

THE DEPARTMENT OF CHEMICAL AND BIOMEDICAL ENGINEERING AT THE FAMU-FSU COLLEGE OF ENGINEERING

KIMBERLY HUNTER, STEPHEN ARCE, SUBRAMANIAN RAMAKRISHNAN, DANIEL HALLINAN, SAMUEL C. GRANT, AND BRUCE R. LOCKE
FAMU-FSU College of Engineering • Tallahassee, Florida 32310

INTRODUCTION

The FAMU-FSU College of Engineering, established by the Florida Legislature in 1982, is a unique collaboration between two state universities, Florida Agricultural & Mechanical University (FAMU) and Florida State University (FSU). Combining the strengths of FAMU – the top-rated public Historically Black College and University (HBCU) according to the 2021 college rankings of the *US News & World Report*, and FSU – a Carnegie Classified R1: Very High Research Activity university – the college serves a diverse population of students who reflect the composition of the United States. Students enroll at one of the two universities (their home institution) where they complete their prerequisite and non-engineering courses. In the sophomore year all students begin taking engineering courses together at the joint college campus with faculty from both institutions. Students graduate with a degree from their home institution. Faculty members teach and supervise students in research from both institutions in common classes and laboratories, thus providing all students with experience working in diverse groups and access to state-of-the-art research opportunities.

The Department of Chemical & Biomedical Engineering (CBE) (originally the Department of Chemical Engineering) was one of the four founding departments (1984) in the FAMU-FSU College of Engineering, along with Mechanical, Electrical (now Electrical and Computer), and Civil (now Civil and Environmental). The college added Industrial (now Industrial and Manufacturing) Engineering in 1986. The college mission includes excellence in both graduate and under-



Figure 1. Main building of the FAMU-FSU College of Engineering, Tallahassee, Florida.



Figure 2. Main atrium of the College of Engineering during senior design day.

graduate education, attracting minorities and women to professional engineering, and attaining national and international recognition through research, education, and service. The college and department enrollments are shown in Table 1 and indicate significant proportions of students from underrepresented groups. Table 2 shows engineering enrollment and graduates for the two universities. Of significance is the number of PhD degrees awarded to Black students. The college ranks fourth in the US in production of doctoral engineering degrees to Black students, and among R1 universities, it ranks first.^[1] The college also ranks 37th in total bachelor's degrees awarded to underrepresented minorities and 45th in percentage of doctoral degrees awarded to minorities.^[2]

Since the last profile of the department was published in *Chemical Engineering Education* in 1993,^[3] there have been many major changes and developments. CBE now offers two undergraduate degrees: chemical engineering (ChE) and biomedical engineering (BME). Within these degrees are five majors: chemical engineering, chemical-materials engineering, biomedical-cell and bioprocess engineering, biomedical-biomaterials and biopolymers, biomedical-imaging and signals processing. CBE added a Master of Science and a Doctorate in biomedical engineering in 2000 and more recently established the 5-year BS-MS pathways in both chemical and biomedical engineering. Our faculty has grown from six tenure track/tenured faculty members to 17, and from one part-time teaching faculty member to four permanent full-time teaching faculty members. Additionally, we hired a full-time academic advisor in 2019. Two lab engineers run the chemical and biomedical engineering teaching labs, and one departmental administrator oversees the department office and two additional staff members.

Table 1 shows student enrollment in CBE. The ratio of the enrollment of BME to ChE undergraduates is 1.3 (302/233), reflecting national trends in these disciplines.^[2] Female enrollment in CBE is similar to national data on graduation percentages of BME (48.1%) and ChE (35.8%).^[2] Both Hispanic and Black enrollment in the department are significantly above the national engineering enrollment averages for all engineers of 5.2% Black and 14.5% Hispanic.^[2] Reflecting the national average of 90.6% domestic undergraduate enrollment,^[2] approximately 92% of our undergraduate students are US citizens or permanent residents, with many of our domestic students from Florida due in large part to the Florida Bright Futures Scholarship (Bright Futures).

Bright Futures is funded by the Florida Lottery and was introduced by an act of the State Legislature in 1997 to encourage academically top-achieving students to stay in the state for higher education. FSU also has an international campus in the Republic of Panama, which is a major source of excellent international undergraduate students.

	College	Dept – BME	Dept – ChE
Undergraduate	2377	302	233
Graduates	455	22	33
% Female	28	54	32
% Hispanic	20	25	21
% Black	20	23	15

	FAMU	FSU
Engineering Enrollment	368	2200
BS Engineering Graduates	26	372
MS Engineering Graduates	10	71
PhD Engineering Graduates	7	34

As of Spring 2021, the BS program had an 82% 5-year graduation rate, with 84% of these students graduating in the major. This graduation data included three cohorts of full-time, first-time-in-college (FTIC) students for the entry years 2013-15, graduating in 2016-2020. All of these students had a declared major in chemical engineering during their junior year. The program's 5-year graduation rate is slightly higher than the college average of 80%. According to the 2017 ASEE National Undergraduate Engineering Persistence and Graduation Benchmarks Report,^[4] the 2015 4-year and 6-year national graduation rates for engineering programs were 33% and 59%, respectively, which is significantly below FAMU-FSU's CBE graduation rate.

