



University of Colorado **Boulder**

2018 Program Review

Department of Chemical and
Biological Engineering

Academic Review and Planning
Advisory Committee Report

Approved

A handwritten signature in black ink, appearing to read 'Russell Morse'.

05/06/2019

Provost and Executive Vice Chancellor for Academic Affairs. | Date

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Process Overview

The review of the Department of Chemical and Biological Engineering (CHBE) was completed in accordance with the 2018 review guidelines. The Academic Review and Planning Advisory Committee (ARPAC) conducts and writes the final reviews of all Boulder campus academic units. CHBE completed a self-study in December 2017. An internal review committee of two CU Boulder faculty members from outside of the unit checked the study and issued findings in February 2018. The internal reviewers generally found the report fair and accurate and noted several issues for subsequent exploration by the external reviewers and ARPAC. The external review committee, consisting of two experts within the discipline from outside of the University of Colorado, visited the unit over April 26-27, 2018, reviewed relevant documents, and met with faculty, students, staff, and university administrators. Internal and external reviewer comments and recommendations are cited at appropriate points throughout the report. This public document reflects the assessment of and recommendations for the Department of Chemical and Biological Engineering as approved by ARPAC.

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Unit Overview

The campus's standardized description of the unit is available on the website of the Office of Data Analytics (ODA) at

<https://www.colorado.edu/oda/institutional-research/institutional-level-data/information-department/academic-review-and-planning>.

ODA updates the profile annually in the fall semester. This report cites data posted in October 2017, reflecting the state of the Department of Chemical and Biological Engineering (CHBE) as of the academic year (AY) 2016-2017.

The Department of Chemical and Biological Engineering (CHBE) is a highly ranked program with faculty members recognized for their teaching and research excellence and innovation. The department specializes in several areas that span the science and engineering disciplines, including bioengineering, renewable energy, pharmaceutical biotechnology, catalysis, polymer and soft materials, tissue engineering, and computational materials science. CHBE faculty members collaborate extensively with other college and campus units (e.g., Civil, Architectural and Environmental Engineering; Mechanical Engineering; Physics; Chemistry and Biochemistry; Molecular, Cellular and Developmental Biology; etc.) and with CU Health Sciences departments (e.g., Dentistry, Surgery, and Pharmacy), as well with colleagues at institutions elsewhere. CHBE faculty members also participate in several CU Boulder research centers and networks (e.g., the BioFrontiers Institute, the Soft Materials Research Center, the Membrane Applied Science and Technology Center, etc.) and with research centers elsewhere (e.g., the National Science Foundation Industry/University Cooperative Research Center for Fundamentals and Applications of Photo Polymerization, and the Center for Pharmaceutical Biotechnology).

The department offers two BS degrees: one in chemical engineering and one in chemical and biological engineering. It

offers three graduate degrees: an MS in chemical engineering, and two PhDs – a longstanding PhD in chemical engineering, and another, new (as of fall 2018) PhD in biological engineering. Almost all MS degrees awarded within the department are earned by CHBE PhD students as an optional milestone; the MS is not considered a terminal degree.

Personnel
and
Governance

The Office of Data Analytics (ODA) reports that CHBE rosters 23 tenured/tenure-track faculty members (ranked sixth of seven engineering departments). This group includes two distinguished professors; ten professors; five associate professors, and six assistant professors. One full professor shares a 50% appointment with the Department of Biochemistry. Another holds a primary appointment at CU Denver and a CHBE courtesy appointment. According to the department self-study, 14 faculty members (note: ODA records two) hold institute or research center joint appointments, and nine (note: ODA records eight) hold titled and/or endowed professorships (the most among engineering departments). Twelve have won one or more national research awards. Several others have received national, college and campus awards for achievement in teaching, service, and technology transfer. CHBE faculty member salaries for combined ranks slightly exceeds (106%) the national average among peer institutions. Broken out by rank, full professors average 103%; Associates, 116%; and Assistants, 102%.

Since the previous program review, five faculty members have retired (one remains as a research professor), one left to join another institution, and one was denied tenure. CHBE has offset these losses by hiring nine new faculty members. Within the next five to seven years, the unit anticipates up to four additional retirement-created vacancies. For this reason, and in response to recent, significant undergraduate and graduate program growth, the unit is currently engaged in recruiting

faculty members to fill four new tenured/tenure-track (TTT) faculty member lines, including a line dedicated to the new interdisciplinary Materials Science and Engineering Program (MSEP), and three research program lines affiliated either with the Renewable and Sustainable Energy Institute (RASEI) or the BioFrontiers Institute.

