



University of Colorado **Boulder**

2019 Program Review

Department of Molecular, Cellular and
Developmental Biology

Academic Review and Planning
Advisory Committee Report

Approved

DocuSigned by:

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Provost and Executive Vice Chancellor for Academic Affairs | Date

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Process Overview

The Academic Review and Planning Advisory Committee (ARPAC) review of the Department of Molecular, Cellular and Developmental Biology (MCDB) was conducted in accordance with the 2019 program review guidelines. The MCDB self-study report's responses were prepared by the unit and checked by an internal review committee composed of two University of Colorado Boulder (CU Boulder) faculty members outside of the unit. The internal reviewers submitted a summary of findings derived from the self-study report and from interviews and/or surveys with faculty, staff, and student unit members. An external review committee, consisting of two experts from outside of CU Boulder, visited the unit and submitted a report based upon review of relevant documents and interviews with faculty, staff, and student unit members and university administrators. Internal and external reviewer comments and recommendations are shared when relevant throughout this report.

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Academic year 2019-20
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Unit Overview

The Office of Data Analytics (ODA) maintains a standard description of the Department of Molecular, Cellular, and Developmental Biology (MCDB) [on its website](#). ODA updates the profile annually in the fall semester. This report cites data posted in October 2018, reflecting the state of MCDB as of the academic year (AY) 2017-2018. Additional data obtained from MCDB's self-study report is also cited where relevant.

Disciplinary context

MCDB has achieved international recognition and acclaim for its faculty and its graduates from both its undergraduate and graduate programs. Founded in 1968, MCDB's research portfolio covers seminal works that contribute to our understanding of the structures of cells and organisms and the molecular underpinnings of life processes. The study of cellular biology interacts with various health sciences using high-powered electron microscopy, and with RNA/DNA studies and information technology.

As noted in the self-study, MCDB maintains close partnerships with several units across campus as well as CU's Anschutz Medical Campus, with joint ventures on faculty appointments, shared course development, collaborative grants, publications, and seminars. That said, it would appear that the founding of the BioFrontiers Institute has impacted the entire unit. The external reviews note significant connections between BioFrontiers and MCDB, with "six among the best laboratories of MCDB ...[are] now at BioFrontiers," and new hires in MCDB are given the option to have joint appointments with BioFrontiers. Several recent hires have chosen this option. This development, coupled with physical disassociation of the two units, "has undoubtedly detracted from the overall intellectual atmosphere". On the other hand, MCDB has extremely close connections with CU's Anschutz Medical Campus, and this collaborative partnership appears to have fared better. Three years ago, MCDB hired a senior scientist from Anschutz who

became chair shortly thereafter, and who by all accounts is doing an excellent job.

The unit currently offers Bachelor of Arts (BA) and Doctor of Philosophy (PhD) degrees. A master's (MA) degree is also available for students who exit the PhD program having completed the requirements for an MA. There is no indication that concurrent degrees are offered. The MCDB webpage advertises PhDs that combine, for example, biophysics (with the Department of Physics), interdisciplinary quantitative biology (with the BioFrontiers Institute) and a graduate training program in signaling and cellular regulation (with the Department of Biochemistry). The department has 792 undergraduate majors, many of whom are involved in undergraduate research. A total of 126 students received BAs in 2017-2018 (ranking the department fifth among eight degree-granting departments reviewed in this cycle), with the median time-to-degree being 3.67 years. MCDB is the top-ranked of 46 units in the College of Arts and Sciences (A&S). MCDB has seen a five-year 3% drop in majors; the department is taking steps to address this decline. The undergraduate program provides all students with opportunities to take part in hands-on research, and available survey results show undergraduates giving the department high marks for overall satisfaction. The National Research Council (NRC) in 2010 ranked the MCDB graduate program 21st out of 122 programs in cell and developmental biology.

Research
and
scholarship

MCDB has a stellar research reputation, and an acclaimed history of electron-microscopy research. Its faculty is amongst the most distinguished on the CU Boulder campus. According to ODA records in 2017-2018, MCDB had one rostered distinguished professor and two affiliated distinguished professors. Its website notes a newly appointed distinguished professor in fall 2018 and another in fall 2019. Five MCDB

faculty members are fellows of the American Academy of Arts and Sciences. Four faculty members are members of the National Academy of Sciences. Three relatively junior faculty have been awarded Sloan Research Fellowships. One faculty member earned a National Science Foundation CAREER award in 2014. In 2010, one pre-tenure faculty member was awarded the PECASE (Presidential Early Career Awards for Scientists and Engineers). MCDB's self-study lists 29 national or international awards that its faculty have received since 2012, and the webpage lists two more awards from 2019.

The main areas of MCDB research listed in their self-study include genetics, developmental biology, and bioinformatics, virology and microbiology, electron and light microscopy, discipline-based educational research, and stem cell research and technology.

Collaborations

Many of MCDB's faculty members partner with Anschutz researchers. The self-study states plans to explore avenues for collaboration with organizations based at the Anschutz Medical Campus, such as with the CU School of Medicine, the Cancer Center, University Hospital, Children's Hospital, and the Veterans Affairs (VA) Hospital. MCDB hopes to expand this partnership through the establishment of joint pilot and seed grant programs, and through concerted publications and seminars, thus accelerating an already active record of collaborations.

National
and
international
context

The self-study authors as well as the external and internal reviewers noted that MCDB has earned an excellent reputation amongst its peer departments, but also expressed concerns about the longevity of its reputation given the departure of key laboratories to the BioFrontiers Institute. Despite this relocation of research activity, MCDB's self-study report contains an extremely impressive list of notable research articles published

by its faculty members in the two-year period of 2016-2018, including papers in prestigious journals such as Cell, Proceedings of the National Academy of Science, Science, and Nature. During 2012-2018, 31 patents listing one or more MCDB faculty members as patent holders were granted and are still active.