During the past six years, the *US News and World Report* rankings (USNWR) of FSU, FAMU, the FAMU-FSU College of Engineering and the chemical engineering bachelor's program have improved significantly. In the 2022 USNWR, FSU ranks 19th among public universities and 2nd among Florida public universities. FAMU ranks 7th among all HBCUs and first among public HBCUs. The USNWR ranking of the FAMU-FSU College of Engineering increased dramatically in the last six years, reaching 69th among doctoral granting engineering programs and 40th among public universities in the same category in the latest report (2022). Our undergraduate chemical engineering program also improved to 88th in the 2022 ranks for undergraduate chemical engineering programs. CBE ranked 43rd of 160 institutions in total bachelor's degrees in chemical engineering.^[2]

UNIVERSITIES

FAMU, founded in 1887 as a public land grant university, is the only Historically Black College and University (HBCU) among the twelve universities in the State of Florida University System. Data on enrollment and university programs are shown in Table 3. Of the 12 doctoral degree programs at FAMU, six are in engineering with others in pharmaceutical sciences, physics, educational leadership, environmental science, and entomology. FAMU is recognized as one of the leading HBCUs in the nation, and it is the only HBCU that offers doctoral degrees in both chemical and biomedical engineering.

FSU was originally founded in 1851 as a Florida seminary and later became the Florida State College for Women (FSCW), serving only female students until 1948. Following World War II, FSCW became co-educational and was renamed Florida State University. FSU is a Carnegie Classified R1 (Highly Active Research) institution currently designated by the State of Florida as a Preeminent University. Data on enrollment and university programs are shown in Table 3. FSU has strong programs in the natural sciences (physics, chemistry, biology) and liberal arts, including music and performing arts.

	FAMU	FSU
Colleges and Schools	12	19
Degree Offered	98	274
Enrollment Total	10,000	44,000
% Female	64	58
% Black	82	9
% White	8	58
% Hispanic	4.4	20

ADMINISTRATION

The previous department chair, Dr. Teng Ma, passed away unexpectedly in 2019. Dr. Ma, Fellow of the American Institute of Medical and Biomedical Engineering, was the first faculty hired into the department with expertise in biomedical engineering. Although his doctorate was in chemical engineering from Ohio State University, his research was oriented towards tissue and cellular engineering. He was a world-renowned expert in this field and made major improvements in CBE as chair through faculty and staff hiring, as well as initiating the development of the new bachelor's degree in biomedical engineering. He was an outstanding

leader, professor, mentor, colleague, and friend. We currently are developing the first endowed professorship in honor of Dr. Ma. Dr. Bruce R. Locke, a CBE faculty member since 1989 and FSU Distinguished Research Professor, currently serves as department chair, having previously served from 2004-2012.

The FAMU-FSU College of Engineering is administered jointly by the two universities through a Memorandum of Agreement (MOA) originally signed by the universities in 1988 and last revised in 2018. The MOA establishes a Joint Management Council (JMC) that consists of the Chancellor of the State University System and both university presidents, provosts, vice presidents for research, and chief financial officers. The engineering dean and two student representatives are *ex officio* non-voting members of the JMC. The JMC approves the joint engineering budget. The MOA establishes that the academic home of the dean is to be FAMU, whereas FSU is designated as fiscal agent with fiduciary responsibility for the state-allocated budget and management of the facilities.

The dean is the administrative head of the college and is appointed by the FAMU President in consultation with the FSU President. The position reports jointly to the FAMU and FSU provosts. Dr. J. Murray Gibson has served as Dean since 2016 and returned to the faculty in January 2022.

The college is located less than three miles from the main campus of each university and adjacent to Innovation Park, a research and development park established by state statute with a mission to “foster the start-up, growth, and attraction of private companies that create high wage jobs, and contribute to our region’s innovation ecosystem companies.”^[5] The National High Magnetic Field Laboratory (NHMFL) is a National Science Foundation (NSF)-funded national laboratory that conducts leading research in all aspects of high magnetic fields through in-house researchers and several thousand visiting researchers per year. Several departmental faculty members (Drs. Jamel Ali, Samuel Grant, Subramanian Ramakrishnan, Theo Siegrist) have active laboratories at the NHMFL in areas including magnetic resonance, solid-state electronic materials, bioengineering, and complex fluids. Other faculty members (Drs. Rufina Alamo, Daniel Hallinan, Hadi Mohammadigoushki, Ralm Ricarte) extensively utilize facilities at the NHMFL.

