

Jay Bailey as Mentor—The Students' Perspective

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Abstract: Professor James E. Bailey was not only a world-renowned leader and pioneer in biochemical engineering but also a mentor to the many graduate students and postdoctoral researchers in his group. To provide non-“Bailey-ites” with an impression of Jay as a mentor, we begin with a brief review of his career, focusing on the dynamics of the research group. Typical student experiences of being part of the Bailey group are then discussed, including the recognition of a particular research style and Jay's expectations for hard work. Finally, we provide some thoughts on Jay's mentoring style, which was marked by an ability to foster independence, a sense of quality, and passion for research. Jay's contributions as a mentor can perhaps be recognized as being as significant as his research achievements. © 2002 Wiley Periodicals, Inc. *Biotechnol Bioeng* 79: 484–489, 2002.

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INTRODUCTION

While many people are familiar with the research accomplishments of Professor James E. Bailey, his record as a mentor to nearly 100 graduate students and postdoctoral researchers (Fig. 1) over a 30-year career is also noteworthy. In this article, we attempt to describe Jay from his students' perspective and a little of what it was to be a part of his large and dynamic research group. Since each of us had a different experience during our years with Jay, this summary can never be completely accurate. Nonetheless, it reflects impressions common to the authors and several of our academic family.

HISTORICAL PERSPECTIVES

As a graduate student, Jay worked with Professor Fritz Horn at Rice University, making significant progress in the area of catalyst selectivity. He completed his Ph.D. in about 3 years and coauthored seven papers with Prof. Horn. Al-

though he didn't mention it to us, this level of graduate career productivity was not lost on Jay's students. Apparently it was remarkable to others as well, since Jay secured a faculty position at the University of Houston in 1971, at a time when very few positions were available.

Jay's career as an academic had three distinct phases, from his days as an Assistant Professor at the University of Houston to his 12 years at the California Institute of Technology (Caltech), and then on to the Swiss Federal Institute of Technology (ETH).

1971–1980: University of Houston

As an assistant professor, Jay made a concerted effort to strengthen his mathematical knowledge and abilities, and he soon recognized connections between reaction engineering (his primary area of expertise at the time) and biochemical engineering. Turning his attention towards problems in biochemical engineering, Jay published his first article on enzyme catalysis in 1973 (Bruns et al., 1973) and continued this work for the next 15 years. With Dave Ollis, he wrote a landmark textbook, *Biochemical Engineering Fundamentals*, and he served the University of Houston as Associate Dean of Facilities for Research from 1976–1978. What marked this period in Jay's career was his skill at self-learning and his desire to reach out to scientific problems and areas beyond his formal training. In extending the range of his research endeavors, he was careful to build on his expertise in chemical reaction engineering. One area that he initiated while in Houston was his effort to study the dynamics of bacterial and yeast cell populations. This work marked the start of an important hallmark of the Bailey approach: the integration of advanced modeling techniques with state-of-the-art experimental tools.

While the scale of the effort of the research group at the University of Houston was relatively limited compared to that in the later years, the group was still characterized by students very focused on their particular projects. Access to

