Moving Microbial Science Forward

Today, operating out of borrowed space in Harvard's Center for the Environment, the Microbial Sciences Initiative (www.msi.harvard.edu) funds six postdoctoral fellows who typically bridge two labs in different departments, often across schools; sponsors 12 undergraduate summer fellowships; arranges monthly seminars that bring in speakers from around the world; and hosts an annual symposium. This past summer, MSI held a workshop for high-school teachers designed to help them incorporate microbial education into their curricula. In the current academic year, the initiative will introduce two new undergraduate courses: Life Sciences 190hf, "Diverse Microbial Strategies for Metabolism, Pathogenesis and Chemical Signaling," taught by Harvard Medical School (HMS) professor of genetics Gary Ruvkun, and Life Sciences 110, "A Microbial World," designed for students pursuing microbial science as a secondary field and co-taught by professor of microbiology and molecular genetics Roberto Kolter and professor of biological chemistry and molecular pharmacology Jon Clardy, both of HMS, and Cabot associate professor of earth and planetary sciences Ann Pearson, a biogeochemist in the Faculty of Arts and Sciences.

1: These cave mineral deposits were difficult to explain through purely geologic processes. Spelunker scientists in the 1970s discovered that microbes play a role in their formation.
2: The recognition that microbes can respire insoluble metals has led to a complete reassessment of processes, such as rusting, that used to be considered largely abiotic (nonliving) and are now known to have a microbial component. Scientists refer to this as "microbial-assisted corrosion."

something from similar molecules found in contemporary microbes." It turned out that the bacterium that Losick's lab studies has genes similar to those known to produce a certain type of these molecular fossils. Their shared MSI-sponsored postdoctoral fellow, Tanja Bosak (now an assistant professor at MIT), learned the microbial genetics techniques Losick's lab uses and obtained evidence that in the contemporary bacterium, these molecules help to protect its spores from damage by oxygen. (Although many life forms need oxygen, it can also cause a lot of damage.) *Bacillus subtilis*, Losick explains, creates a "particularly macho type of spore, maybe the most sturdy kind of dormant cell on the planet. It can survive extremes of time and temperature and radiation." What might this molecule have been doing two billion years ago? "The exciting implication," Losick replies, "is that these molecules may have appeared as a response to the rise of oxygen in the atmosphere, so the timing of their appearance in the rock record may bear on the issue of when oxygen levels first rose."

"The planet is about 4.5 billion years old," elaborates another of Pearson's collaborators, paleontologist Andrew Knoll, Fisher professor of natural history and professor of earth and planetary sciences. "The oldest rocks we can look at are 3.8 billion years old." Chemical evidence suggests that life was already present then, but certainly "by 3.5 billion years ago there were active microbial communities on the earth's surface." These microbes were a little different from those we know today because there was still no oxygen. (Even today, he says, oxygen is just a "veneer on the surface of the planet. If you put your shovel in the mud of a marsh and dig a centimeter beneath the surface you are down to anaerobic microbial ecosystems, which remain critical for most of the biologically important element cycles on the earth's surface.") By 2.4 billion years ago, the chemistry of sedimentary rocks suggests that there was "at least a little bit of oxygen in the atmosphere and surface ocean." Then, "for a period of about eighteen hundred million years, oxygen levels hovered at maybe a couple of percent of today's levels. Only in the last 600 million years or so do we have environments with enough oxygen to support the biology of large animals, and only in that interval do large animals actually appear," Knoll says. That is also when the algae first become ecologically important, joining and eventually displacing photosynthetic bacteria as the basis of early food chains in the world's oceans. "So there is a time coincidence," he says, "between major events in the history of *life* and major events in the history of the *planet*." Following those threads might also suggest how life could arise, and what it might look like, elsewhere in the universe.

"Everybody is interested in finding the perfect molecule to trace cyanobacteria," Pearson reports, in order to trace the origins of oxygenic primary production (cyanobacteria use a type of photosynthesis that releases oxygen, and this process is responsible for our oxygen-rich atmosphere). More broadly, she hopes to "figure out how to relate the incredible diversity of microbes