The college administers other nearby laboratories, including the Aero-Propulsion, Mechatronics and Energy Center (AME); the Center for Advanced Power Systems (CAPS); the High Performance Materials Institute (HPMI); Applied Superconductivity Center (ASC), Center for Accessibility and Safety for an Aging Population (ASAP), Center for Intelligent Systems, Control, and Robotics (CISCOR), Energy and Sustainability Center (ESC), Florida Center for Advanced Aero-Propulsion (FCAAP), and Center for Resilient Infrastructure and Disaster Response (RIDER). CBE

faculty members utilize labs in the FAMU-FSU College of Engineering building, FSU Department of Chemistry & Biochemistry, FSU College of Medicine, FAMU Centennial Research Building, and AME.

DEPARTMENT GRADUATES

Since the first undergraduate class of five graduated in 1987, CBE has conferred approximately 1,200 Bachelor of Science degrees. The inaugural class of 32 biomedical engineering BS degree students graduated in 2021. The first ChE and FAMU-FSU College of Engineering PhD was awarded to Dr. Darren Ridgeway, who worked under the supervision of a previous faculty member and chair, Dr. Thomas Hanley, and who is now a faculty member at Ohio University. The first BME PhD was awarded in 2005 to Dr. Warren Grayson, who worked under the supervision of Dr. Teng Ma. Dr. Grayson is now a faculty member in biomedical engineering at Johns Hopkins University. Since its inception, we have awarded approximately 200 master's and doctoral degrees in chemical and biomedical engineering.

CBE graduates are engaged in a wide range of industrial, academic, and governmental careers and have pursued graduate studies at many universities. Our graduates are faculty members at a number of major institutions in the US and the world, including Clarkson University, University of Florida, Johns Hopkins University, University of Michigan, University of Paris, University of Pittsburgh, University of Southern California, University of Texas-Austin, and Yarmouk University.

Several of our alumni serve on the Departmental Advisory Board, including Mike Acton (MS 1999, Associate Director, Abbie Global Systems), Mark Bacchus (BS 1998, Senior Manager, Toyota), Dr. Cordell Hardy (BS 1998, Senior Vice President, 3M), Jason Maxwell (BS 1999, Vice President, KaMin Performance Minerals), and Kevin Warner (MS 1997, Principal Engineer, Geosyntec). *C&E News* recently profiled Dr. Hardy for his professional achievements.^[6]

In addition, the advisory board includes representatives from other chemical and biomedical engineering companies. Academic members include two leading chemical engineering professors (both members of the National Academy of Engineering): Dr. Ruben G. Carbonell, Frank Hawkins Kenan Distinguished Professor, Department of Chemical and Biomolecular Engineering, North Carolina State; and Dr. Stuart Cooper, Distinguished Professor of Engineering in the Department of Chemical and Biomolecular Engineering, The Ohio State University. Both Dr. Carbonell and Dr. Cooper have served on the advisory board for many years and have provided invaluable assistance and advice in the development of the program, including key aspects of both chemical and biomedical engineering.

FACULTY

CBE faculty are quite diverse, including permanent professors who are 24% female, 19% Black, 24% Asian, and 14% Hispanic. Table 4 shows the list of current departmental faculty members, including seven full professors, five associate professors, five assistant professors, four teaching faculty, and one adjunct faculty member. Department faculty highlights include:

- Five current NSF CAREER awardees: Drs. Natalie Arnett, Daniel Hallinan, Yan Li, Hadi Mohammadi-goushki, and Ralm Ricarte
- One Young Investigator Award from the US Air Force Office of Scientific Research: Dr. Jamel Ali
- Three society fellows: AIChE – Dr. Bruce Locke; APS – Drs. Rufina Alamo and Theo Siegrist
- The 2020 Joseph Cannon Award for Excellence in Chemical Engineering from NOBCCHE: Dr. Subramanian Ramakrishnan
- Humboldt Research Fellow, Alexander von Humboldt Foundation: Dr. Theo Siegrist
- Two Fulbright Scholars: Drs. Egwu Eric Kalu and Bruce R. Locke
- Two named professors: Dr. Rufina Alamo is the Simon Ostrach Professor and Dr. Subramanian Ramakrishnan is the 3M Professor
- Two noted emeriti professors include Dr. John Collier, who provided departmental and college leadership, and Dr. Loren Schreiber, who developed the undergraduate chemical engineering teaching laboratories leading to the current standard of excellence.

