Now I have no problem with that last name. Soon after I realized Dr. Intaglietta is a co-founder of the department. That would have been impossible to pronounce. Dr. Fung was busy then because while explaining what was required with the Bioengineering major he was thumbing and glancing through manuscripts. At the end I asked if it would be easy to find a job with this major. To this question Dr. Fung put down his documents, 'laughed', and said, "If you are the best in your field, there is no problem finding a job."

The undergraduate Bioengineering curriculum at that time consisted of courses in math, continuum mechanics, fluid mechanics, solid mechanics, thermodynamics, and a chemistry and biology sequence. At the end of the second year I got a summer job in Dr. Fung's lab. I was given the task of designing a device for two dimensional stress strain tests on dog mesentery. The first day I walked into the lab I was blocked by a seemingly intimidating huge figure sitting with his back against the door. This was no other than Gene Mead, Dr. Fung's most innovative and unusual engineer, and we became best friends in the years to come. There were a few graduate students working busily away, Frank Yin, Evan Evans, John Pinto, Hyland Chen and Mike Yen. Dr. Fung did not have a big lab but everyone has his own area. Graduate students worked mighty long hours those days because John would sleep in the lab while experiments were running and Hyland would come in at wee hours of the night to check on his specimen. When they found out what I was supposed to do everyone chipped and offered advice. Bioengineering has just moved over from Urey Hall and occupied one wing on the fifth floor of the Basis Science Building. Next to Dr. Fung's biomechanics lab was Dr. Zweifach's microcirculation lab, then it was Dr. Fronek's cardiovascular lab and Dr. Intaglietta's lab involving the development of instruments and animal models for microcirculation research. At the end of the hall was Dr. Bailey's Radiology lab. He was from the Medical School. Since there were not too many people in the department and everyone was right next to each other we had plenty of opportunities to interact academically and socially. Bioengineering was one big happy family.

I continued to work for Dr. Fung after the summer session. This time I was sitting in his secretary's office with Barbara Johnson. My task was to help Tong Ling run computer programs. This was 1970 and programs were entered with punch cards. Tong Ling would give me an equation to program and I would present the results to Dr. Fung. Computed output consisted of pages and pages of numbers with no graphics. One time Dr. Fung took a cursory glance at a printout and told me the answer was wrong. I am still amazed at how Dr. Fung can transform a sea of numbers into a picture.

When I was about to graduate Dr. Fung encouraged me to obtain a Ph.D. degree at UCSD and I have been working in the department since, meeting many new friends, getting involved in moving twice to new buildings and seeing the department grow by leaps and bounds to become the recognized leader in the field today.

We are celebrating the department's 10th anniversary on this occasion but Bioengineering at UCSD has close to a 40 year history in the pioneering efforts to define this field and setting examples and standards for others to follow. We can attribute the success to the visionary leadership of the founders, the earnest collaboration from our excellent faculty, the dedicated support of the research and administrative staff, the ever motivated students, and the strong backing from communities. Together, UCSD Bioengineering will stay at her peak and maintain the one big happy family image.

A Good Decision

Roland Kaunas, Ph.D.
Postdoctoral Fellow,
Department of Bioengineering &
Whitaker Institute of Biomedical Engineering

I will always appreciate the advice of my former mentor, Dr. Shu Liu, when I was getting my Master's degree in Biomedical Engineering. Being a very satisfied alum of UCSD, he often encouraged me to apply there for my PhD training. Coming to UCSD has been one of my most rewarding decisions. The department has provided wonderful opportunities for me to broaden my graduate experience with access to the best facilities, interaction with leaders in the field and an active student body. When the day comes to move on to new endeavors outside of UCSD, I look forward to helping guide eager future bioengineers toward the school which proved to be THE place for bioengineering research.

166K Miles Away

Carlos J. Vera, M.D., Ph.D.
Postgraduate Researcher,
Department of Bioengineering, UCSD
Professor of Medicine,
Universidad Autonoma de Baja California,
Campus Tijuana, Mexico

I first tried to get into the bioengineering program in 1985 after finishing my electrical engineering studies in México. During that summer, I was working as a volunteer with Dr. Jorge Barroso, a postgraduate researcher at Dr. Schmid-Schoenbein's laboratory, in hemorrhagic shock. During the experiments, I realized the complexity of the biological systems and the need to have a better background in biology and mathematics. Dr. Barroso recommended me to study medicine in México and to improve my computational skills. I followed his recommendation and 10 years later, I finished a specialization certificate in mathematics and my M.D. degree.

I thought that I was ready to initiate my graduate studies in bioengineering, but there was a missing part…the money required to pay for the $13,250 tuition and fees as an international student, and the proofs of having at least $21,000 for the living expenses just for the first year! To my fortune, I had a lot of good friends: Armando Muñoz deposited 21K for the living expenses, and Alfredo Escobedo together with Antonio Rosquillas offered me part-time work during the evenings and weekends. I continued to look for financial supports and luckily the department has a Spanish-speaking professor, Dr. Marcos Intaglietta. He recommended me to apply for a fellowship from the Mexican National Science and Technology Council (CONACYT). I applied but unfortunately did not get the fellowship that year. I had the option of either waiting until the next year, or finding a way to obtain the money required. I decided not to wait for another year, so I organized a sale of my valuable belongings, and used the money I saved from my previous work to pay for the first quarter at UCSD.

Finally in Fall of 1996, I started my graduate studies! I was very happy with the classes, the excellent teachers, and the research environment. After an inspiring lecture given by Dr. Amy Sung about the erythrocyte membrane

skeleton, I decided to join the Molecular Bioengineering Lab, here I started to learn the techniques of molecular biology. As confirmed later during my training in the use of the micropipette system by Dr. Paul Sung, patience is a key component in performing many of the biomedical experiments.

The sudden sickness of my mother and the lack of financial funds, forced me to apply for a leave of absence in Spring 1997. My mother always encouraged me to follow my dreams and helped me unconditionally; it was my turn to take care of her. Even in the illness, my mother encouraged me to continue my graduate studies. During that summer, I came back to conduct research in Dr. Sung's lab. Without the money then to continue my studies, I was sure that it would be my last quarter as student at UCSD. But another unknown friend was waiting on the road! Thanks to the generosity of Dr. Shu Chien and the request of Dr. Amy Sung, I received the McNally Endowed Bioengineering Fellowship. One year later, finally I got the long desired UCMEXUS-CONACYT fellowship.

I always have a great time in the lab! Together with Dr. Amy Sung, we spent many long hours, thinking and learning some of the secrets inside the structure of the erythrocyte membrane skeleton. The departmental seminars are an excellent source of inspiration. In one of those seminars, we met Dr. Robert Skelton from MAE Department and his amazing tensegrity models which resemble many biological structures. Together with Dr. Bossens and Dr. de Oliveira from Skelton's Lab, we developed mathematical models of the junctional complex in the erythrocyte membrane skeleton to analyze its nanomechanics. Now, we are developing more complex models, trying to understand more deeply the erythrocyte network dynamics, which will have potential implications in membrane transport, mechanotransduction and nanotechnology.

Since my days as a graduate student, I have commuted every day from my home in Tijuana to UCSD (I have crossed the San Ysidro international border at least 2,080 times and have driven 166K miles in these years!). As I drove, I visualized the intense contrast between two different countries and cultures. From the colonias in Tijuana to the clean and luxurious streets of La Jolla; from a Mexican university with incipient research to a world renowned research university, which is further surrounded by some of the most prestigious biomedical research institutes in the world. There are some evident differences between the two countries, but there are some common issues too.

As part of my UCMEXUS-CONACYT fellowship requirements, I have to teach Molecular and Cell Biology class and lab to first year medical students in Tijuana. This activity, instead of being a burden of extra works, happens to be an invaluable opportunity. Every morning in the classroom, I tried to motivate my students to study harder and deeply. They are as smart as medical students in USA, and even though they don't have well equipped labs or top researchers as teachers, they have the dedication and will to be good medical doctors. In both sides of the border, there are a lot of good and intelligent people working hard to follow their dreams and to contribute to the human welfare; the only difference is the resources available to each of them.

UCSD is a unique place to do science, research facilities have cutting edge technology and equipment but more importantly, expertise and unique human resources are always available. In the Department of Bioengineering, you can find expert opinions to help you design your experiments or solve any problem during your research. The quality of the research performed in our department really supports the statement that "We are creating the future".

I am a fortunate man, with the generosity of many known and unknown friends and the support of my family, specially my wife Patricia, I was able to realize my dreams. I have the moral obligation to help others to reach theirs.

A Decade of Excellence!

Yingxiao Wang, Ph.D.
Post-graduate Researcher,
Department of Bioengineering

Before I came to UCSD for my Ph.D. study in 1996, my major was in fluid mechanics. Because the study of my Master's thesis in volves the computational simulation of cardiovascular fluid dynamics, I was lucky to get admitted into bioengineering graduate program in UCSD and was provided financial support from the department. The financial aid is crucial for me to join the department. At that time, China was not as developed, therefore the tuition and fees of UCSD is way beyond the capability of most Chinese families, including mine. Even today, sometimes I still wonder what my life would be like if I had not been accepted by UCSD.

In 1996, Dr. Shu Chien was the chair of the department. He served as the instructor for Cell and Molecular Biology, which Drs. Amy Sung and Paul Sung co-instructed, a core course for all the first year bioengineering graduate students. It was the hardest class that I had ever had. In retrospect, I think there are two reasons: 1, My English was not good enough to keep up with the speed of the class (we had to finish the heavy textbook within one quarter); and 2, I had not had any chemistry or biology classes since high school and I would have difficulty in understanding many terms even if they were taught in Chinese. Therefore, before each class, I had to read all the chapters which would be covered. Finally, I got an A- for this class and it really opened for me the world of mechanobiology which I am currently working on.

After one year of intensive course work, I decided to join Dr. Shu Chien's laboratory. There were two places for Dr. Chien's laboratory: one in EBU1 where Dr. Shunichi Usami, Yingli Hu, and Jerry Norwich were located; the other one in BSB where the people in the lab, included Drs. John Shyy, Julie Li, Steve Wu, students Song Li, Kurt Lin, Shila Jalali, Mohammad Sotoudeh, Pin-Pin Hsu, and research associate Suli Yuan. Because we only had very limited space in BSB, people had to share benches. In fact, if I remember correctly, Kurt Lin purposely came to work at night to avoid the "traffic" in the lab. Things are obviously getting better for our lab as well as for other bioengineers in UCSD every year. My office was moved from Chemistry Research Building to the SERF building. Our lab also extended its lab space and established a branch in SERF. Then in December 2002, the new PFBH was ready for the department and we have had a brand-new home. Now almost everybody has his/her own bench and there is no need to follow Kurt's research schedule.

