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# Plankton on the Stage: Microscopes in Middle Schools

By James M.S. Foley and Barbara C. Bruno

The Center for Microbial Oceanography: Research and Education (C-MORE) aims to understand the important roles that marine microbes play in ocean ecosystems. Marine microbes, such as bacteria and archaea, recycle nutrients, convert elemental nitrogen into useful forms, drive biogeochemical cycles, produce a significant amount of oxygen, and are an essential component of the marine food web (Bowler et al. 2009). They are arguably the most important organisms on Earth!

Scientists use different magnifying tools to unravel the secrets of marine microbes. Basic light microscopes are familiar to most people. Epifluorescence light microscopes shine ultraviolet light onto a prepared sample, causing stained cells to fluoresce and glow like stars (Figure 1a). This tool enables the counting of bacteria and viruses in seawater samples. Electron microscopes use a beam of electrons to create detailed images of very small objects (Figure 1b).

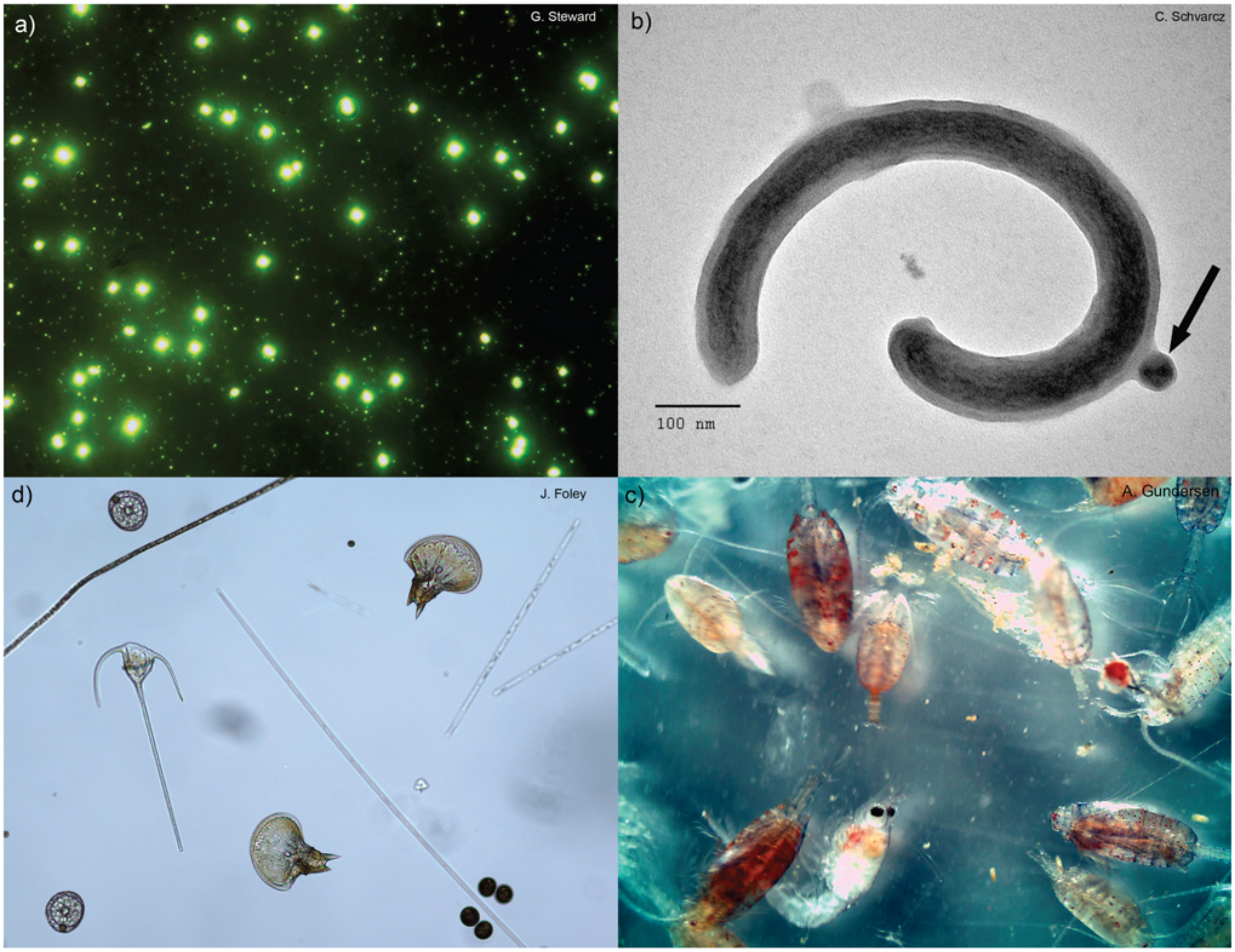


Figure 1. Key components of the ocean food web clockwise from top left: a) Epifluorescence image of a seawater sample stained with fluorescent dye showing bacteria (large dots) and viruses (small dots); b) Transmission electron micrograph of a prokaryote cell with an attached virus (indicated by arrow); c) zooplankton viewed under a stereo microscope; and d) phytoplankton viewed under a compound microscope. The basic links in the food web are that bacteria break down organic matter, rematerializing nutrients that phytoplankton use during photosynthesis, then zooplankton feed upon phytoplankton.

Is it possible to create connections between C-MORE research and the classroom? How can teachers generate interest in unseen marine life among K–12 students? One way is to introduce students to zooplankton: aquatic organisms that can be easily caught with a simple net and viewed with a microscope (Figure 1c). By having students learn about zooplankton, teachers can ask questions and guide students to speculate how these microscopic animals survive. This can lead to discussions about phytoplankton and the communities of indispensable organisms smaller than a hair's width, upon which zooplankton rely (Figure 1).

To help teachers bring microbial science into Hawaii's classrooms, C-MORE created a program to equip middle schools statewide with a digital video microscope (which connects to a computer for whole-class viewing), plankton net, and lesson plans (C-MORE 2013). The equipment and lessons are based on those in the C-MORE plankton kit, which have been shown to produce significant gains in student learning (Foley et al. 2013). All lessons are aligned with Hawaii Content and Performance Standards (HCPS III) for sixth through eighth grade (HiSD 2005; C-MORE 2012). Lessons about the importance of marine microbes in the marine food web and biogeochemical cycles are examples of crosscutting concepts that address the disciplinary core ideas mentioned in the Next Generation Science Standards (NGSS).