The CHBE self-study does not address postdoctoral fellows as a separate cadre, but these number approximately 34. The self-study describes support for their work in combination with a description of graduate student mentoring, training, and professional development. Assigned faculty mentors facilitate postdoctoral fellows' training in laboratory research, teaching, manuscript preparation, and research presentation.

Additionally, postdoctoral fellows assist the faculty in research proposal preparation and undergraduate and graduate student research supervision. The department classifies most of its postdoctoral fellows as "research associates."

Additionally, CHBE rosters seven non-TTT instructional faculty, including five instructors (three at the senior rank), one adjunct professor, and one lecturer. In addition to the 34 postdocs, an extensive group of research personnel supports CHBE, including one research assistant professor; five senior research associates; one senior professional research assistant; and eight professional research assistants.

Finally, CHBE employs 13 exempt staff members: five work in academic, business and finance/accounting roles; eight work in various temporary roles. Six classified staff members provide additional administrative support (e.g., student services and accounting work) and facilities management (e.g., machining, laboratory coordination, and electronic engineering).

Generally, unit bylaws follow the college model, are thorough and clear, and indicate sound governance. One exception is that the bylaws do not adequately specify annual merit evaluation criteria. The CHBE chair is appointed and reappointed to a relatively powerful role by a faculty member majority vote (the bylaws do not specify term length or term limits). Three associate chairs support the chair, respectively overseeing the graduate and undergraduate programs and faculty affairs. Non-TTT faculty do not automatically enjoy voting privileges. Permission for instructors to vote on instructional and student-related matters requires assent from a TTT faculty member majority. An executive committee advises the chair on budget, personnel, and administrative matters and conducts annual faculty performance reviews. CHBE faculty members recently modified the bylaws to change the process to recommend TTT job candidates to the dean for approval from a super majority to a majority. Furthermore, the revised bylaws permit the chair to employ her/his discretion in advancing majority recommendations.

Both the internal and external reviewers praise CHBE leadership for inspiring faculty and staff member cohesion and commitment to a strategic vision, and for hearing and responding to students' concerns.

Research
and
Scholarship

CHBE faculty members enjoy wide visibility and esteem for their research programs, which demonstrate the admirable scope (e.g., including fundamental, applied, and translational categories), scale (e.g., from the molecular to the macroscopic), innovation, and collaboration of the department's research enterprise. As outlined in the self-study, CHBE research impacts materials science and engineering, tissue engineering, catalysis, bioengineering, polymer science, and renewable energy. The faculty's work draws on expertise in applied mathematics, biology, chemistry, computational sciences,

physics, and related theory. As already detailed, CHBE faculty members contribute significantly to college, campus, university, and national interdisciplinary research. This distinguished work has merited federal funding directed to graduate student research and training in the areas of pharmaceutical biotechnology, functional materials, micro- and nanoparticles, and macromolecules.

Whether measured by disciplinary or campus metrics, CHBE faculty research appears strong. In the global Shanghai Rankings, the unit falls 11th internationally and seventh nationally. The National Research Council ranks CHBE 17th among 35 peer institutions. ODA rankings based on seven-year TTT faculty member publication rates place the unit either first or second in all categories (e.g., refereed articles and chapters, conference presentations, etc.) among CU Boulder engineering departments. CHBE faculty members have a record of publishing in high-impact journals, increasing their visibility and citation rates. Between 2011 and 2017 the unit's annual research funding rate accelerated 27% (from \$11 million to \$14 million), ranking CHBE first among the six engineering comparators in per TTT faculty member expenditures. As already mentioned, various national academies, representing engineering, medicine, and invention, have recognized a majority of CHBE faculty members with awards, as have major professional associations such as the American Institute of Chemical Engineers. The CU Boulder campus has also recognized CHBE faculty members for their research, including citations by the Boulder Faculty Assembly and by the engineering dean.

Undergraduate
Education

As noted above, CHBE offers BS degrees in chemical engineering and chemical and biological engineering. The department offers no minors. The fall 2016 ODA census counted 759 majors (third among eight engineering units),

representing a 73% five-year increase (note: CHBE reports a 2017 student census figure of 667, a 35% seven-year increase). Undergraduates comprise 82% of the unit's students. In fiscal year (FY) 2016-2017, CHBE generated 11,938 student credit hours (third of eight review units), a 43% five-year change. Undergraduate-generated student credit hours (SCH) constitute 88% of the unit's total. The ratio of CHBE majors per tenured/tenure-track faculty member is 32.3 (second of six review units). During FY 2016-2017, CHBE tenured/tenure-track faculty members generated 56% of SCH (third among seven review units), representing a 3% five-year decline. Courses taught by CHBE TTT faculty members averaged 94 students per section (second of seven review units), representing a 49% five-year increase. CHBE instructors generated 39% of SCH (fourth among eight review units), forming an 18% five-year increase. Instructor-taught sections had an average 86 student enrollment, representing an 18% five-year decrease. Non-majors generated 18% of 2016-17 SCH (fifth among eight review units).

