Dibakar "DB" Bhattacharyya

. . . of the University of Kentucky

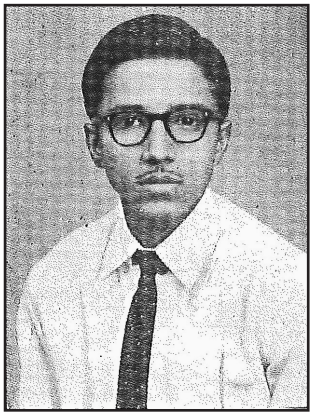
Douglass Kalika, University of Kentucky

In 2016, the University of Kentucky (UK) will celebrate the 60th anniversary of the establishment of the Department of Chemical Engineering in 1956. The UK Department of Chemical Engineering emerged from an industrial chemistry program that existed for much of the first half of the twentieth century, and which graduated such chemical engineering luminaries as long-time MIT faculty member William McAdams and Eger Vaughn Murphree of Standard Oil. For nearly 50 of its 60 years, chemical engineering at the University of Kentucky has been the professional home of Dibakar "DB" Bhattacharyya, and the department, its faculty, and its students have benefitted from his outstanding technical achievements, his skilled mentorship, and his indefatigable energy and passion for the profession of chemical engineering. DB has made enormous contributions in the areas of membrane separations, water purification, and other technologies, and personifies the consummate engineering educator—impacting the lives of hundreds of chemical engineering undergraduates and graduate students who have been inspired by his commitment to the discipline and the excitement that he brings to all aspects of engineering education.

DB with his first Ph.D. graduate Edward Saad and UK ChE alumna Rebecca Liebert at the 2014 UK College of Engineering Hall of Distinction induction ceremony.

ORIGINS AND EDUCATION

Dibakar Bhattacharyya was born and raised in Jhingra, India, a small village (population of approximately 500) in West Bengal about 20 miles outside of Kolkata (Calcutta). DB was one of nine children, with his father working for the Brooke Bond Tea Company and commuting each day by train to the city. Jhingra in the 1940s was very much a rural setting and during these early years DB came to appreciate



Counter clockwise: DB with one of his older sisters in Jhingra, India, 1950; DB's senior yearbook photo from Jadavpur University, 1962; DB's parents in 1964.

the importance of living in harmony with nature and the surrounding wildlife, and also developed an appreciation for the crucial role of water resources in the prosperity of the village and its citizens.

DB attended the local elementary school near the village. His family put a high value on education and in addition to his regular classes, DB recalls extra tutoring sessions by candlelight as the village did not yet have electricity. He attended high school (through completion of tenth grade) in neighboring Jagatballavpur, experiencing a rigorous curriculum with classes six days per week and demanding examinations. Although DB displayed an early interest in math and science, he was a self-described "late bloomer," and his energies during this period were directed as much towards soccer and cricket as they were towards classwork. It was only after his tenth-grade national exams that DB's academic potential fully emerged, and he completed his final two years of high school and the ISC (Intermediate Science College) in Kolkata. Although his mother encouraged him to pursue a degree in medicine, DB initially studied physics at the Scottish Church College in Kolkata. However, while in his first year, he became interested in engineering and applied for admission to the chemical engineering department at Jadavpur University on the outskirts of Kolkata. Here, he received a broad engineering education that encompassed exposure to aspects of mechanical and electrical engineering, as well as core chemical engineering subjects. The curriculum offered a range of laboratory experiences and an in-depth exposure to industrial plant design. DB graduated "First Class with Distinction" at the top of his class from Jadavpur in 1962.

GRADUATE STUDY: NORTHWESTERN AND IIT

At the time of DB's graduation, an earlier Jadavpur chemical engineering graduate was studying successfully at Northwestern University, and the program wrote the Jadavpur department chair seeking recommendation of a top senior for potential admission to the master's program at Northwestern. DB was the sole senior selected to apply for the position and was accepted to the M.S. degree program in chemical engineering at Northwestern—receiving the Walter P. Murphy Fellowship and a stipend of $160 per month! Chicago was definitely a new environment for DB (including his first exposure to snow), and he adapted to life in the United States with the strong support of his fellow students living in the Alpha Chi Sigma chemistry fraternity. During his first months at Northwestern, DB also benefited from supportive relationships formed with individuals outside the university, most notably a strong and enduring bond with an international student host family.

