

*Chemical Engineering at . . .***THE UNIVERSITY OF ALABAMA**

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Over the past decade The University of Alabama has been one of the fastest growing flagship universities in the United States. Much of this growth has been fueled by a surge of out-of-state students, transforming the cultural diversity of the campus (currently less than 40% are in-state students) and simultaneously spreading the love of Alabama football around the world! The relative growth in student population has been even larger in the College of Engineering and the Department of Chemical and Biological Engineering. In order to provide some perspective, our previous department profile was published in 2004,<sup>[1]</sup> and at that time our total undergraduate enrollment stood at 230 students. A little more than a decade later, we are granting over 200 BS degrees in chemical engineering per year (undergraduate enrollment peaked at 971 undergraduates in 2016), ranking us as one of the largest chemical engineering programs in North America. With such rapid expansion in the student body, shifts in demographics, aggressive faculty hiring, and campus construction (Figure 1), it is hard to find an aspect of

The University of Alabama or the Department of Chemical and Biological Engineering that has not been transformed during this period of rapid growth.

In engineering one of the most difficult aspects of “scaling up” a chemical process is quality control, and the same can be said in chemical engineering education. This is a challenge that a number of other chemical engineering departments around the country have also faced. Many of our day-to-day operations in the department have been restructured, different communication mechanisms have been developed, and a long list of logistical issues have been re-engineered (e.g. student advising, classroom scheduling, teaching laboratories, etc.). For our department, necessity has truly been the mother of invention, pushing us into new directions and developing innovative academic opportunities, with the main objective of producing high-quality chemical engineering graduates. Keeping tabs on this transformation has not been easy, with nearly 75% of our departmental faculty being hired since our previous 2004 profile (we currently have 11 tenure-track



*Figure 1. South Engineering Research Complex, one piece of the recently constructed 900,000 ft<sup>2</sup> Science and Engineering Quad on The University of Alabama campus.*

assistant professors in the department). However, reflecting back on our recent history, there are a long list of “firsts” that help capture the personality of our current department compared to 2004. In the same vein, there have been some remarkable student achievements along the way that help keep us motivated and reinforce our focus on the difficult task of growing in both quantity and quality.

## CENTENNIAL CELEBRATION

As the third oldest continuously operating chemical engineering department in the country, we were one of the first departments to celebrate a centennial anniversary in 2010. This was an exciting event for the faculty, students, and alumni. The highlight of the celebration was an alumni dinner at the North River Yacht Club in Tuscaloosa, which included speeches from UA President Robert Witt and US Senator Richard Shelby (Figure 2). This was also a great opportunity to celebrate the achievements of our alumni over the last century, culminating in the recognition of 100 Centennial Fellows who have achieved noteworthy success in their respective professions.



*Figure 2. Department Centennial Anniversary at North River Yacht Club.*

## EXPANSION OF BIOLOGICAL ENGINEERING

Approximately 15 years ago, our department, like many others around the country, began to more deeply embrace the biological aspects of chemical engineering. This led us to change our department name to the Department of Chemical and Biological Engineering, in order to reflect changes in our curriculum as well as a broadening of our research into more biological topics. Shortly thereafter, we received our first major funding from the National Institutes of Health (NIH) into the department (Prof. Brazel), which has subsequently been followed by many other NIH awards. In terms of our teaching focus, our biological elective courses have significantly

expanded over the last decade, including popular topics like Stem Cell Bioengineering, Microbial Engineering, Tissue Engineering, and Biochemical Engineering. The University of Alabama does not offer a degree in biomedical engineering or a similar discipline, so students who have strong interests in both biology and engineering fields are able to find a natural fit in our department, often leading them towards future careers in the health professions. Many of our recent graduates are continuing their education with advanced degrees in Chemical Engineering, Biomedical Engineering, and Biochemical Engineering programs, as well as in medical schools for MD/PhD programs.