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THE JEB PATHWAY

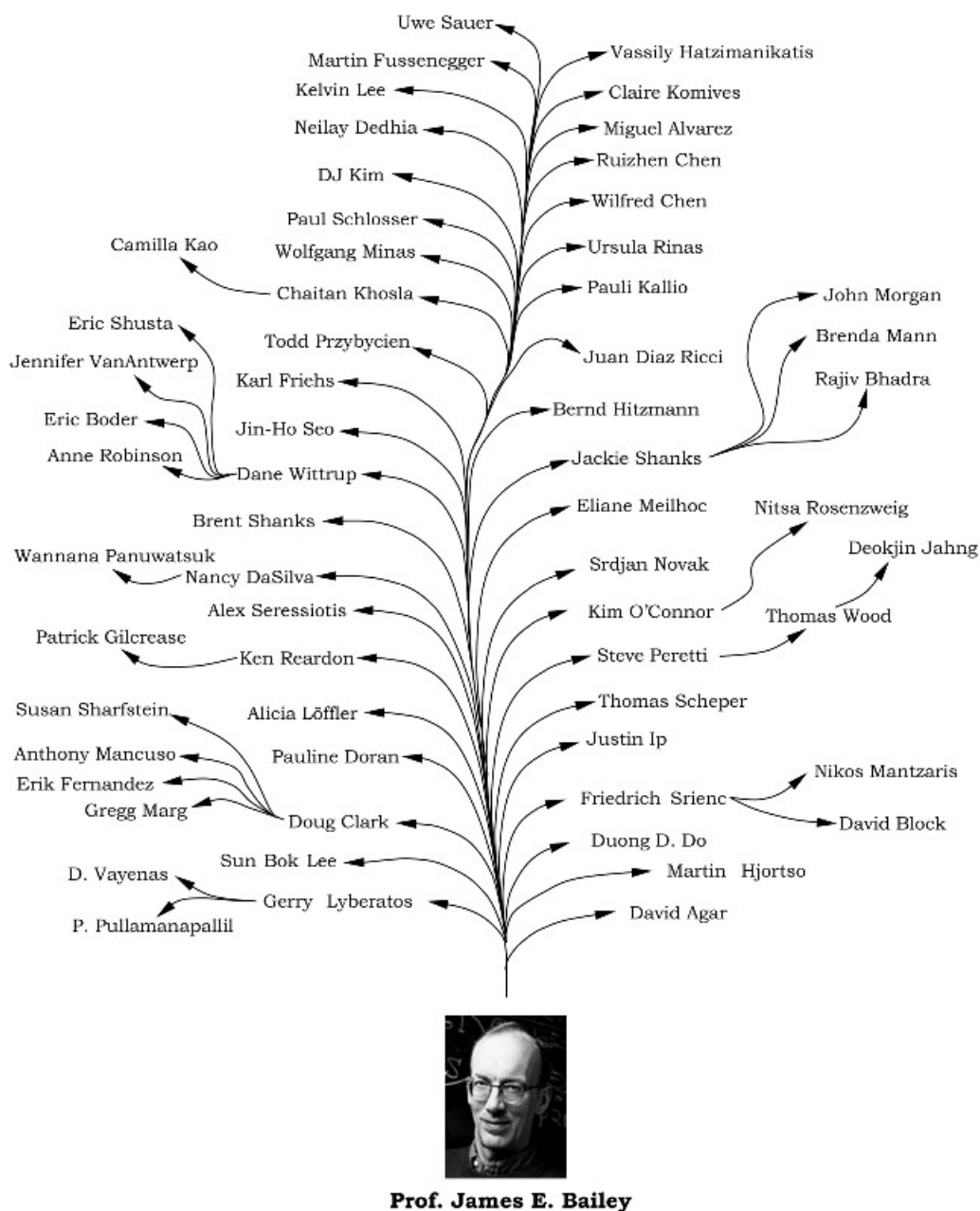


Figure 1. The Bailey academic family tree, appropriately depicted as a pathway. To simplify the tree, only those alumni in faculty or equivalent positions at academic or research institutions are shown. More than 50 other alumni from Jay’s academic career (1971–2001) work in industry or government.

state-of-the-art technology (e.g., flow cytometers) was available through interactions on campus, bringing students in contact with scientists in other disciplines. Overall, there was a definite feeling that Jay’s research interests were moving away from reaction engineering (although the reaction engineering effort did not more formally close until well into the Caltech years).

