

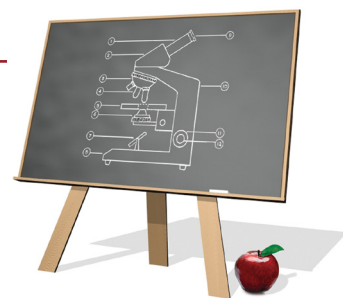
MicroscopyEducation

STEM/STEAM 2022

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Abstract: Many universities, commercial companies, and science organizations who use microscopy have outreach programs. The members of such generally love to share their enthusiasm and passion with the next generation. Content and confidence on providing such a program often comes from sharing ideas with like-minded scientists. These programs are typically delegated with the acronym STEM or STEAM: science, technology, engineering, art, and math. One of MSA's outreach programs is ProjectMICRO. Included are some STEAM ideas to share.

Keywords: microscopy, outreach, STEM, STEAM, Women in Science, ProjectMICRO

By now, most people will have heard of STEM in schools—science, technology, engineering and math. These days though, we talk about STEAM—science, technology, engineering, art, and math for a more rounded education. Microscopy is one of those subjects that covers the lot.

Students will often make up their minds in middle school whether they want to go into the sciences. Most (~95%) of the teachers in middle school come from the Arts program and sometimes need a little assistance with the sciences. Fortunately, they have more and more avenues to go to for this assistance. Most universities and science associations, such as the Microscopy Society of America (MSA), have outreach programs. In the case of the MSA, it is called ProjectMICRO, which mostly targets middle school students, but can be adapted for any age. Part of our plan for getting more science into schools, as well as talking to the students, has been to excite the teachers. If the teachers are excited by the subject, they can inspire the whole class! Why should the teachers be made excited? Maybe because the more we can encourage students into a STEM career, the more chance some of the world's problems will be solved. Young people have shown they can be passionate about such global problems as climate change and sustainable energy, even asking questions such as “What happened to the dinosaurs?” or “How can we live on Mars?” Helping teachers to help young people, as well as encouraging students to go to work on these problems, will eventually help us all.

My predecessor as chair of ProjectMICRO, Caroline Schooley, arranged a collaboration of MSA with the GEMS (Great Explorations in Math and Science) program out of Lawrence Berkeley labs in California (www.lawrencehalloffscience.org/educators/gems). They put together a book of ten microscope activities (stations) for schools, which is still relevant

today (<https://store.lawrencehalloffscience.org/Item/gems-microscopic-explorations>) (Figure 1).

Once you start working with these stations, other stations come to mind. I have 15 different stations now. My confidence on using these stations came from networking at the annual Microscopy & Microanalysis (M&M) meetings. One of my best mentors, Janet Schwarz, now retired from the Department of Pathology and Laboratory Medicine, University of Vermont, still uses the program in schools and libraries in her area (Figure 2). Increasingly, as members of MSA retire, it is one way to pass on their knowledge to inspire the next generation and have fun.

Just before COVID struck, I was privileged to receive a tabletop scanning electron microscope (SEM; TM4000Plus) from Hitachi to take into schools as part of their STEM Outreach program (<https://www.inspirestemeducation.us/>). All the major microscopy manufacturers produce tabletop SEMs, but Hitachi has developed a worldwide STEM program to inspire children to go into the sciences, with several nodes in the USA loaning SEMs to schools and science museums.

As COVID spread, so did the opportunity to interact digitally with remote schools who would probably not have been able to visit the University because of the cost of travel and time. Now, via Zoom, even when the students are isolated they can still come as a class to the University, as the University has a site license for 300 Zoom connections at a time. I usually have two goals in my talks: one, no one is to go to sleep, and two, I want at least one “Wow!” from every member of the audience. Fortunately, with scanning electron microscopy, this is not difficult.