Over the past six years, four non-tenure track, full-time permanent teaching faculty members were hired by the department. These unique positions were provided by the FSU provost. Currently, these four faculty members teach courses across the curriculum and serve as dedicated instructors for the laboratory and senior design courses. All are consistently highly rated on their teaching evaluations and participate actively in service, including the curricular committees and accreditation efforts. In particular, these teaching faculty members make important contributions to the instructionally-intensive undergraduate teaching laboratories and capstone design sequence in both degree programs.

Dr. Kimberly Hunter is the instructor for the Transport Phenomena Laboratory and Unit Operations Laboratory. Dr. Robert Wandell covers the chemical engineering capstone design sequence. Dr. Stephen Arce teaches biomedical engineering senior design as well as other core chemical and biomedical engineering courses. Dr. Scott Thourson teaches core biomedical engineering courses, including biomechan-

TABLE 4
Department Faculty

Faculty Name	Degree	Rank
Rufina Alamo, PhD	PhD - Chemistry, 1981 University of Madrid	Professor
Jamel Ali, PhD	PhD – Mechanical Engineering and Mechanics, 2016 Drexel University	Assistant
Stephen Hugo Arce, PhD	PhD – Chemical Engineering, 2014 University of Florida	Teaching Faculty II
Natalie Arnett, PhD	PhD – Molecular Science and Engineering, 2009 Virginia Polytechnic Institute and State University	Associate
Hoyong Chung, PhD	PhD – Chemistry, 2011 Carnegie Mellon University	Associate
Tristan Driscoll, PhD	PhD – Bioengineering, 2015 University of Pennsylvania	Assistant
Samuel Grant, PhD	PhD – Bioengineering, 2001 University of Illinois, Chicago	Professor
Jingjiao Guan, PhD	PhD – Biomedical Engineering, 2005 Ohio State University	Associate
Daniel Hallinan Jr., PhD	PhD – Chemical Engineering, 2009 Drexel University	Associate
Christina Holmes, PhD	PhD – Biomedical Engineering, 2013 McGill University	Assistant
Chang Samuel Hsu, PhD	PhD –Physical Chemistry, 1974 University of Kentucky	Adjunct Professor
Kimberly Hunter, PhD	PhD – Biomedical Engineering, 2013 Florida State University	Teaching Faculty II
Egwu Eric Kalu, PhD	PhD – Chemical Engineering, 1991 Texas A & M University	Professor
Yan Li, PhD	PhD – Chemical Engineering, 2002 The Ohio State University	Associate
Bruce R. Locke, PhD	PhD – Chemical Engineering, 1989 North Carolina State University	Professor, Chair
Hadi Mohammadigoushki, PhD	PhD – Chemical and Biological Engineering, 2014 University of British Columbia	Assistant
Subramanian Ramakrishnan, PhD	PhD – Chemical Engineering, 2001 University of Illinois, Urbana-Champaign	Professor
Ralm Ricarte, PhD	PhD – Chemical Engineering, 2016 University of Minnesota	Assistant
Theo Siegrist, PhD	PhD – Solid State Physics, 1982 ETH, Zurich	Professor
Scott Thourson, PhD	PhD – Bioengineering, 2018 Georgia Institute of Technology	Teaching Faculty I
Robert J. Wandell, PhD	PhD – Chemical Engineering, 2020 Florida State University	Teaching Faculty I
Yaw Yeboah, ScD	ScD – Chemical Engineering, 1979 Massachusetts Institute of Technology	Professor

ics and both chemical and biomedical engineering computations. These faculty members may teach core and elective courses in both chemical and biomedical engineering.

UNDERGRADUATE PROGRAM

In addition to the traditional core chemical and biomedical engineering courses, CBE offers key undergraduate electives in bioengineering, colloids, complex fluids, materials, neural engineering, petroleum engineering, and polymers. The undergraduate teaching labs are extremely well run and maintained by full-time lab engineers and supervisors Richard Crisler (ChE) and Emily Thiel (BME). The Unit Operations Laboratory (UOL) serves as a major active-learning tool for our chemical engineering students. In addition to the three chemical engineering laboratories (Unit Operations, Transport Phenomena, Process Control), we run six biomedical engineering labs (Cell and Tissue Engineering, Quantitative Anatomy and Systems Physiology I and II, Bioinstrumentation, Medical Imaging, and Biodynamics & Control). Indeed, our laboratory is a powerful integrator of fundamental principles with practical applications, while providing superb environments for assessing and strengthening student performance before entering the workforce.

Another unique aspect to our undergraduate program is a new course taught by Dr. Hunter, Chemical Engineering Statistics. This course, required for all ChE majors, seeks to introduce the statistical tools needed to implement a variety of techniques for design and analysis of experiments. This course was introduced as a response to feedback and advice from our external advisory board. The students develop “wizard” level skills in software packages widely used in the chemical process industry, namely JMP Pro statistical software. The culmination of the Chemical Engineering Statistics class is the Design of Experiments project. The project requires utilization of all the tools in the statistical “toolbox.” In this project, teams of students have the freedom to design and conduct original experiments and determine how they will analyze, display, and interpret the results.

