INTRODUCTION

For a disciplinary society, student members represent the future. Their training must be progressive today to ensure a vibrant profession tomorrow. To support students and other budding scientists, the American Society for Microbiology (ASM) Education Board continually seeks ways to enhance their development. Fellowships and travel grants are among the Board’s most prominent programs for these members, providing opportunities for them to conduct research, disseminate findings, connect with mentors, and network.

To assess the impact these programs have had on participants and inform future directions for ASM fellowship activities, the Society commissioned a private, retrospective study of two Board initiatives in 2015—the ASM Undergraduate Research Fellowship (URF), established in 1993, and the ASM Robert D. Watkins Graduate Research Fellowship (Watkins) Program, established in 1980. A mixed-methods approach was used to collect data about the participants’ fellowship experience, track educational and employment status, and determine program impacts from 325 individuals (223 URF and 73 Watkins fellows). Challenges presented by the study include the fact that inherent in fellowships is the provision of financial support that affords participants opportunities that might otherwise be unavailable to them. As a result, participant feelings of indebtedness to the Society may have introduced biased study responses. In addition, some respondents were asked to reflect on experiences from 20 to 30 years ago—a lapse in time that may have challenged their memories. Based on measures such as enrollment in or completion of advanced degree programs, employment in science, and publication and presentation history, project participants show evidence of accomplishment. Participants also reported gains in affective behaviors such as confidence and belonging.

OVERVIEW OF PROGRAMS

URF

The ASM Undergraduate Research Fellowship seeks to encourage undergraduates to pursue advanced training in the microbial sciences. Launched in 1993, this fellowship program supports awardees conducting microbiology-related summer research. The initiative also 1) helps fellows develop communications and networking skills and 2) provides career-planning assistance. Awardees are selected based on their academic achievement, relevant career objectives, and demonstrated motivation to participate in the program.

Watkins

The ASM Robert D. Watkins Graduate Research Fellowship seeks to increase the number of students from underrepresented minority (URM) groups who complete graduate studies in microbiology. Established in 1980, the Watkins fellowship provides support to senior-level graduate students from URM groups to conduct microbiology research for three years. The program 1) helps fellows develop communications and networking skills and 2) provides access to ASM professional skills training in communications (e.g., publishing and grantsmanship) and career planning. Awardees are selected based...
on their academic achievement, research plan developed in collaboration with a research mentor, career goals in the microbial sciences, and involvement in activities that serve the needs of URM groups.

For both the URF and Watkins programs, the awardee group proportionally mirrors the applicant pool. Table 1 presents a summary of the programs.

**METHODOLOGY**

**Approach**

To evaluate the programs, a mixed-methods approach was used to collect quantitative and qualitative data to learn about the participants’ experience in the programs, track their educational and employment status, and determine program impacts. Primary data were collected via multiple-choice and open-ended questions. Secondary data were gathered through questionnaires, artifacts, and web resources. Responses were recorded in SurveyMonkey (Gold Plan version) and analyzed using SPSS V22.0 analytics software.

**Sample**

The URF and Watkins programs have supported 718 fellows including 607 URF and 111 Watkins participants. The study sample comprised 511 individuals, which corresponds to all program participants for whom ASM had valid contact information. The sample distribution was 412 URFs (68% of the total URF population) and 99 Watkins fellows (89% of the total Watkins population). A total of 296 individuals responded to online surveys for a 58% response rate. The breakdown was 223 URF respondents (54% response rate) and 73 Watkins fellow respondents (74% response rate). Table 2 shows demographic information for respondents.

**FINDINGS and DISCUSSION**

Given the nature of fellowships, it is perhaps unsurprising, but nevertheless important to note, that many URF and Watkins respondents reported that financial support from ASM was a key factor in their careers, providing them the opportunity to conduct independent, focused research without having to worry about finances. A similar finding was reported by the Council of Graduate Schools in the Ph.D. Completion Project, which identified financial support as one of six factors important for successful completion of doctoral programs (3). Our respondents also indicated that ASM support gave them opportunities to participate in scientific meetings and conferences that might otherwise have been unavailable to them. One caution regarding this study is a bias inherent in the financial nature of fellowships. The survey questions may have appealed to fellows who were more resource limited or whose research experience was more productive and who thus may have responded more favorably to the survey questions.