For his M.S., DB pursued a project in thermodynamics modeling (P-V-T behavior of alcohols) under the direction

of renowned Northwestern faculty member George Thodos. Thodos made it clear at the outset that his expectation for completion of the M.S. degree was the production of two publications. DB successfully satisfied this requirement, and profited from Thodos' high standards for technical communication and outstanding attention to detail (as well as his expertise in the repair of old cars in the chemical engineering lab bay at Northwestern).

Graduation day at Northwestern University (June 1963) with DB's M.S. research advisor, Prof. George Thodos (right).

During completion of his M.S. degree, DB became increasingly interested in the environmental aspects of chemical engineering and the work of Northwestern civil engineering assistant professor Robert Grieves. Around that time, Grieves had an opportunity to head the environmental engineering program at Illinois Institute of Technology. With Grieves' encouragement, DB enrolled in the Ph.D. program in environmental engineering at IIT, marking the start of a highly productive 15-year collaboration with Grieves that would have a lasting impact both on DB's professional development and his career at UK. Working in the area of foam fractionation, DB completed his Ph.D. in three years (1963-1966) under Grieves' direction, with this early research resulting in two publications in *Nature*. Here again, DB received strong guidance in the development of his technical writing and communication skills, describing Grieves as an exceptionally clear and precise technical communicator.

In 1967, Bob Grieves was recruited to the University of Kentucky as chair of the Department of Chemical Engineering. During the 1960s, the University of Kentucky was placing increased emphasis on research and the establishment of new graduate programs. Grieves was hired to lead the chemical engineering program forward in this regard, and the department produced its first MSChE (1968) and Ph.D. (1969) degrees during this period. After completion of a one-year post-doc at IIT, DB was invited by Grieves to come to UK in the Fall of 1967—a transition that would set the trajectory of DB's career for the next five decades.

EARLY YEARS AT UK

DB was initially recruited to UK to collaborate with Bob Grieves as a research faculty member and during these early years he directed a wide range of projects with an environmental engineering orientation, serving for most of this interval as associate director of Environmental Research. It was during this time that DB pursued his first research on membranes, with numerous publications related to ultrafiltration and the application of charged UF membranes. DB had an opportunity to direct his first graduate students during these years, including his first Ph.D. graduate, Edward Saad (co-advised with Prof. Richard Kermode). Also, DB was increasingly called upon to contribute to the teaching function of the department, offering classes in water pollution, biochemical engineering, and related subjects.

In addition to his technical progress, DB's early years at UK were also important from the perspective of his family life. Lexington of the late 1960s was still very much a small town, and DB returned regularly to Chicago to enjoy the attractions of the big city. It was there that he met his first wife, Gloria, and they were married in 1969. A daughter, Anita, was born in 1972. After completion of high school in Lexington, Anita would go on to complete a pharmacy degree at Purdue. Anita and her husband would eventually settle in Oregon, where they are raising three children: Nathan, Madeline, and Lila.

PROFESSOR BHATTACHARYYA

As the 1970s came to a close, there were a number of transitions in the Department of Chemical Engineering at UK. Prof. Bob Grieves concluded his 12-year service as department chair and would move into the position of associate dean of Engineering; in 1982, Grieves left UK to assume the position of dean of Engineering at the University of Texas – El Paso. In 1979, Prof. Leonard Peters took over as chemical engineering chair and explored ways to further increase the size and the quality of the regular series faculty in the department. It was at this point that DB was invited to move from research faculty to a tenure-track line at the rank of associate professor. According to DB, this opportunity was accompanied by a pay cut at the time! Of course, given DB's track record as a researcher and mentor, it was a natural transition and would mark the beginning of his far-reaching impact on all facets of engineering education, both at the University of Kentucky and beyond. DB taught across both the undergraduate and graduate core, expanded the size and scope of his research activity, and extended his streak of continuous research support that dates from 1972 to the present. DB rapidly ascended to the rank of full professor, and from 1983-1989 held the Ashland Professor Chair in Chemical Engineering at UK. In 1990, he was named a University Alumni Professor, one of the most prestigious faculty designations at the University of Kentucky.