CBE faculty members are very active in supervising and mentoring undergraduate students in research. We have a vigorous Undergraduate Research Program (URP) that includes students who pursue Honors-in-the-Major (HITM) through academic credit for two semesters of 3-credit hour courses of directed research. Active since the early 1990s, 80 students have completed this program since 2008, and many of these students have gone to graduate school and have become leaders in industry. Graduates include such outstanding leaders as Dr. Cherie Stabler (Professor, Biomedical Engineering, University of Florida) and Jason Maxwell (Vice President, KaMin Performance Materials). We currently have 14 HITM students in the academic year 2021-22.

We have active student chapters of American Institute of Chemical Engineers (AIChE), the Biomedical Engineering Society (BMES), the Electrochemical Society (ECS), and the Society of Petroleum Engineers (SPE). The goal of the AIChE student chapter is to provide professional enrichment and social support to all undergraduate students in the Department of Chemical & Biomedical Engineering at the college.^{17]} The group organizes professional development activities, such as resume workshops,

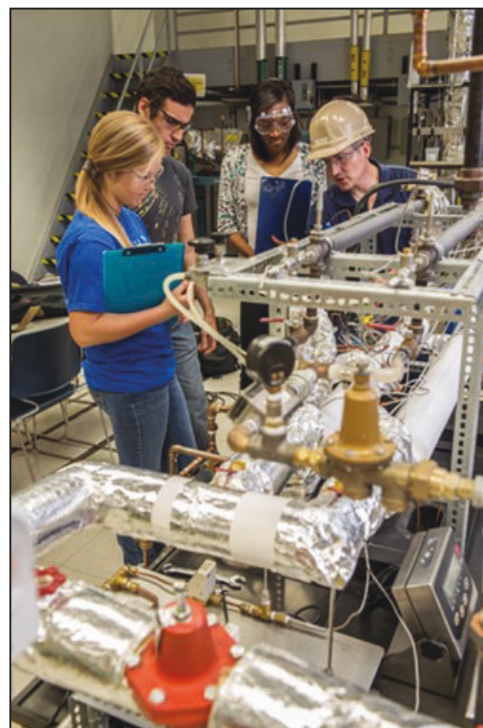


Figure 3. Undergraduate chemical engineering students working with lab director, Richard Crisler (far right).



Figure 4. Undergraduate biomedical engineering students working with Dr. Samuel Grant (center with blue shirt).

and has acquired a 3D printer for student use. Chapter members are actively involved in conducting tutoring and help sessions for core chemical engineering classes. In recent years the chapter has put forward a team to compete in the Chem-E-Car Competition[®]. The chapter also organizes and participates in many educational outreach activities, including hands-on activities at the Challenger Learning Center (CLC). The CLC is a K-12 outreach center operated by the college that serves 40,000 to 60,000 students annually from the Tallahassee community and Tri-State surrounding area. It houses a space mission simulator, demonstrational and hands-on laboratory activities, IMAX theatre, and planetarium. The CLC in Tallahassee is the only such center managed by an engineering college in the US.

The FAMU-FSU Student Chapter of BMES is active in various outreach opportunities to local schools, including on-site demonstrations and philanthropic activities. Additionally, BMES has sponsored seminars with technical and industrial leaders from the local community and beyond to inform the student membership about advances and careers in biomedical engineering. BMES sponsors award-winning collegiate student teams that participate in the International Genetically Engineered Machines (iGEM) competition as well as BMES Coulter College for Translation of Biomedical Innovation. A recent iGEM team advised by Dr. Cesar Rodriguez from the FSU College of Medicine won a gold medal in 2019 and silver medal in 2021. Dr. Rodriguez also works closely with BME students and teaches an Introduction to Synthetic Biology elective course open to BME and other students.

Both the AIChE and BMES student chapters sponsor large contingents of undergraduates and graduate students to attend the organizations' regional and national meetings. Both groups also participate in the FAMU-FSU College of Engineering Open House. Coordinated with the NHMFL Open House, these community events attract more than 10,000 visitors^[8] from the greater Tallahassee area to see demonstrations and interactive activities on a wide range of STEM topics, with booths from many faculty members from the department. The student chapter of SPE was initiated by Dr. Sam Hsu, a veteran of the petroleum industry and creator of an undergraduate/graduate course in petroleum engineering. An American Chemical Society (ACS) Polymers and Polymer Materials Science and Engineering (Poly/PMSE)

student chapter was established as a collaborative effort between CBE and the chemistry departments at FAMU and FSU. This student chapter has held symposia and workshops at conferences on additive manufacturing and has performed outreach in the area of materials research. The AIChE, BMES, ECS, SPE and Poly/PMSE student chapters enrich the educational experiences and professional development of their student members.