One of the key ingredients to engaging the whole class is to have the right specimens and stories about the specimens. Luckily, having a gift of a “specimen that keeps on giving” helps. I live on the coast, and coastlines around the world have eelgrass beds. They are important for all sorts of reasons including fish nurseries, world oxygen production, and erosion reduction. When a piece of eelgrass came floating by our sailboat a summer ago, I dried it on the deck in the sunshine. Mounting sections on a stub with carbon tape and then gold coating was all the preparation needed for the tabletop SEM, though sometimes we can get away without coating. One of the advantages of a tabletop SEM is that you can put damp material into it and use backscattered electrons, reducing the charge effect.

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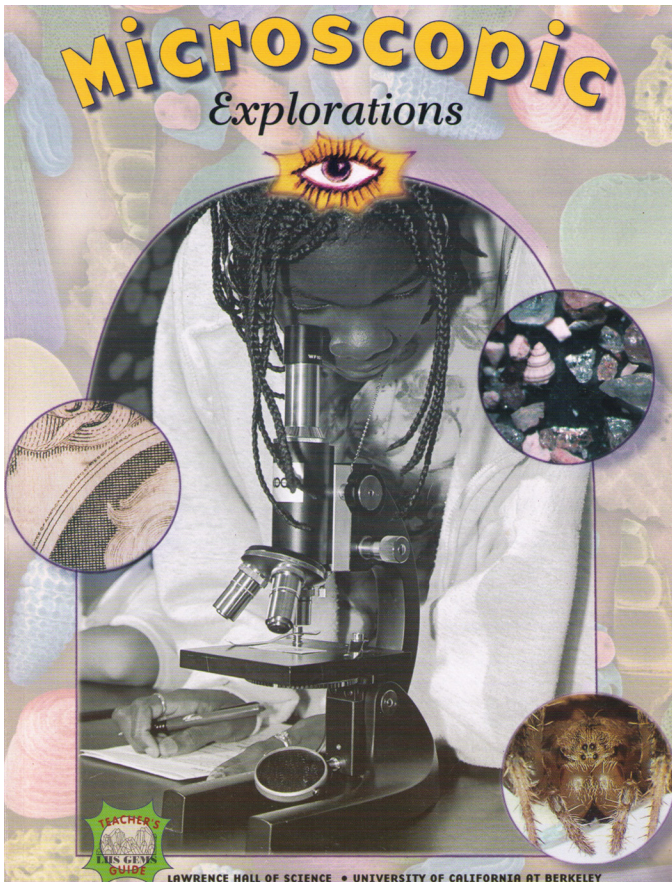


Figure 1: Microscopic Explorations from the Lawrence Hall of Science.

Resolution is limited, but for most insects or plant materials there is enough to thrill the class.

The eelgrass had a whole ecosystem living on it, but mostly diatoms. Every time we look at it, we find another species. The excitement of discovery is infectious. At the time of writing, we are up to over 50 species of diatoms and a few microscopic animals (Figure 3). For the younger children (and older), rather than bore them with a list of species names, they are asked “what does it remind you of” in the typical fashion of Kerry Ruef from The



Figure 2: Microscopy is fun. Community outreach at the University of Vermont Medical Center. Courtesy of Janet Schwarz.