According to ODA, in 2016-2017 CHBE tenured/tenure-track faculty member-taught courses averaged 70% FCQ ratings (seventh out of eight engineering units; a 7% five-year increase). During that time, CHBE instructors netted an average 79% FCQ rating (seventh out of eight engineering units; a 6% five-year increase). Between 2010-2017, the CHBE self-study documents increases from 4.3 to 4.7 for the department's average tenured/tenure-track member FCQ scores and from 4.8 to 5.1 for instructors. The unit has three undergraduate advisors. In FY 2016-2017, CHBE graduated 158 majors, a 1% five-year increase and a number that represents 77% of all department degrees awarded that year. CHBE undergraduates took an average 3.67 years to graduate (first of seven engineering units). The department's undergraduates have

higher average ACT scores and GPAs than other engineering students.

A 2013 student engagement survey measured CHBE senior satisfaction and reported ratings ranging from a low of 51% for academic advising quality (fifth among six engineering departments), upward to 81% for course availability (second of six units), to a high of 85% for academic quality (second of six units). An ODA-administered spring 2016 senior survey indicated an average satisfaction score of 60.14 across seven categories, with ratings ranging from a low of 41% for average career advising satisfaction to 72% for average satisfaction with the major as a whole and 73% for CHBE's helping students attain their educational goals. A January 2018 internal review committee-administered survey yielded replies from 72% of those surveyed. Among those respondents, 89.36% reported that they were, overall, either "satisfied" or "very satisfied" with the program. Comparable ratings on seven related breakout items ranged from a low of 43.4% for "support for research projects" to a high of 89.43% for "logical sequencing . . . of courses."

Graduate
Education

As noted above, CHBE offers the MS in chemical engineering and PhDs in chemical engineering and (as of fall 2018) in biological engineering. ODA census figures for fall 2016 show 162 CHBE graduate students across MS and PhD programs, representing a 36% five-year increase (seventh among nine engineering units). The CHBE self-study reports a 131 student academic year (AY) 2016-2017 graduate program census count. The MS program enrolled 16 students and the PhD program 146, a 27% five-year increase (first out of eight departments). The ratio of MS students per tenured/tenure-track faculty member was 0.7; that for PhD students was 6.2 (forming a 27% five-year decrease; first of six units).

The department's graduate SCH generation increased 51% over five years ending with 2016-2017 (totaling 1560 hours; eighth of nine units). CHBE TTT faculty members generated 89% of that SCH, a five-year 4% decrease. CHBE graduate course FCQ ratings averaged 77% (a 14% five-year increase; sixth of nine units); the FCQ ratings for instructors averaged 84% (a five-year 10% increase; third of nine units). In fiscal year 2016-2017, the unit awarded 47 graduate degrees: 38 MS and nine PhD. These figures represented a five-year change of +153% and -47%, respectively; they contributed to the unit's ranking eighth of nine, and sixth of eight, respectively. Graduate degrees represented 23% of all CHBE degrees awarded in FY 2016-2017.

The five-year average of GRE scores of entering CHBE graduate students remained virtually unchanged and ranked in the middle of engineering units. Over those five years, the average GPA score was ~3.9. Notably, CHBE graduate students won highly competitive fellowships 44 times in 2017, including those awarded by the National Science Foundation, the National Institutes of Health, the United States Department of Agriculture, and the United States Department of Energy.

The internal reviewers' January 2018 survey of CHBE graduate students showed that 83% of participating students reported they were, overall, either "satisfied" or "very satisfied" with the program. Other ratings ranged from a low of 44% for "availability of electives" to a high of 90% for "accessibility of supplemental resources."

Space
and
Infrastructure

CHBE occupies space in two East Campus buildings—the Jennie Smoly Caruthers Biotechnology Building (JSCBB) and the Sustainability Energy and Environment Complex (SEEC)—and space in the Engineering Center on Main Campus. JSCBB houses the majority of CHBE classrooms, labs, and offices and

functions as a state-of-the-art teaching and research facility that opened in 2012 (teaching labs opened there in 2015). CHBE teaching and other spaces occupy approximately 109,000 of the building's 363,000 square feet. The department's executive committee administers CHBE-controlled spaces and also represents the interests of two cohabiting JSCBB units. The building will soon gain an additional 60,000 square feet, which will include three additional interactive classrooms and a conference room. The department also anticipates completing renovations of JSCBB undergraduate study and computing spaces following the allocation of a \$120,000 allowance. Control of these spaces is currently the subject of negotiation between building occupants. Four CHBE faculty members have SEEC-based offices and five others remain in the Engineering Center.