For organizational purposes herein, other results are presented separately for each fellowship initiative and are listed in four benchmark categories: degree completion and matriculation, learning, affective behaviors, and contribution to science.

**URF program**

Completion of the bachelor’s degree and matriculation to next development phase. Our study results suggest that URF participants complete the bachelor’s degree at a higher rate than other undergraduates in biology and biomedical sciences. The majority of URF participants (96%) have completed their bachelor’s degree or are currently matriculating in undergraduate institutions, whereas according to the NSF Science and Engineering Indicators...
2014 report, the six-year graduation rate for first-time students completing their bachelor’s degree at a four-year institution in fall 2007 was 59% (5).

Sixty-four percent of URF respondents are currently in master’s, doctorate, or postdoctoral programs. Although not an exact comparison, data from the NSF report indicate that in 2011, the number of first-time, full-time students pursuing graduate studies in the biological sciences was 17,327, out of 93,654 students who graduated with a bachelor’s degree in the biological sciences (5), giving a ratio of students graduating with a bachelor’s degree and entering graduate school as first-time, full-time students of 18%. According to these numbers, the study results suggest that URF participants are pursuing graduate education at a higher rate than others.

Similar trends were found in employment. Forty-three percent of URF respondents are employed full time. Of the full-time employees, 55% are employed in academia in a variety of professions including assistant and associate professor, researcher, and laboratory scientist. Approximately 11% are employed in government agencies and 5% in medical facilities. The remainder are employed in other industrial laboratories and research facilities. When compared with other science and engineering undergraduates, URFs tend to pursue academia at a higher rate. The NSF Report states that 70% of science and engineering graduates pursue positions in industry, 17% in academia, and 13% in government (5). This discrepancy may be due to the inclusion of engineering graduates in the NSF data and their tendency toward industry.

Learning—development of new skills. Most URF respondents reported that the fellowship program furthered their problem-solving, reasoning, and research skills and

| TABLE 2. | Survey respondent demographics. |
|----------|-------------------------------|
| Gender   | URF (%) | Watkins (%) |
|          | (n = 223) | (n = 73) |
| Female   | 53       | 68         |
| Male     | 47       | 32         |
| Race/Ethnicity<sup>b</sup> |        |            |
| Alaska Native, American Indian, Native Hawaiian, or Pacific Islander | 0 | 8 |
| Black/African American | 3 | 33 |
| Hispanic or Latino | 4 | 50 |
| White or Asian | 97 | 18 |
| Other race/ethnic groups or Not available | 2 | 4 |
| Current Education Level |        |            |
| Post-doctorate | 21 | 0 |
| Doctorate | 39 | 86<sup>c</sup> |
| Master’s | 4 | 14 |
| Undergraduate | 20 | 0 |
| N/A | 16 | 0 |
| Current Employment |        |            |
| Employed, full time | 43 | 59 |
| Employed, part time | 3 | 1 |
| Employed, part time and attending school | 12 | 0 |
| Postdoctoral training position | 12 | 23 |
| Other | 18 | 17 |
| Not employed | 13 | 0 |

<sup>a</sup> Some items may not total 100% due to rounding and an N/A response in some categories.

<sup>b</sup> Some respondents indicated more than one category.

<sup>c</sup> Includes 4% who completed medical programs.

URF = Undergraduate Research Fellowship; N/A = not available.
exposed and connected them to other researchers. Eighty-nine percent of respondents indicated either significant or much contribution in their ability to collect data and present findings, and 87% indicated significant or much contribution in their ability to analyze data and interpret findings (Fig. 1). This finding is supported by an URF respondent—a recipient of the award 22 years prior—who stated that the fellowship “was a fantastic opportunity to pursue an independent, mentored research project in a professional, basic sciences laboratory and to then have the opportunity to present my data at a national meeting.”