For FY2018, MCDB's research funding was \$13,921,000, which ranks fourth among 13 units reviewed this year, rising 7% from five years prior. For FY2014-18, its total research funding after allocation from institutes was \$72,803,000, ranking third among 13 units. ODA lists MCDB's research funding per tenure-stream faculty member for FY2018 as \$488,000, ranking it second out of eight degree-granting units reviewed this year and up 7% over a five-year period. MCDB's funding record is strong and should be commended.

The average number of refereed articles and chapters in books published per faculty member in the time period 2011-2017 is 22.6 (which ranks twelfth of 13 units under review) whereas the average number of conference presentations and papers during the same time period is 36.4 (which ranks eighth of 13 units). In a rapidly evolving discipline such as molecular and developmental biology, refereed conference papers may provide a preferable outlet for timely publication of results.

Campus context

MCDB offers BA and PhD degrees, with its PhD program being extremely prestigious. Its list of past PhD recipients over its 50-year history includes members of the National Academy of Sciences and even a Nobel Prize winner. It offers the MA degree only as a parachute to those exiting the PhD program. It taught 10,211 credit hours in 2017-2018, with 47% were taught to students outside the major. It offers various active-learning formats, including CURE labs (Course-Based Undergraduate Research Experience laboratories). Cutting-edge lab equipment

is used regularly and frequently in and beyond the department. Two faculty members are dedicated to discipline-based educational research that incorporates the work of undergraduate learning assistants. The department is currently in discussions with the Leeds School of Business to implement a joint certificate in biomedical entrepreneurship. It has close collaborations (and related rivalries) with the BioFrontiers Institute through joint faculty appointments, with the Department of Biochemistry through a shared graduate training grant, with the Department of Psychology and Neuroscience through a joint faculty hire and a common neuroscience education program, and with the Anschutz Medical Campus through collaborative grants, publications, and seminars. Both the department and the external reviewers worry that MCDB might lose its research pre-eminence and associated resources to the BioFrontiers Institute. Based on MCDB's activities this cycle, this anxiety concerning research reputation does not seem warranted; MCDB has continued to make excellent faculty hires, and its grant production has increased slightly in this last cycle.

Faculty
and
research
personnel

According to the Office of Data Analytics (ODA) profile for AY 2017-2018, faculty and research personnel in MCDB consist of 29 tenured/tenure-track (TTT) faculty, four instructor-track faculty, and four lecturers and other instructional personnel. ODA lists 31 total tenure-stream faculty members, which ranks third among 13 units reviewed in this cycle. At least six tenure-stream faculty have BioFrontiers Institute-based laboratories, and so have East Campus offices, effectively reducing these individuals' research presence in the core of the department. MCDB also has 80 research associates, laboratory assistants, postdoctoral fellows, and other research personnel.

MCDB had three new hires in 2018-2019 and seven new tenure-stream hires over the five years spanning 2012-2017,

with two of the latest hires moving into BioFrontiers. MCDB successfully recruited five women, including their current chair. The self-study report requests more financial support from the administration for startup packages to successfully recruit excellent faculty. The external reviewers note that MCDB has lost prominent scientists due to retirement, including several members of the National Academy of Sciences.

In 2017-2018, MCDB full professor salaries (including distinguished professors) were 86% of their American Association of University Professors (AAUP) public peer salaries; MCDB associate professor salaries were 113% of AAUP public peer salaries, and assistant professor salaries 107%.

Staff The ODA profile for AY 2017-2018 lists staff personnel in MCDB as consisting of 14 exempt professional staff members, six classified staff members, and 50 student hourly employees. Among the more recently filled administrative staff positions is an individual working as a science communications manager. The self-study report notes MCDB's difficulty in keeping highly trained support staff, since BioFrontiers and other institutes hire people away. The department has requested more laboratory staff to help with CURE labs, and would also like to hire a grant-writing staff member.

The self-study report states that MCDB has sufficient administrative staff. The external reviewers note that human resources and procurement staff are local to MCDB, and recommend keeping it that way due to MCDB's highly specialized procurement needs.

Undergraduate
education

In AY 2017-2018, MCDB awarded 126 bachelor's degrees, a 2% drop over five years, ranking fifth out of the eight degree-granting units under review this year. MCDB's number of

bachelors' degrees per tenure-stream faculty member is 4.4 and ranks sixth out of eight degree-granting units in the review cycle and 16 out of 44 degree-granting units overall. Ten percent of majors graduated with honors, rising 10% over five years. The median time to degree is 3.67 years, ranking first out of eight degree-granting review units and first of 46 units total. MCDB does not offer a minor track.

The five-year change in undergraduate majors is down 12% to 710 majors as of the 2017 census. By contrast, two other biology-based units under review this year (the Department of Ecology and Evolutionary Biology and the Department of Integrative Physiology) show increases in the same time period. There are 27.8 majors per tenure-stream faculty member. Faculty course questionnaire scores for the unit during AY 2017-2018 are slightly below average in undergraduate and graduate courses. However, in the next year AY 2018-2019, these scores and MCDB course/instructor average ratings balanced out and were not dissimilar from IPHY's. The average class size of sections taught by MCDB tenure-stream faculty members in 2017-2018 was 52 students, and the average size of sections taught by instructor-track faculty was 24 students. MCDB taught 10,211 credit hours in 2017-2018, ranked sixth out of eight degree-granting review units (a 1% decrease over the five-year period); and 47% of credit hours were taken by non-majors – this ranks fourth out of the eight degree-granting review units and 40th of 54 units.