When I first joined Dr. Chien's lab, it was a pioneering field to study the signaling transduction in response to shear stress. I was also thrilled by this topic and chose mechanotransduction as the focus for my Ph.D. study. Before my joining, Dr. Chien's lab has investigated the molecular mechanism by which flow regulates the gene expression of Ras and the activation of MAPK. It was clear that both membrane receptors integrins and receptor tyrosine kinase VEGFR2 are involved in this mechanotransduction action. My work continued this study and revealed that these receptors do not function in isolation. Rather, they form a well-organized hierarchy in regulating the flow-induced signaling transduction. Like other members in the lab, I am very interested to know the detailed mechanism by which cells sense the physical distortions and transmit them into biochemical signals. This is the focus of my current study. Step by step, we are getting closer to have a clear and comprehensive understanding of mechanotransduction.

The evolvement of our laboratory is a miniature of the development of the Bioengineering Department in UCSD. Embracing the principles of engineering, biology, medicine, physics, mathematics, and statistics, the Department continues to grow and lead the community in interdisciplinary integrative research and education. The department has been consistently recognized as one of the top programs in the world, and it is ranked 2nd nationally in the most recent US News survey. Today, we are here to celebrate a decade of excellence for the Department of Bioengineering and we are confident that the Department will continue to lead and to advance our knowledge in biology and medicine and to benefit the human well-being.

Sea Changes Move on Sea Breezes

Thomas C. Skalak, Ph.D.
Professor and Chair,
Department of Biomedical Engineering
University of Virginia

U.C.S.D. – the name itself conjures up a picture of leadership in modern bioengineering. The institution has made a reputation for moving rapidly into new directions in the sciences and engineering overall, but particularly in the integration of biosciences with engineering approaches. In bioengineering, it all started with a forward-thinking group of scientists and engineers who were able to imagine the future of a new global discipline and act on it personally. Y.C. Fung, Ben Zweifach, and Marcos Intaglietta were among the pioneers who converged on a relatively undeveloped region of land above the La Jolla beaches to form the U.C.S.D. bioengineering program as a part of Applied Mechanics and Engineering Sciences. Certainly, a large part of the institutional culture was created by these role models, who had the judgment not to be overly concerned about the appellation that the program carried, but rather to join together to produce significant bodies of work in quantitative cell and tissue function. The culture has served well, as the Department of Bioengineering was formed 10 years ago, in a formalization that was important, yet, in a way, was swept along by the force of the intellectual vision of the founders and the new faculty leaders who have since created equally compelling new visions reflecting the state of bioengineering today.

When I was there in 1979-1986 as a doctoral student and as a post-doctoral fellow, one main emphasis was on the fusion of applied mechanics with the study of cardiovascular function. I was fortunate to be able to study simultaneously with Geert Schmid-Schönbein, Ben Zweifach, Y.C. Fung, Arnost and Kitty Fronek, Sid Sobin, and Marcos Intaglietta among others who were focusing on the microcirculation at that time. Dave Gough was just achieving the early exciting measurements of glucose oxidase-based glucose sensor stability for long-term implantation. Savio Woo and Alan Hargens offered tremendous programs in musculoskeletal tissue function. Gene Mead, Paul Pattituci, Peter Chen, Frank DeLano, and Steve Kovalcheck were key technical leaders on the staff. Many students there at the time remain great friends, including Erik Engelson, Thay Lee, Jeff Omens, Scott Simon, Don Sutton, Patricia Conway, Fred Fields, Paul Zupkas, Tadashi Tamura, Taka Nakagawa, Steve Jones, Michelle Mazzoni, Amy Tsai and many others. All of these people were guideposts and partners in my learning and development, and I am grateful for the experience of being part of the U.C.S.D. program.

Another key part of the San Diego bioengineering experience was the sense of culture and family that was created by the people there. I remember Mrs. Zweifach, Mrs. Fung, Renate Schmid-Schönbein, and now of course Mrs. Chien, very well, and they are great parts of the overall social fabric. When my parents moved to San Diego in 1988, then I had even more reason to continue visiting frequently, which has been a great pleasure. It has been a great satisfaction to me to be able to return on several occasions to give formal seminars to the Bioengineering group at U.C.S.D. and for various national meetings.

My work was in microvascular hemodynamics and structure, and while I will not mention scientific details here, I would just say that each member of my doctoral committee had formative influences on my thinking and career, including Geert, Y.C. Fung, Ben Zweifach, and Frank White – who was at Scripps Institution of Oceanography – in the old building next to the original Scripps Pier. And of course, I could never forget the didactic power of Marcos Intaglietta's graduate course on non-equilibrium thermodynamics, which etched a final exam problem forever in my mind – in approximate form: Ducks fly south for the winter. Compute the change in entropy. Dr. Fung gave us the ultimate role model for being incisive and clear, something most of us can still only aspire to. Geert was constantly available to his students, and of course, was ready with a complete explanation for essentially any phenomenon that we might bring to his attention – but also drove us to ask completely new questions. Dr. Zweifach inspired us with his command of the field and constant thirst for reading. Each in their own way, all the faculty instilled an appreciation for creative work, and for the power of ideas.

On the personal side, there were many diversions that allowed us to thrive in that pristine paradise, as we considered San Diego to be. Erik Engelson was constantly dis-assembling his motorcycle engine and putting it back together – which paid off in his later leadership of a renowned medical device assembly patent and corporate success, Thay Lee's pickup truck – filled with surfboards and shivering graduate students, and dynamic slashes in the surf were key forms of inspiration that got us moving by 5 am on many days, and Don Sutton's endurance exercise experiments on himself (competitive cycling) led him to his discovery of skeletal muscle flow resistance changes. We played many a softball game on the very location where the Bioengineering building now proudly sits. It is certain that Scott Simon's frequent 100 mph warrior jaunts on his Honda motorcycle affected his white cell activation state, which enabled his studies of the mechanical basis of phagocytosis because he used his own cells. It was a heady time. The landscape of La Jolla Mesa, swept by sea breezes – pristine as one-hundred years before. The Pacific Ocean – primitive and unaffected by the technological advances above it. Courses had to be taken all over the campus, yet we didn't mind at all – the intellectual center was the research labs and the minds of the people in the Basic Science Building, 5th floor. Now that has blossomed into a beautiful bioengineering building complex and Department. Congratulations to all and especially Shu Chien for making this vision a reality.

While there are thought leaders located around the nation in this well-developed field today, U.C.S.D. was and remains a premier programmatic leader in the discipline. Originally, the biomechanical characterization of tissues and microvascular dynamics helped to make it a leader, and now the move to lead in computational systems bioengineering demonstrate this well. These are sea changes in the discipline of bioengineering. To maintain such leadership over time - even into areas of science that were not anticipated at the outset - is a tribute to the people and the culture of U.C.S.D. bioengineering.

Best wishes for the next 10 years!

Growth and Change of Bioengineering at UCSD

Robert Schinagl
BSE (Bioengineering,Univ. Pennsylvania, 1989)
MSE (AMES, UCSD, 1993)
PhD (Bioengineering, UCSD, 1997)
Director, Project Management
Yamanouchi Pharma America, Inc., Paramus, NJ

It might be fair to say that bioengineering at UCSD changed as much between 1991 and 1997 as I did.

During those years, I eagerly adopted the southern California lifestyle after leaving the Northeast, where I had spent most of my life. Less readily, I accommodated the life of a graduate student after leaving the medical device industry – motivations and salaries were quite different in these two worlds. After six enjoyable years and much hard work, I left UCSD as a confident and capable researcher, proud of one of the most significant and satisfying accomplishments of my life.

When I arrived at UCSD in 1991, the distinguished faculty, staff and students of bioengineering were a relatively small group within a department known as AMES (Applied Mechanics and Engineering Science). Most of us shared a few cramped laboratories on a single floor of EBU-I. The fledgling Institute for Biomedical Engineering had only just begun to foster the campus-wide collaborations that are at the heart of the interdisciplinary field of bioengineering. Graduate students were a friendly, but not terribly cohesive, group. To those who founded bioengineering at UCSD many years earlier, this was terrific progress. It was great, but it was only the start.

I had the privilege to see our group become its own department. The Whitaker Foundation funds enabled the hiring of new faculty, drawing new students and staff. Campus-wide collaborations grew stronger. A new EBU appeared at the opposite end of the Warren Mall – more lab space. Graduate student programs were enhanced. The annual graduate student research symposium, which had changed little over the years, rapidly approached the sophistication of a professional society conference. I was fortunate enough to help start the Bioengineering Graduate Student (BEGS) group, giving us a group to call our own. From this group, the student-driven Breakfast with Industry was born. It was a great time to be a graduate student. When I graduated with plans to return to the East Coast, I was leaving a significantly different place as a significantly different person.

A recent visit after nearly seven years away made it clear to me that the department's growth has only accelerated since I left UCSD. There are new buildings, new professors, new students – I barely recognize the place. I was comforted to see some of the old familiar equipment tucked away in a dark corner (the museum?) of Dr. Robert Sah's Cartilage Tissue Engineering laboratory. That lab is now in a different building and is at least four times the size of the nearly empty room that Bob and I stepped into shortly after his arrival at UCSD as a new professor. I'm so proud to be among the alumni of the "CTE" lab and the department.

This kind of growth and change is evident throughout the department and is to the credit of faculty, students and staff throughout the history of bioengineering at UCSD. Present and future generations of the UCSD bioengineering family will, without doubt, continue this tradition of excellence.

How UCSD Bioengineering Produced A Successful Patent Attorney

Fariborz (Faffi) Moazzam, Ph.D., J.D., M.B.A.
UCSD Degrees: Ph.D., C.Phil., M.S.E., Bioengineering
Managing Partner, Moazzam Latimer LLP

Ten years have gone by since I first heard about the formation of our beloved Department of Bioengineering at UCSD. Ten years have gone by since I first looked up on the Assignment Board near the BIOE offices on the administrative floor of EBU-1 and first noticed that our newly formed department no longer had the name of "AMES." Yet, ten years have gone by before I could fully appreciate how fortunate I was to have been a small part of the Bioengineering at UCSD.

As I first began college in the '80's, I never imagined that I would one day have six college degrees, let alone five of them at the graduate level. I also never imagined that I would be a UCSD graduate. In fact, I only became aware of UCSD at the end of my junior year at my undergraduate university in Washington, D.C. I had only begun to consider graduate biomedical engineering programs and my advisor at the time, who was also a good friend and former colleague of many at UCSD, Dr. Aydin Tözeren, suggested that I look into UCSD. I did and never thought that I would be accepted. I was lucky to be accepted and my life and career changed as a result.

Of my five graduate degrees, the ones that I have received from UCSD have had the most significant impact on me personally and professionally. This admission may sound odd coming from a practicing lawyer, but not if we take a few steps back and realize how the training that I received from the Bioengineering Department at UCSD helped me become a successful lawyer.

It was at UCSD Bioengineering that I learned to develop the tools I needed to become a reputed lawyer. In essence, it was there where I learned how to "think like a lawyer." It is at UCSD where I learned that being a bioengineer means being a problem solver. It's applying all that is known from a multi-perspective view. It involves solving a problem by looking at it from all angles -- as a biologist, as an engineer, as a scientist. What I did now know when I was a graduate student is that what I was learning as the philosophy of a bioengineer is not limited to the field of bioengineering, but also applicable to other fields, particularly law.

