leaves large gaps in the available spectrum. So a tunable machine would offer unprecedented possibilities for spectroscopic analysis of chemical structures and reactions in the high ultraviolet range. Indeed, says Ilan Ben-Zvi of Brookhaven National Laboratory, "interest is on the rise everywhere in the scientific community. People see that [tunable] UV and x-ray [lasers] are around the corner and are thinking of new uses for them." In addition to their applications in basic chemistry research, the lasers might be valuable for laser surgery, making holographic images of subcellular structures, and etching extremely fine circuits on miniature computer chips.

Free-electron lasers (FELs) are so versatile because they lack the lasing material of conventional lasers, Madey says. In conventional lasers, energy is pumped into a chemical compound, like carbon dioxide, in such a way that its electrons absorb the energy and subsequently emit it in the form of light. The wavelength of the light emitted depends on the atomic structure of the material used. As a result, a conventional laser is generally limited to emitting just one wavelength of light.

But free the electrons from their atomic structures and it is theoretically possible for them to absorb and emit at almost any wavelength, from the lower infrared to the upper reaches of the UV range. That's the theory behind the FEL, which incorporates a cathode tube to generate a beam of pure electrons. Even so, far ultraviolet lasers have been hard to achieve, because so much energy must be pumped into the electrons to get them to emit such short wavelengths, says James R. Allen, who works with the FEL at the University of California, Santa Barbara. And that's where Madey's accelerator, which he built especially for use with an FEL, comes in.

The Russians had been operating their FEL with a storage ring built in the 1960s, which was not powerful enough to push the FEL beyond the low-to-middle ultraviolet. And in the current economic climate in Russia, says Litvinenko, it is unlikely that the Novosibirsk team would get the funds to develop their own storage ring. Hence the decision to move it to Duke. "Initially, when I came here," says Litvinenko, who has been at Duke since January 1991, "I had in mind that I could bring this [FEL] system [to Duke], but until the recent changes in Russia following the coup attempt, it wasn't possible."

But funding may also be a problem for the Duke group, which has yet to come up with the financing to move the Russian FEL and to support the subsequent research and development of their tunable laser. And on this score Madey is philosophical, saying that whether or not their efforts result in a new laser, the new openness between the Americans and the Russians is certain to provide valuable "intellectual cross-fertilization."

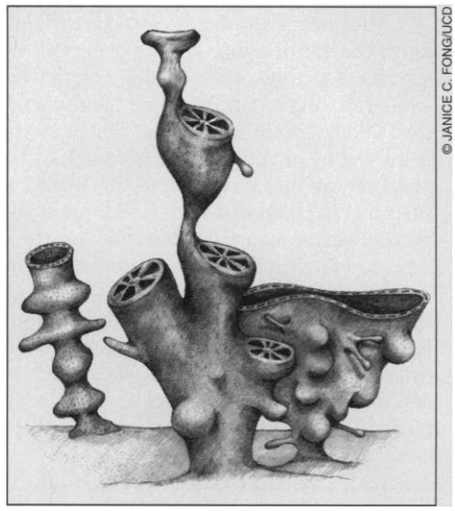
–Michelle Hoffman

PALEONTOLOGY

The Earliest Mass Extinction?

Surprises still turn up in the Cambrian explosion, the wild proliferation of marine life forms during the Cambrian Period beginning roughly 570 million years ago. It was a time when soft-bodied animals as well as those that had just learned how to form shells and exoskeletons seemed to go into an evolutionary frenzy, appearing in shapes both familiar and bizarre. By about 520 million years ago, life in the sea seemed to be on a roll. Then calamity struck, as University of California, Davis, paleobiologist Philip Signor recently reported to colleagues at the North American Paleontological Convention in Chicago. By Signor's reckoning, up to 80% of the existing genera of marine animals disappeared.

That would rank this early Cambrian extinction event, which Signor is the first to propose, with the five generally recognized mass extinctions of the past 600 million years—select company indeed. Each mass extinction marked a watershed in the evolution of life, in which whole groups of flora and fauna fell by the wayside, giving the survivors a chance to reign supreme for 100 million years or more.



Lost in the Cambrian. During a major extinction 520 million years ago, sponge-like archaeocyathans (5 centimeters tall) were major victims.

Signor had not expected to find one of life's turning points as he compiled Cambrian fossil records scattered through the literature; instead he was trying to sort out which life forms coexisted in the early Cambrian. That meant deciding which of four subdivisions of the early Cambrian, called stages, each of 886 genera of marine animals fell into. When he finished, though, he saw a surprising pattern. Although 40% or more of the genera in the first and second stages failed to make it to the next stage—times were hard in the early Cambrian—the losses between the third and fourth stages soared to 80%. That was as sharp an increase over the background rate of extinction as took place in the ocean during the mass extinction 65 million years ago, when the dinosaurs disappeared.

In other respects, too, the early Cambrian crisis was "a fairly typical mass extinction," said Signor. Like many others, it coincided with a drop in sea level. And, as in other cases, creatures that built reefs on the continental shelf—in this case an entire phylum of odd sponge-like organisms called archaeocyathans—lost big. The archaeocyathans never recovered and disappeared before the end of the Cambrian. The drop in sea level may have left the archaeocyathans' habitat high and dry, but Signor isn't speculating what might have wiped out the numerous other groups that vanished at the same time.

Signor's proposed mass extinction has gotten a mixed reception. John Sepkoski of the University of Chicago, who specializes in compiling marine fossil records, agrees that "there's something there," but he worries that Signor may have overstated the magnitude of the extinction event. It may have been sizable but not large enough to fall in the top class of extinctions, he says. Allison "Pete" Palmer of the Cambrian Research Institute in Boulder won't even go that far. "I would view it with skepticism," says Palmer, who works primarily on Cambrian rocks in North America. "I don't think the record is adequate to justify calling it a mass extinction. It's an artifact of how little we know about the [early] Cambrian."

If there was a mass extinction in the early Cambrian, or even a major one, it may well have had an effect on the evolution of life much like that of the mass extinction 65 million years ago. That one cleared the way for mammals to rise to the top of the heap after millions of years as mouse-sized underlings of the dinosaurs. The early Cambrian extinction may have done the same for the primitive arthropods called trilobites, which passed through the extinction event unscathed and went on to dominate the seas for the next 100 million years.

And this particular pruning of the tree of life could have been all the more important, notes Signor, falling as it did so close to its root. It may take one step further the argument made by Stephen Jay Gould of Harvard—that life was reshaped for all time by the loss of the wonderful diversity of beasts evident in the Burgess Shale fossils, dating from later in the Cambrian. If Signor is right, the mayhem began far earlier.

–Richard A. Kerr