1980–1992: Caltech

In 1980, Jay provided his research group with a new environment by moving to Caltech. In this process, he demon-

strated that one of his most important commitments and responsibilities was to his graduate students. While the graduate students carried the major responsibility for packing up the laboratory, shipping it to Pasadena, and later unpacking everything, Jay made sure that there were no financial barriers for students to move and no logistical barriers to establishing themselves as Caltech graduate students. Perhaps one of the more notable outcomes from the move was the close bonding among graduate students that occurred for those students who moved from Houston to Pasadena. Indeed, this bonding among “Bailey-ites” is a

hallmark that continued throughout Jay's career and across generations of students.

Although Jay's career has been characterized by sustained, high-impact activity despite location and other issues (Fig. 2), the Caltech years were probably the most important to Jay's legacy as the bulk of the graduate students and postdocs come from these years. For most of this period, the group consisted of 12–18 graduate students and 3–5 postdocs and functioned as a highly productive and highly social research team.

At Caltech, Jay continued his work on bacterial population dynamics and extended this effort to plasmid-bearing cells. In doing so, Jay made a strong case for the need for biochemical engineers to have a detailed knowledge of biology as well as advanced mathematics. Moreover, Jay remained true to his style of using state-of-the-art experimental tools by being the first chemical engineer to embrace recombinant DNA technology and to use the molecular biology toolkit in the design of organisms with new properties. In this regard, the second edition of the Bailey and Ollis textbook was the first chemical engineering textbook to explicitly include a detailed discussion of the importance of recombinant DNA technology. The work in reaction engineering was phased out by the mid-1980s, and the research group was fully engaged by a plethora of problems in biochemical engineering. Jay's landmark article in 1991 (Bai-

ley, 1991) codified the concept of metabolic engineering and the work on *Vitreoscilla* hemoglobin served as a leading example of the power of metabolic engineering. While at Caltech, the laboratory adopted nuclear magnetic resonance imaging as an important experimental technology essential to metabolic engineering.

The Caltech years also marked the start of a long-lasting tradition: the Friday afternoon "Ho-Ho." This was our group social event held Friday afternoons in the Atheneum basement at Caltech, with snacks and beverages provided by Jay. Any visitors to the group were also invited, and the event gave everyone a chance to socialize and relax. Jay recognized the value this had for the wellbeing of the group (Finn, 1988) and made it a priority to keep this tradition going.

1992–2001: Swiss Federal Institute of Technology

In 1992, the laboratory prepared for a transition to the Swiss Federal Institute of Technology (ETH). Despite the many challenges associated with transplanting his research effort overseas, Jay's primary concern was again for his students. While it may not have been evident to students in daily conversations with Jay (or evident to any student with their faculty advisor), Jay's sense of responsibility for his students and their wellbeing meant that students could continue to focus on their educational and professional goals with minimal effort dedicated to the logistics of moving during the transition and start-up of the laboratory in Zurich.

Jay had a vision and desire to build a large, integrated, multidisciplinary group, and the move to the ETH provided an ideal opportunity to access the resources necessary to make this happen. While in Zurich, Jay saw the promise of genomics and the potential benefit that genome-wide studies could provide to metabolic engineering. No other biochemical engineering group at the time had a dedicated automated DNA sequencer. Similarly, he foresaw the promise of proteomics. At the same time, Jay saw a potential role for the biochemical engineer to aid in functional genomics. The research program extended to efforts to develop novel products as well as to the control of posttranslational processing, cells, cell cycles, and cell proliferation.

The time in Zurich was also characterized by a significant broadening of the collective background and culture of the group. Perhaps for the first time in Jay's career, coffee table conversations among group members took place in any of several languages including English, Spanish, Chinese, German, Swiss-German, and Italian. Although the differences between the Swiss and American academic systems had the potential to confound progress, the Bailey laboratory—with people from many different backgrounds working on different projects but guided by a single vision—took the best of both systems and synergistically grew the overall effort. The ability to access state-of-the-art instrumentation and computational power was one of the benefits of working in the laboratory at this time; however, an even more important benefit was the ability to engage people from