Affective behaviors—confidence, belonging. Confidence in oneself and in one’s ability to conduct research, along with a sense of self as a scientist is a critical component of persistence in science (1, 7). URF respondents showed large or very large gains in interest in science (80%) and increased confidence in their ability to conduct research (77%) (data not shown). In addition, respondents reported large or very large gains in seeing themselves as scientists (84%), understanding the research process (78%), and learning to act professionally in a research setting (77%) (Fig. 2). For URFs, the fellowship experience may have clarified both the tasks involved in and the expectations for conducting research that may not be apparent to undergraduates without previous research experience. In the open-ended responses, one URF participant reported, “I learned how to think like a scientist, develop as a scientist, and how to be a good scientist.” We can conclude that, for this participant, the undergraduate fellowship experience was significant in the launch of his or her scientific career.

Contribution to science—publications and presentations. Collectively, the 223 URF respondents produced more than 1,200 publications—many in peer-reviewed scientific journals—and conducted more than 1,900 presentations. About 95% of current URFs present at the ASM annual meeting (currently ASM Microbe, formerly the ASM General Meeting). The fellows compete with others submitting abstracts for the meeting, and they fare very well. The URFs make up the majority of undergraduates presenting at this national conference. The 5% who do not present generally have scheduling conflict due to college graduations. Additionally, many undergraduates present at campus-based research symposia and regionally based ASM Branch Meetings.

Although undergraduates are not likely to publish papers immediately after their fellowships, the study suggests that they share their research as they continue with doctoral studies. The study findings offer a sampling of their publication in ASM journals (e.g., Applied and Environmental Microbiology, Journal of Virology, Journal of Bacteriology); non-ASM, microbiology-relevant journals (e.g., Virology, Journal of Infectious Diseases, Immunity, Environmental Microbiology); other scientific journals (e.g., PLOS ONE, Journal of Molecular Biology, Journal of Biological Chemistry); and other publications (e.g., Morbidity and Mortality Weekly Report, Current HIV/AIDS Reports).

Watkins Fellowship Program

Completion of doctoral education and matriculation to next phase in development. Given that the Watkins Fellowship targets senior-level graduate students,
completion of the doctoral degree is a benchmark for Watkins fellow achievement. The study results show that 86% of Watkins respondents have completed terminal degrees in the sciences: 82% completed doctoral programs and 4% completed medical programs. The remaining 14% completed master's programs. Fifty-nine percent are working full time, and 23% are in postdoctoral training programs. According to the NSF report, in 2011 a total of 17,327 students entered into doctoral programs in the biological sciences as first-time, full-time graduate students and 7,596 students earned doctorates in the biological sciences (5). The ratio of those who completed the doctoral degree to those who entered doctoral programs is 63%, suggesting that Watkins respondents complete doctoral programs at a higher rate than peers without the fellowship.

In 2011, African Americans earned 1,426 science and engineering doctorates, Hispanics earned 1,397, and American Indians and Alaska Natives earned 122—accounting for 8% of science and engineering doctoral degrees earned in the United States (5). Based on these findings, Hispanics comprise 50%, African Americans 46%, and Native Americans/Alaskan Native 4% of URM doctoral degree holders in science and engineering. The Watkins fellows represent an ethnic or racial demography similar to that of URM doctoral degree holders, but not exactly the same. The largest percent of Watkins respondents were Hispanic or Latino at 50%, African American at 33%, and White at 15%. With regard to gender, the NSF reported 53% of doctoral degrees in the biological sciences awarded to females and 47% to males (5). Among the Watkins respondents, 68% were female and 32% were male. Thus, the Watkins fellows may be skewed toward more female participation than national peers.