## PROFESSIONAL DEVELOPMENT: WORKSHOP ORGANIZATION AND CONTENT

Simply providing equipment to schools without accompanying training or curriculum is often ineffective and can result in resources ending up in storage closets. Therefore, the *Microscopes in Middle Schools* program requires at least one teacher from each recipient school to attend a one-day professional development workshop, to make the equipment available to other teachers, and to agree to train their colleagues in equipment use. Through a Memorandum of Understanding between C-MORE and the Hawaii State Department of Education, participating teachers are eligible to earn professional development hours.

Hawaii has a single statewide school district, with 81 public middle schools on six islands. To ensure all teachers could access a "local" workshop, we organized six workshops on the four major islands between December 2011 and November 2012. University of Hawaii campuses, public schools, and science centers served as venues. Workshop announcements were sent directly to middle school principals and posted on local education email lists. As of May 2013, 65 teachers from six islands attended workshops and 46 middle schools (57% statewide) received the equipment.

The workshops employed a combination of lectures and lesson modeling during the morning session and hands-on exploration in the afternoon. They incorporated several key characteristics of effective professional development, such as increasing content knowledge, promoting collaboration, providing resources and follow-up support, and incorporating an evaluation component (Guskey 2003). All presentations and workshop handouts are available online at no cost (C-MORE 2013).

The morning session of the workshops began with a college-level overview of the key concepts in microbial oceanography (C-MORE 2008). As prior content knowledge varied among teachers, we acknowledged that the presentation may be review for some, and new for others. Two standards-based, middle-school-level classroom lessons on phytoplankton were then conducted. To model classroom implementation, teachers played the role of students (Browder et al. 2012). The first lesson, *Introduction to Plankton,* began with a narrated PowerPoint™ presentation, followed by a lab identifying phytoplankton from images. The teachers sketched and identified organisms, noting adaptations such as color, shape, spines, whether the organism formed chains, etc. In the second lesson, *Design Your Own Plankton,* teachers designed and drew a new phytoplankton species by creating and incorporating two new survival adaptations, provided a scientific name, and presented their plankton creation to the group (Figure 2).

During the workshops, 25 C-MORE volunteers who were undergraduates, graduate students, and post-docs provided individualized instruction and shared their interest and excitement in microbial oceanography. A networking lunch among teachers and volunteers allowed time for small group discussions about topics ranging from microbial oceanography to education. The combination of teachers, researchers, students, and workshop facilitators created an exceptional community for collaborative learning.

Figure 2. Molokai Middle School teachers Iolani Kuoha and Jennifer Ainoa share their plankton designs.