Inclusive
Excellence

The department has not submitted an inclusive excellence plan to the Office of Diversity, Equity and Community Engagement, but the self-study provides a draft de facto plan.

A closer look at the diversity of principal unit groups shows the following:

Faculty: The Office of Data Analytics (ODA) reports that as of fall 2016, 21% of CHBE's TTT faculty members identified as women (third of seven engineering units) and 21% as belonging to a minority group. Members of underrepresented minority groups constituted 4% of TTT faculty members (third of seven units).

Staff: Neither ODA nor the self-study details staff member diversity.

Graduate students: In fall 2016, ODA identified 35% of CHBE graduate students as women (third of nine engineering units),

representing a five-year 18% decrease. (Note: CHBE reports figures of 32.1% women for 2016, and 30.8% for 2017.) Eighteen percent of graduate students identified as belonging to a minority group (sixth of nine units), a 41% increase. Members of underrepresented minority groups constituted 8% of CHBE's graduate student population (eighth of nine units), a 9% five-year increase. [Note: On this item, the USS reports figures of 4.4% for 2016, and 4.8% for 2017].

Undergraduates: In fall 2016, 40% of CHBE undergraduate students identified as women (ranked second of eight engineering units), a five-year 14% increase. Thirty percent of CHBE undergraduates identified as belonging to a minority group (fifth of eight units), a five-year 31% increase. Underrepresented minority groups constituted 15% of majors (sixth of eight units), a 92% five-year increase. In responding to the January 2018 internal review committee survey, 93% of participating CHBE undergraduates either "agreed" or "strongly agreed" with the prompt that the department "encourages a climate that is tolerant and respectful of diversity."

Climate Climate surveys administered by ARPAC staff in September 2017 and addressed to CHBE faculty and staff members and to graduate students holding teaching or research appointments report the following findings:

Faculty: Seventy-four percent of CHBE faculty members participated. Ninety-five percent either "agreed" or "strongly agreed" with the prompt that they experience respectful treatment by other department groups. Scores on breakout items in this category ranged from 91% agreement with experiencing respectful treatment by the chair and by faculty colleagues, to 100% for respectful treatment by staff members. An average of 74% of participating faculty either "agreed" or "strongly agreed" that the unit climate is generally positive for

faculty groups distinguished by rank, gender, race, sexual orientation, and religious and political affiliation. Scores on breakout items in this category ranged from 57% agreement that individuals of “different sexual orientations” are well treated to 87% agreement that faculty members of all ranks are well treated.

An average of 17% of CHBE participating faculty members either “agreed” or “strongly agreed” that their faculty colleagues behave in humiliating or intimidating ways. Scores on breakout items in this category ranged from a low of 13% agreement that graduate students receive such mistreatment, to a high of 22% agreement that some faculty members mistreat their colleagues.

An average of 86% of participating faculty members either “agreed” or “strongly agreed” that the unit enjoys a positive, civil, supportive, and inclusive sense of community. Scores on breakout items in this category range from a low of 83% agreement that CHBE informal network feel inclusive, to a high of 91% agreement that civility guides department operations.

Staff: Nine of 12 staff members (75%) responded to the climate survey. One hundred percent of respondents either “agreed” or “strongly agreed” that the chair, faculty members, students, and other staff members treat them respectfully. Likewise, 100% of staff members either “agreed” or “strongly agreed” that the department climate is positive for women staff members. “Community”-related items assessing the behavior of different department groups towards each other as being positive, civil, supportive, and inclusive received an average 62% positive assessment from CHBE staff. Related scores on breakout items in this category ranged from a low of 33% agreement that faculty members humiliate and intimidate staff members, to 100% agreement that staff members are friendly

and supportive of each other. Interpretation of these breakout scores should take into account that a “don’t know” response averaged 17% (ranging from a low of 0% “don’t know” for the prompt “I feel like a valued member of the department,” to a high of 44% “don’t know” for how faculty members treat each other).

Graduate Student Appointees: Overall, graduate students on appointments averaged 94% “agreement” or “strong agreement” with items concerning their respectful treatment by other department groups. Scores for breakout items in this category range from 82% agreement that graduate advisors treat the students respectfully, to a high of 100% for treatment by other graduate students.