The percentage of undergraduate student credit hours taught by tenure-stream faculty members is 45% (a decline of 1%, ranking third of the eight degree-granting units this cycle). The percentage of undergraduate student credit hours taught by instructors and senior instructors is 30%, the amount taught by teaching assistants and graduate part-time instructors is 1%, and the number of credits taught by others is 24%, which ranks

them second of eight degree-granting units reviewed this year and 13th out of 51 units total. In their strategic plan, MCDB states that they want to increase the number of teaching staff to help with the undergraduate-level inquiry-based laboratory classes. It is unclear whether these will be instructor-level additions.

One key achievement of MCDB in recent years has been the development of CURE (Course-Based Undergraduate Research Experience) labs, which are semester-long research laboratories for introductory-level students. These began in 2014 with a Howard Hughes Medical Institute grant of \$1.5 million to MCDB. At last count, there were two such courses carrying six sections each per semester, and every MCDB major is required to complete at least one course. In AY 2017-2018, 450 students enrolled in these classes, and MCDB plans to change its MCDB 3140 Cell Biology course to a sophomore-focused CURE lab. CUREs offers firsthand research experience to all MCDB undergraduates as well as to many students in other departments. The culmination of all of the MCDB CUREs entail research poster presentations at the CURE Symposium that includes an oral defense of the work assessed by peers and instructors for quality. The external reviewers spoke highly of the CUREs in their exit meeting with the provost, and other departments (IPHY, in particular) have noted the success of the CURE programs and started their own such lab discovery classes. The Howard Hughes grant has since expired, and the current annual budget needed to offer the CURE courses is \$160,000, with \$70,000 needed for personnel. The university has provided MCDB with a permanent instructor line, a professional research associate line, and a temporary instructor position for CUREs. MCDB also offers optional one credit hour co-seminar courses. Anecdotal evidence, faculty course questionnaire results, and ODA surveys show that students find the co-seminars helpful.

The ODA report notes that 10% of MCDB graduates receive honors upon graduation. The self-study report records about 40-50 honors students each year with 14% of majors graduating with distinction and/or honors, and many graduating with a second major in Biochemistry. MCDB serves as the lead department in a grant received to sponsor Beckman Scholars, which funded six undergraduate researchers and their mentors to do supervised research over one academic year and two summers.

MCDB's undergraduate student organizations include the MCDB Club and the MCDB Mentors. To further facilitate and encourage engagement from its undergraduates, the MCDB Student Learning Lounge provides a place for MCDB undergraduates to study and meet with their teaching assistants.

MCDB runs internal surveys to assess the effectiveness of undergraduate programs, and also relies on ODA surveys which have a greater response rate. Results from an internal MCDB survey administered in fall 2018 highlights the most common reason undergraduates change their majors: they struggle with MCDB coursework. In 2016, 59 graduating seniors (41%) took the Spring Senior Survey; and 76% agreed that the program was meeting their educational goals. Sixty-eight percent gave the maximum positive rating to opportunities for interaction with faculty. The ODA January 2019 survey reports general satisfaction with the major, but students would like better access to required classes, more access to research opportunities, more scholarships, more diverse class offerings, more emphasis on analysis over memorization, and a more nurturing environment.

As another point for improvement of MCDB's undergraduate education, the external reviewers suggest that the department should keep a more thorough record of the research activities of undergraduate majors and their placements after graduation.

Graduate education

The self-study report states that graduate education is a pillar of the unit's success. Over the 50-year period they have been in existence, the department has graduated over 300 PhDs, including one Nobel Laureate and several members of the National Academy of Sciences. MCDB's graduate program is ranked highly by external organizations. In 2012, the National Research Council (NRC) ranked MCDB 21st out of 122 molecular biology departments, and the 2018 US News and World Report ranked MCDB's graduate program as tied for 33rd out of 256 biological science departments nationwide.

MCDB offers the PhD degree, with the MA degree offered as a certification for those who do not complete the doctorate. At present, there are 55 PhD students, and the average number of incoming graduate students is about ten per year. This total number of graduate students is down 18% from 2012. The external reviewers state that the size of the graduate student body (around two students per tenure-stream faculty member) is appropriate for the department. Many strong graduate applicants choose to pursue the BioFrontiers PhD certificate program and enroll in the Biochemistry PhD program on the East Campus. MCDB states in its self-study that it would like to merge the BioFrontiers, Biochemistry, and MCDB graduate recruitment efforts to change up the current "balkanized and competitive process."

The total number of graduate credit hours taught in 2017-2018 was 558, down 30% from 2012, and ranking MCDB seventh of eight degree-granting units reviewed this year and 33rd of 49 units overall. Four hundred of these credit hours involved

individual instruction. The faculty course questionnaire scores for graduate courses were low in 2017-2018, ranking at the bottom of 43 total units.

In 2017-2018, MCDB granted eight PhD degrees (ranking fifth out of eight degree-granting units reviewed this year and 19 out of 42 units overall), and one master's degree. The median time to complete the PhD is 5.97 years, which ranks seventh out of eight degree-granting units reviewed this year.

The research culture of MCDB is intense, assigning first-year students a heavy introductory load. The external reviewers remarked: "To our surprise, students did not feel overwhelmed by the huge demands of the first year (teaching assistant assignments, rotations, core courses). Nonetheless, we feel this heavy first-year load puts the students at a disadvantage compared to their peers at other schools." A "rotation" refers to a student spending six weeks working in a professor's research laboratory.

