

*Chemical Engineering at...**NC State University*

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**M**uch has changed in the 30 years since *CEE* last published an article, in 1979, on the chemical engineering program at North Carolina State University. That is an understatement—almost everything has changed: our name, our location, our faculty, the advent of online graduate distance learning, and departmental diversity, to name a few.

We added “Biomolecular” to our name in 2004 to reflect the broader impact of life sciences on our discipline. The same year we moved from Riddick Engineering Laboratories, a building that we occupied on the NC State main campus for 55 years, to a showcase facility on the university’s new and rapidly growing Centennial Campus. We have expanded our Ph.D. graduate research program and have developed an internationally subscribed online M.S. degree program that is a model for such activity. And compared to the “old” days, we have become more diverse in faculty and students. What has remained unchanged over these 30 years is the quality of the education that our faculty provides undergraduate and graduate students.

#### **THE UNIVERSITY, THE COLLEGE, AND THE DEPARTMENT**

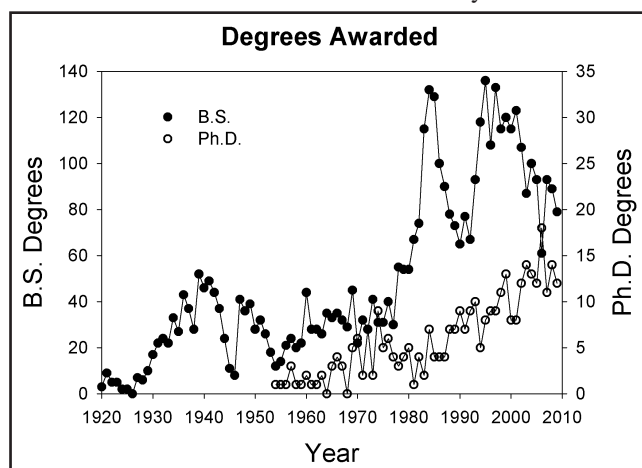
To many folks, the mention of North Carolina brings to mind the four seasons as experienced from the scenic Outer Banks in the east to the Appalachian Mountains in the west; sweet tea and barbecued pork; and the fierce rivalry of ACC basketball traditions among NC State, Duke, and UNC-Chapel Hill. The state is also increasingly well known for its technology focus, however, as evidenced by the renown of the Research Triangle Park; the state’s investment in education; its position as a growing hub of biotechnology and biomanufacturing (currently more than 500 companies); and the international recognition that the NC State Centennial Campus has gained as a model for the promotion of university and industrial interactions and cooperation. The state’s business climate has been ranked the best in the nation by *Site Selection* magazine for the fifth year in a row—and eight of the last nine years.

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North Carolina State University is located in Raleigh, NC, the state capital. NC State is the largest university of the 16 campuses in the University of North Carolina system, and it receives more applications than any of the others. The university has a current enrollment of almost 25,300 undergraduate and 8,600 graduate students. The academic campus has more than doubled in size since 1979 with the opening of our Centennial Campus in 1985—which at the time consisted of 805 wooded acres within walking distance of the main campus. Centennial Campus, named to celebrate NC State's founding in 1887, is a unique environment for a university and an extraordinary success story—a research park and campus providing corporate, governmental, and nonprofit partners close proximity to world-class research facilities and a highly educated workforce, all in an amenity-rich environment (<<http://centennial.ncsu.edu>>).

The College of Engineering (COE) consists of 12 engineering departments that, combined, offer 18 bachelor's-, 17 master's-, and 13 doctoral-degree programs. The undergraduate enrollment is near 6,000, and graduate enrollment is approximately 2,300. The COE is among the largest engineering colleges in the nation and is commonly in the top five in the number of B.S. degrees awarded annually. We anticipate in the next few years that the College's move to Centennial Campus will be completed and the COE will join the College of Textiles as the two anchor academic units on the new Campus.