An average of 74% of CHBE graduate student appointees either “agreed” or “strongly agreed” that the unit climate is generally positive for graduate student groups distinguished by nationality, gender, race, sexual orientation, and religious and political affiliation. Breakout items in this category averaged from 62% agreement that “graduate students of color” are treated respectfully to a high of 80% that students of “different sexual orientations” and non-U.S. nationalities are treated that way. These scores should take into account that “don’t know” responses averaged 21%: from a low of 16% “don’t know” regarding how non-U.S. nationals are treated, to a high of 31% “don’t know” for the treatment received by “graduate students of color.”

Prompted to assess community-related items, graduate student appointees at a rate of 82% assessed the behavior of different department groups towards each other as being positive, civil, supportive, and inclusive. Related scores on breakout items in this category range from a low of 36% agreement that faculty members humiliate and intimidate graduate students, to 100%

agreement that graduate students are friendly and supportive of each other.

For FY 2017-18, the college provided CHBE \$6.01 million for operations, representing a one-year 5.7% increase. The department's budget allocation over seven years has grown in parallel with department program growth. Faculty salary expenditures totaled \$2,911,814 in FY 2017, representing a 21.93% seven-year increase (partly attributable to eight new faculty hires during this period). The college gives CHBE 23% of the department's externally sourced money back and allocates 8% of these indirect cost recovery funds (i.e., ~1/3 of the total) toward unit staff salaries. CHBE returns 15% of indirect cost recovery monies to principal investigators, who can use this money to pay for a course release. Additionally, CHBE relies on ~\$5.4 million in endowment funds and expendable accounts totaling ~\$2.5 million. These monies help to cover unexpected expenses and to fund the department's required 1/3 contribution to new faculty start-up packages. Since 2012, CHBE has committed \$2.5 million of its own funding to support multi-year faculty startup packages; it has spent \$1.2 million to date.

Past Reviews

ARPAC last reviewed the Department of Chemical and Biological Engineering in 2011. At that time, ARPAC recommended that CHBE undertake strategic planning that would encourage broad participation and a shared vision among unit members, while also serving the department's evolving teaching and research needs during its relocation to JCSBB. ARPAC also recommended that CHBE modify its governance structure to allow greater faculty member participation (principally, through the creation of executive and salary committees), thereby cultivating both greater transparency and future leadership. ARPAC advised the unit to create a graduate studies associate chair position and to assign oversight of unit advising and teaching improvements to its undergraduate studies associate chair. ARPAC additionally recommended that CHBE revise its mentoring program to give junior faculty members greater say in selecting mentors, to formalize mandatory annual mentoring feedback sessions, and to supplement these with written feedback and recommendations. ARPAC advised CHBE to investigate graduate student confusion and discontent concerning qualifying exams and research advising and to engage advancement personnel in finding funding for multi-year graduate fellowships. ARPAC directed CHBE to investigate and mitigate declining undergraduate FCQ ratings. Additionally, ARPAC requested that CHBE bring its bylaws into alignment with campus policy on instructor rights.

CHBE actively responded to several of these recommendations, including to undertake a comprehensive strategic planning process, transform its governance structure, enhance its mentoring and coaching of under-performing instructional faculty, attempt teaching assignment optimization, hire a new undergraduate advisor, and additional instructors, as well as additional TTT faculty members—all to enhance majors' satisfaction. CHBE also took steps to revise its mentoring

policies; improve communications regarding graduate program policy and performance expectations; form a graduate leadership council; reconstitute its alumni advisory board; enhance diverse faculty recruitment and hiring; and cultivate its fundraising strategies. CHBE chose not to revise its bylaws concerning instructor participation in unit governance, claiming that they conformed to campus guidance.

Campus Context

The department's teaching and research programs display significant interdisciplinarity. Arguably, this quality is inherent in CHBE's combination of at least two (if not more) engineering specializations that remain distinct at other institutions. Additionally, the unit shares faculty members' work and sponsors student research in groups ranging across several college, campus, and university institutes and networks. The unit offers both introductory service courses and electives serving students from other engineering programs. The excellence of CHBE's teaching and research has been validated by a high percentage of faculty members' receiving college, campus, and university awards.

Disciplinary Context

As already described, and as the internal and external reviewers affirm, CHBE is a highly ranked and visible organization within its discipline—a status documented in national and international survey rankings that assess both unit reputation and performance metrics. The department’s teaching and research excellence is validated by the number and frequency of prestigious awards given to a high percentage of unit faculty by the discipline’s professional associations (e.g., the American Society for Engineering Education, the American Institute of Chemical Engineers, the National Society of Professional Engineers, the American Chemical Society, and the Institution of Chemical Engineers), and by related national academies. The internal and external reviewers concur that current conditions are ripe for the unit’s disciplinary status to rise higher, provided that CHBE can successfully navigate key challenges.