Both the self-study report and the external reviewers note that graduate student stipends in their department are significantly lower than in peer public institutions. The self-study outlines MCDB's requests that fees and health insurance be paid by the university, as is done in many peer institutions. The external reviewers suggested that the university should fund more merit fellowships at the graduate level for the department to stay competitive. The external reviewers also suggested that the department use its own endowment funds to offer its own \$2,000 recruitment fellowships for graduate students.

Despite the apparent shortfalls above, MCDB graduate students remain actively engaged with the department and campus writ large. The MCDB graduate students founded and lead the CU Boulder science, technology, engineering, and

mathematics-based blog “Science Buffs” covering research at the University of Colorado Boulder and beyond, and the “Buffs Talk Science” podcast. In both 2017 and 2018, MCDB graduate students were named as CU Boulder Graduate Student Leaders of the Year.

Over the past two years, MCDB has made changes to the first-year graduate curriculum, including to engage more faculty members in graduate student training by increasing the number of lab rotations, and providing more emphasis to employment opportunities outside academia for graduating PhDs.

The external and internal reviewers agree with the self-study report that MCDB is lacking in computational and quantitative training at the graduate level. The self-study states that most MCDB graduate students receive no formal training in statistical analysis of large data samples. The self-study states an intention to introduce quantitative courses for graduate students, but expresses concern about computing costs. The external reviewers state: “Better and easier access to quantitative training is badly needed ...The Department is advised to consider a more systematic approach to providing this training which is crucial to the modern molecular biologist.” The external reviewers suggest looking at courses in the IQ Biology certificate (offered by the BioFrontiers Institute) for ideas.

The self-study report lists select placements for 38 doctoral graduates from 2012-2018, including postdoctoral fellow placements at Stanford University, Harvard University, University of Chicago, University of Utah, Yale University, and the Salk Institute, as well as employment in pharmaceutical industries, assistant professorships and visiting assistant professorships at a variety of institutions.

The self-study report noted that MCDB intends to drop the Graduate Record Examinations (GRE) requirement for admission to the PhD program, based on studies that show the GRE to be a better indicator of sex and skin color than of ability and ultimate success. The admissions committee was told to minimize the weight given to the GRE during the 2018-2019 admissions cycle. The results on admissions demographics of deemphasizing GREs will not be known for a few years.

MCDB's internal survey given in September 2018 notes that "graduate students are satisfied with the program and the faculty but would like to see improvement in graduate curriculum, graduate teaching by the faculty, better communication about program requirements, preparation for career development, and better pay and/or elimination of student fees for services that graduate students do not use." The external reviewers reported that although the graduate students have a strong sense of community, there appears to be a communication gap between graduate students and faculty concerning programmatic issues. Students complained that details for the comprehensive examination were not given out in a timely fashion, and that there was a lack of information about the change of the number of laboratory rotations (increasing from three to five) in the first-year graduate curriculum.

The internal reviewers' survey of students dated January 2019 show that most graduate student respondents were satisfied overall. However, 39.4% of respondents were "dissatisfied" or "very dissatisfied" with the department's clarity about requirements, including milestones, deadlines, and finding a thesis mentor. The external reviewers also noted some of this dissatisfaction in their interviews.

Postdoctoral
fellow training

The ODA lists three postdoctoral fellows, and the self-study report says that historically these fellows have formed an important and highly beneficial part of the department. There is an impressive partial list of postdoctoral placements from 2012-2018 in academia and in industry. There are also postdoctoral research associates working in laboratories. For the most part, MCDB's postdoctoral fellows are trained and mentored by lab leaders.

The external reviewers noted problems with current postdoctoral mentorship. Until recently, postdoctoral researchers and some permanent staff scientists had the same job code, so it was hard to track how many postdoctoral fellows were actually research-active members of the department. The external reviewers suggested that MCDB consider setting up a distinct organization for its postdoctoral fellows, as their needs are different from those of long-term staff in the department. Although this has changed, a feeling persists among postdoctoral fellows that they are not considered to be future peers or even trainees of the department. For example, in a recent MCDB retreat, the postdoctoral fellows were initially discouraged from attending, and were allowed to attend only after negotiation. In contrast to the graduate students who give seminars during the fall and spring semesters, the postdoctoral fellows give their seminars in the summer, resulting in poor attendance by faculty members. The chair is making efforts to make postdoctoral fellows feel more a part of the department by allowing them to have representation at faculty meetings, but the external reviewers indicated that not all faculty are aware of the postdoctoral feeling of "separation" from MCDB. However, the four postdoctoral fellows that the external reviewers met with felt well-supported in their scientific work. The unit self-study remarks that the department itself plans to take a more active role in mentoring postdoctoral fellows in future.

Staff The self-study report reports an operating budget of \$53,888 for office supplies, copiers, postage, vendor parking, student and staff support, software site licenses, student funds, grad student applicant aid, and matching funds for minor infrastructure improvements.

CU Boulder's departmental administration indirect cost recovery (DAICR) rate, the amount of indirect cost recovery on grants coming back to departments before skims are taken out, is now at 29%. However, the amount of DAICR that MCDB has been getting annually is in decline. In FY2019 it received a ten-year low of \$743,122, down from a high of \$1,069,500 in 2011. This is a concern since 61.55% of DAICR is used to support key support staff and portions of managerial salaries.