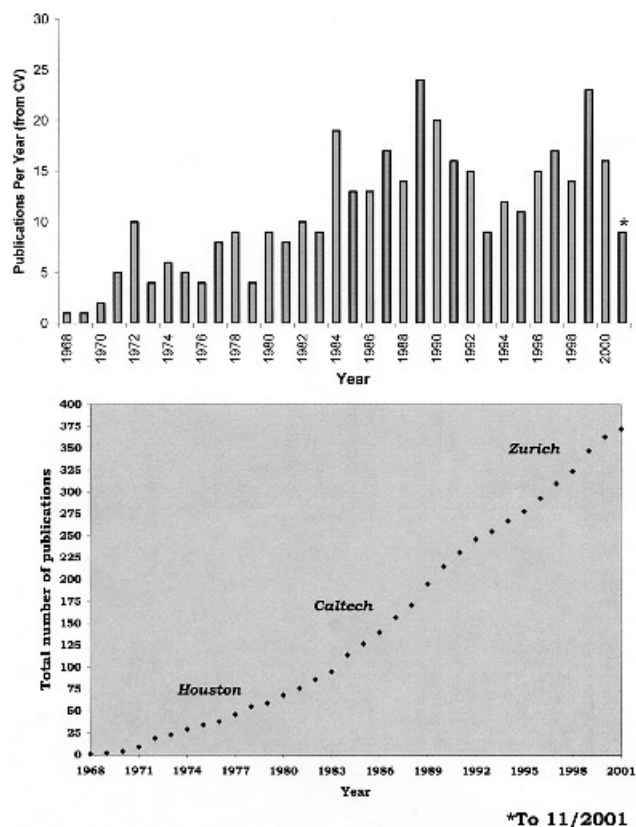


Figure 2. Bailey group publications, by rate (top) and total number (bottom).

such very different backgrounds and cultures. The level of personal growth associated with such interactions, which all the students from 1992 and beyond achieved, is a benefit that extends beyond our professional lives. Beyond these intragroup interactions, which were fostered by ongoing Ho-Hos at a beer garden overlooking Zurich, there was no shortage of connections to the biochemical engineering community in the United States. Many professors from the U.S. found themselves enjoying sabbatical visits to Switzerland.

STUDENT EXPERIENCES

While each of Jay's students and postdocs had their own experience as a member of the Bailey research group, there are many themes that we all remember. First, the group was diverse and full of interesting people working on a wide range of fascinating projects. We came from all parts of the U.S., Europe, and the world, each with our own tastes in music and food, our own hobbies, and our own definitions of "early." Starting from the early Caltech years, the group was large, so there were many chances for interesting conversations between experiments and calculations. Parties, whether at Jay's home or elsewhere, were times to relax away from the lab and trade stories and jokes (Fig. 3).

Adding to this diversity were the many scholars from industry and academia who visited the group, some for only a day and others for several months. While we often had discussions with these visitors in our offices and labs, the more interesting (and perhaps, productive) conversations came during the weekly Ho-Ho.

The variety of projects in the group was sometimes astounding—group meetings could feature updates on catalyst bifurcation experiments, flow cytometry, NMR, yeast genetics, plasmid stability, protein precipitation, and other topics. Hearing about these topics from our peers was a wonderful learning experience that allowed us to broaden our knowledge far beyond our own projects, and sometimes to bring new approaches to our work.

To do research for Jay as a student or postdoc meant working independently with high expectations for success. There were also expectations of creative new approaches since we knew that Jay was always interested in using new experimental tools, particularly those that yielded quantitative output and could thus be incorporated into a modeling effort. We were fortunate in having relatively few restrictions placed on our projects, including the cost of equipment and supplies (those of us now in academia or otherwise responsible for managing groups of researchers often wonder how he supported this enormous research effort). This atmosphere of letting nothing stand in the way of our research goals was revealed in large and small ways, even to the point of clearing red-tape roadblocks with the Caltech purchasing department.