Analysis

The external reviewers agreed with the words of the internal reviewers that CHBE is “a vibrant, well-performing and well-led department that is doing an excellent job of meeting its mission and goals.” In turn, the external reviewers added, “the department’s strengths include its leadership, the new facilities, a faculty committed to excellence in teaching, research and scholarship, and strong support from the dean to hire faculty and act strategically.” That said, both review committees agree that CHBE must address specific challenges in order to achieve its considerable potential. Related sources of challenge here include growing undergraduate enrollment, graduate student recruitment and training, faculty mentoring and professional development, research and teaching infrastructure, and unit climate and diversity. ARPAC notes that CHBE has thoughtfully acknowledged the reviewers’ concerns and is already addressing them by adapting its strategic planning.

Strategic Vision

The department’s self-study describes CHBE as aspiring to become “a highly-ranked, top-tier program widely recognized for outstanding students, faculty, and alumni; for excellence in education with attention to individual students; and for innovative research and student training at the forefront of interdisciplinary science and engineering, particularly in the areas of biotechnology, energy, and materials.” Additionally, the unit commits to “educat[ing] a diverse set of students in modern chemical and biological engineering fundamentals and practice to prepare them to be leaders in their chosen professions, for lifelong professional growth and a dynamic range of careers, to engage actively both graduate and undergraduate students in discovery learning through research, to recruit and support diverse faculty who excel in both research teaching, and to advance the frontiers of interdisciplinary science and engineering.” The unit assigns particular importance to the specific metrics of “the quality of our graduating Ph.D. students, the quality of published work (as

measured by number of citations, journal quality and impact, etc.), major research awards won by faculty, [and] research expenditures.” CHBE recognizes the vital interdependence among achieving these targets, communicating that success to stakeholders, improving unit visibility and reputation, and recruiting high-quality students and faculty required to sustain those achievements. CHBE also acknowledges that, to date, it has underutilized its existing strategic plan, and resolves to regularly review and update the plan and to integrate it more effectively into program development and operational decision-making. The external reviewers endorse the chair’s request to gain more time to focus on such work. ARPAC notes that the CHBE strategic plan is admirably concrete, thorough, and accountable (e.g., in specifying targets and timelines).

Undergraduate
Education

As is the case with several other engineering departments, CHBE is concerned with maintaining teaching quality in the face of growing enrollments and uneven student preparation levels. In order to achieve that goal, CHBE has established an program in which alumni mentor students, has reviewed and revised its curricular requirements, and has displayed admirable initiative in instituting innovative (and award-winning) “screencasts” and online pedagogy for remediating sub-par student performance. ARPAC encourages the unit to continue to explore the effective usage of these programs. Additionally, CHBE seeks:

1. Financial and logistical support to construct a planned JSCBB fifth wing, to complete an undergraduate computing infrastructure and student workspace renovations there, and to facilitate CHBE management of JSCBB spaces it cannot currently control, and
2. College support for instituting undergraduate enrollment restrictions.

ARPAC encourages CHBE to further assess its undergraduate program and to design responses that separate student

enrollment concerns from concerns about student persistence. For example, the latter set of concerns may suggest the need for more preliminary testing. CHBE could incorporate knowledge testing into its undergraduate applicant review and use this information to channel new majors into gateway courses that are not redundant of their prior knowledge, but are also not so far above their heads as to be unnecessarily frustrating. Regarding enrollment concerns, ARPAC encourages CHBE to complete an analysis of factors such as patterns of relative demand displayed during students' four-year progress through the major and to present a demand management plan to the dean. ARPAC notes that it seems more likely that the college will support the use of soft caps, rather than enrollment-restricting hard caps.

Graduate
Education

CHBE has resolved to increase PhD program applications from and reduce program attrition by excellent and diverse students and to improve the overall graduate student and postdoctoral fellow experience. In order to achieve these goals, CHBE has recently engaged its recommender network, revised its graduate curriculum requirements, and made its electronic admission system more efficient. The department also plans to leverage the novelty of its biological engineering PhD to stimulate recruitment. Faculty members plan to attend the meetings of societies that represent students from underrepresented minority populations and to develop a program to connect CHBE PhD alums with applicants who attended the same undergraduate institution. CHBE plans to improve its graduate student/faculty advisor matching system (e.g., by increasing policy communication and by structuring admissions to ensure even distribution among research areas). The department has plans to expand PhD program electives, to increase student fellowships, to better manage student expectations for interacting with faculty during comprehensive examinations and thesis defenses, and to enhance systems for

communicating student concerns and grievances. CHBE plans to ask advancement personnel for help in improving the quality, quantity, and diversity of Ph.D. enrollments, including by securing additional graduate fellowships and summer research appointment funding.