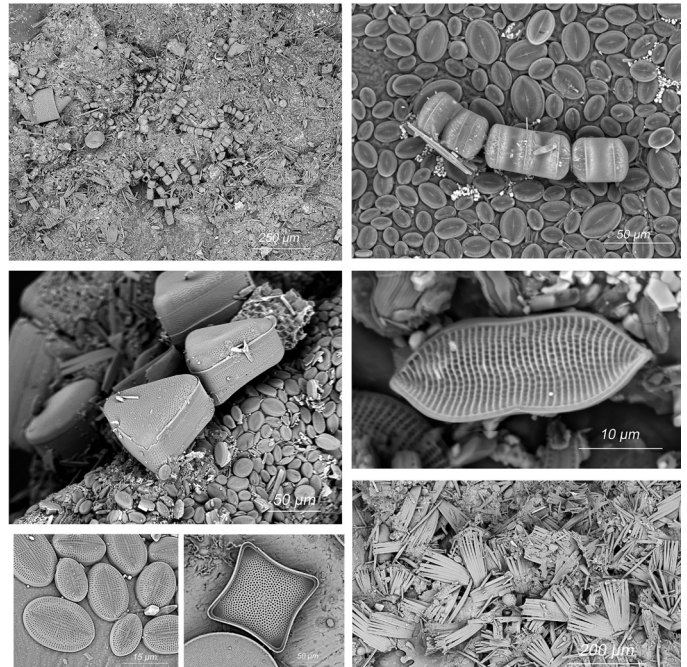


Figure 3: Diatoms come in many shapes and sizes. SEM images.

Private Eye (<http://www.the-private-eye.com/index.html>). We have frisbees, matchsticks, cocoa beans, Toblerone bars, marshmallows, pillows, cushions, guitars, bananas, peanuts, canoes, etc. Once the students are hooked, they want to know more. Even the ones who think they are artists and not scientists get hooked with the patterns they see in the diatoms. My favorite is the “Toblerones,” *Trigonium* sp. (Figure 4). I’m sure I’ve seen a wallpaper with this

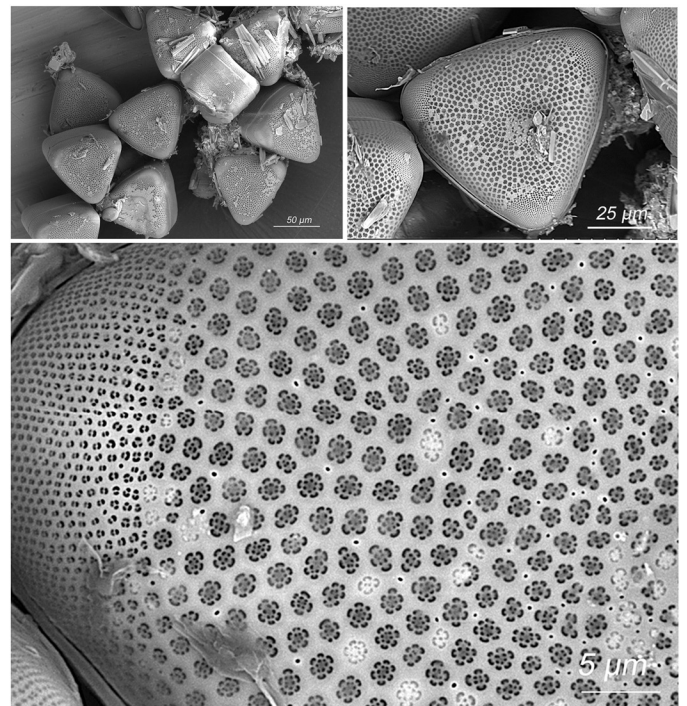
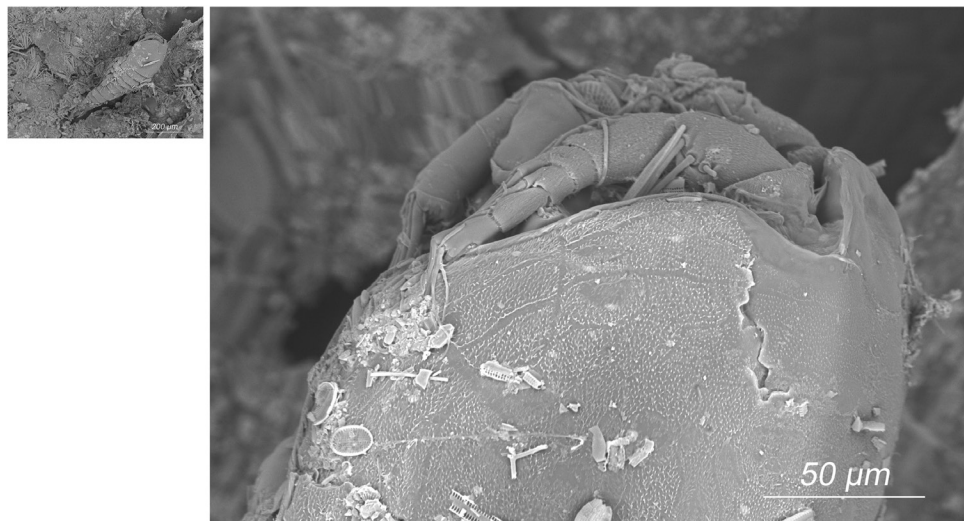