Jay had high expectations both for performance and effort, and was typically clear in expressing these. As a result, the Bailey labs and offices were active late at night and



Figure 3. Bailey group gatherings. Top: Group members at a Friday afternoon Ho-Ho in the basement of Caltech's Athanaeum. Bottom: Thanksgiving dinner in Zurich.

throughout the weekend. Fortunately, there were always several other Bailey-ites around, and the work time became partly social time as well. Many of us made strong friendships with other group members through late-night lab conversations.

Despite the large size of his group, his substantial workload, and frequent travel, Jay was usually available to meet with us to discuss our projects and ideas. In hindsight, the fact that he could switch from discussing yeast population modeling to enzyme catalysis to metabolic pathway fluxes, with no apparent effort, is amazing. It was also a fascinating experience to listen as Jay showed a visitor around the lab, describing our projects. Considering the number of students and postdocs, and the fact that Jay had never actually done any biochemical engineering experiments, we were (nearly always!) impressed with how well he explained our research—and often he explained the goal of our work in terms we hadn't yet composed.

The Bailey group always had a strong sense of identity, particularly during the Caltech years. In hindsight, it is clear that Jay had evolved a lab with many of the elements cited by Kathy Barker as "The Lab Where Everyone Wants to Be" (Barker, 2002), including a recognizable culture of hard

work, excellence, and humor. Through Jay's comments about what made our work different from that of others, and our own experiences of this at conferences, we became aware that our brand of combining engineering with biology (and often molecular biology) somehow set us apart. We also took pride (and still do) in our group's achievements—conference presentations, journal articles, job offers, and especially the completion of a Ph.D. It is difficult to know whether this came as a result of a sense of group spirit somehow imparted by Jay, or bonding through long hours in the lab (or over drinks at Ho-Hos in the Athenaeum bar). Many of us have continued to interact on personal and professional levels, and there are often Bailey group reunions at AIChE and ACS meetings. A particularly memorable reunion took place in October 2000, when about 20 group alumni traveled to Rockford, Illinois to spend a weekend with Jay and one another. The event featured Jay's guitar playing (Fig. 4), and provided us with the chance to tell him how our time in the Bailey group had influenced our lives.

JAY BAILEY AS MENTOR

The 17 Bailey group alumni who are U.S. chemical engineering faculty members form a major part of Jay's legacy. The research programs of these individuals (including the four co-authors of this article) span the full breadth of biochemical engineering research, and reflect the unparalleled scope of the Bailey research program. During the Caltech years, the group often jokingly referred to itself as the BIT (Bailey Institute of Technology), so extensive were our ef-

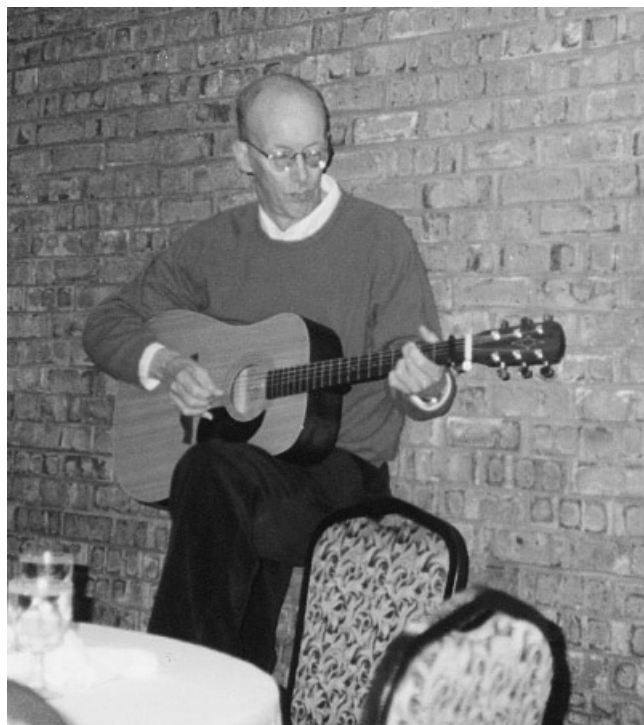


Figure 4. Jay playing the guitar at the group reunion in Rockford, IL (October, 2000).

forts and interests in the lab. What sort of training did Jay provide to launch so many academic careers?