As a classroom teacher, DB quickly displayed the characteristics that would make him a legend among generations of UK chemical engineering students and alumni. DB has a remarkable breadth and depth of knowledge across the chemical engineering discipline, and through his passion and energy conveys a high level of enthusiasm that has shown absolutely no signs

DB with UK chemical engineering seniors, Class of 1982.

of diminishing as the years have passed. Beyond his skill in the classroom, students have identified DB as a faculty member who takes a strong interest in their professional development and personal well-being, and is always available and willing to take the extra time to meet with them to discuss coursework, career options, and life in general. Not surprisingly, DB has received numerous awards and accolades in recognition of his teaching contributions, including having been named the UK outstanding chemical engineering professor 15 times since 1981, Tau Beta Pi Outstanding Professor (1984, 2005), UK College of Engineering Lutes Award recipient (1989), and UK Chancellor's Award for Outstanding Teaching (1992). In addition, DB is one of only two faculty members in the history of the University of Kentucky to have been awarded the UK Alumni Association Great Teacher Award three times, across three decades (1984, 1996, 2008).

One of DB's most enduring instructional contributions to the department is a fully controlled reverse osmosis experiment that he designed and built with a team of select undergraduates for the chemical engineering unit operations laboratory. This unit, which was originally commissioned more than 25 years ago, has seen numerous instrumental upgrades over the years, and has remained in continuous use each fall semester since its deployment. Hundreds of UK chemical engineering seniors have received hands-on exposure to the foundational principles of membrane-based separations as a result of this thoughtfully conceived and now "classic" experiment.

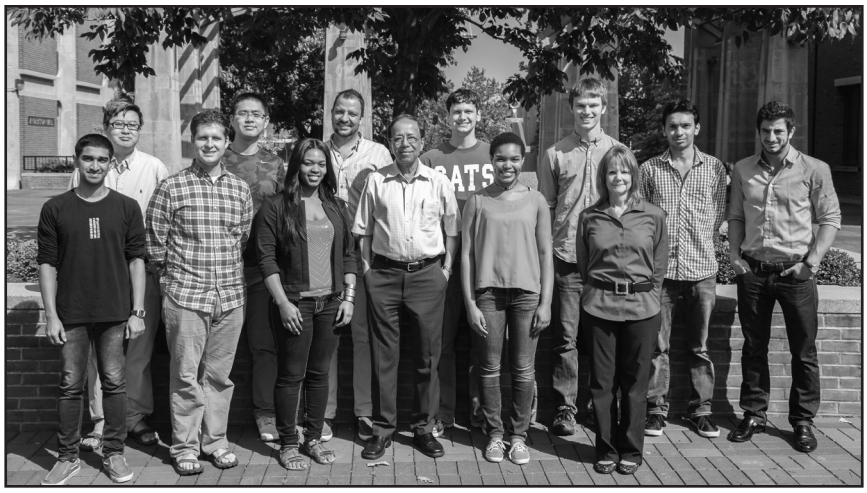
In the early 1980s, DB had the opportunity to serve as the faculty advisor for UK's AIChE student chapter. At that time, the UK student chapter was relatively inactive, with only a very modest level of participation within the North Central Region. DB rapidly revitalized the chapter, increasing on-campus programming and outreach, and facilitating strong student leadership in all areas of chapter activities. The results were quickly evident, and with a decision to move affiliation to the Southern Region (with its warmer conference sites), student attendance at the regional and national meetings increased substantially. By 1984, the UK AIChE Student Chapter had achieved the Outstanding Student Chapter designation (awarded to ~10% of all student chapters each year), and would go on to earn this distinction in 30 of the next 31 years, including a current recognition streak of 27 consecutive years (1988-2014). DB served as student chapter advisor from 1981-2001, and again from 2003-2009, and twice was named the national Outstanding Student Chapter Advisor for all of AIChE (1983, 1991). In addition, the UK AIChE student chapter has twice hosted the Southern Region Student Conference in Lexington, in 2000 and, more recently, in 2013 (under current chapter advisor Zach Hilt).

RESEARCH AND THE UK CENTER OF MEMBRANE SCIENCES

Throughout the 1980s, DB vigorously pursued a research program focused largely on the application of membrane science and technology for a range of environmental applications including wastewater purification and reuse, removal and recovery of heavy metals from contaminated water, and separation and destruction of hazardous organics. DB's research funding from this period was drawn from a range of sources, including the U.S. Department of the Interior, U.S.-EPA, DOE, and various industrial grants. The importance of DB's environmental research and service contributions was recognized early, when he received the AIChE Environmental Division Larry K. Cecil Award in 1986. DB mentored a total of 28 M.S. (thesis) students during this decade, and began to direct an increasing number of Ph.D. projects as the emphasis of the department's graduate program shifted more strongly towards doctoral education (see Table 1).