In my specialty field of intellectual property law, an intertwined multi-disciplinary mix of science, law and policy, I have gained a reputation in the field as a problem-solver, one to call upon to handle troublesome cases, one to call upon to understand a particularly difficult technology, one to reverse something detrimental that has been done or to tackle on a matter that others have refused to accept or given up on.

My training as a bioengineer from UCSD Bioengineering has made me especially suitable to study, consider and provide innovative solutions to such complex legal problems. I view all legal issues that I encounter from the eye of a bioengineer. I consider how I can solve my client's problem by first identifying the problem as a bioengineer would. I view the problem from multiple perspectives, the client's perspective, the market perspective, the ethics perspective, the litigation perspective, the policy perspective. After a complete and thorough review of the problem, I then present a multi-faceted solution. It is rare in law, as it is in biomedical research, for there to only to be one unique solution to any legal problem. Every problem has multiple solutions. Every solution has unique advantages and disdadvantages. Each solution should be individually tailored to meet the needs of the client.

My years at UCSD Bioengineering were spent absorbing. I felt like a child in his first few years of life, absorbing and emulating others, those for whom I had and continue to have great respect and admiration. The aim of a great educator is to instill a thirst for knowledge into his pupils. My advisors at UCSD instilled such a sense into me that has had impact on my success today. I was lucky to have had two of the best to serve as my advisors.

Dr. Schmid-Schönbein taught me about the importance of being focused, setting goals and doing everything to achieve those goals. His unbridled enthusiasm for science, in his research and discoveries has had a remarkable influence on me. I have applied the same principle in my career and social goals and have achieved great success as a result. His goal-focused drive is a model for my short- and long-term goals.

Additionally, I have been one of the truly fortunate few in the world who have had the honor of being advised by the legendary Dr. Benjamin Zweifach. His philosophy has had a significant impact on my life in being focused on the overall goal and never losing sight of the all-encompassing goal of all research activity, to aid mankind by improving health. Through years of sage and patient guidance, I have learned that in whatever paths we follow, there must be larger goals that we must never lose sight of. Along every step of the path, we should stop to ask, "and how does this aid mankind?" I have truly been blessed to learn amongst the greatest in the field. Drs. Schmid-Schönbein and Zweifach are just two among the many at UCSD Bioengineering.

Without my years at UCSD Bioengineering, I would not have learned to view problems from multiple perspectives as a bioengineer does. I would not have learned to think of the problems using a combination of different perspectives as a bioengineer thinks. I would not have learned that there are multiple solutions as a bioengineer knows. I would not have learned to solve the problem using unique combinations of well established disciplines as a bioengineer does. I would not have learned directly from the living and past legends of the field. I would not have been as successful a patent lawyer as I am now.

So thank you, UCSD Bioengineering and happy first decade. Thank you for making me a patent lawyer with the problem-solving philosophy of a bioengineer. All that go through the department will benefit themselves and mankind by becoming better problem-solvers in whatever field and career they eventually practice. Here is to many more successful decades of existence, and more importantly, to countless more humans benefitted and lives saved. That is why you are in existence. As Dr. Zweifach always said, never lose sight of why you do what you do. Keep doing it.

Memories and Reflections

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My time at UC San Diego spanned the years 1992-2000. When I arrived in La Jolla, Bioengineering was fledgling, administratively still a part of the AMES department and physically straddled between the new Engineering Building Unit 1 and the "old" seven story Urey Hall in Revelle College, which was shared with the departments of Chemistry and Physics.

At the time, our graduate student offices were on the top of Urey Hall. I recall late night study breaks there with my friend David Carta (Ph.D., ~1997). We would pause from our homework sets, which involved infinite variations of length-tension curves, to "study" the aerodynamics of his ever-present Frisbee. He would stand outside along the railings of the building and send me down to the parking lot. Then he'd hurl the Frisbee down to me, which I'd gamely try to catch and hurl back. It didn't occur to me at the time that my job was considerably more difficult than his!

In our classes, I will never forget the teachings of Dr. Y.C. Fung, who constantly reminded us to focus and to simplify our problem-solving approach. He taught us to analyze our problems with elegant mathematical descriptions based on physics first principles. This approach gave our work clarity, a particular "UCSD perspective." This perspective is characterized by a certain timelessness, and many of the department's manuscripts continue to be considered classic contributions to the scientific literature.

In the mid-90's, our classes were spread out between the Medical Teaching Facility, and the colleges of Revelle, Muir, and Warren. Most of our advisor's research labs were in EBU-1 or the VA. As we began our research work in earnest, the camaraderie we had in class was replaced with camaraderie in the labs, and friendly competition between the labs. After hours, we would engage in long inter-connected virtual games of the particularly violent program, "Doom." This occurred when Dr. McCulloch's lab space on the 4th floor of EBU-1 represented the entire Bioengineering department's computer center.

Outside of our work, may of us tried to engage in some form of physical fitness, again a trait of the UCSD environment. I particularly enjoyed swimming and decided along with "Faffie" Moazzam (Ph.D., 1998) to swim across La Jolla cove to La Jolla Shores beach. About a third the way across, Faffie developed severe cramps in his legs, limiting his ability to swim. We linked arms and managed to work our way across the kelp beds to the safety of shore, exhausted. After that experience, my swimming was limited to the Canyon View pool.

Back in the "safety" of the department, we were ably led by Dr. Shu Chien. He too encouraged us to focus and start with approachable problems to which we'd add layers of complexity. This was applied not only to research, but teaching and administrative duties. Dr. Chien encouraged teamwork and echoed the collaborative tone of the UCSD campus. As a leader, he is inspirational, making sure to be inclusive of all personnel for which he is responsible. He always said that the Bioengineering department is like a three-legged stool, consisting of the faculty, administration and students (in no particular order!). All three constructs are vital for the functioning of the whole. In my later experiences, I found this to be a very unique but true perspective.

Now Bioengineering has several beautiful buildings of its own, and is one of the most popular majors among the students. I am very proud to be associated with such a great endeavor, and the lessons learned over my years at UC San Diego have stood me extremely well. Graduate student life is tough and at times lonely, but I can't think of a more inspirational, supportive and educational experience to be had than at UC San Diego.

WALT BAXTER, PH.D.
Bioengineering, UC San Diego, 1999
Principal Scientist,
Medtronic Cardiac Rhythm Management

The best advice that I ever got was from a young faculty member in the Mechanical Engineering Department at Georgia Tech, Dr. Cheng Zhu. During long-running discussions with Cheng about potential graduate schools, I asked him to recommend a final graduate school to apply for. The resulting conversation was quite funny:

Dr. Zhu: "You should think about UC San Diego for graduate school."
Walt: "You mean where Fung is, right?"
Dr. Zhu: "Yes! It's a good place and they might let you in."
Walt: "That's in La Jolla [I pronounced the city 'la joe-lah']."
Dr. Zhu, a Chinese emigrant, correcting me on my Spanish: "NO! It's 'LA HOYA'!"
Walt: "La Hoya. La Hoya. I get it. Will you recommend me for that place as well?"
Dr. Zhu: "If you learn to pronounce the name. I don't want you embarrassing me."

Unbeknownst to me, the faculty had procured a large grant from the Whitaker Foundation in late 1992 that established their presence amongst the elite in Bioengineering. So I showed up to the AMES department in the summer of 1993 and took classes in the Bioengineering wing of the department—the sputtering San Diego aerospace industry had belched forth a number of experienced engineers that dramatically boosted the reputation (and size) of that class. The Department was formed in 1994, and we were off!

We worked ungodly hours in tight, cramped conditions, became good friends, and were able to meet deadlines under extreme conditions, even preparing talks while on the subway. I now know that we were building a foundation for the future with strong student involvement in the Department, a rich tradition of forcing oral/poster presentations on students, and good involvement with the local industry. Three former students—Ann Lee-Karlon, and Bill Karlon, and myself—founded the Industrial Liaison Committee in 1995 and hosted our first Breakfast with Industry shortly thereafter. Bill, Ann, and I went to the extreme in order to procure funding, but we got it done and it was no Mickey Mouse Operation.

This tradition continues and is just a small part of what it akes the Department great. The best-case scenario has happened for me: The Department I joined has blossomed to the point where it would no longer admit me—but no one can take my degree back!

Bioengineering at UCSD, Our Roots

Shila Jalali, Ph.D.
Staff Scientist, Nanogen, Inc.
San Diego, CA

Mohammad Sotoudeh, Ph.D.
Principal Scientist/Bioengineer
Synthasome, Inc.
San Diego, CA

Once in a while we still come across a person who asks us "What do Bioengineers do?" when he/she hears what our background is. It was a time when the field of Bioengineering was much less known compared to present. We would like to thank the Bioengineering program at UCSD for the recognition they have given to this field both in San Diego area and nationwide. It is quite an honor to explain who bioengineers are and especially where we have received our degrees from. We almost always do sense an admiration from the audience when Bioengineering at UCSD is mentioned.

We joined the bioengineering program at UCSD (part of the AMES department at the time) on Sept 1993 a year after we got married to pursue Masters Degrees. Considering that we came with bachelor degrees in computer science (Shila) and chemical engineering (Mohammad), it was quite exciting to start a new path in a completely new direction. All we knew was that we enjoyed applying engineering concepts to solve biological problems. One year later, the bioengineering program officially formed its own department and separated from AMES. That was a grand milestone for bioengineering at UCSD which influenced the bioengineering nationwide in the coming years. We were so proud to be fortunate to see this historical moment and be part of the first class who received Masters Degrees under the Department of Bioengineering's name rather than AMES. The department gave us a choice to either choose AMES or go with the new department. It was quite an easy choice for us considering legends including Drs. Fung (known as father of bioengineering), Zweifach, Chien, Intaglietta, McCulloch, Schmid-Schönbein, Gough, and Skalak were some of the professors in this newly shaped department. These group of faculties worked together for many years to make the bioengineering recognized as an original discipline and the formation of the bioengineering department was one the fruits of their efforts.

We enjoyed our journey so much that we elected to continue on to the Ph.D. program under Dr. Shu Chien's excellent mentorship. At the time, our lab was in Basic Science Building. We were fortunate enough to witness how the department grew in every aspect. Number of faculties, students, staff and affiliates grew every year. Some groups moved to the SERF building after couple of years. We did graduate in Dec 1999, but kept our contact and collaboration with Dr. Shu Chien and department of Bioengineering through all these years till now.

Since then, we have been working in different tissue engineering and nanotechnology companies including Nanogen, Advanced Tissue Sciences, Biosite, and Synthasome, Inc. all located in San Diego. Staying in San Diego, we have been fortunate to be able to have access to bioengineering department and witness the tremendous growth of the department over the last five years with such an accelerated pace. The department has had 9 new faculty members since five years ago when we left. Grand opening of the new Powell-Focht Bioengineering building is another grand milestone achieved which will even more accelerate the future growth of the department. Close relationship between the bioengineering department at UCSD with some of the leaders in biotech industry around San Diego and nationwide has created remarkable opportunities for graduate students to easily find positions in biotech industry and apply their knowledge towards making products that will influence lives of many in coming years. Again, we would like to thank all the faculties and staff at department of bioengineering for their amazing visions and teamwork and wish them more success in the coming years.