The growth of the biological aspects of the department is a great reflection of our faculty expertise and the strategic hires that have been made over the last several years. Prof. Christopher Brazel was one of the early pioneers leading our expansion, followed by the hires of Profs. Yuping Bao, John Kim, Shreyas Rao, Ryan Summers, and Chao Zhao. At this point our biological activities are in full swing, with very active research labs and collaborations, diverse electives, and a significant number of undergraduate researchers. Just recently, the department developed a Biological Engineering Concentration, which will formally take effect in the fall of 2021, and this is expected to be a very popular option for our undergraduate students.

## EDUCATION ABROAD

So if you want to scale an undergraduate chemical engineering program by 400%, what is the biggest bottleneck that you would expect? No surprises here. Our rapid growth put a major strain on our undergraduate unit operations lab facilities, and we encountered this roadblock very early on during our growth curve. At the time we were one of the few departments in the country with a traditional (and required) summer unit operations lab. This course runs all day, six days a week over the summer, so it is very time intensive for both the students and faculty. It provides an excellent opportunity for developing teamwork skills, effective communication, technical writing, and troubleshooting. However, many operational features of this course were difficult or impossible to expand, limited by personnel, facilities, and time.

In the middle of this dilemma, a helping hand and guidance from a peer are always valued. At the annual Southeastern Chemical Engineering Department Chairs meeting in 2011, Prof. John Walz (then Head at Virginia Tech) provided some game-changing advice to our Department Head at the time (Prof. Heath Turner). Prof. Walz described their international unit operations lab running in Denmark, along with details and advice about cost, logistics, academic details, etc. That conversation not only alleviated our growing pains, but it also



sparked the rapid expansion of our department's education abroad programs over the next decade.

Soon thereafter, we kicked off our first faculty-led education abroad program in 2012 at the Technical University of Denmark with nine students. In the second year our cohort grew to 19 students (Figure 3). Very quickly, we started expanding our international venues to other locations, including Austria, Ireland, and Scotland. During the past several summers (other than 2020), our faculty have led 60-70 chemical engineering students to study in Europe each year, often ranking us as the #1 study-abroad major at The University of Alabama. While our rapid growth created some major challenges for our department, in retrospect, it has provided some unique learning opportunities for our students and faculty. Ironically, our ballooning enrollment provided the critical mass to

ensure that our program budgets and other details are viable and sustainable.

In addition to coursework, our study abroad programs feature a rich assortment of group activities and excursions that enhance the students' appreciation of the host city and country. Highlights of group activities over the years from each program include:

- Denmark: Dinner banquets at Noma, one of the top restaurants in the world; trips across the Øresund to visit Malmö, Sweden; July 4th at Tivoli Amusement Park;
- Scotland: Weekend guided trip to the Scottish Highlands and Isle of Skye, attending Edinburgh Fringe Festival shows in late July.



*Figure 3. Top: Unit operations lab students in Copenhagen (2018); Bottom, left: We quickly converted Lars Kiørboe (DTU, Head of Pilot Plant) to a Bama fan; Bottom, right: we ran unit operations lab for two summers at TU-Wien.*

- Austria: Classical music shows; weekend trips to Prague (2015) and Budapest (2016).
- Ireland: Visits to the Cliffs of Moher, the Giants Causeway, and various Game of Thrones filming sites, as well as observing chemical engineering principles firsthand at the Guinness Storehouse and the Jameson Distillery.

## REU PROGRAMS AND UNDERGRADUATE RESEARCH

With an expanding faculty, growing interest in undergraduate research, and many new physical facilities coming online, we were motivated to provide more comprehensive programs for nurturing undergraduate research within the department. In 2011 Profs. Heath Turner and Jason Bara teamed up to develop our first NSF-sponsored REU Site program with a theme focused on clean energy. Along with the research experience provided to the students, the REU program injected additional energy and excitement into the department over the summer, helping to distract us all from the heat and humidity in Tuscaloosa. Immediately after the first REU Site program ended, Profs. Turner and Bara landed a second round of REU Site funding, with an overarching theme focused on combining experimental and computational research tools. Success tends to breed more success, and currently we have two simultaneous REU Site programs in the department. One is led by Profs. Jason Bara and John Kim, with a polymers research theme, while the other program is led by Prof. Summers, with a focus on interdisciplinary biotechnology. In addition to the hands-on research experience, these programs afford the students with a wide range of professional development opportunities, mentoring, and camaraderie. These students are also typically provided the opportunity to present their research work at a professional conference, such as the annual AIChE Student Meeting, leading to many presentation awards for these students (Figure 4).