Figure 4: *Trigonium* sp. (“Toblerone bar”). SEM images.



the hard stuff on the outside. We have our squidgy stuff on the outside and our hard stuff on the inside. When you zoom into a copepod, you see the pattern of sensory hairs on the surface, particularly important for knowing what the environment is like outside their hard exterior (Figure 5). When we zoom into annelids, we see the nephridia pores (Figure 6), which leads to a story about what happens to the ammonia from metabolism of proteins in water-living animals (out through any membrane) as opposed to land-based animals (urea and kidneys), or chicks in an egg with no water to wash it out, a feature retained by adult birds (uric acid, so you get a plop on your car and not a whoosh).

Figure 5: The pattern of hairs on the carapace of a copepod. SEM images.

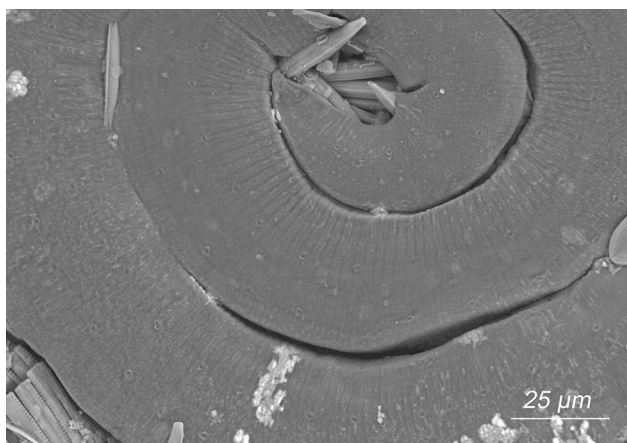


Figure 6: The pores on the segments of a marine annelid. SEM image.



Figure 7: The beautiful sculpturing on a slime mold elater. SEM image.

pattern. We continually bring in the sciences, such as how diatoms keep us alive (20–50% of the world's oxygen), and how the broken pieces of diatoms make the very useful diatomaceous earth (we are up to six uses, from filtering beer to dynamite). Copepods and amphipods have their squidgy stuff on the inside and

Then I went on a mini-Bio-blitz of Galiano Island as part of the IMERSS group (Institute of Multidisciplinary Ecological Research of the Salish Sea) where we went through the forest and I came back with lichens, slime molds, fungi, mosses, and ferns. Who knew that when you zoom into a slime mold, the threads (elaters) and the spores have so much beautiful sculpturing on them (Figure 7)! We also found a stunning fern spore (Figure 8). Now I have another stub of “walk through the forest” specimens to engage the students! That Zoom works for sharing microscopy in real time is confirmed by the feedback and return visits I am getting, such as Shuswap Middle School, on the other side of the mountains (<https://sms.sd83.bc.ca/2020/12/05/thank-you-dr-humphrey/>). Microscopy can engage the whole class, even ones who have learning difficulties.

I expected that contacting the school boards to announce my program would not go very far, as the notice would get stuck on the principal's desk since they are so busy these days. So, I decided I had to go through the teachers, parents, and grandparents. This was accomplished by contacting a local Canadian Broadcasting Company radio program, *North by NorthWest*, aired on Saturday and Sunday mornings. They interviewed me and it was very successful. I can recommend the advantage of grandparents and parents and word-of-mouth. Connections with institutes such as science museums that liaise with schools also work. Science World in Vancouver, BC, has a program, *Scientists and Innovators in Schools*, which has been another way to contact teachers. Many cities now have a science museum, or Science World with teacher contacts.

