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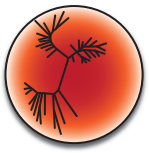

Introducing the *JMBE* Themed Issue on Scientific Citizenship

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As most of our readers are aware, the statistics on scientific knowledge in the United States paint a grim picture. At a global level, US high school students achieve a mid-range proficiency in science literacy; only 7% of US students achieve high-level proficiency, which is defined as the ability to "…use scientific knowledge and develop arguments in support of recommendations and decisions that center on personal, social, or global situations" (2). Less than half of Americans self-report that they understand what scientists do in their daily jobs, only 20% can articulate how to study something scientifically, and one-third can describe an appropriate experimental design (3).

However, all is not lost: 40% of Americans report being interested in scientific topics (3). The majority of Americans get their scientific information from the Internet, and approximately half of the US population visits informal science venues, such as zoos or aquariums, annually. Not surprisingly, participation in informal science learning strongly correlates with perceived understanding of science in adults (1). Thus, if we can engage these interested individuals in meaningful scientific inquiry, it potentially allows for an increasingly scientifically literate society.

When we conceived of the Scientific Citizenship theme, we wished to address the following seemingly simple question: How can we engage people in science? Whether the goal is to increase the number or diversity of science, technology, engineering, and mathematics (STEM) majors, produce scientifically literate students, or have the public meaningfully contribute to scientific experiments, we hoped that this themed issue would provide a snapshot of current ideas and best practices. Once again, the community rallied around our themed issue, and we have 40 articles to share with you—enough to make its own separate issue and the first issue of *JMBE* to be published solely on the ASMscience platform!

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Citizen science is undoubtedly a major contributor to this issue, and we begin in "Perspectives on Citizen Science" with essays that consider this current trend in scientific education. Dunn et al. start by placing citizen science within a historical context and posit that we are on the cusp of a renaissance in science education at both K–12 and undergraduate levels. Garbarino and Mason continue this idea by considering the powerful impact that citizen science has already had on the scientific community. Essays by Van Vliet and Moore and by Shah and Martinez give us primers to current citizen-science projects. Finally, we specifically address the role of microbiology in citizen science: Barberan et al. argue the case for why microbial ecology should be central to science education, while Westenberg places citizen science within the context of ASM programs and specifically K–12 education.

Participation in a science project is one thing, but can data collected by nonscientists yield useful information to the scientific community? In "Engaging and Training Citizen Scientists in Data Collection," we consider how citizen scientists must be recruited and trained to effectively contribute to field data collection. Dahlhausen et al. consider the role of social media in funding and participation in citizen-science projects. Council and Horvath share their strategies for making citizen science engaging in both formal and informal learning environments. Nebeker et al. describe their approach for training community health workers, with eight modules that cover research design, data collection, and scientific ethics. Debelius et al. and Philippoff and Baumgartner address specific issues regarding data collection and give solutions to address common mistakes. Finally, Bear describes the levels of training needed for multiple marine citizen-science projects and considers the motivations behind citizen scientists' contributions to scientific endeavors.

We then broaden our definition of scientific literacy by detailing how individuals can participate in "Authentic Research Experiences in the Laboratory" and "Public Outreach Activities" that use informal science learning or seek to increase participation of individuals in STEM. From

searching for soil symbionts (McKenney et al.) to tracking Lyme disease (Seifert et al.) or finding purple bacteria for bioremediation (Agate et al.), these essays describe multiple models of engaging nonscientists in the laboratory. Outreach endeavors at the Chicago Botanical Garden (Johnson) and in rural Appalachia (Kelly) help increase the number of individuals interested in STEM, while Scheifele and Burkett describe a community lab environment which provides space for "DIY Biology." Finally, articles by Webb and Northcutt describe service-learning projects that provide educational opportunities for both the teachers (undergraduate students) and the learners (outreach populations).

Looking for some specific classroom activities? Look no further than "Curricular Approaches for Engaging Scientific Citizenship" and "Nontraditional Approaches to Engage Citizens in Science." There are so many inspirational ideas within these sections that we do not have the space in this editorial to do them justice! From science games (Burnett et al.) to controversies (Yoho and Vanmali) to literature scavenger hunts (Lijek and Fankhauser), these articles describe specific ways to educate the public about the process of science. Want to turn microbial data into music (Larsen)? Teach epidemiology using the zombie apocalypse (Lofgren et al.)? Some of these approaches reach into the nontraditional and are definitely intriguing.

We are just beginning to understand the impacts of citizen-science initiatives on individual learning about the scientific process. "Measuring Outcomes of Citizen Science Activities" details some of the early findings from this relatively recent trend in science education. Nuhfer et al. describe results of a citizen-level science concept inventory which assesses scientific reasoning. Schnetzer et al. analyze citizen-scientist contributions from a worldwide ocean sampling project. Freeman et al. consider how the use of microbial data from an undergraduate laboratory can provide antibiotic resistance surveillance information for the community. Interested in learning more? Reviews by Begley, Kavouras, and Mochnick describe three books which can further your knowledge on the subject of citizen science.

Finally, we would like to dedicate this issue to Dr. Joseph Caruso, an incredible educator who was committed to bringing authentic research experiences into the classroom. A touching tribute can be found in Dr. Pamela Marshall's Letter to the Editor in this issue. Dr. Caruso and his colleagues submitted their manuscript about outcomes from the Small World Initiative shortly before his passing, which can be found on page 156.

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