ARPAC encourages CHBE to closely assess its graduate student support requests (e.g., for additional graduate research assistantships; graduate part-time instructorships, etc.). ARPAC also encourages CHBE to collaborate more broadly with Chemistry, Biochemistry, MCDB, and the University of Colorado Medical School to pursue large training grants.

Climate CHBE readily acknowledges that its climate negatively affects a significant minority of its members and may inhibit its ability to increase faculty, student, and staff diversity and departmental inclusiveness. The unit commits to the principle that all its members should treat each other with respect, and to “engag[ing] in a concerted and deliberate effort to improve the climate for members of the department.” While the number of identified offenders appears to be few, CHBE acknowledges the inherent unacceptability of faculty mistreatment of graduate students and staff. As a result, the department plans to institute listening sessions and discussions with affected individuals and groups to identify problems and to facilitate holding offenders accountable CHBE also plans to use campus resources (e.g., the Office of Institutional Equity and Compliance and the faculty relations director) to institute faculty-training programs and to develop new policies and practices. On a positive note, the external reviewers say that widespread concern among department members about the intertwined issues of climate and diversity has spurred widespread resolve to achieve progress.

ARPAC encourages CHBE to work with college and university administrators to develop and communicate policies concerning uncivil and disrespectful behavior. These policies should include a written conduct code as well as a faculty, staff, and student reporting structure. The department should integrate existing campus guidance from the Professional Rights and Duties of Faculty document. In addition, CHBE needs to be prepared to report and act on violations, including applying sanctions as called for by campus policies. One possibility here involves employing the post-tenure review process to adjust salaries for faculty members demonstrating persistently non-compliant behavior.

Space and Infrastructure

CHBE identifies two major challenges regarding its space and infrastructure needs:

1. The impact of the department's dispersal across multiple buildings on cohesion, morale, and collaboration, particularly associated with recruiting, hiring, and supporting new faculty; and
2. A "lack of world-class shared facilities and instrumentation and staff support for those resources," which the unit believes restricts its ability to recruit top faculty. Shortfalls here include "high-resolution transmission electron microscopy for materials research, XPS, clean room facilities, [and] nanofabrication equipment."

In addition to requesting support for completing a JSCBB space renovation, CHBE seeks a university commitment to developing "a plan to provide state-of-the-art research equipment to enable ambitious faculty and departments to reach their research goals." The external reviewers encouraged CHBE to explore sharing arrangements with other college and campus units to achieve this outcome.

ARPAC echoes the external reviewers and recommends that CHBE collaborate with fellow JSCBB and SEEC occupants, with other engineering units, and with affiliated campus units to conduct an equipment inventory. Such stock taking should also document existing policies and agreements concerning equipment ownership and usage and arrangements to prioritize and schedule requests for shared equipment, etc. An inventory should seek to eliminate redundancies, to identify ways that greater inter-unit cooperation can do more with less, and to prioritize future investment requests. CU's shared instrumentation network might prove a useful resource for this work: <https://www.colorado.edu/sharedinstrumentation/>.

Personnel In addition to the previously described concerns related to personnel recruitment, hiring, development, and retention, the internal and external reviewers agree in recommending that CHBE pay greater, more specific, and sustained attention to its instructors. According to the reviewers, CHBE instructors would benefit from better development support and unit decision-making that keeps their interests in mind. CHBE concurs and continues to review and revise related unit policies and programs.

CHBE also seeks changes in college policy that it feels would help it to develop better strategies and resources directed at hiring an outstanding and more diverse faculty cohort (for example, by relaxing the current requirement for CHBE to cover 1/3 of the cost of new hire startup packages). CHBE further seeks support for “the hiring of at least [four additional] outstanding and diverse mid-career [tenured/tenure-track] faculty members who are internationally-recognized as research leaders, as well as the hiring of 10 excellent junior faculty and the retention of our entire existing faculty;” as well as college support for hiring additional staff to perform proposal

preparation, graduate advising, and HR duties (such as payroll and visa application work).

The external reviewers endorse CHBE's hiring plan, while noting that it must balance several potentially competing interests, including: complementarity with existing research strengths; the potential for expansion into new areas; and increased diversity. Additionally, the external reviewers recommend that CHBE "evaluate their on-boarding and mentoring programs and ensure that they are appropriate" for all instructional faculty categories and ranks.