In 1986, a gathering was held on the University of Kentucky campus that would have fundamental ramifications for the scope and external profile of membrane science at UK. Noting the strength of membrane-oriented research being conducted in various sectors across campus, graduate dean Wimberly Royster assembled a meeting of approximately 20 faculty members working in areas related to synthetic and biological membranes. This meeting led to the establishment of the UK Center of Membrane Sciences with DB Bhattacharyya and chemistry professor D. Allan Butterfield as co-founders. The Center, with its unique focus on exploring the interface between synthetic and biological membranes, has served as an important focal point for all membrane-related research on campus, with participating faculty representing a wide range of disciplines including agriculture, biology, chemistry, engineering, pharmacy, and the medical sciences. The strength of the Center and its collaborating faculty resulted in two significant NSF-EPSCoR multi-investigator grants at its founding led by DB and Allan Butterfield, as well as long-standing NSF-REU support for undergraduate research in membrane sciences led by chemistry professor Leonidas Bachas (1989-2009). In addition, the Center was responsible for hosting two meetings

of the North American Membrane Society (NAMS) in Lexington (1992, 2001), with DB serving as technical program coordinator and meeting co-chair. Over the years, collaborations among faculty associates in the Center have resulted in wide-ranging extramural support including two NSF-IGERT grants, additional REU awards, and a host of other interdisciplinary research grants and contracts.



DB's research group at the University of Kentucky, July 2015.

The next 25 years would see DB's research program thrive as he pursued a number of fundamental membrane and water purification themes with significant practical applications. For example, DB and his graduate students pioneered the development of a range of functionalized membranes for enzyme catalysis and ultra-high capacity metal capture for environmental and biological problems. More recently, he developed a novel platform for detoxification of organics in water by synthesizing iron-based nanoparticles directly within the membrane structure, the resulting particle immobilization thereby avoiding potential concerns with nanoparticle release and worker exposure. In addition to this important fundamental work, DB has consistently sustained close ties to industry that help inform his efforts and that create opportunities for real-world implementation. Current or recent industrial research includes projects with Sepro Membranes (now Nanostone Water, Inc.), Southern Company, Compact Membranes, Chevron Corporation, NEI Corporation, and Huber Corporation.

In advancing his research efforts, DB is first and foremost an outstanding mentor for the post-docs, graduate students,

TABLE 1
Ph.D. and M.S. graduates under Prof. DB Bhattacharyya at the University of Kentucky

Ph.D.	2014	Li Xiao	M.S.	2014	Andrew Tomaino	M.S.	1987	Majid Dosani
Ph.D.	2014	Minghui Gui	M.S.	2012	Ruo He	M.S.	1987	Sandra Back
Ph.D.	2012	Noah Meeks	M.S.	2009	Abhijit Patil	M.S.	1986	Alireza Haeri
Ph.D.	2011	Scott Lewis	M.S.	2007	Morgan Campbell	M.S.	1986	Theresa Barranger
Ph.D.	2009	Ajay Makkuni	M.S.	2004	Meghan Kane	M.S.	1985	Richard Northey Jr.
Ph.D.	2008	Abhay Ladhe	M.S.	2001	Paul Rodgers	M.S.	1985	Michael Hsieh
Ph.D.	2007	Jian Xu	M.S.	2000	Phillip Sisk	M.S.	1985	Bruno Coqueblin
Ph.D.	2007	Yong Chao Li	M.S.	1996	Susan Mawhinney	M.S.	1985	Kevin Adams
Ph.D.	2007	Saurav Datta	M.S.	1996	William Mangum	M.S.	1984	Stephen Hohman
Ph.D.	2006	Yit-Hong Tee	M.S.	1994	David Schieche	M.S.	1984	William Glynn
Ph.D.	2006	Vasile Smuleac	M.S.	1994	George Verghese	M.S.	1984	Chun Yuen Cheng
Ph.D.	2006	Deepak Ahuja	M.S.	1994	S. Daniel West	M.S.	1984	Lih-Fen Chen
Ph.D.	2005	David Meyer	M.S.	1994	Amy Freshour	M.S.	1983	Jeffery Siler
Ph.D.	2004	Aaron Hollman	M.S.	1992	Madhusoodhan Venkatachalam	M.S.	1983	James Kozminski
Ph.D.	2002	Dharmesh Bhanushali	M.S.	1992	Tamara Van Dierdonck	M.S.	1983	Nusayr Azam
Ph.D.	2001	Dhaval Shah	M.S.	1991	Harish Venkatachalam	M.S.	1982	Richard McAskill
Ph.D.	2001	Stephen Ritchie	M.S.	1991	Murali Rao	M.S.	1982	Young Ku
Ph.D.	2000	Jamie Hestekin	M.S.	1991	Anup Kothari	M.S.	1982	Milan Jevtitch
Ph.D.	1999	Priya Rangarajan	M.S.	1991	Yemeni Chowdary	M.S.	1981	Richard Dickinson
Ph.D.	1999	Jayant Gotpagar	M.S.	1990	Paul Ragubathy	M.S.	1980	Gene-Hua Sun
Ph.D.	1997	Shekhar Viswanath	M.S.	1990	Ronald Martin, Jr.	M.S.	1980	Ching-Shun Cheng
Ph.D.	1996	Sowmya Ganapathi	M.S.	1989	Michael Williams	M.S.	1979	Linda Shelton
Ph.D.	1993	Michael Williams	M.S.	1989	Ranjit Deshmukh	M.S.	1978	Stephen Gentry
Ph.D.	1993	Myeong-Jin Han	M.S.	1989	Myeong-Jin Han	M.S.	1976	Desikachari Murali
Ph.D.	1990	Michael Hsieh	M.S.	1988	Robert Adams	M.S.	1976	Michaelee Moffitt
Ph.D.	1987	Jeffery Siler	M.S.	1987	M. Rasoul Madadi	M.S.	1975	Kenneth Garrison
Ph.D.	1986	Milan Jevtitch	M.S.	1987	Darrell Hance	M.S.	1974	David Schaaf
Ph.D.	1977	Edward Saad	M.S.	1987	Suzanne Greenleaf	M.S.	1973	William Schomp