CBE conducts an annual event called the Bridge to Industry (B2I) series that provides valuable mentorship, networking, and recruiting opportunities for the undergraduate students. Each fall semester, faculty, alumni, industry partners, and all CBE seniors are invited to participate in the B2I event. During B2I, speakers present their personal and professional journeys, and all the attendees network. The event, organized by Dr. Hunter, began in Fall 2016 in response to student, alumni, and advisory board feedback. It has become an annual tradition, and alumni participation has grown. In Fall 2020, 14 alumni and industry speakers addressed the senior class and faculty. The candid talks resonate with students who are facing uncertainty in the process of designing their futures. The response from students has been overwhelmingly positive. Additionally, alumni who experienced the B2I event as students have traveled from great distances to participate after graduation, which is a testament to its self-sustaining and long-term value.

GRADUATE PROGRAM AND RESEARCH INTERESTS

CBE seeks to develop internationally-recognized programs in chemical, materials, and bioengineering leveraging the close connections between chemical engineering and biomedical engineering. Table 5 shows some of the key research areas and participating faculty members. We

Bioengineering	Cell/tissue engineering	Driscoll, Grant, Holmes, Li
	MRI/NMR	Grant, Mohammadigoushki
	Biomaterial	Ali, Guan, Holmes
Materials	Polymers	Alamo, Arnett, Chung, Hallinan, Ricarte
	Inorganic materials	Mohammadigoushki, Ramakrishnan, Siegrist
Chemical Engineering	Complex fluids/rheology	Mohammadigoushki, Ramakrishnan
	Electrochemical engineering	Hallinan, Kalu
	Plasma reaction engineering	Locke

currently have approximately \$17.7M of active externally funded grant projects with over \$3.2 M in annual research expenditures funded by a diverse range of agencies including the NSF, National Institutes of Health (NIH), US Department of Defense, US Department of Agriculture, National Aeronautics and Space Administration, and US Department of Energy. Seventy-six percent of the tenured and tenure-track faculty currently have active research funds.

We have also invested significantly in expanding our graduate student program that offers master's and doctoral degrees in both biomedical and chemical engineering. With the largest current graduate population in our history (currently 55 students), the CBE graduate program and department research rely heavily on our students and their success. CBE students are meeting that challenge as indicated by their recent accomplishments.

Shannon Helsper, PhD candidate in BME, was awarded one of the inaugural FAMU-FSU College of Engineering Dean's Fellowships with her admission in 2018 and since has earned a Young Scientist Award from Elsevier's *Journal of Magnetic Resonance*. Helsper has also received an NIH F31 Ruth L. Kirschstein Predoctoral Individual National Research Service Award that funds her studies with Dr. Samuel Grant in the MRI evaluation of human mesenchymal stem cells and products for ischemic stroke treatment.

Dr. Roneisha Haney, a recent PhD graduate in ChE, was selected to attend The Dow Company's Annual Building Engineering and Science Talent (BEST) Symposium, which introduces PhD students and postdoctoral scientists to a wide range of careers in industrial research. Dr. Haney recently accepted a position at the Materials and Manufacturing Directorate at Wright Patterson Air Force Base to employ her expertise in additive manufacturing and materials characterization, which she developed under the tutelage of Dr. Subramanian Ramakrishnan.

Richard Jeske, PhD candidate in ChE and student of Dr. Yan Li, recently earned an NSF grant for Non-Academic Research Internships for Graduate Students (INTERN) to work with the company PBS Biotech on specialized bioreactors to generate and harvest extracellular vesicles from stem cells. This federally-funded internship allowed him to work onsite with the company in California and continues to support his dissertation research.

A team of researchers lead by Dr. Ramakrishnan, including faculty from CBE (Ali, Arnett, and Hallinan), from Industrial and Manufacturing Engineering (T. Dickens), and the FAMU College of Pharmacy (Dr. Mandip Sachdeva), created a center to investigate the structure-function relationships in novel materials and develop design rules for their processing, e.g., 3D printing. These materials will be used in magnetic shielding for spacecraft, energy devices, and drug delivery systems. The Center, titled the Center for

Complex Materials Design for Multidimensional Additive Processing (also known as the CoManD Center), is funded by a National Science Foundation Centers of Research Excellence in Science and Technology (CREST) grant. The technology and devices developed at CoManD will result in novel methods for drug delivery to treat cancer, better aircraft/space shuttle wings that will not be affected by radiation, and highly-portable electronic devices with longer lasting batteries that will aid a number of industries, as well as the US Department of Defense (Army, Air Force). CoManD and CREST already have made a significant impact on the department and college research infrastructure, aiding faculty in procuring a number of federal grants. Of particular importance is a recent award from the Department of Defense to aid the US Army in making lightweight composites. CoManD research is highly integrated with the education of undergraduate and graduate students. This grant has helped FAMU make a larger impact in materials and biological research and has created a pipeline of new science, technology, engineering, and math (STEM) professionals to address the challenges of the future. There are currently 12 domestic minority PhDs affiliated with the center. Graduates of CoManD include Dr. Bobby Haney, currently a postdoctoral fellow at Harvard University.