**Figure 4.** Prof. Jason Bara and our REU students enjoying a round of mini-golf during a break from the 2019 AIChE meeting in Orlando.

In conjunction with our REU Site programs over the summer, there is a tremendous amount of interest and activity in undergraduate research throughout the academic semester. There are several different mechanisms for stimulating and supporting these activities, including the Randall Research Scholars Program (the first university-wide undergraduate research program in America), the Emerging Scholars Program, and several others. These students invest tremendous time and energy into their projects, and they receive excellent mentoring from their faculty advisors, frequently leading to first-author publications for the students and other scholarly recognition. Currently, UA is one of the national leaders (often ranked #1) for Goldwater Scholarships, with a total of 57 awards to date. Over 25% of these Goldwater Scholars are students from the Department of Chemical and Biological Engineering, and many of these students have since embarked on extremely productive careers in research.

## GRADUATE EDUCATION AND FACULTY RESEARCH

Along with the rapid expansion of our undergraduate program over the last decade, our faculty and graduate populations have expanded in many new directions as well. With over 20 faculty members in the department, our research profile is now fairly comprehensive, spanning biological research (cancer, biomaterials diagnostics, therapeutics, metabolic engineering), electrochemical systems, polymers, membranes, separations, electronic materials, catalysis, molecular and quantum simulations, soft robotics, and sensors (Table 1). Although the department is most heavily populated with assistant professors at this point, there are already many positive indicators that have begun to emerge. In addition to external research funding growing at a rate of 36% per year for the last five years, there has been similar progress in scholarly output, intellectual property, and teaching recognition. Currently, the department has six NSF CAREER awardees, and with a faculty of 11 tenure-track assistant professors, there is still a lot of opportunity to grow this number in the next few years.

Although we have very few senior faculty members in the department, their leadership and mentoring have been a key component to our progress. These senior faculty members have invested a significant amount of time to provide advice and feedback with respect to becoming an effective teacher in the classroom, writing competitive research proposals, and engaging in professional societies and service. This has helped maintain a very healthy atmosphere among colleagues, and our professional camaraderie is certainly one of the highlights of the department. External to UA,



**TABLE 1**  
**Faculty rank and research interests**

| Faculty               | Rank   | Research Interests                                       |
|-----------------------|--|--|
| Yuping Bao            | Associate Professor  | Drug discovery, nanostructures for imaging and therapy   |
| Jason E. Bara         | Professor  | Polymers, 3D printing, separations, green chemistry      |
| Christopher S. Brazel | Associate Professor  | Nanotherapeutics, polymers, toxicological evaluation     |
| Milad R. Esfahani     | Assistant Professor  | Functionalized membranes, water treatment, nanomaterials |
| Arun Gupta            | Professor  | Assembly of nanomaterials, controlled synthesis          |
| James W. Harris       | Assistant Professor  | Catalysis, infrared spectroscopy, reaction engineering   |
| Qiang Huang           | Assistant Professor  | Electrochemical engineering, Nanodevices, nanostructures |
| Y. John Kim           | Associate Professor  | Bioengineering, oncology, translational medicine         |
| Tonya Klein           | Associate Professor  | Thin film deposition                                     |
| Amanda Koh            | Assistant Professor  | Environmental remediation, soft robotics, sensing        |
| Russell J. Mumper     | Professor, VP for Research & Economic Development          | Antibody-drug conjugates, mucoadhesive gels              |
| Qing Peng             | Assistant Professor  | Surface and interfacial engineering                      |
| Shreyas Rao           | Assistant Professor  | Biomaterials, drug resistance, tumor microenvironment    |
| Stephen M. C. Ritchie | Associate Professor  | Functional materials for separations and catalysis       |
| Ryan M. Summers       | Assistant Professor  | Biochemical engineering, pharmaceuticals, synthetic bio  |
| Tibor Szilvási        | Assistant Professor  | Computational catalysis, sensors, soft matter            |
| C. Heath Turner       | Professor, Dept. Head                                      | Computational materials screening, interfacial modeling  |
| John W. Van Zee       | Professor  | Electrochemical engineering                              |
| Steven Weinman        | Assistant Professor  | Functionalized membranes, water purification, fouling    |
| John M. Wiest         | Professor, Assoc. Dean for Research & Economic Development | Transport phenomena in polymeric systems                 |
| Evan K. Wujcik        | Assistant Professor  | Advanced materials, bio/nanosensors, nanofibers          |
| Chao Zhao             | Assistant Professor  | Biomaterials, drug delivery, tissue engineering          |