Successful Integration

Gang Jin, Ph.D.
Group Leader of Genomics Lab
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The UCSD-Department of Bioengineering's 10th anniversary is certainly something for me to be proud of and to celebrate. Although I left UCSD in 2000, I have always felt that the Department of Bioengineering was a family to me. During my Ph.D. and Postdoc from late 1993 to early 2000 in the Department of Bioengineering, I saw the Bioengineering's transition from a Program in the Department of AMES to an independent Department of Bioengineering in 1993/1994. I am extremely pleased to see the tremendous growth of the department in the past 10 years since it was established in 1994.

My memory of Bioengineering at UCSD is simply that of integration, which I see as one of the department's strengths. The integration of many scientific disciplines at UCSD Bioengineering is one of the most important benefits for Bioengineering students to succeed in their job searches and career development.

There are many examples to illustrate the integration of disciplines in the department. For example, our Bioengineering's faculty infrastructure is an integration of well-known professors, focusing on a variety of interdisciplinary studies; our Bioengineering's syllabus is an integration of multidisciplinary courses covering mechanics, biology, medicine, electronics, etc., and our Bioengineering's graduate student team is an integration of outstanding students from various majors.

Our Bioengineering "giants" reflect the best examples of the department's culture of integration strategies. Dr. Y. C. Fung, the "Father of Bioengineering" in the U.S.A. and the Founder of Bioengineering Program at UCSD early in 1966, integrated the traditional mechanics in organ systems, tissues, and biological molecules. The range of Dr. Fung's encyclopedic knowledge covers all the fields of

mechanics, mathematics, medicine, and life science. Dr. Richard Skalak, the former President of the Biological Engineering Society and internationally famed scientist in bioengineering, my former Ph.D. advisor, integrated his mathematical and mechanical modeling to the individual cell. Dr. Shu Chien, the Founder and Director of the Department of Bioengineering at UCSD and the Bioengineering Institute of California, one of the most active senior leaders in the global bioengineering society, my Ph.D. and Postdoc advisor, successfully integrated the engineering concepts in his major fields of medicine, physiology, and molecular biology.

Dr. Chien's integration achievements are demonstrated not only in his research, but also in his scientific and administrative leadership. Almost all of the Bioengineering milestones in the past 10 years are attributable to Dr. Chien's artful execution of integration strategies in his leadership, which is important in keeping our Bioengineering at the top place in the national rankings of bioengineering programs over the years. In recognition of his ideas and ability to integrate many different scientific disciplines, Dr. Chien led the effort in getting the Whitaker Foundation Development Award in 1993 that allowed the recruitment of new faculty and the creation of the new Bioengineering department in 1994. Dr. Chien also was the driving force that won the Leadership Award from the Whitaker Foundation in 1998 and gifts from the Powell Foundation, and the Von Liebig Foundation in 1999, which allowed the construction of the new Powell-Focht Bioengineering Hall to help fulfill the growing mission of research, education and technology transfer. The integration of over 100 campus-wide faculty members and research fellows in the Whitaker Institute of Biomedical Engineering is another one of Dr. Chien's masterpieces that facilitated bioengineering research collaborations across biology, medicine and engineering. Dr. Chien's efforts to integrate the departmental faculty members in applications of NIH grants allowed receipt of two terms of PPG within the last 10 years, supporting major research projects, staff, research fellows, and graduate students in the department.

Another two examples of Dr. Chien's achievements from his magic integration strategies directly benefited my Ph.D. thesis and postdoctoral research projects. Through his application of my thesis project of gene therapy to the pharmaceutical needs of target drug discovery, we received an award from Alliance Pharmaceutical Inc. to support research in gene therapy of cardiovascular diseases. When I was developing the microarray platform as a postdoc in early 1999, Dr. Chien integrated the activities of many in the departments of Bioengineering, Biology, and Medicine to establish a microarray core facility to support projects using microarrays at UCSD.

Happy 10th Anniversary UCSD Bioengineering!

A Historical Perspective

The Bioengineering Graduate Student Symposium

Karen D. May-Newman, Ph.D.
Associate Professor and Chair,
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The Bioengineering Graduate Student Symposium (BGSS) has long been a tradition in Bioengineering at UCSD. It was initiated in 1987 by a group of graduate students (urged by faculty) to give a brief overview of their research projects in a symposium setting. The target audience has primarily been the incoming graduate students, in order to provide information for them regarding their choices for thesis projects. However, the other students and the faculty all benefit from the exchange and understanding of research in the department.

Since its inception, the symposium program, facilities, catering and publications have been organized and executed entirely by the students, who devote long hours to ensure that the event runs smoothly. Traditionally held on a Saturday, the day begins with a continental breakfast followed by 2-3 sessions of 8-10 talks each. Customarily, each lab group first provides an overview talk, followed by several brief individual talks.

Every graduate student was "strongly encouraged" by the faculty and other senior graduate students to participate each year first, as speakers, and eventually as organizing committee members. This experience provides several opportunities for students: first, it offers a friendly environment for what is often a student's first professional-style oral presentation; second, students can gain experience in different organizational roles which prepares them for future involvement with professional

organizations. Finally, it is a social event which brings together students, staff and faculty of the department and promotes exchange and interaction.

Each year, the organizers tried to improve upon the previous year's symposium. In the early days, no formal budget existed for the event, and the dinner was often a pot luck with delicacies prepared by students, staff and faculty. Eventually a fundraising effort was launched, and a budget created to cover the expenses of catered food and printing a symposium booklet. When the Whitaker Foundation initiated its support of the UCSD program, additional funding was provided to expand the BGSS to its current level. The evolution of this event over the years is a testimony to all students past and present.

One particular year, a major focus of improvement was to ensure that the symposium did not extend too long past the scheduled conclusion. The previous year, several speakers had not restricted the length of their talks to the recommended level, and consequently the event had gone more than an hour overtime. This had greatly annoyed several students, and the organizing
committee was determined not to let such a thing happen again. The apparent solution to the problem was to create a schedule, then stick religiously to it. Technology was acquired to assist in this goal, in the form of a timer that could be set to show a green light (keep talking), yellow light (time to end now), and red light (that's all, folks) between which the intervals could be set. Every speaker was provided with the timer and asked to use it to help them modulate the length of their presentation. However, even with such a reliable device to reinforce the schedule, manual intervention was ultimately required. One student, apparently extraordinarily enthusiastic about his presentation, did not seem to notice the light change to red, or perhaps felt that the rest of his research story was too important to stop much to the dismay of the organizing committee. Fortunately, one of the committee members, who was also serving as the Master of Ceremonies, took a bold course of action and stepped neatly in front of the microphone, thanked the speaker for an interesting presentation, and announced the next talk. One could almost envision the Shepherd's crook appearing from behind the curtain. After an initial surprised silence, the next speaker began his talk and the event went smoothly from there. Needless to say, everyone that followed completed their talk within the allotted time.

The event traditionally culminates in a dinner at a faculty members house. For many years, it was held at Professor Intaglietta's house with its beautiful view of Mission Bay. The warmth he extended at his home, and the camaraderie of the students and faculty following a day of meaningful professional exchange was one of the special occasions/events that made the UCSD Bioengineering program special.

The BGSS has undoubtedly continued to evolve to provide a unique opportunity for UCSD students to participate in conference organization at an introductory level. This event was founded on the willingness and perseverance of senior students to initiate this ambitious event. The creativity and hard work of these early organizers has resulted in a strong foundation which generations of students that have followed have built upon. With the support of the Whitaker Foundation, this event has blossomed further, providing a unique mechanism for students to gain valuable career experience as well as contribute to the continuing growth of UCSD Bioengineering.

Withstanding the Test of Time

Reza Mazhari, Ph.D.
Director of Cardiovascular Physiology,
Artesian Therapeutics, Inc., Gaithersburg, MD

In 1967, Krebs wrote "Scientists are not so much born as made by those who teach them research" (Nature; 215:1441), and teaching research excellence is the cornerstone of Department of Bioengineering at UC San Diego. While attending the annual Biomedical Engineering Society meeting in Nashville in 2003 and getting a chance to see many of the Department's alumni, it occurred to me that each and every one has become very successful in their profession. More importantly, the level of success of alumni is not only prevalent to the ones that pursued an academic route, but also others that followed alternative professions in sectors such as law, biotechnology and drug discovery, medicine, and finance. This attests to the core values and educational goals that the founders of the Bioengineering Program (and subsequently Department) set almost 40 years ago and pursued many years thereafter. In my opinion, the strength was in teaching the essentials of biology and physiology (partly thanks to close relation with the Department of Medicine), and applying the fundamentals of engineering to explore and elucidate the underlying mechanisms of normal and diseased function from cells to organs. In this process novel methods and tools have been developed, and many hypotheses have been tested. The product of this has been talented and multifaceted graduates and trainees at all levels—bachelors to post-doctoral fellows—that approach problems in a systematic and quantitative way, with a clear understanding of the "big picture". This approach has endured the test of time, even in the era of "you-name-it"-omics.

I joined the Department as a junior pursuing a bachelor's degree in 1993 and stayed on until 1999 finishing my Ph.D. The breadth and value of my education provided by the Department became more apparent at each stage in my career: first in transition from cardiac biomechanics to cellular biophysics and electrophysiology as a post-doctoral fellow at Johns Hopkins School of Medicine; next as a research faculty for a short stint at Hopkins' Biomedical Engineering Department; and most recently as a key member of a drug discovery and development start-up team. The Department and its faculty and their vision all played a crucial role in this diverse and challenging journey.

Growing and Helping Others to Grow

Melissa Kurtis Micou, Ph.D.
The Cooper Union for the
Advancement of Science and Art, New York, NY

Teaching is a pursuit that is inspired by the example of others. For me, the inspiration came during my time in the bioengineering department at UCSD, where I studied for five years while obtaining my Ph.D. The most memorable features of the graduate program were the faculty's excellent leadership and their eagerness to work closely with students in the classroom, laboratories, and elsewhere. To have access to so many great minds—minds that pioneered and shaped the field of bioengineering—is more than any student could have asked for.

I remember the day I turned in my dissertation unexpectedly running into someone who had inspired me even before my arrival at UCSD, Professor Y.C. Fung. He immediately said hello and apologized for not attending my defense several days before. He went on to relate a story about the day he turned in his own dissertation. I was both humbled and grateful to have such a venerable professor share his time, wisdom, and personal experiences with me. These are the kind of encounters that make the bioengineering department at UCSD such a special place to learn.

Having had the opportunity to gain motivation and insight from the people whose ideas originated the subjects I now teach, has developed in me a strong commitment to bioengineering education. Currently, I am a professor at the Cooper Union, a small undergraduate college. The transition to teaching has been very natural for me, largely as a result of the exceptional role models I have had. However, when difficulties arise, I find myself benefiting from the strong network of UCSD bioengineering alumni, collaborators, and friends whom live and work alongside of me in New York.