The Department of Chemical and Biomolecular Engineering (CBE) moved in 2004 to Engineering Building I on Centennial Campus, a building that we share with the Department of Materials Science and Engineering. Our department has an enrollment of about 500 undergraduates and 120 graduate students, and over the last 10 years we have averaged 95 B.S., 20 M.S., and 12 Ph.D. degrees awarded annually. Our undergraduate program is consistently in the top 10 producers of B.S. degrees, and our graduate program has reached that same milestone several times in the last 10 years.



**Figure 1.** Our historical production of B.S. and Ph.D. graduates.

## HISTORY

The NC State Chemical Engineering Department was formally established within the School of Engineering in 1924, but the origins of chemical engineering actually date to 1899 when a four-year program leading to the “Degree of Bachelor of Engineering” and a two-year graduate program leading to the “Degree of Chemical Engineer” were introduced. The catalog of the time for “North Carolina College of Agriculture and Mechanic Arts” (as the university was then known) described the program: “For young men seeking employment in the analytical or engineering departments of the various chemical industries such as the manufacture of soap, paper, leather, vegetable oils, glass, porcelain, illuminating gas, sulphuric acid, fertilizers, etc.” The program was modified in 1902 so the six students who started in chemical engineering were eventually awarded B.S. degrees in Industrial Chemistry. Incidentally, one of these students, O. Max Gardner, later became governor of North Carolina—another testament to the (even then) breadth of education afforded to a chemical engineering student. A chemical engineering program was started once again in 1916, at which time the various engineering disciplines were administered together—separate departments did not exist. Twelve students obtained chemical engineering degrees before the department was officially created in 1924.

In 1928 the first Master's of Science in Chemical Engineering was awarded. The department received approval to establish a Ph.D. program in chemical engineering in 1949 and five years later graduated its first Ph.D., **Jim Ferrell**, who was selected in 1966 as department head after recommendation of a committee chaired by Professor **Warren L. McCabe**.

### **Student Demographics and Number of Degrees Awarded**

Both the number of graduates and the percentage of females in the program have increased dramatically since the *CEE* profile appeared in 1979. The number of B.S. graduates in the 10 years preceding 1979 was 364, and the number over the past 10 years is 2.6 times greater, at 947. The percentage of women graduates increased from 6% in the 10 years preceding 1979, to 35% in the past 10 years. The percentage of females is still on the rise, with 47% of our 2008-09 B.S. graduates being women. Figure 1 shows our historical production of B.S. and Ph.D. graduates. Over our history, the department has conferred 4,500 B.S., 534 M.S., and 342 Ph.D. degrees.

We have a mission as a land grant institution to educate the citizens of North Carolina, but we encourage applicants and welcome students from around the country and the world. Over the last 10 years, 79% of our B.S. graduates were from North Carolina, 16% from other states, and 5% international. Over the same period, 59% of our M.S. and Ph.D. graduates were from the United States and the remaining 41% from other countries.

## FACULTY

Our faculty members and the universities of their doctorate degrees are listed under the group photo, facing page.

The interdisciplinary aspects of our research and teaching interests are reflected in the appointment of two faculty members from other NC State colleges (Flickinger, of Agriculture and Life Sciences, and Pourdeyhimi, of Textiles) with associate faculty member status, as well as the appointment of the first faculty member in the UNC system to have full faculty status at two institutions (DeSimone, joint with Chemistry UNC Chapel Hill). In addition, we are pleased to include a number of adjunct and research faculty who are listed at our department Web site along with the staff who underpin our enterprise (<[www.che.ncsu.edu](http://www.che.ncsu.edu)>).