Budget The department's other important source of revenue is the MCDB Research and Education Fund endowment (also known as the Gold Fund), which arose from the invention of a faculty member and had net assets of \$13,700,040 at the time of the self-study report. This produces roughly \$500,000 every year in returns to the department, and helps to support faculty startups, as well as new equipment purchases and infrastructure upgrades. The department recently reached an agreement with the CU Foundation on a dispute over royalty revenue, resulting in a substantial repayment to MCDB. They hope to use this to pay off debt coming from retention agreements and other challenges that include equipment purchases, service contracts, and startup packages. For FY2019 startup packages, MCDB paid a share of \$426,296 from the endowment principal, and \$268,134 from royalties; and they predict a budget shortfall of over \$200,000 in FY2020 for faculty startups. In each of these areas they are requesting additional funding from A&S. For example, currently there is a deficit of \$303,697 for service contracts related to equipment in

the electron microscope facility. The Fluorescence Activated Cell Sorting Facility is running a deficit of \$160,126 due to service contract costs.

Fundraising The self-study report notes that MCDB marked its 50th anniversary in September 2018 with a two-day symposium attended by successful alumni from undergraduate, graduate, and postdoctoral ranks. The department wants to once more reach out to potential donors; on this front, MCDB is in conversations with A&S to obtain a part-time development officer, and is working with the Office of Advancement on new approaches to soliciting donations. The self-study repeats three times that its fundraising efforts should no longer “be subjugated to the needs of the BioFrontiers Institute”.

Space and infrastructure MCDB has 99,168 square feet, which ranks first of eight departments undergoing review this year, and fifth of all units in the campus. Laboratory space comprises 76% of their space, split between laboratories in the Porter and Gold Biosciences buildings and in BioFrontiers, which serves as home for six MCDB faculty member labs. In terms of square footage, MCDB has adequate space for their needs. However, in order to recruit top-quality faculty in the field of molecular biology, MCDB wants to totally renovate and modernize the laboratory space on the fourth floor of Porter Biosciences, with a view towards a novel open lab space concept that will house in the range of four to five MCDB laboratories.

Support needs MCDB hopes to continue implementing new CURE discovery-based research courses, but will need further help and support from the campus to do so—for example, for instructor and teaching assistant support and supplies, and course approval from the A&S curriculum committee.

MCDB notes that many different units make use of their state-of-the-art core facilities mentioned above. Yet the other units using the facilities do not contribute enough money for maintenance of these expensive pieces of equipment. To give an example, MCDB paid \$232,865 in service contracts for MCDB-housed service center equipment in FY2018. Even more was spent on electron microscopy maintenance, mass spectrometry instrumentation, machinery in the newly-opened StemTech lab, and the flow cytometry machinery, which the external reviewers say is outdated. MCDB notes that most staffing costs can be and are being paid through the endowment from the Gold Fund. Still, A&S and MCDB need to work out a business model to have users from other units share maintenance costs for expensive equipment proportionately.

In addition, the self-study report notes a need for more classroom space, including more active lab classrooms. Laboratories need to be prepared prior to class and this cannot presently be accomplished because lab classes are scheduled back-to-back. In terms of computing capabilities, the self-study notes that the size of their scientists' data sets have outgrown the storage infrastructure and in-house facilities, and are too big for current campus enterprise tools like Google Drive and CU Scholar. Thus, they need to work with the Office of Information Technology (OIT) regarding their growing need for large amounts of high-throughput, long-term storage.

Finally, in order to ease transportation issues for MCDB personnel commuting for meetings and seminars between the East Campus-based BioFrontiers Institute and Main Campus, MCDB wants the Office of Parking Services to work out arrangements for the department and the institute in parking lots on the Main and East campuses.

Governance MCDB has a thorough set of bylaws that were revised and adopted in fall 2018. The bylaws define voting rights, including for instructor-track faculty, in terms of a “voting matrix”. The primary governing officials and standing committees are described in detail. The evaluation procedures and milestones for annual evaluation, reappointment, tenure, and promotion are spelled out, and another description is given for the reappointment procedures of non-tenure track faculty. Annual merit review procedures are discussed in the bylaws, including the process for salary equity review. The mentoring system for untenured faculty was revised and is thorough, with the internal reviewers mentioning that only the preparation of the teaching portfolio needs to be fine-tuned. Grievance procedures mentioned in the bylaws consist of salary grievances, and grievances between a faculty member and the department chair.

Inclusive excellence The faculty members of MCDB have improved gender diversity, with 13 out of 31 (38%) of affiliated tenure-stream faculty members identifying as women, ranking fourth of 13 units under review. Eight members (24%) identify as a minority (Asian American, African American, Hispanic/Latino, or Native American), ranking third of 13 units reviewed this year. One faculty member (3%) identifies as an underrepresented minority (African American, Hispanic/Latino, or Native American), ranking eighth out of 13 units reviewed this year. The department has been successful in recruiting women, including five women into tenure-stream faculty members positions between 2012 and 2018. They have found it more difficult to recruit faculty from underrepresented minority groups.

As for the undergraduate majors, in fall 2017 56% were women, ranking fourth of eight departments reviewed; 33% were minority, ranking first of eight departments reviewed, and 18% were underrepresented minority, ranking fifth of eight

departments reviewed. Student numbers show a considerable increase from the respective percentages in 2012. During fall 2017, a demographic study of graduate students showed that 49% were women (a decline of 11% over the five-year period), 20% were minority (up 87% from 2012), and 10% were underrepresented minorities. The percentages of minority and underrepresented minority graduate students were up from 2012.

Significant catalysts for the growth in underrepresented minority students include the MCDB Club and participation by MCDB graduate students and staff in the PCDP, a first-generation pipeline summer program with college-like classes emphasizing microscopy. MCDB also takes part in the SMART program, the National Institutes of Health/Howard Hughes Medical Institute Scholars Program for Diversity in the Biosciences, MASP, the National Institutes of Health Initiative for Maximizing Student Development, the Colorado Advantage Program, and the Colorado Diversity Initiative. MCDB sends its graduate students to the annual SACNAS (Advancing Chicanos/Hispanics and Native Americans in Science) and ABRCMS (Annual Biomedical Research Conference for Minority Students) conferences to recruit. In the fall of 2018, MCDB graduate students started their own SACNAS chapter, with four MCDB graduate students taking on duties as officers.