In the future, I see the department continuing to grow at the rapid pace it has established for itself since its inception ten years ago. In the few years since I have left, the department has significantly expanded its facilities, areas of research, and personnel. As the department's capacity to perform valuable research increases, so too will the many academic opportunities enjoyed by the students. I salute the bright future of bioengineering at UCSD, and wish upon its students the same superior quality of education that I received and now hope to pass on to future engineers.

Wonderful Days at UCSD

Song Li, Ph.D. '97
Assistant Professor, Bioengineering
University of California, Berkeley

I joined the bioengineering graduate program at UCSD in 1993, and I fortunately experienced the birth and the growth of the Department of Bioengineering. In 1993, bioengineering was a program in the Department of Applied Mechanics and Engineering Sciences. As I remember, the bioengineering program had about 10 core faculty, and occupied about half of the fifth floor in Engineering Building Unit I. I was impressed by many things when I went to bioengineering program at UCSD: excellent faculty, the diversity of the students' background, the creative curriculum, the second-to-none intellectual environment, the beautiful beaches, and nearly perfect weather. The graduate curriculum integrated the engineering and biological sciences very well. Some of the courses such as biomechanics, physiology and molecular biology for engineers probably were the first of the same type of courses offered in engineering schools across the country. The Friday seminar was a traditional gathering of the faculty and students for decades. Extensive collaborations between engineers and biologists resulted in productive research. I benefit tremendously from the training (especially from my advisor Dr. Shu Chien) and the intellectual environment at UCSD. My learning experience as a graduate student, postdoc and research scientist at UCSD has great impact on my career development. In 1994, with the efforts of the bioengineering faculty led by the founding chair Dr. Shu Chien, the new Department of Bioengineering was born. Since then the department has been growing, and ranked as one of the best bioengineering program nationwide. I still remember the exciting moment of the groundbreaking for the new bioengineering building. My best wishes for my academic home-the department of Bioengineering at UCSD!

Bioengineering Leadership

Bioengineering Graduate Students
Vicki Chin, M.S., Ph.D. Candidate
University of California, San Diego

The Bioengineering Graduate Students group, known as BEGS, was formally begun in 1994, shortly after the formation of the Department of Bioengineering at UCSD. So, BEGS is also celebrating its 10th anniversary this year!

Our mission over the years has been to support and enrich graduate student life in the department by providing social, academic, and industrial connections. We have began and now run several events that are annual traditions. In the fall, we host the Breakfast with Industry, now in its tenth year, where we bring together local industrial representatives and graduate students to discuss research and industry activity. In the spring, we host the Bioengineering Graduate Research Symposium. An annual event for the last eighteen years, this event showcases our latest research progress to fellow students, faculty, local industry, and prospective graduate students. Graduate students from all labs in bioengineering give talks, and students present individual work in a poster session. During the symposium, senior graduate students make a special effort to reach out to undecided first year graduate students and to increasingly sophisticated prospective students who are planning ahead to their graduate research. Current graduate students also play a crucial role in recruiting new graduate students. During the annual recruitment weekend, we hold several events where we can socialize and discuss grad school life away from the lab.

At the beginning of the school year, BEGS also helps ease the transition for new graduate students by running a big sibling program, where new students are paired with older students who provide advices on the academic program, research opportunities, and life at UCSD in general. We organize several social hours in September to help new students to get to know each other. In addition, BEGS also holds monthly social hours throughout the year to provide a convenient way to relax and get together with students from different labs or different years.

A recent improvement to bioengineering graduate student life was the addition of the Graduate Student Lounge, made possible by a challenge grant from Erik Engelson. His generous gift enabled the department to set aside space for graduate students to gather, study, and socialize. In the lounge, desks, conference tables, and couches provide different opportunities to work, while the ping-pong table and foosball table help relieve stress during exams and after long hours in the lab. Another new initiative to improve graduate life includes a program targeted to female graduate students. Every few months, female graduate students and faculty gather over dinner to socialize and discuss issues ranging from work-life balance to the workout to relieve stress. In the next ten years, we look forward to further enriching graduate life in bioengineering through these programs, as well as developing new programs to meet the changing needs to graduate students.

Dedication to Education

Geoffrey von Maltzahn
Ph.D. Candidate

I firmly believe that the strength of any institution lies in its ability not only to educate, but also to inspire. As a result, when I was deciding where to attend graduate school, I was immediately drawn to UCSD's bioengineering program not only for its accomplished faculty and majestic location, but also because of its perfect ranking in the US News "Quality of Teaching" category.

Now, having just finished my first year of classes, I can fully endorse this ranking. UCSD Bioengineering students are truly fortunate to have faculty as dedicated to their research as their teaching. My professors have been at once extremely approachable, kind, forthright, and fun—traits that have made my classes both interesting and inspiring. I believe this is the great strength of UCSD Bioengineering and it is one that promises to continue for many years to come.

BMES AT UCSD

Shirley Lee
Class of 2006, BMES President 2004-05
Eun Hee Han
Class of 2004, BMES President 2003-04

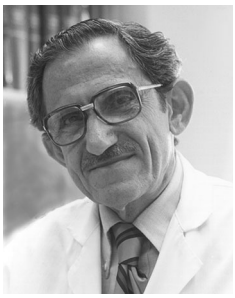
UCSD undergraduate chapter of the Biomedical Engineering Society was established in 1985. Since then, UCSD BMES has been active in promoting biomedical engineering among the undergraduate students.

Our chapter of BMES has been rapidly expanding in the last few years and has offered students a broad range of activities to enrich their social, academic, and professional development. We have had and plan to continue an outreach program that allows students to inspire elementary school children to develop interests for science and engineering and a mentor program that matches freshmen and sophomores with upper class students who can provide guidance and advice. We also sponsor quarterly Industry Nights that expose students to company profiles and possible career paths, graduate student and alumni panels that provide insights into graduate school and industry, and graduate school application workshop for those who have decided to apply. These events and programs would not have been successful without the support of the Bioengineering Department. Some of these events started out as grand ideas that we dreamed about. But our faculty advisor Dr. Sah, undergraduate advisor Margene Wight, and Department Chair Dr. Chien, and the Department allowed us turn these visions into reality by helping us with contacts, location, A-V equipments, publicity, food for hungry students and constant encouragement.

We have been able to accomplish much in the last few years, but like any other organization, we are always looking for ways to improve. Some of the goals for the organization in the coming years include strengthening student membership, fostering professor/student relations, increasing inter-organization collaborations, and solidifying national involvement.

Benjamin W. Zweifach - A Visionary in Bioengineering

Geert W. Schmid-Schönbein
Bert Y. C. Fung



Benjamin Zweifach was with YC Fung and Marcos Intaglietta one of the three founding members of Bioengineering at UCSD. In 1966 he was far ahead of its time and catapulted for the creation of this new discipline. Among the three founding members of Bioengineering at UCSD, Professor Zweifach made the longest jump into the unknown. He left behind a stellar career in Physiology, Biology and Pathology in New York to follow an entirely new direction in engineering, not only in spirit but also in distance. He was working on the most challenging problems in medicine and saw the need for a giant leap forward. He used a sabbatical at the California Institute of Technology to meet a group of engineers, expert on how to make airplanes faster and safer and improve the electronics, with the plan to interest them in biological problems. That was the start of Bioengineering, born out of an unlikely wedding of academic disciplines.

Benjamin W. Zweifach received a B.S. degree from the College of the City of New York in 1931 and his Ph.D. degree in Cellular Physiology from New York University in 1936. He served as Assistant Professor and then as Associate Professor of Physiology in the Cornell Medical School from 1947 to1952. He then returned to New York University as Associate Professor of Biology and Pathology until 1958 and Professor of Pathology until 1966. At UCSD he served as Professor of Bioengineering until the very last day of his life in 1997. He directed and served for 28 years from the birth of the program to the creation of a full service University Department. For years he was a center of thinking and activity in the bioengineering group.

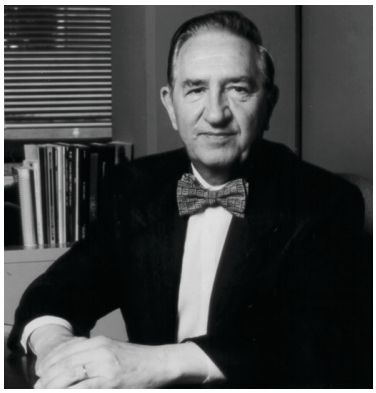
His interest was in the microcirculation and development of modern techniques to measure events in biological tissues. He used the study of a living tissue as a unifying theme in Bioengineering. He saw an opportunity for engineering and the tremendous advantage to integrate medicine and engineering. He introduced engineering students to the study of the Inflammatory Process, a phenomenon that today is taking on center stage in cardiovascular research of human disease. He pioneered the exploration of blood rheology in the microcirculation, the study of transport in different tissues, lymphatics, and many aspects of physiology. His rich record of writings are a cornerstone of bioengineering ediucation today and they have triggered many new lines of investigation. He saw the opportunity to expose young bioengineers to the challenges of medical problems from hypertension to diabetes and shock. He made discoveries that inspired a generation of bioengineers. . His work lead to the development of fundamental new approaches to study the microcirculation with engineering techniques, which are now used world wide and serve the benefit of patients. His vision remains still guidance for modern bioengineering.

Widely recognized, he was member of many learned societies and a friend and consultant around the world. In 1979 he and YC Fung chaired the World Congress for Microcirculation on the campus of UCSD. He co-founded and developed the Microcirculatory Society and was Honorary Member of many Microcirculatory Societies world-wide. The Microcirculatory Society recognized his extraordinary achievements and set up a ZWEIFACH GOLD MEDAL AWARD in 1982, which is issued every four years to one worker with outstanding research in the field. An extraordinary leader, his students are working today at Universities and in Industry throughout the world and make important contributions to daily medical practice, new diagnostic techniques and therapeutic developments. Benjamin Zweifach is the founder of modern 20th Century Microcirculation Research.

We are extraordinary grateful to Professor Zweifach. In his honor the Library on the 4th floor of the Powel-Focht Bioengineering Hall is designated as the Zweifach Library.

Richard Skalak, Ph.D.

Professor of Bioengineering



Professor Richard Skalak was born in New York City in February 5, 1923. He grew up in New York City and was educated in its public schools system. He received his B.S., C.E., and Ph.D. in Civil Engineering and Fluid Mechanics from Columbia University, where he stayed as a faculty member and became a Full Professor in 1964. Until his leaving for UCSD in 1988, he was James Kip Finch Professor of Engineering Mechanics from 1976, Director of the Bioengineering Institute from 1978, and Chairman of the Department of Civil Engineering and Engineering Mechanics from 1985. He made sterling contributions to research, education and administration as a faculty at Columbia for over forty years.