We are proud of the accomplishments of our faculty and the recognitions that they have received. Among these achievements, we are pleased that three of our faculty are members of the National Academy of Engineering (DeSimone, Gubbins, and Hall); 12 faculty members are Fellows of professional societies (Carbonell, DeSimone, Fedkiw, Felder, Flickinger, Genzer, Gubbins, Hall, Kelly, Parsons, Spontak, and Westmoreland); and eight faculty members are NSF CAREER award winners (Dickey, Genzer, Haugh, Lamb, Peretti, Parsons, Velev, and Westmoreland). In addition to numerous awards at the national, regional, and local level from the AIChE, ACS, ASEE, and other professional societies or organizations, we are pleased that three of our faculty (DeSimone, Gubbins, and Hall) were recognized in the 2009 AIChE Centennial celebration as members of the “100 Chemical Engineers of the Modern Era,” and that the list of groundbreaking chemical engineering texts in the discipline included one co-authored by Felder.

## TEACHING IS IMPORTANT

Our department places particular emphasis on teaching effectiveness. Twelve of our faculty members have won University-wide Alumni Association teaching awards. Rich Felder, Dave Ollis, and Lisa Bullard are especially well known in the profession for their contributions to chemical engineering education. Our department won the inaugural NC State University “Departmental Award for Teaching and Learning Excellence,” an indication of how well we are respected by our university peers.

Perhaps our department is most well known as the birthplace of the best-selling chemical engineering textbook, *Elementary Principles of Chemical Processes* by Rich Felder and Ron Rousseau (who was at NC State when the book was written and is now chair at Georgia Tech). This book is used at more than 80% of chemical engineering departments in the United States and has been translated into seven languages. Rich and his wife and colleague, Rebecca Brent, have brought international recognition to NC State as a result of the more

than 300 teaching-effectiveness workshops they have given around the world, including the National Effective Teaching Institute offered annually at ASEE meetings since 1991.

Other textbooks written by NC State faculty include *Chemical Reactions and Chemical Reactors* (George Roberts), *Biochemical Engineering Fundamentals* [David Ollis (NCSU) and James Bailey], and *Unit Operations of Chemical Engineering* [Warren McCabe (NCSU) and Julian Smith].

## UNDERGRADUATE PROGRAM

### Curriculum

Out of 125 credit hours required for the B.S. degree, our undergraduate students take 12 core courses in chemical engineering and six in chemistry. In addition to a core chemical engineering program, the B.S. students may enroll in one of five concentration areas that reflect the research interests of our faculty and the types of industrial positions that our graduates may pursue:

- **Biomanufacturing Concentration** – *The biomanufacturing concentration provides students with the knowledge base and hands-on skills to prepare them to quickly contribute to a cGMP (current good manufacturing practice) biomanufacturing operation.*
- **Biomolecular Concentration** – *The biomolecular concentration integrates a unique set of core and advanced bioscience course offerings that are relevant to the pharmaceutical, medical, and agricultural fields.*
- **Honors Program** – *The honors program allows talented students to gain a deeper understanding of chemical engineering principles in preparation for graduate study. Honors versions of core coursework, an advanced math elective, a graduate CHE course, and an honors thesis are required.*
- **Nanoscience Concentration** – *The nanoscience concentration allows students to develop an understanding of the scientific and technological principles associated with the design and manufacture of patterns and devices with features and advanced functionality on the nanometer scale.*
- **Sustainability, Energy, and the Environment Concentration** – *This concentration involves the study of critical environmental issues in product design, process development, and research on industrial and energy systems.*

### Undergraduates' Careers

Our B.S. graduates begin their careers in a wide variety of industries. Figure 2 shows the initial placement of our graduates over the last 10 years. Although many of them accept their initial position in the Southeast United States, they are eventually located across the country and the world. Almost one-quarter of our B.S. graduates immediately enter a graduate program in engineering, law school, medical school,



*Faculty members of CBE at 2009 retreat (not listed in order of appearance).*

**Kenneth Beatty**, *Michigan*, Emeritus

**Chase Beisel**, *Cal Tech* (starting 2011)

**Lisa Bullard**, *Carnegie Mellon*,  
Director of Undergraduate Studies

**Ruben Carbonell**, *Princeton*

**Joseph DeSimone**, *VA Tech*

**Michael Dickey**, *UT Austin*

**Peter Fedkiw**, *Cal Berkeley*,  
Department Head

**Richard Felder**, *Princeton*, Emeritus

**Michael Flickinger**, *Wisconsin*

**Jan Genzer**, *Pennsylvania*,  
Associate Department Head

**Christine Grant**, *Georgia Tech*,  
Associate Dean of Faculty Development and Special  
Initiatives, College of Engineering