One common aspect to all our experiences in the Bailey lab was the fostering of independence. Jay expected us to take an active hand in defining the underlying questions and approaches to answering them, rather than simply serving as a pair of hands in the lab. Jay's encyclopedic knowledge and questing intellect were responsible for scouting out a general research area, which was then conveyed to us in a "blue sky" introduction, often encapsulated in a single phrase intended to serve as our defining goal (e.g. "inclusion bodies," "yeast plasmid distributions," "in vivo phosphate NMR"). With these marching orders, we then went forth to attack the problem by whatever means necessary. Jay believed that our participation in formulating our projects was a critical part in learning how to do research (Finn, 1988). It was always clear that we needed to find a new and interesting approach to the problem, one that was up to the high standards set by Jay and our predecessors.

We were never completely alone in these endeavors, though. The support (both technical and emotional!) provided by the extended Bailey group was a critical component of our successes. By bringing together 20 or so highly motivated young researchers in one place, Jay created a critical mass of expertise that we all drew upon extensively. And although we didn't turn to Jay for trench-level advice on protocols and lab procedures, he was always readily available to help untangle intellectual puzzles or celebrate exciting results.

Another common aspect of our experience was the fearlessness with which we were encouraged to bring to bear whatever tools were necessary to solve the problem. It was this early experience in crossing boundaries that helped each of us (and, arguably, the discipline of biochemical engineering) expand into new research areas at the interface with modern biology (e.g., metabolic engineering, proteomics). Jay refused to be confined to the role of scaling up production processes for molecules that other people invented. The choice was not between being a first-rate biochemical engineer or a second-rate biologist (as famously posed by one of Jay's contemporaries)—the choice was whether or not to do work that solved important problems, regardless of the methods required. This attitude continues to be embraced by all of the Bailey alumni.

In addition to guiding our research efforts, Jay cared deeply about our professional development. He made it a rule that each of us present our work at one or more conferences, and regularly brought large contingents to AIChE and Engineering Foundation meetings. In the mid-80's, when many of us were considering academic careers, Jay held a series of mini-workshops on the nature of faculty jobs, proposal writing, student mentoring, and the like. Even after we left his group, he took great interest in our progress and helped many of us with convincing letters of recommendation and insights on how to work with students, balance workloads, and look at new research directions.

It is true that Jay's mentoring style was not of a particu-

larly warm and fuzzy variety, but this did not correspond to inattentiveness or lack of concern. We each knew that our particular project mattered, and had the potential to have significant impact. Jay shared our passion and ambitions for our work, and conveyed this enthusiasm both to us and to the outside world. His high expectations meshed with our own and permeated the group to such an extent that the lab would at times be half full on a Friday night (with creativity appropriately lubricated by earlier participation in the group Ho-Ho at the Athenaeum). Despite the hard work involved, we recall the excitement and atmosphere of Jay's group as a wonderful experience.

CLOSING THOUGHTS

Throughout his productive career, Jay often remarked that his greatest professional legacy and his finest accomplishments related to the students and postdocs whom he mentored. But all of us recognize that on the technical front, "he forever altered what biochemical engineering will be . . . as he understood the broad context of science and engineering better than anyone else in the field" (Shuler, 2001).

In the closing months of Jay's life, he discussed with several of us how he had begun to appreciate the human dimension of research mentorship. It had been a part of our experience with him all along, whether or not it was explic-

itly recognized as such. Jay launched many of us on fulfilling career paths that continue to form the central intellectual adventure of our lives—this could be nothing other than intensely personal, and is something for which we will always be grateful.

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