Climate
and
culture

The self-study reported that the climate is viewed as positive by faculty, staff, and graduate students. However, the internal reviewers noted that the graduate student climate survey responses create room for concern. The survey showed that 47% of faculty surveyed either “agree” or “strongly agree” that one or more faculty say things or behave in ways that humiliate or intimidate other faculty members and 61% of graduate students either “agree” or “strongly agree” that one more

faculty say things or behave in ways that humiliate or intimidate graduate students.

ODA issued a climate and culture survey to graduate students on appointments in March 2018. Almost all 28 respondents “agreed” or “strongly agreed” that they were treated with respect by their advisor, by MCDB faculty as a whole, by department staff, and by other MCDB graduate students, and that the overall atmosphere was friendly and supportive. When asked to “agree” or “disagree” with statements that women graduate students, graduate students of color, of different sexual orientations, and from countries outside the United States were treated with respect, a large percent chose the response “don’t know/not applicable,” and two or three students chose “disagree” with these statements concerning respectful treatment. 10.7% of graduate students “agreed” or “strongly agreed” that faculty incivility was having a disruptive effect on the functioning of the department, 14.29% “disagreed” with the statement that they were valued members of the department, and 14.28% “agreed” or “strongly agreed” that they felt excluded from informal networks in the department. As mentioned earlier, the external reviewers discussed the lack of inclusion felt by postdoctoral fellows.

The internal reviewers made the recommendation that MCDB hold various training sessions on diversity and inclusion issues for faculty and graduate students. In response, MCDB inserted plans into its updated self-study to bring in members of campus diversity and support groups to give presentations and run training sessions twice per semester.

Past Reviews

The 2012 ARPAC report noted MCDB's stellar reputation, but also commented that with the establishment of the BioFrontiers Institute, MCDB could be in the position of losing both its leadership base, key research laboratories with National Institutes of Health, and the collaboration's accompanying support to BioFrontiers. ARPAC encouraged the unit and the administration to work on finding a strong chair for MCDB and to make strong hires, perhaps a senior hire. This was done, first with an internal chair and then a senior hire who became chair in Spring 2017, along with other strong hires. ARPAC encouraged MCDB to try to improve its undergraduate teaching, particularly the faculty course questionnaire course and instructor ratings. In response, MCDB developed its CURE program. MCDB was asked to revise its bylaws in part to address voting rights for instructors, and this was done. Additionally, ARPAC asked MCDB to continue its diversity recruiting efforts. This has been done successfully in the undergraduate and graduate student body, but with less success at the faculty level. ARPAC asked MCDB to have faculty advise undergraduates on career and research opportunities. Although MCDB added a "senior advisor" service position to the faculty portfolio, students still want more career and research advice. ARPAC asked MCDB to work with the departments of Ecology and Evolutionary Biology and Integrative Physiology to consolidate their introductory biology courses, with A&S facilitating this process; this was not done.

Analysis

MCDB's stellar reputation for its research and graduate program is hard-earned and well-deserved. From the 1980's through the present, it has been a preeminent department in the university. At the same time, the opening of the BioFrontiers Institute in 2012 and the movement of several key laboratories and the Department of Biochemistry to the East Campus has led to a literal segmentation of the department, with the unit acknowledging in its self-study that some "vitality" was taken from MCDB on the main campus. The self-study mentions that BioFrontiers has poached MCDB staff, recruited some of the best graduate students to East Campus, and convinced top new MCDB faculty to align more closely with the institute on the East Campus. The self-study implies that the Office of Advancement prioritizes the needs of BioFrontiers than those of MCDB. The external reviewers warned that MCDB might lose its ability to hire top faculty as a result. These statements are hard to prove, but MCDB makes explicit their perception that BioFrontiers has depleted MCDB's excellence.

On a more positive note, over the past review cycle MCDB has kept its high research profile, and has hired at least ten tenure-stream faculty members during the period 2012-2018, half of whom are women, and one of whom is a joint hire with the department of Psychology and Neuroscience. It has lost several distinguished professors to retirement, and one former chair to another university, but the unit has since hired a new senior scientist who recently became chair, and just promoted another senior faculty member to distinguished professor this year. Although its numbers of majors and graduate students have declined, the unit is aware of this and has moved quickly to develop the innovative CURE discovery lab research program for undergraduates. It has worked to increase underrepresented minorities in its graduate and undergraduate populations, and has much to be proud of. Although MCDB expresses concern about staff, graduate students, donations, and new hires

moving to the units on East Campus, this should not prevent MCDB from building on its own research success to adapt and strengthen its undergraduate and graduate programs.

Strategic
vision
and
planning

In light of MCDB's reputation, the unit retains a vision of maintaining its high level of research and graduate training. MCDB wants to keep hiring high-quality faculty to replace retirements and departures, and also increase their overall number of tenured/tenure-track faculty members to 35 in the long term. At this time, their low undergraduate and graduate student per tenure-stream faculty member ratio do not justify such faculty growth, unless some of the new hires are joint with other units. The department argues that they have sufficient space for new hires, and such an increase is needed to reduce class sizes, increase the amount of individual instruction, and develop more CURE classes. In the next five to seven years, MCDB would like to hire four additional faculty members, and if provided with start-up costs, this could be a realistic number that will ensure retirements and replacements are taken care of. However, they do not state whether some of these planned faculty hires should be instructors.