**Keith Gubbins**, *Kings College, University of London*

**Carol Hall**, *Stony Brook*

**Jason Haugh**, *MIT*

**Wesley Henderson**, *Minnesota*

**Harold Hopfenberg**, *MIT*, Emeritus

**Robert Kelly**, *NC State*

**Saad Khan**, *MIT*,  
Director of Graduate Studies

**Henry Lamb**, *Delaware*

**P.K. Lim**, *Illinois*

**David Ollis**, *Stanford*

**Gregory Parsons**, *NC State*

**Steven Peretti**, *Cal Tech*

**Behnam Pourdeyhimi**, *Leeds*

**Balaji Rao**, *MIT*

**Gregory Reeves**, *Princeton*

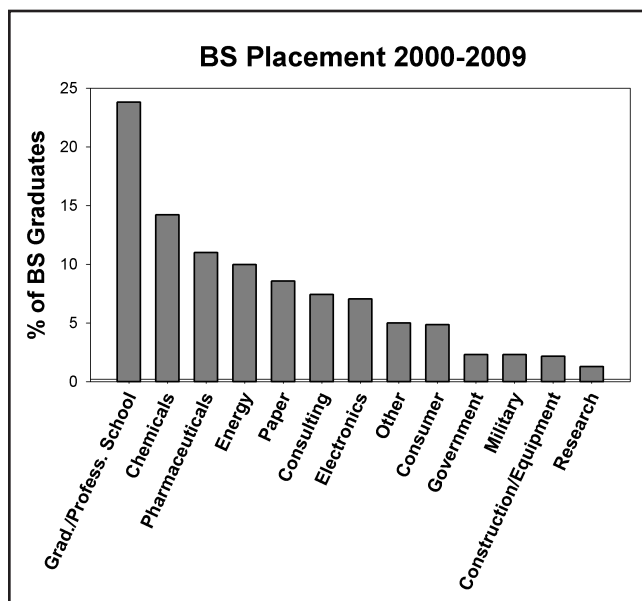
**George Roberts**, *MIT*, Emeritus

**Richard Spontak**, *Cal Berkeley*

**Orlin Velev**, *University of Sofia*

**Phillip Westmoreland**, *MIT*

**Hubert Winston**, *NC State*, Emeritus



**Figure 2.** The initial placement of our undergraduates over the last 10 years.

dental school, business school, or pharmacy school. Selected achievements of our graduates include: presidents and CEOs of Fortune 500 corporations; company owners and entrepreneurs; membership in the National Academy of Engineering; military leaders, including a four-star general; leadership positions in academia; renowned M.D.s and surgeons; and court judges, among others.

## STUDENT ORGANIZATIONS

Our AIChE student chapter was the 15th chapter established in the United States and the first in the South, and has been in place continuously since 1930. It has won a national student chapter of the year award 14 times in the past 20 years. Our students have been instrumental in establishing student chapters of the International Society of Pharmaceutical Engineers in 1996 and Omega Chi Epsilon in 1997, and many are active in the Society of Women Engineers, National Society of Black Engineers, Society of Hispanic Professional Engineers, and Engineers Without Borders. Our graduate students have had a Graduate Student Association (GSA) chapter since the 1970s (its organizer and first president was **Francis O'Dell**, now the department's director of development). The GSA plays an active role in the social fabric of the department and is instrumental in our annual recruiting efforts of first-year graduate students.