Learning—development of new skills. Valuing the opportunity to present research was particularly strong among Watkins respondents. Due to the fellowship’s target audience of advanced graduate students in doctoral education and training, more emphasis is placed on fellows’ development of communication skills than on their technical skills. Large or very large gains in ability to communicate research findings (72%), prepare a scientific presentation (56%), and prepare a scientific poster (48%) were reported (Fig. 3). In addition, more than 40% of Watkins respondents reported large or very large gains in the ability to make oral presentations (44%) and collaborate with other researchers (43%). The greatest gains reported were in the ability to obtain external funding to support research (62%) (Fig. 4).

Affective behaviors—confidence, belonging. Several reports have shown a reduced rate of success in scientific disciplines for URM populations, and much research relevant to these populations in science, technology, engineering, and mathematics (STEM) points to the fact that poor self-identity, lack of confidence, and little sense of belonging lead to reduced likelihood of persistence and success in science fields (2–4, 6, 7). Given this research, factors contributing to becoming a professional scientist (scientist identity, research ownership, belonging to a community, and behavioral norms in a scientific setting) become essential to academic progress and success in the discipline. Large or very large gains were reported by Watkins respondents in seeing themselves as professional scientists (79%), having a sense of belonging in the academic culture (74%), expanding academic and professional contacts (73%), and interacting with others with similar research interests (72%) (Fig. 5).
Several Watkins fellows reported a sense of belonging to a like-minded community and stated that the Watkins program validates one’s success as a scientist. This is illustrated in open-ended comments:

*The boost to my professional career, the experience writing grants, being exposed to career development programs, and networking with people I would not have had the opportunity to meet. I am sure the award is one of the key reasons why I was accepted in my postdoc lab. It really helped differentiate me from other applicants. Being a participant of the Watkins Fellowship has been very helpful for my professional development. The Watkins Fellowship is one of the strongest points on my CV. I have been told by my employers and colleagues that having the Watkins on my CV is very impressive to them.*

**Contribution to science—publications and presentations.** Of the 71 Watkins fellow respondents, 65 reported conducting over 1,000 research presentations. Fewer Watkins fellows than UR fellows present at the ASM annual meeting (currently ASM Microbe, formerly the ASM General Meeting), which covers more general topics in the microbial sciences than smaller, more narrowly focused scientific conferences. Rather, the ASM Watkins fellows present at numerous small conferences representing the diversity of the microbial sciences. Examples include the American Society for Virology Annual Meeting, American Society of Tropical Medicine and Hygiene Annual Meeting, the Fungal Genetics Meeting, the West Coast Retrovirus Meeting, and several Gordon Research Conferences.

Fifty-nine Watkins fellows respondents published more than 430 publications in a diversity of microbiology-related journals published by ASM and others. Twelve respondents reported 10 or more publications, with the highest number of publications for any one individual being 47. The study findings offer a sampling of Watkins publications in high-impact journals (e.g., Science, Cell, Proceedings of the National Academies, and Nature); ASM journals (e.g., mBio, Applied and Environmental Microbiology, Journal of Virology, Infection and Immunity); non-ASM, microbiology-relevant journals (e.g., Virology, PLOS Pathogens, Journal of Infectious Diseases, Immunity, Environmental Microbiology); and other scientific journals (e.g., American Journal of Tropical Medicine and Hygiene, Journal of Food Science, Journal of Biological Chemistry). The presentations, which are too numerous to report, offer similar samplings, suggesting that both publications and presentations reflect the Fellows’ research concentration.

**Challenges and limitations**

**Challenges.** The evaluation results revealed some challenges in the study. First, the small sample size of 412 URF fellows and 99 Watkins fellows may not be reflective of the total population of science and engineering bachelor and doctoral degree holders. The 2014 NSF Science and Engineering Indicators report stated that 93,654 individuals completed bachelor degrees and 7,596 individuals completed doctoral degrees in the biological sciences in 2011 (5). Second, some respondents participated in the program decades ago; their recall could therefore be hazy or influenced by extraneous factors (e.g., academic preparation or other experiences in research or higher education). Third, the survey results may be inherently biased or skewed favorably due to the nature of the award—monetary support that frees awardees of debt and fosters gratitude or obligatory payback.