As a person who has been involved in the sciences for a few decades now, it has been wonderful to see so many girls being excited by STEM in recent years. When I first trained as an undergraduate, we were lucky to see a dozen girls in a full lecture room. Now it is almost 50:50. Much of this success comes from STEM/STEAM programs targeting girls, especially where mentors are willing to share their enthusiasm and passion for STEM/STEAM.

There are a number of STEM programs directed at girls. They show how much fun science can be for girls by interviewing women scientists with an enthusiasm for their subjects and

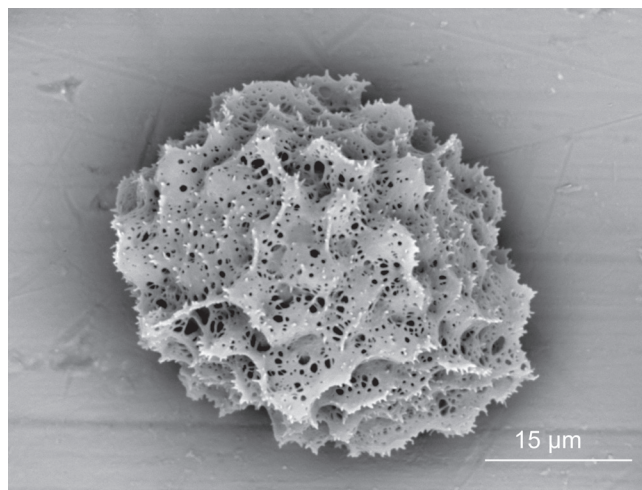


Figure 8: A fern spore. SEM image.

would-be mentors. One such program is Girls' STEM-pede (www.girlsstempede.com).

A quick Google of your local University website and Women in Science will provide contacts of possible mentors. My University has a Women in Science group that interviewed me (<https://www.uvicwomeninscience.com/interviews/2018/12/21/dr-elaine-humphrey>).

Even the United Nations has a Women in Science page (<https://www.unwomen.org/en/news-stories/in-focus/2022/02/>

in-focus-international-day-of-women-and-girls-in-science) demonstrating the worldwide effort to improve access to STEM and STEAM programs for girls and women.

In January of this year, I was asked to participate, with the tabletop SEM, at an Island WISE (Women in Science and Engineering) event out of Cape Breton University on the other side of the continent (<https://www.islandwise.cbu.ca>). It wasn't the furthest I have Zoomed with the SEM. That goes to a primary school in Melbourne, Australia. With Zoom and connecting in real time, it doesn't matter now how far away anyone is, as long as there is an internet connection. With companies such as Hitachi, and scientists willing to give their time and enthusiasm, nothing is impossible.

This year at M&M 2022 in Portland, because I can drive down, I am hoping to bring my tabletop SEM so we can share ideas at the ProjectMICRO outreach booth, part of the MSA MegaBooth in the exhibit hall. I get a lot of my ideas for outreach programs networking with delegates at the M&M meeting.

I strongly encourage our readers to become proactive and check out if there are any STEM/STEAM programs in your area, particularly with the MSA Local Affiliated Societies (LAS). Why re-invent the wheel! If there are none in your area, then I strongly encourage you to start a STEM/STEAM initiative in your local communities and LAS. I hope you have as much fun as I have been having, and I hope you will network winning ideas.

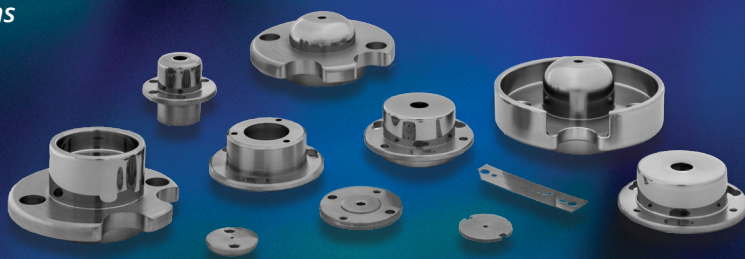
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