In 1988, Professor Skalak was recruited to UCSD as Professor of Bioengineering. In addition to his outstanding educational and research accomplishments, he played a major role in the formation of the Institute of Biomedical Engineering and the Department of Bioengineering at UCSD, and the successful application for the Whitaker Foundation Development Award. From 1992-1996, he was the Founding Director of the Institute of Mechanics and Materials established by the National Science Foundation at UCSD. He did a marvelous job in promoting interactions between the disciplines of mechanics and materials across the nation, through symposia, workshops, lectures, scientist exchange, and academia-industry interactions.

Professor Skalak had an illustrious academic career. His early research interests were in the engineering applications of fluid mechanics, especially in the fields of water hammer effects and fluid turbulence. In early 1960s Professor Skalak began to combine engineering mechanics and biomedical sciences. His performed pioneering work on wave propagation in the pulmonary circulation. In 1967-1968, he took a sabbatical leave to work with Dr. P.-I. Brånemark in the University of Gothenburg. There he performed the classical study on flow and deformation of human blood cells in the living microcirculation. Upon returning to Columbia, he initiated a series of imaginative and elegant research studies on biomechanics of blood and blood cells, including the material properties of red blood cells and cell membrane, viscoelasticity of white blood cells in the passive and active states, micromechanical and molecular bases of cell aggregation and adhesion, blood cell interactions in capillaries and microvascular network, and flow properties of blood in the circulation. These interdisciplinary studies have important implications in a number of clinical conditions including inflammation, blood diseases, cardiovascular disorders, and cancer.

Professor Skalak also made prominent contributions in several other areas of biomechanics including craniofacial growth, skin replacement, material transport in tumors, osseointegration and titanium

implants. He played a major role in fostering tissue engineering as a new frontier in biomedical engineering.

Professor Skalak has an unusual ability to combine engineering analysis with biomedical experimentation. He was able to formulate problems by distilling their essence into clear mathematical form, and to seek out the subject that is fundamental and important. His analytical approach guided many innovative experimental studies, provided novel insights, and generated new understanding of biological function. He had an unceasing, unselfish, drive to create innovations and to teach these qualities by example to students and associates.

Professor Skalak was a talented and dedicated teacher; he won the Great Teacher Award of Columbia University in 1973. He trained many graduate students and postdoctoral fellows, who hold key positions in academia and industry.

In recognition of his outstanding achievements, Professor Skalak received many prestigious awards and honors. His leadership and visionary role was sought after by many governmental academic and private organizations. Particularly noteworthy is the multitude of accolades bestowed upon him by the American Society of Mechanical Engineers (ASME) for his outstanding service. He received the Centennial Service Award in 1980, the Lissner Award in 1985, the Melville Medal in 1990 and the Applied Mechanics Award in 1997. Professor Skalak served as Chairman of ASME Applied Mechanics Division and was elected as ASME Fellow in 1981. Professor Skalak was Editor of the Journal of Biomedical Engineering of ASME from 1983-1987.

The other awards and honors conferred to Professor Skalak included the ALZA Medal from the Bioengineering Society in 1983, the Theodore von Karman Medal from Engineering Mechanics Division of the American Society of Civil Engineers (ASCE) in 1987, the Poiseuille Medal from the International Society of Biorheology in 1989, an Honorary M.D. Degree from the University of Gothenburg in 1990, and the Medal of Merit from the Czechoslovakian Academy of Sciences in 1990.

Professor Skalak was elected to many other honorific societies and academies, including Fellows of American Academy of Mechanics in 1982, ASCE in 1985, New York Academy of Medicine in 1985, Society of Engineering Science in 1990, American Institute of Medical And Biological Engineering in 1990, and American Association for Advancement of Science in 1996. A most distinguished honor is his election to membership in the National Academy of Engineering in 1988.

He was President of the Society of Engineering Science in 1982 and Society of Biomedical Engineering in 1983, and Co-Chairman of the First World Congress in Biomechanics in 1990 and Biomedical Engineering Society Annual Fall Meeting in 1997.

Professor Skalak was kind, considerate, generous, encouraging, creative, self-disciplined and hardworking. He was tireless in his working habit, including the efficient use of time on the airplane and in the hotel during his many trips in U.S, and abroad. He has an outstanding administrative ability and inter-personal affinity. A "Richard Skalak Colloquium in Biomedical Engineering" was established at Columbia University in 1996. At UCSD, a "Richard Skalak Bioengineering Lectureship" has been established in honor of his outstanding accomplishments and leadership.

Professor Skalak is survived by his wife, nee Anna Lesta Allison, whom he married in 1953. They have four children, Steven, Thomas, Martha, and Barbara. Thomas Skalak is a proud alumnus of UCSD Bioengineering (Please see his article in this book) and Chair of Biomedical Engineering at the University of Virginia.

As we celebrate the Tenth Anniversary, we recall with fond memories and warm gratitude that the Department were graced by the presence of such a giant in bioengineering and such a marvelous human being. Professor Skalak's spirit, thoughts, and deeds have been spread to all parts of the world, and he will always be a guiding light for generations to come.

Sidney Sobin, Ph.D.

Professor of Bioengineering

Professor Sidney Sobin was a physician and physiologist who turned himself into a superb bioengineer. His broad knowledge in physiology and enthusiasm in bioengineering research greatly influenced the formation of our department in early years. Sid was born on Jan. 1, 1914 in Bayonne, N. J., son of Ben Hur and Eva Neuman Sobin. He entered the University of Michigan in 1931 on an athletic scholarship, received his Ph.D. in 1938, and M.D. in 1941. In 1942-44, he was Instructor at Washington University, St Louis. In 1944-46, he was Fellow at Harvard with Dr. Landis. He was Research Physiologist at the University of Southern California from 1947-56 and Professor and Director of the Greater Los Angeles American Heart Association Cardiovascular Research Lab from 1957 on. From 1976 on he was Adj. Prof. of Bioengineering at UCSD. Dr. Sobin's worked closely with Dr. Fung in the development of the lung sheet flow theory and model. He developed many surgical models and standardized a casting technique for making models of microvascular beds in vital organs. Dr. Sobin gave advice freely and was attentive to people's needs. Faculty, students and staff considered him as a walking encyclopaedia and a true scholar and gentleman. At the age of 87, Dr. Sobin was the principal investigator of a California Cancer Program grant involving the early diagnosis of bladder cancer. He passed away on October 25, 2001 after a brief attack of leukemia.

Dr. Sobin was one of the founders of the Microcirculation Society. He wrote the Society's first set of Bylaws, and served as its President in 1965-1967. On June 12, 1980, he was honored with the Landis Award. In his acceptance speech he said, "My personal feelings are lofted by the name attached to the award. Eugene Landis exemplifies both in his science and in his personality." The same can be said of Sid Sobin, who, in science and in personality, are the finest in our profession.

Drahoslav Lim

Professor of Bioengineering

Drahoslav Lim was born on Sept 9, 1925, in what is now the Czech Republic, and passed away on the August 22, 2003 in San Diego. He received a Master's, Ph.D., and D.Sc. from the Technical University of Prague. He was the cofounder and head of the Division of Chemistry at the Institute of Macromolecular Chemistry in Prague, and he served as professor and head of the Polymer Department at the Technical University of Prague from 1966 to 1972. He came to UCSD as a visiting professor in 1980. He is survived by Jana, his wife of 47 years, their two children and five grandchildren.

Drahoslav made a remarkable achievement early in his scientific life. In the early part of the last century, doctors trying to find materials that could be used as implants for bone replacements, substitute blood vessels, artificial kidneys and other devices attempted to simply adapt existing construction materials for implant use. This led to an extensive trial-and-error process of material testing that was largely ineffective. Drahoslav's approach was to determine why the existing materials were not successful and then synthesize completely new materials specifically for implantation. He noticed that tissues have water throughout and reasoned that an implant with a polymer gel surface that imbibes water would appear as a watery surface to the tissue and would not be recognized as foreign. He reasoned that the polymers should have a relatively rigid structural backbone, but should be capable of becoming hydrated and gel-like in a controllable way. The new material was named a "hydrogel," and a description of the polymer was published in a landmark Nature paper. It also led immediately to soft and comfortable contact lenses, which became an enormous world-wide application, as well as gel coatings for a variety of other implants. Drahoslav's idea of designing novel implant

materials to coincide with the requirements of the body was a completely new way of thinking at the time. It led to the use of new words such as "biocompatibility," and made the way for research of many others in the field.

Dr. Lim came for an extended visit to the US in 1970 and was appointed a visiting professor at Stanford, working with Professor Paul Florey. He was soon contacted by Dr. Willem Kolff of the University of Utah, who was a developer of the artificial heart, to address the problem of blood damage when it came in contact with the internal surfaces of the artificial heart. Dr. Lim was asked if his hydrogel coatings could be developed to create a watery gel surface coating that would not damage blood. His various recommendations led to rapid advances in the success of the artificial heart.

During several subsequent years, Drahoslav was not publicly involved in science and spent much of his energy in negotiating with the Czechoslovakian communist government over the legal emigration of his family to the United States. The Communist government then in power was not sympathetic with his desire to leave and used the excuse that his work was a "state secret" and had military importance. Instead of simply defecting, Drahoslav took a long and tortuous approach to legally wining his right to emigrate. This was one of the only times that negotiation with the Communist bureaucracy was actually successful, but it left Drahoslav with a healthy skepticism about the Communism, and slightly less so about other governments.

At UCSD, Dr. Lim made a remarkable range of novel membranes for implantable glucose sensors. The membranes were made of biocompatible polymers, but he was able to impart of variety special properties by combining various polymers together. Individually, these are significant challenges, but to incorporate all of these features in desirable ratios and still have a membrane that is mechanically strong, sterilizable and can be made in large quantities is quite remarkable.

Dr. Lim was always keenly interested in education and he had strong opinions about how the teaching of chemistry should be more practical than it often is at present. Instead of standard textbook solutions, he often came up with novel approaches that were surprising for their simplicity. He was a very practical man. Although he had over 80 scientific publications in technical journals, he authored over 150 patents, many of which were technical landmarks.

Drahoslav was also a very modest man. He spoke little of his own achievements. During his years at UCSD, many of us had the pleasure of meeting with him to discuss the technical subjects and a variety of other subjects. These discussions revealed his wonderful humanity, appreciation for culture in the broadest sense, and positive outlook on life.