**Limitations and options for additional studies.** The following limitations should be noted. First, the study relied on self-reported data. Although relatively easy to conduct due to the widespread availability of online survey tools (e.g., SurveyMonkey), self-reporting survey questionnaires do not always provide consistently valid datasets. Respondents are not monitored, so results are dependent on their honesty and willingness to participate. Self-reporting also relies on respondents’ understanding of survey questions, as there is little opportunity to clarify confusing statements or questions. Testing survey questions before implementation is therefore critical. Second, although respondents’ perceptions provided an assessment of their views of newly acquired knowledge and skills, the reported gains may not

![FIGURE 3. Percent gain in communications skills: Watkins respondents (n = 71).](image)

![FIGURE 4. Percent gain in sustaining research skills: Watkins respondents (n = 71).](image)
be true reflections of genuine knowledge gains or increased competencies as measured through written, oral, practical and/or professional practice examinations. Third, the study was not a controlled experiment. If our resources permitted a controlled study, we could identify a control group from those applicants who were awarded but did not accept the fellowship, the population of ASM student members who are sponsored by individual investigators, or the population of NSF-sponsored graduate trainees who pursue doctoral education in the microbial sciences. In addition, another control group might be other society-sponsored minority fellowships, such as the Minority Fellowship Program sponsored by the American Sociological Association, or foundation-sponsored minority fellowships, such as the Gilliam Fellowships for Advanced Study sponsored by the Howard Hughes Medical Institute.

The study was limited to examining the effects on fellows solely and did not include an examination of effects on the research mentors. A future study may examine whether research mentors benefit from the ASM fellowships in their own scientific productivity, visibility through association with a national awardee, credibility as a research adviser, or additional funding as a scientific leader. Since all research mentors must be members of the ASM, are the fellowships an attractive member benefit? If yes, what tangible value do the fellowships provide for members? Finally, the study did not examine the marketing, recruitment, and selection processes or support services for fellows and mentors. Future studies may examine these processes to inform program administrators.

CONCLUSION

This report summarizes findings from a retrospective study of two longstanding ASM fellowship programs. Data collected in this survey indicate that the ASM Undergraduate Research Fellowship and ASM Robert D. Watkins Graduate Research Fellowship Programs are achieving their stated goals. Ninety-eight percent (98%) of all respondents reported high levels of satisfaction with their program experience. Very few respondents indicated no gains in any of the constructs measured by the survey. Many respondents also had long-lasting positive impressions of the opportunity and attributed much of their success and professional trajectory to their participation in the evaluated programs.

It is evident that URF participation fosters the development of scientific identity in undergraduates and clarification about a research career. Additionally, the program contributes to persistence and advancement in the microbial sciences and helps students gain needed skills and confidence. For example, in the qualitative comments, one URF respondent indicated long-term effects of program participation:

Receiving this award solidified my decision to attend graduate school after college and inspired a lifelong interest in microbiology and virology.

The oldest continuous program with ASM is the Watkins Fellowship, which provides an avenue for doctoral-level URM candidates to complete research, gain the skills needed to be successful in the discipline, and belong to the disciplinary community. Without the fellowship, many Watkins program participants may not have achieved as much or persisted in the discipline. In qualitative comments, one fellow described the contrast between belonging to the Watkins community and the isolation felt in the academic program:

It was a major highlight of my Ph.D. career. I never got the sense at my home institution that I was anything special or that there is excitement around careers in
biomedical science. Our small department became an echo-chamber for demoralization, and so it was exhilarating to join a like-minded group of people that work moving in a positioned direction. I was quite inspired by my peers, encouraged by my growing confidence in talking to faculty members that attended our events, and allowed me to attend general meetings where otherwise there was no funding to attend. This was absolutely instrumental in integrating me professionally into the discipline. I would have been much more isolated without the chance to attend meetings (and feel a part of something at the same time).

Both programs are providing positive benefits to their target participants, and respondents indicated positive impacts in their career trajectory in the microbial sciences as a result of participation in the programs.

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