Since MCDB feels that external funding is strengthening in the areas of translational and clinical research, their aim is to hire the best biologists who are also interested in pursuing more tangible connections to human disease. They want to strengthen and hire in the following areas: imaging and optics-related, stem cells, structural biology, and machine learning/computational biology. They hope that future BioFrontiers hires working in stem-cell related areas will roster in MCDB, thus furthering MCDB's reputation in stem cell/regeneration-related research programs.

MCDB's recent senior hire came from CU Anschutz and is involved with translational research. As a result of this success,

MCDB wants to further strengthen ties with Anschutz. The external reviewers caution that with the emphasis on translational research in the hiring plan, MCDB leaders should make certain to retain the department's current strengths in basic science; in particular they note that an "...emphasis (on translational research) should come naturally from the research programs of the Faculty rather than be created artificially." In light of BioFrontiers' similar desire to work more closely with the Anschutz campus, it may be beneficial for MCDB to collaborate with BioFrontiers in the searching and hiring faculty with expertise in translational research.

The number of undergraduate majors as well as the total number of undergraduate credit hours at MCDB has decreased slightly, at a time when the total number of students in A&S and the number of majors in the departments of Ecology and Evolutionary Biology and Integrative Physiology have increased. MCDB aims to modify one-third of 2000-level courses by changing the lectures into a discussion-based format. By introducing medical connections and case studies into more courses, MCDB hopes to increase student participation. More discussion-based courses could increase MCDB's average course and instructor faculty course questionnaire scores, which in 2017-2018 were fourth out of the units reviewed this year, but is lowest of the biology units. (However, as noted above, the MCDB course/instructor average ratings for AY 2018-2019 were above average in undergraduate and graduate courses, and were not dissimilar from course/instructor average ratings for AY 2018-2019 in the departments of Ecology and Evolutionary Biology and Integrative Physiology.) The self-study notes a certificate program in biomedical entrepreneurship is being planned with the Leeds Business School, which sounds promising.

The department might also want to reexamine its first-year program and any changes to its structure, taking in consideration the external reviewers' concern of heavy student workload.

Graduate
education

The number of PhD degrees and graduate credit hours taught in MCDB has decreased over the last five years. The external reviewers state that the graduate student body size (around two students per tenure-stream faculty member) is right for the department, but ARPAC argues that this is debatable. MCDB would benefit by strengthening this program. Both the department and the external reviewers commented on the need to come up with a structured sequence of courses offering graduate training in computational and quantitative methods. This might be a potential area of collaboration with BioFrontiers via the IQ Biology certificate program's quantitative courses. ARPAC suggests that the BioFrontiers Institute offer one quantitative course from its IQ Biology certificate on the main campus every year, and that MCDB select and offer statistics courses from other A&S departments as alternative courses for its graduate students. As noted by both the self-study and the external reviewers, the primary hindrance to successful graduate student recruitment is the systemic issue of graduate teaching assistant stipends and required fees that further reduce graduate student stipends below its peer public university average, and relative to cost of living.

Postdoctoral
training

The ongoing confusion about the tracking of postdoctoral researchers, as it relates to their job code and their research-active status in MCDB has made their position in the department unclear. This has caused the postdoctoral fellows to feel isolated from the rest of the department, although they indicated to the external reviewers that their scientific support was good. The MCDB chair is taking steps to have more engagement between the postdoctoral fellows and faculty

members, but a more formal mentoring program/agreement, similar to the one for junior faculty, should be developed.

Budget MCDB is well-funded by its Gold Fund, which is used to support faculty startups, new equipment purchases, and upgrades to buildings and infrastructure. They also received a one-off funding source in the form of a settlement from the CU Foundation, also used to help pay for start-ups. They have considerable DA-ICR money, which they use to support salaries of several key staff members. The self-study states that MCDB wants to move forward in its fundraising goals without constraints. ARPAC agrees that further work with the Office of Advancement could yield significant rewards in this case of this department.

Space, infrastructure, and support needs MCDB cites an increasing demand by students for individualized CURE/Discovery Lab experiences in requesting more lab-based classrooms, and as a whole, they claim vastly insufficient classroom space for their student numbers. They also request an additional budget of approximately \$160,000 for laboratory courses, including \$70,000 per year to support the salaries of instructors, staff, and graduate students running these courses. MCDB and A&S should develop a business model to ensure that maintenance costs of expensive equipment housed in MCDB are covered proportionately by users coming in from other units.

The external reviewers mentioned the divide between MCDB faculty members dispersed between the main and east campuses, suggesting a long-term goal should be to move all of MCDB personnel to East Campus. As an immediate goal, it may be more feasible to work with the Office of Parking Services to make parking arrangements so that all faculty members can easily attend meetings and seminars on either campus.

Governance	<p>As previously noted, the Department of Molecular, Cellular and Developmental Biology bylaws were last revised in the fall of 2018 and address the instructor voting rights and annual merit review procedures mentioned in the previous program review. The governance and committee structure is clearly laid out, including mentoring and grievance committees. The external reviewers mention, however, that faculty, including instructors, are not convinced that salary raises are entirely fair and that most big raises come as a result of retention offers. ARPAC notes that this is a systemic problem across campus, not limited to MCDB.</p>
Inclusive excellence	<p>MCDB should be commended for its work on inclusive excellence, diversity issues, and outreach to underrepresented groups. ODA calculated that MCDB's number of underrepresented minorities in the graduate program was up 17% from 2012. Even though the overall number of MCDB majors trended downward in the five-year period, the number of women majors was up 5% over the five-year period, and the number of underrepresented minorities was up by 32%. As far as faculty, the department has been successful in recruiting women, recruiting five women into tenure-stream positions between 2012 and 2018, but it has been less successful in recruiting faculty members from underrepresented minority groups. ARPAC believes that if future funding becomes available for hiring diverse faculty, MCDB's commitment to increasing faculty and student diversity and departmental inclusive excellence should be recognized as part of college- and campus-level evaluations of where that funding would best be used.</p>
Climate and culture	<p>Although the self-study report says that faculty, staff and students are in general content with the climate and culture, the internal reviewers found room for concern in the results of the ODA climate surveys, and the external reviewers also</p>

commented on problems for graduate students and postdoctoral researchers. The internal reviewers made the recommendation that the department hold various official training sessions, both for faculty and for graduate students. MCDB has already begun doing this and should continue with that effort.

