A number of national reports, including Vision and Change in Undergraduate Biology Education: A Call to Action, have called for drastic changes in how undergraduate biology is taught. To that end, the American Society for Microbiology (ASM) has developed new Curriculum Guidelines for undergraduate microbiology that outline a comprehensive curriculum for any undergraduate introductory microbiology course or program of study. Designed to foster enduring understanding of core microbiology concepts, the Guidelines work synergistically with backwards course design to focus teaching on student-centered goals and priorities. In order to qualitatively assess how the ASM Curriculum Guidelines are used by educators and learn more about the needs of microbiology educators, the ASM Education Board distributed two surveys to the ASM education community. In this report, we discuss the results of these surveys (353 responses). We found that the ASM Curriculum Guidelines are being implemented in many different types of courses at all undergraduate levels. Educators indicated that the ASM Curriculum Guidelines were very helpful when planning courses and assessments. We discuss some specific ways in which the ASM Curriculum Guidelines have been used in undergraduate classrooms. The survey identified some barriers that microbiology educators faced when trying to adopt the ASM Curriculum Guidelines, including lack of time, lack of financial resources, and lack of supporting resources. Given the self-reported challenges to implementing the ASM Curriculum Guidelines in undergraduate classrooms, we identify here some activities related to the ASM Curriculum Guidelines that the ASM Education Board has initiated to assist educators in the implementation process.

INTRODUCTION

Over the last 20 years, there has been a push at the national level for discipline-specific content and standards for critical-thinking skills for undergraduates in STEM (science, technology, engineering and math) (6, 15–17). In biology, the AAAS report, Vision and Change in Undergraduate Biology Education: A Call to Action (3) noted that the interdisciplinary nature of biological research, the growing complexity of data, and the power of new technologies required a change in how biology is taught (22). The report called on educators to provide undergraduate biology students with a deep and enduring understanding of biological concepts, so that students could apply biological concepts to new and changing problems. The report organized biology into five core concepts and outlined a set of core scientific process and communication skills that students should acquire. In addition, they called on educators to focus on student-centered learning goals (19) and to incorporate active-engagement instructional approaches, which have been shown in many studies to be more effective for student learning than lecturing alone (10).

Vision and Change prompted educators to rethink the design of undergraduate biology courses (3). According to Allen and Tanner (2), the most common approach to biology course design entails creating a list of topics that reflect the most important material in the textbook, such that the course content is dependent upon the course textbook and the expertise of the instructor. The overreliance on textbooks for course design often leads to a course curriculum with too much information and more vocabulary than a student can assimilate in one semester (2, 4). This “traditional” approach to course design often presents topics as disjointed scientific facts and leads to rote memorization and lower-level student thinking (2, 14). In a new model of course design suggested by Vision and Change, termed the “discipline-based approach of biology curriculum design” (3), course instructors first consider core competencies and core concepts as the initial step in course design. These core competencies and core concepts are set by the disciplinary practice of biology and the organizing themes of biology, respectively. Following the decisions regarding
course core competencies and concepts, instructors design student learning outcomes, assessments, and teaching and learning activities, in that order, in accordance with the backwards course design model (21) and the integrated design model (9).

While the principles of *Vision and Change* are beginning to initiate reform in some educational realms (1, 7, 18), widespread national reform has been difficult (20). Faculty often lack the time or incentives to change their teaching methods (3, 8). They may choose to focus on research, for which there are many more professional rewards, at the expense of teaching (3, 5). At the college and university level, administrators often lack resources to train and/or reward faculty who revise courses (5, 11), or they may not be aware of, and/or be able to implement, the educational research that supports different teaching approaches.

Because discipline-specific professional societies have national stature and are often the organizations that set standards within a discipline, they are well suited to play a role in promoting systemic change. To that end, the ASM Education Board developed new ASM Curriculum Guidelines for undergraduate microbiology in 2012 (13). These Guidelines incorporate many of the recommendations made in *Vision and Change* (3, 13). They embrace the scientific process and thinking skills put forth in *Vision and Change*, adding microbiology-based laboratory skills. Further to adopting the five core concepts of *Vision and Change*, the Guidelines added a sixth core concept, Impact of Microorganisms, specific to this field. Each of the six core concepts is exemplified by four or five microbiology-specific fundamental statements, which reflect basic concepts that are important for all microbiology students to understand in depth. These 27 fundamental statements, together with the four scientific thinking skills and seven laboratory skills, form a comprehensive framework for an undergraduate microbiology course (13). In addition, the ASM Curriculum Guidelines were designed to focus microbiology teaching on student-centered goals and priorities and to enable educators to adopt the discipline-based approach to course design for microbiology courses.