David Gough

Full Professors
Chien, Shu (Joint w/Medicine)
Fung, Y.C. (Emeritus)
Giles, Wayne (Joint w/Medicine)
Gough, David
Heller, Michael (Joint w/ECE)
Intaglietta, Marcos (Joint w/Medicine)
McCulloch, Andrew
Palsson, Bernhard (Joint w/Medicine)
Schmid-Schönbein, Geert (Joint w/Medicine)
Subramaniam, Shankar (Joint w/Chem/Biochem)
Sah, Robert
Watson, John

Associate Professors
Bhatia, Sangeeta (Joint w/Medicine)
Sung, Amy

Assistant Professors
Hasty, Jeff
Huang, Xiaohua
Huber, Gary
Ideker, Trey
Silva, Gabriel (Joint w/Ophthalmology)

Adjunct Professors
Albisser, Michael
Berns, Michael
Bjursten, Lars
Cantor, Charles
Galas, David
Hugli, Tony
Johnson, Paul
Lee, Jen-Shih
MacKenna (Asst.)
Ruoslahti, Erkki
Tong, Pin

Affiliated Faculty
Chau, Pao (MAE)
Chien, Ken (Medicine)
Covell, James (Medicine)
Ellismen, Mark (Neuroscience)
Hoger, Anne (MAE)
Kellner, Al (ECE)
Lieber, Richard (Orthopaedic Surgery)
Omens, Jeff (Medicine)
Sung, Kuo-li Paul (Orthopaedic Surgery)
Thomson, Scott (Medicine)
Wagner, Peter (Medicine)
West, John B. (Medicine)

Lecturers
Citron, Paul
Dobak, John
Kedrosky, Paul
Lutz, Michael

Research Scientist
Usami, Shunichi

Associate Research Scientists
Baker, Dale (Lecturer)
Price, Jeffrey (Lecturer)
Tsai, Amy G. (Lecturer)

Assistant Research Scientists
Mihaylova, Anouchka P.
Wang, Nanping

Project Scientists
Chen, Peter C.Y. (Lecturer)
Mikale, Milan T.

Associate Project Scientists
Hu, Ying-li
Huang, Wei
Li, Yi-shuan
Zhao, Yihua

Assistant Project Scientists
Chen, Albert
Miao, Hui
Usyk, Taras
Volfson, Dimitri

Department of Bioengineering Awards and Recognition

United States National Medal of Science Y.C. Fung, 2000

U.S. Academies

National Academy of Engineering
Member: Y.C. Fung, 1979; R. Skalak, 1988; S. Chien, 1997; J. Watson, 1998, P. Citron, 2003
The Founders Award: Y.C. Fung, 1998

National Academy of Sciences
Member: C. Cantor, 1988; Y.C. Fung, 1992; E. Ruoslahti, 1999

Institute of Medicine of the National Academy of Science
Senior Member: Y.C. Fung, 1991; Member: S. Chien, 1994; E. Ruoslahti, 2002

American Academy of Arts and Sciences C. Cantor, 1988; E. Ruoslahti, 1993; J.B. West, 2001

American Institute of Medical and Biological Engineering
President: S. Chien, 2000-01
Fellow: S. Chien, M. Ellisman, Y.C. Fung, D. Gough, G.W. J.S. Lee; G.W. Schmid-Schönbein, R. Skalak, S. Sobin, J. Watson, J.B. West, 1992; P. Citron, 1993; M. Intaglietta, 1994: A. McCulloch, 1998; J.A. Frangos, S. Subramaniam, 1999; M. Berns, 2000; B. Palsson, 2002
Pierre Galletti Award: J. Watson, 2002; S. Chien, 2004

Foreign Academies and National Awards

Member, Academia Sinica, Taiwan Y.C. Fung, 1966; S. Chien, 1976
Soviet Union, Kiev, International Cancer Research Technology Transfer Special Award M. Berns, 1977
Finnish Academy of Sciences *Member:* E. Ruoslahti, 1989
Czechoslovakian Academy of Sciences *Medal of Merit:* R. Skalak, 1990
Royal Society for Medicine of Ireland *Member:* M. Berns, 1991
Academy of Sciences and Letters of the Royal Society of Norway
Foreign Member: M. Berns, 1992; K.R. Chien, 2004
Academy of Science of the People's Republic of China
Foreign Member: (Historic first class) Y.C. Fung, 1994
Knight, Order of the White Rose of Finland E. Ruoslahti, 1994
Russian Academy of Sciences *Foreign Member:* J.B. West, 1995
Nobel Fellow, Karolinska Institute, Stockholm E. Ruoslahti, 1995
National Health Medal, Department of Health, Taiwan, ROC S. Chien, 1998
Medal of Merit, Order of Health "Dr. Humberto Fernandez Moran, Venezuela" M. Intaglietta, 2002

U.S. Government Agencies

U.S. Public Health Service and National Institutes of Health
NIH Career Award S. Sobin, 1962-93
PHS Special Fellow J.T. Watson, 1968-1971
NIH Forgaty International Fellow P.C. Johnson, 1984
National Cancer Institute Outstanding Investigator Award C. Cantor, 1985; E. Ruoslahti, 1986
PHS Special Recognition Award J.T. Watson, 1986
Jacob Javits Neuroscience Investigator Award M. Ellisman, 1989
NIH Director's Award J.T. Watson, 1996, 1998, 2000, 2002
NIH BECON Recognition Award J.T. Watson, 2003

Awards and Recognition (continued)

National Science Foundation
Presidential Young Investigator A. Hoger, 1990; A. McCulloch, 1991
Research Initiation & Young Investigator Awards R.L. Sah, 1993-99
CAREER Award G. Huber: 2001-05; S. Bhatia, 2002-07; J. Hasty, 2003-08
Department of Defense
DOD Army Breast Cancer Research Program *Innovator Award:* E. Ruoslahti, 2002

U.S. Professional Societies

American Academy of Dermatology *Leila Gruber Cancer Research Award:* E. Ruoslahti, 1993
American Academy of Mechanics *President:* Y.C. Fung, 1983-84, *Fellow:* R. Skalak, 1982
American Academy of Orthopaedic Surgeons *Kappa Delta Award:* R. Lieber, 1994
American Association for the Advancement of Science *Fellow:* C. Cantor, 1981; M. Berns 1983; P.C. Johnson, 1984; J.B. West, 1987
American Association for Cancer Research *G.H.A. Clowes Award:* E. Ruoslahti, 1990
American Association of Medical Instrumentation *Laufman-Greatbatch Prize:* J. Watson, 1995
American College of Chest Physicians *Presidential Citation:* J.B. West, 1977; *Distinguished Lecturer in Physiology:* P.D. Wagner, 1992
American Bone and Joint Surgeons *Nicolas Andry Award:* R. Lieber, 2002
American Fertility Society *Ortho Pharmaceutical Lectureship:* M. Berns, 1971
American Heart Association *Established Investigators Award:* B.W. Zweifach, 1950-55; W. Giles, 1995-2003; *Fellow:* G.W. Schmid-Schönbein, 2001
American Institute of Aeronautics and Astronautics *AIAA Fellow:* Y.C. Fung, 1969
Jeffries Medical Research Award: J.B. West, 1992
American Institute of Chemical Engineering *Fellow:* B. Palsson, 2002
American Society for Artificial Internal Organs *Hasting Lecture:* J.T. Watson, 2004
American Society for Biochemistry and Molecular Biology *Herbert A. Sober Award:* C. Cantor, 1990
American Physiological Society *President:* J.B. West, 1985-86; S. Chien, 1990-91; *Orr Reynolds Prize for History:* J.B. West, 1987; *Ray Daggs Award:* J.B. West, 1998; S. Chien, 1999; *Carl Wiggers Award:* B.W. Zweifach, 1993; P.C. Johnson, 1981; *Walton B. Cannon Memorial Lecture:* K.R. Chien, 1995; S. Chien, 2002; *Edward F. Adolph Distinguished Lectureship Award:* P.D. Wagner, 2002; *Guyton Teacher of the Year Award:* J.B. West, 2002
American Society of Biomechanics *Borrelli Award:* Y.C. Fung, 1992
American Society of Civil Engineering *Fellow:* R. Skalak, 1985; *Theodore Von Karman Medal:* Y.C. Fung, 1976; R. Skalak, 1987
American Society of Mechanical Engineers *Fellow:* Y.C. Fung, 1979; R. Skalak, 1981; *Lissner Award for Bioengineering:* Y.C. Fung, 1976; R. Skalak, 1985; *Centennial Service Medal:* R. Skalak, 1980; Y.C. Fung, 1981; *Worcester Reed Warner Medal:* Y.C. Fung, 1984; *Awards named after Y.C. Fung:* "Y.C. Fung Young Investigator Award", 1986; "Y.C. Fung Young Investigator Medal", 1999; *Y.C. Fung Young Investigator Award:* S. Bhatia, 2003; *Timoshenko Medal:* Y.C. Fung, 1991; *Bioengineering Division Best Paper Award:* S. Chien, C. Dong, G.W. Schmid-Schönbein, R. Skalak, & K.L.P. Sung, 1989; Y.C. Fung & S.Q. Liu, 1993; A. McCulloch, 1998; *Melville Medal:* S. Chien, Dong, G.W. Schmid-Schönbein, R. Skalak, & K.L.P. Sung, 1991; Y.C. Fung & S.Q. Liu, 1993; S. Chien (with Y. Huang and S. Weinbaum of CCNY), 1996
ASME International *Honorary Membership:* Y.C. Fung, 1996
American Society of Professional Engineers *DOT/RSPA Engineer of the Year:* P. Tong, 1986
American Society for Aesthetic Plastic Surgeons *Simon Fredericks Award:* M. Berns, 1982
American Society for Laser Medicine and Surgery *President:* M. Berns, 1987-88; *William B. Mark Award:* M. Berns, 1990
American Thoracic Society *Robert Grover Prize Pulmonary Circulation Assembly:* P.D. Wagner, 2000; *J. Burns Amberson Award:* P.D. Wagner, 2001; *Edward Livingston Trudeau Medal:* J.B. West, 2002; *President:* P.D. Wagner, 2005-06

Arthritis Foundation *Hulda Irene Duggan Arthritis Investigator Award:* R.L. Sah, 1993-1996
Association of Lab Automation Award: S. Subramaniam, 2001
Biomedical Engineering Society *President:* Y.C. Fung, 1982-83; R. Skalak, 1986-87; G.W. Schmid-Schönbein, 1991-92; J.S. Lee, 1994-95; *ALZA Award:* R. Skalak, 1983; Y.C. Fung, 1989; S. Chien, 1993; *Whitaker Distinguished Lecture Award:* M. Intaglietta, 1996, J.S. Lee, 1998; *Lamport Award:* K.L.P. Sung, 1992; *Outstanding Service Award:* J.S. Lee, 1988; *Distinguished Service Award:* S. Chien, 2001; J.S. Lee, 2002; Y.C. Fung, 2003; *International Distinguished Lecture Award:* M. Intaglietta, 2002
Biomedical Society *Jubilee Award:* E. Ruoslahti, 2003
Biophysical Society *Talbot Award:* R. Lieber, 1981; *Fellow:* C. Cantor, 1992; *Emily M. Gray Award:* C. Cantor, 2000; *Chairs of Departments of Physiology Distinguished Service Award:* P.C. Johnson, 2000; *Chinese Institute of Engineers Pan Asian Lifetime Achievement Award:* Y.C. Fung, 2004; *Computerworld-Smithsonian Institution Pioneer Medal:* D. Galas, 1999; *Federation of American Societies for Experimental Biology:* President, S. Chien, 1992-1993; *Harvey Society Lecture:* E. Ruoslahti, 1988; *ISCO Award for Advances in Biochemical Instrumentation:* C. Cantor, 1989
The Microcirculatory Society *President:* B.W. Zweifach 1960-61 & 1979-80; S. Sobin, 1965-67; P.C. Johnson, 1967-68; S. Chien, 1980-81; M. Intaglietta, 1985-86; G.W. Schmid-Schönbein, 2003-04; *Eugene M. Landis Award:* B.W. Zweifach, 1971; Y.C. Fung, 1975; P.C. Johnson, 1976; S. Sobin, 1980; S. Chien, 1983;
M. Intaglietta, 1999; *Award named after B.W. Zweifach:* "Benjamin Zweifach Award in Microcirculation" given at World Congresses of Microcirculation, 1982; *Innovative Instrumentation Award:* M. Intaglietta, 1993; *Curt Wiederhielm Award:* G.W. Schmid-Schönbein and A. Swei
Orthopaedic Reserach Society *Kappa Delta (Ann Doner Vaughan) Award:* R.L. Sah, 1993
Reticuloendothelial Society *President:* B.W. Zweifach, 1965; *Honorary Life Member:* B.W. Zweifach, 1985
Smithsonian Foundation *Citation for Innovation in Computing:* S. Subramaniam, 1997
Society of Engineering Sciences *President:* R. Skalak, 1982
Society for Biomaterials *C. William Hall Award:* J.T. Watson, 2000