and undergraduates who work in his research laboratory. He is an exceptional facilitator who expects his students to develop the independent research tools and creativity necessary to steer their own projects, and he skillfully helps to assemble the resources and collaborative connections that foster this growth. DB displays an incredible level of engagement and energy for his students, and is always available for consultation, brainstorming, and encouragement. In addition, he is a strong believer in supporting the social and recreational elements of the academic laboratory, whether it might be sitting in on one of the sessions of the Indian card game Mendicot that start up spontaneously in the Bhattacharyya lab, or participating in regular tennis matches and ultimate Frisbee games as part of group activities. According to numerous students, DB has a standing offer on the tennis court of a free trip to Las Vegas for any lab member who can come back from 0-40 to break DB's serve. To date, no one has yet been able to cash in on this proposition!

An accounting of DB's research activity confirms his sustained and influential contributions to membrane science. To date, DB has been responsible for 175 archival journal publications, 33 book chapters, nine U.S. patents, and two books (including *Responsive Membranes and Materials* from Wiley in 2013). He has directed 56 M.S. (thesis) students and 28 Ph.D. graduates, many of whom have ascended to leadership positions in industry. Two of DB's doctoral graduates hold faculty positions and lead the next generation of academic membrane researchers: Prof. Jamie Hestekin (Univ. of Arkansas) and Prof. Stephen Ritchie (Univ. of Alabama). In addition, DB has mentored more than 70 undergraduate students on research projects, and these students have been a consistent presence on award podiums at the AIChE Southern Region Student Conference and in AIChE Annual Meeting student competitions.

DB has been the recipient of numerous honors, awards, and keynote invitations throughout his career. In addition to the AIChE Cecil Award, DB was named an AIChE Fellow (1994) and in 2007 was recognized with an honorary session at the Annual Meeting of the North American Membrane Society. In 2009, DB received the Clarence (Larry) G. Gerhold Award from the AIChE Separations Division, recognizing sustained and outstanding accomplishments in the area of membrane-based separations. In Fall 2015, DB's many contributions were again recognized with two honorary sessions sponsored by the AIChE Separations Division at the Annual Meeting in Salt Lake City.

At the University of Kentucky, DB has been honored with the institution's most prestigious awards for research including the Kirwan Memorial Prize (2004) and the College of Engineering Inaugural Award for Excellence in Research (2013). In 2015, DB was presented with the Billy Barfield Award for Outstanding Contributions in Water Resources Research by the Kentucky Water Resources Institute.