## GRADUATE PROGRAM

We offer two thesis degrees: the Doctor of Philosophy (Ph.D.) and the Master of Science (M.S.). The emphasis, however, is on the Ph.D. program, with 95% of our graduate students being part of it. A unique aspect of our doctoral

program is the replacement of the traditional written qualifying examination with a research proposition—a change that we implemented 18 years ago and was described by Ollis elsewhere (*CEE*, 222-29, Fall 1995). The research proposition has evolved into a pair of research-related courses taken by students during their first year and consists of Introduction to Research during the Fall semester and the Research Proposition course in the Spring. We offer these two novel courses to better prepare students to function at high levels of productivity in both their Ph.D. studies and careers, and to teach the mechanics of effectively communicating to a technical audience through proposals (hypotheses) and papers (results). In the Introduction to Research course, the student independently develops an original chemical engineering research paper and defends it orally to the course instructor. The class also covers issues related to research ethics. In the follow-on Research Proposition course, the student creates an NSF-format-like proposal, typically in the area of his/her anticipated Ph.D. study, under the guidance of the course instructor and thesis advisor, and defends it before a faculty committee. Successful completion of these two courses and four core first-year graduate courses qualifies the student to continue for the Ph.D.

Creativity, collaboration, and innovation are characteristics emphasized and nurtured in our research programs, which encompass a variety of aspects of chemical and biomolecular engineering. Fundamental studies include investigating nanoscale phenomena, reaction pathways in living cells, protein purification, thin-film dynamics, and polymer physics. More applied topics include fabricating functional nanostructures and nanoelectronic devices, using microfluidic systems, and developing alternative sources of clean energy, to name a few. Following are the present areas of research strength in the department and the faculty members involved with them:

- **Biofuels and Renewable Energy Technology:** Dickey, Fedkiw, Henderson, Khan, Lamb, Parsons, Peretti, and Westmoreland
- **Biomolecular Engineering and Biotechnology:** Beisel, DeSimone, Carbonell, Hall, Haugh, Kelly, Rao, and Reeves
- **Catalysis, Combustion, Kinetics and Electrochemical Engineering:** Fedkiw, Lamb, and Westmoreland
- **Computational Nanoscience and Biology:** Gubbins, Hall, and Westmoreland
- **Environmental Studies:** Grant, Ollis, and Peretti
- **Nanoscience and Nano-Engineering:** DeSimone, Dickey, Genzer, Khan, Parsons, and Velev
- **Polymers:** DeSimone, Dickey, Genzer, Hall, Khan, and Spontak

## Graduates' Careers

Figure 3 shows the initial placement of our Ph.D. graduates over the last 10 years. The majority of them continued their studies in post-doctoral research positions at other institu-

tions. Over the 17-year period from 1953-1980, 17 of our Ph.D. students went into academia, while 31 have done so from 1981 through 2009.

### **Distance Master of Science Degree**

The department was a pioneer in establishing a distance-education-based Master of Science in Chemical Engineering program, which originally began with videotapes that were distributed through the mail and has evolved to delivery of content through online streaming video. Students in the program come from all over the United States and abroad. The distance program provides an opportunity for individuals in the work force to complete their studies while maintaining full employment, and also for non-chemical engineers to train themselves to be chemical engineers. This non-thesis M.S. in chemical engineering is a 30-credit-hour program that offers Web access to all core graduate classes and most CBE graduate electives. To earn the degree students must take at least 10 three-hour courses with at least seven being in chemical engineering.