Figure 3. C-MORE alumna Ashley Bulseco-McKim (center) explains the microscope features to Lia Pe'a of Waiakea Intermediate School (left) while Sherri Takamoto of Waimea Middle School (right) views a plankton sample.

The afternoon session focused on hands-on microscope training and plankton viewing. C-MORE staff demonstrated how to use and care for the microscope, project microscope images onto a computer screen, capture images and video, and calibrate the microscope for making measurements. Teachers then set up and practiced with their own microscopes. The volunteers provided essential one-on-one assistance during this process (Figure 3).

Once the teachers were familiar with the microscope, they explored a pre-collected, live plankton sample. They were encouraged to collect plankton for their own classes. Plankton can be collected almost anywhere, including lakes, ponds, streams, and the ocean. The most important aspect of plankton sampling is personal safety. Teachers need to know their own abilities and those of their students and be mindful of local weather and water conditions. Good plankton samples can be collected from boats, surfboards, docks, bridges, beaches, or just by letting a stream or tidal current flow through the fine-mesh net. While it is best to collect plankton on the day of observation, some plankton can survive up to 24 hours if kept refrigerated in a liter or more of water.

For many participants, this was their first time seeing live plankton and they were surprised at the swimming activity, intricacy, and diversity of the zooplankton. This led to lively discussions and questions among the teachers and workshop volunteers, which tied back to the relationships between zooplankton and marine microbes. In their workshop evaluations, participants cited these one-on-one discussions as critically important to their understanding: "[Post-doctoral researcher] Daniela [Böttjer] was SO helpful. It was great to have grad/college students/researchers on hand to assist, ask questions and share their enthusiasm for these microbes."

The workshop session concluded with questions, discussions on additional ways to use the new equipment, ideas for class and science fair projects, and ways in which teachers could get additional support. Some ideas raised include collecting time series data of plankton, developing a student-generated plankton guide, and utilizing a citizen science website (projectnoah.org) to share pictures of the plankton collected. On evaluations, participants noted this closure was helpful: "Q & A [Questions and Answers] was great. It allowed us the time to probe further and find out more info."

Following the workshops, we continue to provide participants with technical support via email, phone, classroom visits, or webinars. C-MORE staff members have also joined classes on plankton collection field trips. We are in the process of arranging follow-up, on-demand workshops on plankton collection, quantification, and biogeography.

## WORKSHOP EVALUATION

Workshops were evaluated by BridgeWater Education Consulting through pre- and post-surveys given immediately before and after the workshop. The surveys included a combination of Likert scale statements and open-ended questions. The Likert scale ranged from "strongly disagree" (1) to "strongly agree" (5). A total of 61 participants (94%) completed both surveys. Quantitative data were analyzed for significance using a paired t-test. A follow-up survey tracking long-term workshop efficacy is under development.

The evaluation survey data showed that teachers found the workshops valuable not only for the equipment received but for the knowledge gained. Most (65%) of the respondents indicated that they would use the lessons and equipment within a month of the workshop, and 99% stated that they would use the materials by the next semester. There was a significant ($p<0.001$) increase in knowledge confidence about marine microbes, plankton, and life in the ocean from pre-survey (respective means: 2.36, 2.69, 3.32) to post-survey (respective means: 3.64, 3.72, 3.77). On the post-survey, over 93% of respondents indicated agreement or strong agreement with the statements "I increased my knowledge of plankton during the workshop" (mean: 4.39) and "I increased my knowledge of marine microbes during the workshop" (mean: 4.39).

Overall, participants found the presentations, lessons, and hands-on activities to be highly useful. When given space to list "least useful information" and "least useful activities", the vast majority of respondents (92% and 85%, respectively) stated "none." In the open-ended questions, 85% of participants indicated that hands-on plankton viewing was the most useful activity. Other responses for most useful workshop activities included small group plankton discussions (28%), presentations (19%), and "everything" (19%). "I thought everything was great! I gained knowledge from everything. I loved it, this will be so helpful in my classroom. :) Thanks!"

## CONCLUSION

*Microscopes in Middle Schools,* a program that equips teachers with the tools and training to bring microbial life into the classroom has reached 46 (or 57%) of Hawaii's middle schools to date. The standards-based lessons have been shown to produce significant learning gains among students, and the teacher survey results indicate a high degree of satisfaction.

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## ADDITIONAL RESOURCES

The resources presented are free to borrow from select locations as the C-MORE plankton kit (http://cmore.soest.hawaii.edu/kits). Public school educators may apply to C-MORE's Grants for Education in Microbial Science (GEMS) to purchase supplies mentioned in this article (http://cmore.soest.hawaii.edu/gems).

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## PHOTO CREDITS

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