PROFESSIONAL SERVICE AND LEADERSHIP

Throughout his career, DB has sustained a high level of professional service contributions, particularly through his affiliations with AIChE and NAMS. In the early part of his career, DB was heavily engaged with the AIChE Environmental Division, serving as chair of the Division's Programming Board from 1981-1987 and then as chair of the Division from 1988-1994. In 2005, DB was selected as the meeting program chair (MPC) for the AIChE Annual Meeting in Cincinnati, a meeting that featured more than 600 technical sessions, 16 topical conferences, and 4,300 attendees. Three years later, DB partnered with Prof. Carol Hall of North Carolina State University to serve as the co-MPC for the AIChE Centennial Meeting in Philadelphia (2008). For both meetings, DB worked tirelessly in his programming responsibilities, and in recognition of his many and sustained contributions to technical programming within AIChE, DB received the Herb Epstein Award in 2010. More recently, DB has served as chair of the AIChE Separations Division (2011-2012) and is currently a member of the AIChE Admissions Committee.

Similarly, DB has a record of continuous activity in the North American Membrane Society that extends back to its founding in 1985. In addition to serving as technical program coordinator and meeting co-chair for NAMS meetings in 1992 and 2001, DB has been twice elected to terms on the NAMS Board of Directors (1993-1996; 2013-2016). Currently, he is the president of the North American Membrane Society for 2015-2016.

LEGACY AND THE FUTURE OF MEMBRANE SCIENCE AT UK

As DB approaches the end of his fifth decade at the University of Kentucky, he continues to sustain the pioneering and enthusiastic spirit of exploration and student engagement that has made him such an important contributor to the field. DB has faced some personal challenges along the way, most notably the loss of his wife Gloria in 2004 following an extended illness. After Gloria's passing, a University of Kentucky connection helped to open up a new chapter in his life as DB became engaged to Gale, a school teacher for 30 years. Gale is the mother of Christa Smothers Hestekin, a 2000 BSChE graduate of UK and the spouse of DB's Ph.D. student Jamie Hestekin. Both Christa and Jamie are tenured faculty in chemical engineering at the University of Arkansas. DB and Gale were married in 2006, and enjoy travel and spending time with their grandchildren, including Christa and Jamie's daughter Zoe.

On the professional side, DB's level of activity and the scope of his work has only continued to increase over the last 10 years, with over $4 million in direct research funding and the production of 13 Ph.D. graduates since 2005. In Fall of 2012, DB undertook his first sabbatical, spending time as a visiting scientist at Sepro Membranes in Oceanside,

California, and at the Singapore Membrane Technology Center at Nanyang Technological University working with Center Director Rong Wang and her students. DB also has sustained joint membrane research activities with Prof. Neal Chung at National University of Singapore. In 2013, eight of DB's patents were licensed by Sepro (*i.e.*, Nanostone Water) for the development of advanced functionalized and nanofiltration membranes at production scale. As a visiting senior scientist, DB continues to work with Nanostone for the commercial development of these systems.

DB and Gale with daughter Anita and grandchildren Nathan, Lila, and Madeline.

At UK, DB is providing crucial leadership on two large multi-investigator grants. He leads one of five programs associated with the university's $12.2M NIEHS (National Institute of Environmental Health Sciences) "Superfund" grant, and is the PI for one of three pillars that constitute the Commonwealth's current $24M NSF-EPSCoR grant ("Advanced Bio-Inspired Membrane Technologies"). In addition to his duties as president of NAMS, in Spring 2015 DB served as co-organizer with Benny Freeman for a very successful ECI Advanced Membrane Conference on Water, Energy, and New Frontiers held in Sicily.

DB and Gale with Jamie and Christa Hestekin and granddaughter Zoe.

In 2016, the UK Center of Membrane Sciences will celebrate its 30th anniversary, as it continues to serve as an important catalyst for interdisciplinary membranes research at the University of Kentucky. In early 2015, DB took over the reigns as center director, succeeding Prof. Allan Butterfield after his long term of distinguished service. One of DB's first actions was to successfully recruit Dr. Isabel Escobar to the UK chemical engineering faculty, helping to further ensure the tradition of excellence in membrane science and technology at the university.

Dibakar "DB" Bhattacharyya is truly one of those iconic and inspiring faculty members who help to define a department, and who forge lasting connections with faculty colleagues, staff, and students that endure well beyond graduations and professional transitions. In essence, he is a complete educator in all aspects of his life, and the profession has benefited tremendously from his talent and commitment to chemical engineering. For those of us at the University of Kentucky, it is a privilege to have him as a colleague and friend. ❒