CBE has developed a vibrant team of polymer and soft matter researchers that has grown over the past eight years from only a few renowned researchers (Dr. Rufina Alamo, expert in crystallization of polymers, and Dr. Subramanian Ramakrishnan, expert in rheology of colloids and complex fluids) to 27 faculty members. These include 13 CBE faculty members and investigators from other departments including FAMU Chemistry, FSU Art, and FSU Biological Sciences, Chemistry & Biochemistry, and Scientific Computing. Student participants hail from these departments as well as the interdisciplinary Materials Science & Engineering (MSE) program in the college. Drs. Hoyong Chung and Daniel Hallinan have developed lignin-based polymers for making battery electrodes,^[9] and Dr. Rufina Alamo and her graduate student, Xiaoshi Zhang, have made important discoveries on the thermal processing and properties of "green polymers" made from sustainable sources.^[10]

Like 3D printing, polymers and soft materials are a natural bridge between the MSE-focused research on the ChE side of the department and BME-focused research. Faculty and students regularly meet as part of a Polymer Journal Club, and the affiliated Poly/PMSE student chapter will hold its first annual Polymer Symposium in 2022. In collaboration with this diverse group of researchers, many CBE faculty members study or use polymers to address National Academy of Engineering Grand Challenges in areas such as solar energy, the brain, medicine, water, and carbon capture.

Complementing these polymer and materials efforts, we have expanded our biomedical engineering research sub-

stantially with a particular focus on regenerative engineering and the assessment of treatment delivery and efficacy for neurodegeneration and cancer. Recent hires (Dr. Tristan Driscoll, postdoctoral associate at Yale University, and Dr. Christina Holmes, postdoctoral associate at Johns Hopkins University) complement the established laboratories of Drs. Samuel Grant, Jingjiao Guan and Yan Li. Their efforts include evaluating the application of stem cell therapies and products to acute and chronic neurological disease; establishing model organoids as testbeds for therapies as well as generating the therapeutics themselves; designing and implementing novel nanoparticles and biomaterials to target disease and foster healing; and characterizing and exploiting intracellular mechanisms related to disease progression.

The department maintains an imaging and spectroscopy facility that has steadily grown. Under the supervision of Dr. Samuel Grant, the central instrument of this facility is the 11.75-T, 500-MHz widebore NMR/MicroMRI magnet located at the college. This system, upgraded in 2022, provides MR microscopy, *in vivo* imaging and NMR spectroscopy capabilities not only to our CBE researchers, but in collaboration with the NHMFL, serves internal college and external users.

In this fashion the 500-WB magnet is used not only as unique instrumentation in its own right but also as a testbed for the high field systems of the NHMFL (e.g., 21.1-T ultrawide bore magnet for *in vivo* imaging and 35.2-T Series Connected Hybrid magnet) and FSU (3-T human MRI). The 500-WB system has been used to monitor and analyze cellulose formation in ionic fluids, diffusion in polymeric micellar systems, *ex vivo* human and rodent brain imaging, 3D cellular bioreactors, and energetic and fluid dynamics in living systems.^[11] The laboratory is also equipped with UV/VIS mass spectrometry and IR spectroscopy as additional means of characterizing materials. In the near future the 500-WB system will be used in the undergraduate BME curriculum to provide students with hands-on experience in medical imaging and transceiver design.

Other faculty research also bridges biomedical and chemical engineering. For example, Dr. Jamel Ali studies how fluid flow affects biofilm formation through collaboration with colleagues at Howard University.^[12] Dr. Hadi Mohammadigoushki, in collaboration with Dr. Samuel Grant, analyzes the *in-situ* structure of monoclonal antibodies at water-air and water-oil interfaces using high field nuclear magnetic resonance spectroscopy. Dr. Bruce Locke, in collaboration with Dr. Cesar Rodriguez (FSU College of Medicine) and

Dr. Youneng Tang (Civil and Environmental Engineering), studies how non-thermal plasma interacts with microbes.

CBE faculty members also have close collaborations and interactions with research programs at the two universities, including:

- National High Magnetic Field Laboratory (NHMFL)
- High Performance Materials Institute (HPMI)
- Aero-Propulsion Mechatronics & Energy Center (AME)
- Biomedical Research Facility (Laboratory Animal Resources)
- Institute of Molecular Biophysics (IMB)
- FAMU College of Pharmacy and Pharmaceutical Sciences
- Departments of physics, chemistry and biochemistry, biomedical sciences, scientific computing, and biological sciences at FSU
- Industrial & manufacturing, electrical & computer, and mechanical engineering departments at the college.