our senior faculty have developed into international leaders in their own right. Prof. Yuping Bao served as one of the Meeting Chairs of the 2019 Materials Research Society Spring Meeting (Figure 5). Prof. Jason Bara has received a great deal of recognition for his innovations in education and research, including the FRI/John G. Kunesh Award (AIChE, 2015), Himmelblau Award (AIChE, 2017), Fahien Award (ASEE, 2018), Membranes Young Investigator Award (MDPI, 2020), and the I&EC Division Early Career Fellow (ACS, 2021). Like many other departments, the extensive accomplishments of the faculty are difficult to distill into a few brief comments, but these few examples are representative of the professional dedication and leadership that elevate the overall progress within the department, and the majority of these awards are the first of their kind to come to our department.

While our departmental growth has been dominated by an expansion of the undergraduate student population, we have also seen our graduate program transition from a small mix of



**Figure 5.** Prof. Yuping Bao with the other Meeting Chairs of the 2019 MRS Spring Meeting.

MS and PhD students to a large and robust program primarily composed of PhD students. In parallel to the accomplishments of our faculty, we now regularly see similar levels of success and awards emerge from our graduate student researchers. Our graduate program has now become a centerpiece of our attention, and it is an aspect of our department that is growing very rapidly in terms of both quantity and quality. A major boost to our PhD program came in 2018 with our first GAANN award from the Department of Education, with a focus on polymers and soft materials research. Consistent with the objectives of this program, these external funds provide additional opportunities for our graduate students to engage in professional development and specialized teacher training. As an added benefit, our GAANN Fellows are given priority to assist with our education abroad courses over the summer. This is a fantastic learning opportunity for the GAANN Fellows, and it provides many unique situations for additional leadership development while abroad.

## FOOTBALL TENTS AND ALUMNI

It is hard to cross the Alabama state border without being indoctrinated with the Alabama-Auburn football rivalry. Saturdays in the fall are dominated by football, tailgates, and time spent with friends and family. Some people have correlated our undergraduate growth with the occurrence of several national championships over the last decade, but regardless of the connection, the reality is that our football program provides an atmosphere that is unlike any other. Coach Nick Saban won his first national football championship at UA in 2009 (followed by four more), and every year since, the expectations are high. About a decade ago, our department embraced the game day tailgating scene to strengthen the connections with our own students and alumni. Our AIChE student chapter began regularly arranging sponsors for a Department of Chemical and Biological Engineering football tent on the UA Quad, including a large spread of catered food and plenty of room for socializing and interacting with campus visitors (Figure 6).



*Figure 6. Prof. Steve Ritchie (faculty advisor) with students and alumni at the AIChE football tailgate tent.*

Outside of football games, our students are able to interact in other ways with our alumni. In addition to industrial speakers in a variety of classes and other visits throughout the semester, we host an on-campus Industrial Advisory Board meeting each semester. As part of the agenda, we have a graduating senior banquet that blends our students with our Advisory Board members, which creates a great atmosphere for networking and mentoring interactions. In fact, there are some formal mentoring relationships between our Advisory Board members and our GAANN Fellows, as this is one component of our professional development experience for these students.

Ultimately, many of our day-to-day activities in the department are directly or indirectly focused on educating our undergraduate, graduate, or postdoctoral students. One of the greatest rewards as a department is seeing our students graduate, thrive in the workforce, and return to campus to invest in preparing the next generation of chemical engineers.

## REFERENCES

1. Brazel CS, Arnold DW, April GC, Lane AM, and Wiest JM (2004) Department: The University of Alabama. *Chem. Eng. Ed.* 38(1): 8-13. □