Recommendations

The members of the Academic Review and Planning Advisory Committee address the following recommendations to the Department of Molecular, Cellular and Developmental Biology and to the offices of responsible administrators:

To the Unit:

1. Work to maintain or increase the number of undergraduate majors in the department, by means of the following actions:
 - a. Expand the Course-Based Undergraduate Research Experience (CURE) labs and summer research programs in which the department is heavily invested, including adding second year CURE courses and involving tenure-stream faculty members directly in the instruction;
 - b. Involve more faculty in the MCDB undergraduate club, so that undergraduate majors feel a greater sense of community;
 - c. Continue to encourage faculty members to offer more advice on career and research opportunities available to MCDB majors and new graduates;
 - d. Formalize lists of research activities, publications and outcomes assessment, and monitor placements for graduating seniors;
 - e. Complete the work on the planned joint certificate in biomedical entrepreneurship with the business school. Such a certificate will be attractive to majors.
 - f. Examine and take appropriate action to remove barriers to retaining students in MCDB through completion of majors.
2. Prioritize faculty hires to maintain a balance between translational science and basic research.

3. Explain how hiring priorities target underrepresented groups.
4. Develop a vision and justification for fitting non-tenure-stream faculty into the unit hiring plan. One possibility would be support for the CURE labs.
5. Keep up the excellent work on increasing the number of under-represented groups in the undergraduate and graduate student population and on offering activities to nurture and sustain the sense of community. This will aid retention and degree completion at both undergraduate and graduate levels.
6. Reconsider the opportunity to collaboratively teach lower-division biology courses with the Departments of Ecology and Evolutionary Biology and Integrative Physiology.
7. Work on communication and structure in the graduate program:
 - a. Keep graduate students more informed about decisions that affect their coursework and exams, and ensure they are not overworked in their first year;
 - b. Offer a section of a quantitative course from the IQ Biology certificate on the main campus each year, and provide a list of alternative courses in statistics and quantitative methods offered in other units that would be appropriate for graduate students who are unable to take the IQ Biology course when it is offered;
 - c. Consider giving out small amounts (\$2,000-\$3,000) of recruitment fellowships for the incoming class from the Gold Fund or DA-ICR other sources to improve recruitment outcomes in MCDB.

8. Formalize a strategy for appropriate postdoctoral fellow mentoring.
9. Continue to work on department climate and faculty civility issues, for example by having appropriate training sessions run by the Office of Diversity, Equity and Community Engagement, the Center for Inclusion and Social Change, Human Resources, etc.
10. Work with the Office of Information Technology on data storage needs, detailing the growing need for large amounts of high-throughput, long-term storage.
11. Together with the Research and Innovation Office (RIO), work on a business model to have maintenance costs of expensive equipment housed in MCDB covered proportionately by users coming in from other units. Consider creative solutions such as bundling service charges into grant applications.
12. Assist MCDB in offering attractive startup packages and laboratory space on main campus to ensure that new hires want to stay on main campus instead of moving over to East campus. At a minimum, sort out the source of tension.
13. Support MCDB in its efforts to fit non-tenure-stream faculty members into the unit hiring plan.
14. Upgrade the salaries of full professors rostered in MCDB to bring them closer to the AAU averages.
15. Create incentives to reform and consolidate first-year biology courses in Ecology and Evolutionary Biology, Integrative Physiology, and Molecular, Cellular and Developmental Biology.

To the Dean of the
College of Arts and
Sciences:

16. Together with the MCDB chair, work on a business model to have maintenance costs of expensive equipment housed in MCDB covered proportionately by users coming in from other units.

To the Dean of the Graduate School:

17. Together with the dean of the College of Arts and Sciences and the dean of the institutes, work as a liaison between the BioFrontiers Institute and MCDB to coordinate their overall interaction, goals, and mission.

18. Continue to work on addressing the issue of comparatively low teaching assistant stipends and attempt to increase the number of fellowships for graduate students.

To the Vice Chancellor for Research and Innovation and Dean of the Institutes:

19. Together with the dean of the College of Arts and Sciences, work as a liaison between the BioFrontiers Institute and MCDB to coordinate their overall interaction, goals, and mission.

To the Vice Chancellor for Infrastructure and Sustainability:

20. Improve and regularize transportation and parking options between off-campus sites and the Main Campus to ease commuting, keeping in mind that the needs for faculty, staff, and students, including individuals with disabilities, may be different. This could take the form of more frequent bus and shuttle transportation, or of offering parking permits that are eligible on the Main Campus, East Campus and Wilderness Place. MCDB faculty and staff who do commute should not have to pay additional costs for such services, as this penalizes campus employees who in many cases have been situated off-campus involuntarily.

Required Follow-Up

The chair of the Department of Molecular, Cellular and Developmental Biology 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 2022, 2023, and 2024) to the divisional dean for natural sciences and the dean of the College of Arts and Sciences and to the provost on the implementation of these recommendations. Likewise, the dean of the College of Arts and Sciences shall report annually on the first of May to the provost on the implementation of recommendations addressed to the program. 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.