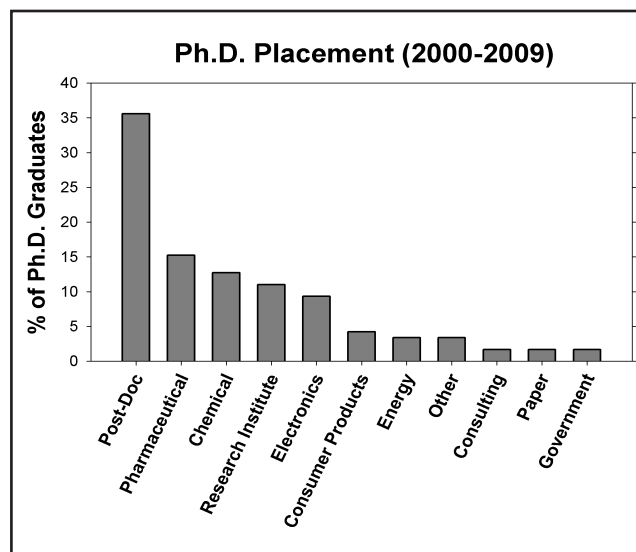
### **BIOMANUFACTURING TRAINING AND EDUCATION CENTER**

The Golden LEAF Biomanufacturing Training and Education Center (BTEC) opened on Centennial Campus in 2007. BTEC simulates a biomanufacturing facility capable of producing sterile bulk biopharmaceutical compounds, and the building includes classrooms, laboratories, and high-purity building and process utilities. The facility delivers a “hands-on” educational experience for all levels of post-secondary students and does so using large-scale, state-of-the-art equipment and process systems in a cGMP environment. This unique facility is the first of its kind in the country and one of only a few in the world. BTEC was founded under the leadership of our former department head, Peter Kilpatrick (now dean of engineering at Notre Dame), and its present director is also a former CBE department head, Ruben Carbonell. Our undergraduate students in the biomanufacturing concentration take BTEC classes and graduate students perform research under the guidance of CBE faculty who participate in BTEC’s mission.

### **OTHER FACULTY INTERESTS**

While our faculty members maintain very high standards in both their teaching and their research, they also enjoy diverse personal interests and all contribute immensely to creating a collegial environment.

Since retiring as the ace pitcher on the graduate student softball team, Peter Fedkiw has become an avid fan of NHL hockey and is a season ticket holder of Raleigh’s Carolina Hurricanes (as well as the Broadway South stage series). Sporting his “Lord of the Rings” jacket, Rich Spontak is our local Tolkien aficionado. Rich is an avid writer (he has a poem



**Figure 3.** The initial placement of our Ph.D. graduates over the last 10 years.

entered in the U.S. Congressional Record) and likes to coach teenagers in Odyssey of the Mind and Math Counts, as well as playing chess and squash. Carol Hall is a ballroom-dance enthusiast and participates in regional competitions. In the summer, she can often be seen paddling her yellow kayak on local lakes. Christine Grant treasures the time that she spends working to support women’s ministries at her church. One of her dreams is to work on the set of a movie as a special-effects engineer.

Orlin Velez relaxes by traveling with his family and often schedules intense programs of sightseeing and cultural events on such trips. At home Orlin enjoys watching movies; he’s keen on documentaries on history, especially those featuring events of the Cold War. Several faculty members are musicians: Jason Haugh is a capable guitarist/multi-instrumentalist and songwriter; Chase Beisel is a drummer who’s played in diverse musical groups ranging from concert bands to a college drumline; Rich Felder plays classical guitar; Jan Genzer played piano for about a decade as a youngster (about a century ago, he jokes) and still finds amusement and inspiration in “teasing” the keyboard; Steve Peretti is a Gilbert and Sullivan aficionado who has performed with the Durham Savoyards; and Lisa Bullard sings in the praise team at her church. Hubert Winston practices tai chi and qi gong—energy techniques based in Chinese medicine—and has also served as a mediator in local small claims court.

Jan Genzer, Jason Haugh, and Chase Beisel are unabashed beer enthusiasts (and quite picky about what they drink). When not trying to keep up with his four teenagers and their activities, Henry Lamb still plays basketball a few times a week, goes horseback riding, and tends to his various critters (horses, dogs, and cats). He enjoys camping and hiking—especially in the NC mountains and the western United States. P.K. Lim has

also made recent visits to the western United States and is unafraid to set off on cross-country road trips with his three small children in tow. Jan Genzer is a talented mimic who can wittily impersonate graduate students and faculty members. Bala Rao reads books on economics in his spare time, while Dave Ollis is the man to see if you ever want to learn about the history of porcelain or re-discover ancient technology of China. Dave is also often accompanied by “Teddy,” a lovable pound hound who whiles away most days sleeping on the Oriental rug in Dave’s office and getting treats from the staff (and getting much attention from just about any visitor who passes by Dave’s office during the day). No wonder Teddy has become the unofficial departmental mascot! Joe DeSimone is a fierce fan of all teams Philadelphia and recently attended, with his son, Game 4 of the World Series in Philadelphia against the NY Yankees. Joe enjoys playing tennis and riding bikes on Holden Beach with his family.