**METHODS**

The goal of this study was to assess the implementation of the new ASM Curriculum Guidelines. In addition, we hoped to identify some best practices and barriers to adopting the new Curriculum Guidelines so that we could better develop support for the microbiology education community. To this end, we designed an online survey (via surveymonkey.com) that was distributed to the microbiology education community through the ASM microedu listserv (905 members). The ASM microedu listserv is a subset of self-identified ASM members who are interested in microbiology higher education instruction. The microedu listserv represents approximately 11.8% of the faculty in the United States who teach microbiology-related courses (total = 7,643; 12) and 12.8% of non-student and non-postdoctoral ASM members who are employed at either a junior college/community college, undergraduate college, or a graduate university (7,035 members as of December 31, 2014). The survey asked general questions about whether and how educators used the Guidelines and why some instructors have not implemented the Guidelines in their classroom. We then sent a second survey (also via surveymonkey.com) to the subset of responders who, in the first survey, indicated that they have used the ASM Curriculum Guidelines in their classroom. The goal of the second survey was to identify the kinds of courses in which instructors have implemented the ASM Curriculum Guidelines and to gauge the usefulness of the ASM Curriculum Guidelines in course planning.

**RESULTS**

Our results from the first survey (n = 353) indicate that over 80% of respondents had heard of the Curriculum Guidelines (Fig. 1), and that they had shared them with colleagues (50%) or administrators (25%). Over 50% of respondents had used the Guidelines, either to redesign an existing course (48%) or module (37%), or to design a new course (13%) or a new module within a course (18%). A few even used it to design new concentrations or majors (3%).

Approximately a third of survey respondents (32%) indicated that they have heard of the ASM Curriculum Guidelines but had not yet implemented them in their classes. We wanted to better understand what barriers these instructors faced when adopting the ASM Curriculum Guidelines. For this inquiry, we used a Likert Scale (1 to 7, where 1 = not a strong barrier and 7 = very strong barrier) to assess which barriers to implementation were highest (Table 1). Survey respondents indicated that a lack of time to develop and test a plan, a lack of financial resources, and a lack of curriculum-related resources were the top barriers to change any aspect of the curriculum to align with the ASM Curriculum Guidelines (Table 1). Similar barriers have been identified by faculty in other aspects of their teaching (3, 8).

We used a second survey to understand more about how some educators were using the Guidelines. Of those

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**FIGURE 1.** Results from a 2014 survey of the ASM Education community (mean %, n = 353). Listed are percentages of survey responses to the question: “If you have implemented the ASM Curriculum Guidelines, how have you done so?”

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**TABLE 1.** Survey respondents were asked to rank on a Likert Scale (1 to 7) the barriers to implementation of the ASM Curriculum Guidelines. The top three barriers to implementation were lack of time to develop and test a plan (4.5), lack of financial resources (4.4), and lack of curriculum-related resources (4.2).
Our survey identified many benefits to educators and students resulting from the adoption of the ASM Curriculum Guidelines. Survey participants indicated that they have used the Guidelines to form the conceptual framework for their courses. One participant said that, because they outline core concepts and skills, the Guidelines were most helpful for new faculty and for faculty who are designing new courses from scratch. Another educator who used the Guidelines throughout a single course stated that the threading of the Guidelines prevented the course from becoming a series of disconnected topics. Our results identified that educators and students in multi-campus systems used the Guidelines to standardize course content across departments and campuses, allowing for easier student transfer. The Guidelines can also provide a check for academic rigor. Finally, many educators reported feeling more confident in the course and assessment planning process when using the Guidelines because they were previously unsure which concepts and skills were most important in microbiology.

Given the input from the education community that the ASM Curriculum Guidelines are helpful but can take time and resources to implement, the ASM Education Board is taking steps to support educators who want to align their undergraduate courses with the Guidelines. While several professional development opportunities and resources are already available, we aim to release many new student and instructor resources within the next year that are aligned with the Guidelines (Table 2). Of note, the ASM Education Board is working with ASM Press to align the 2nd edition of Microbe (Schaechter et al. 1st ed., 2006, ASM Press) with the ASM Curriculum Guidelines. We hope to lower the barriers to using the discipline-based approach to course design through the integration of national recommendations for microbiology curricula into the Microbe textbook. Also, ASM Education committees are currently developing two nationally tested and validated microbiology concept inventories, for General Microbiology and Microbiology for Health Sciences, which promise to assess student learning of the ASM Curriculum Guidelines. We hope that, by providing these professional development opportunities and resources, we can ensure that more biology and microbiology educators will be empowered to implement the Guidelines in their own classrooms.