These collaborations continue to be important strengths in the development of faculty and graduate research. In turn, incorporating these emerging areas of chemical and biomedical engineering into the undergraduate program through elective courses places our students at the forefront of the modern engineering profession.

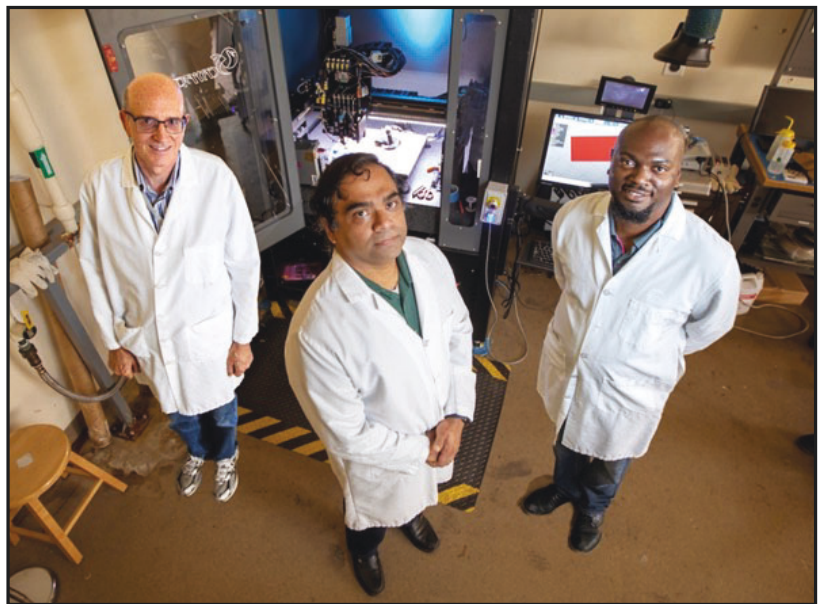


Figure 5. (Left to right): Drs. Theo Siegrist, Subramanian Ramakrishnan, and Tarik Dickens (industrial and manufacturing engineering faculty member) with a high precision 3-D printer for materials research.

FUTURE PERSPECTIVES

The Department of Chemical & Biomedical Engineering at the FAMU-FSU College of Engineering has made major advances in the education of a diverse population of students and in many research areas. We are committed to combining the strengths of FAMU and FSU to continue to serve the state and the nation by producing outstanding graduates who reflect the diversity of the nation. While separate bachelor's degrees in chemical engineering and biomedical engineering are now offered, we seek to continue to build research and educational efforts that span and connect the disciplines at both the graduate and undergraduate levels.

REFERENCES

1. LiGibson JM. FAMU-FSU College of Engineering. Personal communications based upon data from the US Department of Education IPEDS database (Integrated Post-Secondary Education Database).
2. ASEE. <https://ira.asee.org/wp-content/uploads/2021/02/Engineering-by-the-Numbers-FINAL-2021.pdf> . Accessed January 12, 2022.
3. Locke BR, Arce, P, Peters, M (1993) ChE Department FAMU/FSU. Chemical Engineering Education. 27(1):8:13.
4. ASEE. <https://ira.asee.org/national-benchmark-reports/#retentionreports>. Accessed January 12, 2022.
5. Innovation Park. <https://innovation-park.com/about/>. Accessed January 13, 2022.
6. ACS. <https://cen.acs.org/materials/One-on-one-with-Cordell-Hardy/99/i6>. Accessed January 12, 2022.
7. FAMU-FSU CoE. <https://www.eng.famu.fsu.edu/student-org/aiche>. Accessed January 12, 2022.
8. NHMFL. <https://nationalmaglab.org/news-events/events/for-community/open-house>. Accessed January 12, 2022.
9. FAMU-FSU CoE. <https://www.eng.famu.fsu.edu/news/chung-battery-components-plants>. Accessed January 12, 2022.
10. FAMU-FSU CoE. <https://www.eng.famu.fsu.edu/news/alamo-temperature-sustainable-polymers>. Accessed January 12, 2022.
11. Holder SW, Grant SC, Mohammadigoushki H. Nuclear Magnetic Resonance Diffusometry of Linear and Branched Wormlike Micelles. Langmuir. 2021 Mar 30;37(12):3585-3596. doi: 10.1021/acs.langmuir.0c03486.
12. ACS. <https://cen.acs.org/biological-chemistry/biochemistry/Patrick-Ymele-Leki-and-Jamel-Ali-want-to-understand-how-bacteria-form-impenetrable-biofilms/99/i6>. Accessed January 12, 2022. □