International Professional Societies

Gairdner Foundation *International Award:* E. Ruoslahti, 1997
International Institute for Microcirculation *Honorary President:* B.W. Zweifach, 1983; *Distinguished Fellow:* P.C. Johnson, 1985
International Society of Biorheology *Poiseuille Medal:* Y.C. Fung, 1986; R. Skalak, 1989; S. Chien, 2002
3rd International Congress of Biorheology Chairmen: Y.C. Fung and B.W. Zweifach, 1978; *12th International Congress of Biorheology Chair:* S. Chien, 2005 (In conjunction with 5th International Congress of Clinical
Hemorheology Chair: F. Liao)
International Society of Biorheology and the **International Society of Clinical Hematology** *Establshment of "Chien-Fung Young Investigators Award"* for the Chinese Association of Biorheology and Chinese Society of Biophysics, 1995; First Awardee: H. Miao, 1995
International Society for Oncodevelopmental Biology and Medicine *Abbott Award:* E. Ruoslahti, 1995
International Society on Oxygen Transport to Tissues *President:* P.D. Wagner, 1992-93; *International Symposium on Blood Substitutes Award:* M. Intaglietta, 1993; *Young Investigator Award:* A. Tsai, 1993
International Union of Physiological Sciences *35th International Congress of Physiological Sciences Chair:* S. Chien, 2005; *Jacobaeus International Prize:* E. Ruoslahti, 1998
First World Congress of Biomechanics *Chairman of the Steering Committee:* Y.C. Fung, 1986-90. *Congress Co-Chairmen:* S. Chien and R. Skalak, 1990

World Congress for Microcirculation *Second World Congress of Microcirculation Chairmen:* Y.C. Fung and B.W. Zweifach, 1979; *Fifth World Congress for Microcirculation Benjamin Zweifach Award:* S. Chien, 1991
World Council for Biomechanics *Chairman:* Y.C. Fung, 1994-1998; *Honorary Chair:* Y.C. Fung, 1998-99
Asian Conference on Microcirculation *Gold Medal:* B.W. Zweifach, 1993; S. Usami, 2000
British Association for Cancer Research *Walter Hubert Lecture:* E. Ruoslahti, 1992
British Microcirculatory Society *Honorary Member:* B.W. Zweifach, 1984; *Claude Bernard Medal in Physiology, Canada:* B.W. Zweifach, 1964
European Academy of Science *Member:* M. Intaglietta, 2001
European Respiratory Society *Presidential Award:* P.D. Wagner, 2001
European Society for Clinical Hemorheology *The First Fåhraeus Medal in Clinical Hemorheology:* S. Chien, 1981
European Societies for Microcirculation *Malpighi Gold Award:* P. C. Chen, S. Kovalcheck, G.W. Schmid-Schönbein & B.W. Zweifach, 1980; M. Intaglietta, 1994; *Lafon Award:* G.W. Schmid-Schönbein, 1994.
European Societies for Phlebology *Ratchow-Memorial Gold Medal:* G.W. Schmid-Schönbein, 1999
German Society of Clinical Chemistry *Biochemical Analysis Prize:* C. Cantor, 1988
German Phlebological Society *Honorary Member:* A. Fronek, 1988
Hungarian Physiological Society *Honorary Member:* P.C. Johnson, 1990
Japan Society of Mechanical Engineering *Bioengineering Award:* Y.C. Fung, 1995
Japanese Biochemical Society *Honorary Member:* C. Cantor, 2000

Foundations and Other Private Sectors

David Baltimore Whitehead Fellow T. Ideker, 2002
Becton-Dickinson Career Achievement Award A. Albisser, 1981
BioMEMS & Biomedical Nanotechnology *Scientific Leadership Award:* S. Bhatia, 2001
BioMEMS & Biomedical Nanotechnology *World Meeting Clinical Transition Award:* D. Gough, 2002
Bristol-Meyers Squibb/Zimmer *Research Award:* K.L.P. Sung, 1997
Fulbright Fellow B. Palsson, 1995
Genome Technology *All Star Award:* S. Subramaniam, 2002
Guggenheim Fellow C. Cantor, 1973-74
Humboldt Preiss *Senior Scientist Award:* M. Intaglietta, 1982-83
Humboldt Fellow A. Fronek, 1988
IVAC Award D. Gough, 1982
Juvenile Diabetes Foundation *W. F. Talbert Award:* D. Gough, 1981; *David Rumbough Award:* A. Albisser, 1981; *M. J. Kugel Award:* D. Gough, 1996
Eli Lilly *Award in Biological Chemistry:* C. Cantor, 1978
MIT Technology Review *TR100 (100 most innovative young scientists):* Bhatia, 2003
David and Lucile Packard *Fellow:* S. Bhatia, 1999-2004
Robert J. and Claire Pasarow Foundation *Medical Research Award:* E. Ruoslahti, 1991; K.R. Chien, 1996
Alfred P. Sloan *Research Fellow:* C. Cantor, 1969-71; J. Hasty, 2003-05
Popular Science Magazine *"Best of What's New" Award:* S. Bhatia, 2002
San Diego Magazine "5*0 People to Watch in 2004":* S. Bhatia, 2004
T Sector and BIOCOM *Chief Scientist of the Year:* C. Cantor, 2002
Ernst Young *Prize for Medicine*, Hamburg, Germany: J.B. West, 1977

Bioengineering Ph.D. Graduates

1970
Evan A. Evans
Elliot Flicker
Frank C-P. Yin

1972
Gerald J. Kost
John G. Pinto
John Silva

1973
Yu-Liang H. Chen
Michael R-T. Yen

1975
Herbert H. Lipowsky
Robert R. Myers
Donald L. Vawter

1976
Stephen E. Borders
Anthony D. Falco
Larry L. Malcom
Joel M. Price
Geert W. Schmid-Schoenbein

1977
William J. Vlymen

1978
Peter Chen

1980
Jeffrey L. Borders
Bruce M. Fenton
John K. Leypoldt
Peter J. Talmachoff

1981
Cheng-Jen Chuong
Paul F. Zupkas

1982
Dennis C. Schneider
Lewis K. Waldman

1983
Gary L. Boseck
Peter M. Burkhard
Robert J. Siefert
Albert C. Ting

1984
Patrick A. Shoemaker
Thomas Skalak
Pius H-S. Tse

1985
Steve A. Jones
Deborah C. Yager

1986
Patricia J. Conway
Mitsumasa Matsuda

1987
Jorge Barroso-Aranda
Nancy M. Frandson
Joseph Y. Lucisano
Soheila Mirhashemi
Takaai Nakagawa
Donald W. Sutton
Tadashi Tamura
Hao Xue

1988
Christopher J. Armour
Joseph L. Higgins
Joseph M. Hollis
Joerg U. Meyer
Jeffrey H. Omens
Scott I. Simon

1989
Sima Ertefai
Michelle C. Mazzoni
Sima Mehlberg
Bradley J. Sargent
Amy C. Tsai

1990
Gregory R. Collins
Julius M. Guccione
Ghassan S. Kassab
Jye Lee
Shu Q. Liu
Jeffrey H. Price
Jennifer S. Wayne

1991
Gregory A. Breit

1992
Dale A. Baker
Dirk-Uwe G. Bartsch
Jack C. Debes
Ronald J. Podhajsky
Enrique Saldivar
Jianbo Zhou

1993
Shouyan Lee
Karen D. May Newman
Edward K. Rodriquez
Jack M. Rogers
Andrea M. Rourke
Robin Shandas
David Tung

1994
Deidre A. Mackenna
Sandra L. Van Leuven

1995
Wolfgang F. Bluhm
Kevin Costa
Catherine G. Galbraith
Jeffrey W. Holmes
Laura Walsh

1996
Janet C. Hansen
Brian P. Helmke
Thomas Ioerger
David C. Karr
Ann A. Lee
Fariborz Moazzam
Darin Saltzman
Yihua Zhao

1997
Thomas J. Burkholder
David R. Carta
Albert C.S. Chen
Jeffrey L. Emery
Cynthia Gibas
Song Li
Michael R. McCarthy
Keihan Rafii
Robert M. Schinagl
Allen Swei
Malini Viswanathan

1998
Tabassum Ahsan
Shila Jalali
William J. Karlon
Erik B. Kistler
Ming-Chao Lin
Michael E. Miller
Daniel Oblinger
Tina J. Patel
Atipat Rojnuckarin
Mohammad Sotoudeh

1999
Walton W. Baxter
Troy M. Bremer
Douglas G. Chang
Jeremy S. Edwards
Karl Francis
Jin Gang
William G. Lindsley
Reza Mazhari
George Pappas
Gregory C. Steinbach
Sonya R. Summerour
Frederick J. Vetter
Camille J. Vogt

2000
Jeff J. Bishop
Craig B. Clark
Darwin A. Farrow
Adam H. Hsieh
Pin-Pin Hsu
Joe T. Lin
Dennis Livesay
Todd N. McAllister
Christophe H. Schilling
Richard K. Suzuki
Sara M. Weis

2001
Elliot B. Botvinick
Miguel E. Bravo-Zanoguera
Twana Howard Davisson
Michael A. Dimicco
Yiping Fan
George Hunter
Melissa S. Kurtis
Leslie McNeil
James Schnitzer
Derrick Sung

2002
Yiping Fan
Keith L. Herrmann
Susanne Heynen
Michael C. Jablecki
Kelvin W. Li
Nathan L. McKnight
Sameer B. Shah
Carlos J. Vera
Yingxiao Wang
Amanda K. Williamson

2003
Joel R. Bock
Markus W. Covert
Roland R. Kaunas
Ilka Lorenzen-Schmidt
Rampriya Ramarathnam
Sharon J. Wiback

2004
Jared Allen
Won Chol Bae
Imandokht Famili
Stephen Fong
Edgar Gutierrez
Feimo Shen
Valerie Liu Tsang