Although the transition to implementing national curriculum recommendations can be challenging, the ASM Education Board is making it easier for educators to answer the call from Vision and Change (3) and other national education reports (6, 15–17) for higher education undergraduate STEM reform by providing resources and professional development to educators. Since the release of the most recent version of the ASM Curriculum Guidelines in 2012, many educators have chosen to implement them so that students gain a deep understanding of the core concepts of microbiology and acquire the essential skills required. As the ASM Curriculum Guidelines set the framework for any general undergraduate microbiology course, using them is the first step in optimizing the discipline-based approach to course design.

### DISCUSSION

These results suggest that the ASM Curriculum Guidelines are generally viewed as helpful to a wide variety of instructors, as indicated by our Likert-scale questions and the fact that over 50% of survey responders had used the Guidelines to design or re-design a module, course, or major. Our results also suggest that educators find the ASM Curriculum Guidelines to be flexible enough to be adaptable to many different courses.

### TABLE 1.

Identification of common barriers to changing teaching practices in undergraduate microbiology courses.

| Barrier to Implementation | Challenge to Implement ASM Curriculum Guidelines |
|---------------------------|--------------------------------------------------|
| Lack of time to develop and test plan | 4.68 |
| Lack of financial resources to develop and test plan | 3.98 |
| Lack of resources (e.g., practical advice, tips, models) for implementation | 3.23 |
| Buy-in and acceptance from faculty colleagues | 3.14 |
| Buy-in and acceptance from administrators (e.g., curriculum committee, dean, adviser) | 2.89 |
| Lack of mentors to demonstrate and support me during implementation | 2.80 |

Survey participants were asked to use a Likert scale of 1 to 7, where a score of 1 indicated the challenge is not a very strong barrier to implementation and 7 indicated an extremely strong barrier to implementation (mean score, n = 353).

who responded (n = 64), 64% reported using them in a lower division undergraduate course, 52% reported use in an upper division course, and 28% reported that they used the Guidelines in an introductory level course. Many instructors indicated that they use the Curriculum Guidelines for undergraduate Introductory Microbiology and Microbiology for Allied Health students, but instructors report that they have also implemented the ASM Curriculum Guidelines in: General Biology, Immunology, Biotechnology, Virology, Public Health Microbiology, and Research Methods in Microbiology. Using a Likert Scale of 1 to 5, (where 1 = strongly agree and 5 = strongly disagree), we asked them to respond to the following statements: “The ASM Curriculum Guidelines have helped me to plan courses” (average score of 1.7) and “The ASM Curriculum Guidelines have helped me to plan assessments” (average score of 2.1).
TABLE 2.
ASM Education Board–sponsored professional development opportunities and resources that support faculty in the implementation of the ASM Curriculum Guidelines

| Event/Resource | Description | Date Available |
|----------------|-------------|----------------|
| **Professional development events** | | |
| M(icro)OOC webinar | Occasional webinar series about topics related to microbiology teaching | Ongoing; archived webinars available now |
| ASMCUE (ASM Conference for Undergraduate Education) | 4-day conference for educators with many pedagogy sessions | Yearly |
| ASM Science Teaching Fellowship | 5-month online course to prepare early-career faculty for teaching positions at non-doctoral institutions | Yearly |
| Biology Scholars | Year-long residency in the scholarship of teaching and learning | Yearly |
| **Resources** | | |
| ASM Curriculum Guidelines for Undergraduate Microbiology Education | Recommended curriculum for microbiology course or program of study. Includes concepts, competencies, and skills. | Available now |
| ASM Curriculum Guidelines Learning Outcome Examples | Collection of learning outcomes for undergraduate microbiology that was written by the ASMCUE community | Available now |
| ASM Guidelines for Biosafety in Teaching Laboratories | Comprehensive guidebook to uniform biosafety recommendations for working with microorganisms in the teaching laboratory | Available now |
| JMBE: Curriculum and Tips & Tools | Peer-reviewed collection of microbiology classroom activities | Available now |
| ASM MicrobeLibrary Curriculum Archive | 85 peer-reviewed microbiology classroom activities that promote active learning | Available now |
| MicrobeLibrary resources | Peer-reviewed collection of microbiology-related images, videos, animations, and laboratory protocols | Available now |
| CourseSource | Peer-reviewed collection of microbiology classroom activities | Available now |
| Student Learning Assessment in Microbiology Database (SLAMD) | Peer-reviewed multiple-choice questions that assess concepts in the ASM Curriculum Guidelines | 2016 |
| Microbe, 2nd ed. | Undergraduate microbiology textbook that will promote deep learning of the concepts in the ASM Curriculum Guidelines | 2016 |
| Concept Inventories: General Microbiology & Microbiology for Health Sciences | Nationally tested and validated instruments to assess learning of concepts in the ASM Curriculum Guidelines | 2016 |

SUPPLEMENTAL MATERIALS

Appendix 1: Surveys sent to the ASM microedu listserv

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