Regarding the department's request for support in hiring additional TTT faculty members, a follow-up conversation with the CHBE chair indicates that the challenge has to do not with the college's approving searches, but rather with the perennial challenge of cultivating desirable candidate pools and completing hires successfully. The department anticipates that the 2019 hiring cycle will get it within 50% of its overall hiring target, and the remaining needs will get addressed over the following few years. ARPAC encourages CHBE to consider how future TTT faculty member hiring decisions could impact climate issues. Specifically, the department should ensure that any senior faculty hires display both willingness and ability to contribute to climate improvements. Additionally, ARPAC encourages CHBE to better specify its postdoctoral staff needs, and plans for addressing those needs.

Inclusive
Excellence

In addition to plans for enhancing unit diversity discussed above, CHBE reviewed its approach to recruiting women graduate students and faculty and resolved to perform earlier and more frequent outreach to outstanding women candidates, and more intentionally personalize their recruitment. Both the internal and external reviewers encourage CHBE to adopt a proactive stance, and to make specific and concrete plans.

ARPAC emphasizes the need for CHBE to develop and submit an inclusive excellence plan, and the importance of ensuring department personnel accountability in achieving related goals.

Recommendations

The members of ARPAC address the following recommendations to the Department of Chemical and Biological Engineering (CHBE) and to the offices of responsible administrators:

To the Unit:

1. Work with the college to establish and implement specific tenure and promotion and merit evaluation guidelines that conform to regent law. Consider forming a separate annual merit review committee.
2. Review, and revise as needed, existing postdoctoral fellow mentoring and training programs. Ensure inclusion of postdoctoral fellows' needs in addressing unit climate issues.
3. Work with the college and university administrators to develop and communicate policies concerning uncivil and disrespectful behavior. These policies must include a written conduct code as well as a reporting structure for faculty, staff, and students. CHBE should employ campus resources, such as the Professional Rights and Duties document, in enforcing its policies. Report and act on violations, including applying sanctions.
4. Complete and submit an inclusive excellence plan. Continue work to improve diverse faculty recruitment and hiring and to improve undergraduate and graduate student diversity. Identify best practices by studying and pairing with existing college and campus diversity initiatives. Specify progress targets, and assign tasks to personnel accordingly. Regularly share progress reports with affected groups.
5. Continue work to integrate strategic planning into specific contexts of unit operations and decision-making.

6. As needed, present funding requests to college and university administrators for planned instructional space construction and renovation work.
7. Analyze factors related to managing undergraduate enrollments and present a proposal to the college.
8. Continue efforts to identify barriers to student progress through the major. Consider instituting additional prerequisites and/or knowledge testing as part of accepting new majors, so that the department can better channel undergraduates into appropriate gateway courses.
9. Develop a graduate student funding proposal that specifies funding types, amounts, and timelines. Collaborate with other units to identify joint training grant application opportunities. Present these plans to college and university administrators for consideration.
10. Discuss possibilities for adapting new faculty start-up package cost-sharing requirements with the college.
11. Prepare and present to the college a multi-year prioritized faculty hiring plan that accounts for anticipated undergraduate and graduate enrollments and that can respond to other projected developments. Consider prioritizing diversity concerns in searches for senior hires.
12. Collaborate with cognate units in JSCBB and elsewhere to develop an improved campus policy concerning shared research equipment purchases and use.
13. Ensure successful professional development of unit instructors, and their participation in unit governance.

Remove existing voting rights inequities, including by automatically extending to full-time instructors the right to vote on instructional matters.

To the Dean:

14. Support CHBE's efforts to analyze and respond to climate concerns. Hold the unit accountable for progress.
15. Support CHBE's efforts to increase faculty and student diversity. Hold the unit accountable for progress.
16. Consider funding proposals for completing CHBE instructional space construction and renovation work.
17. Consider the unit's undergraduate enrollment management proposal.
18. Consider CHBE's enhanced fellowship funding proposals and other types of graduate support. Assist CHBE in identifying training grant opportunities.
19. Consider unit proposals to change new faculty start-up package cost-sharing requirements.
20. Consider future CHBE faculty hiring proposals.
21. Support engineering units in preparing research equipment inventories, in composing policies concerning their shared ownership and use, and in preparing proposals to purchase new equipment.
22. Support CHBE and the college in developing new proposals for inter-unit research equipment cost- and use-sharing.

To the Vice-Chancellor for
Research and Innovation:

Required Follow-Up

The Department of Chemical and Biological Engineering (CHBE) chair shall report annually on the first of April for a period of three years following the year of the receipt of this report (i.e., April 1st of 2020, 2021, and 2022) to the dean of the College of Engineering and Applied Science and to the provost on the implementation of these recommendations. Likewise, the dean shall report annually on the first of May to the provost on the implementation of recommendations addressed to the college. The provost, as part of the review reforms, has agreed to respond annually to all outstanding matters under their purview arising from this review year. All official responses will be posted online.