Greg Parsons coaches his daughter’s soccer team, and Bob Kelly coached his son’s baseball team. Bob is also a big Mets and Giants fan. Saad Khan whips up a mean curry (besides picking up occasional takeout from Burger King). Wesley Henderson regales the students with tales from his days as an Airborne Ranger parachuting out of planes in the first Gulf War; his claim to cinematic fame is that he was an extra in the movie “Outbreak.” Michael Dickey is a rabid Wolfpack sports fan who has been known to chase down football or basketball coaches to get a photo taken with them. This phenomenon has been witnessed by several faculty members who are willing to confirm it in court if necessary. Greg Reeves likes to swim and play water polo, and is a big fan of Atlanta Braves baseball as well as college football. Greg also likes to ponder the big questions in life and is an active participant in his church ministries. Hal Hopfenberg, in addition to being a famous local gourmet cook and our former department head, has the distinction of having been athletic director of NC State. When he was appointed, the newspapers winked that his previous athletic experience had been on the basketball team at MIT, but in the end he pulled the athletic program through a difficult time. Michael Flickinger is an amateur architect and a lifelong house carpenter, hand woodworker, and furniture designer who donates his carpentry time providing safe, warm, dry, and affordable housing locally and in Appalachia. When he’s not gardening with his wife, or working in his shop, you can

find Michael tending his small flock (no, not his lab group, but his heritage chicken breeds) which provides his family, students and colleagues with fresh eggs every week.

Keith Gubbins, besides being known as a snappy dresser, enjoys bird watching, swimming laps, and boating. Keith owns an extensive art collection. Ruben Carbonell recently obtained his Captain’s license from the U.S. Coast Guard (100-ton vessels, 100 miles offshore) and has charter cruises planned to the West Coast of Florida (Sanibel, Useppa, Marco Islands), the San Juan Islands in the state of Washington, and the Turks and Caicos in the Caribbean. Ruben likes to dance to Cuban music and cook Cuban food, and he is the only faculty member who has had three children graduate from NC State, one from the department—luckily for both, Ruben never had him in class. George Roberts enjoys reading non-fiction about the Civil War as well as visiting Civil War battlefields and museums. For proof, check out Problem 7-7 in *Chemical Reactions and Chemical Reactors*, his recent book published by Wiley. George is also the local faculty expert on American movie classics and is infamous for telling “Pat and Mike” jokes at departmental events with a rollicking Irish accent. Rich Felder enjoys listening to music (mostly classical and opera, some jazz and folk and bluegrass and ’60s and ’70s rock); tacking vacations onto the international trips he takes to give teaching workshops with his wife Rebecca, doing the Sunday *New York Times* crossword, and above all, playing with his seven grandkids. Newcomer Phil Westmoreland has found the Triangle to be an amazingly hip part of the country—a blend of grassroots and the very sophisticated—and enjoys cuisine from barbecue to vegan, music from Piedmont Blues to the Cats Cradle, crafts and art, and hiking trails in the Eno River and Umstead State Parks.

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We hope this description gives an idea of who we are and what we do. We also hope that it conveys the great collegiality and friendship we enjoy in our department. Not only do we have fun, we also work together well, as evidenced by nearly 40% of our graduate students being co-advised by more than one faculty member in our department. The fact that five current faculty who received their ChE degrees at NC State eventually returned to the department to teach and carry out their scholarship reflects the sense of family that extends to our students and graduates. □