Nanosized silver presents an enigma. Silver nanoparticles themselves, because of their size and shape, could be toxic; on the other hand, silver nanoparticles could be toxic because they release silver ions, which are well-known for their antibacterial and other destructive behaviors. New research published in *ES&T* (DOI 10.1021/es8026314) presents evidence that points to both ions and nanoparticles as the source of nanosilver’s toxicity, with nanoparticles furthering the ions’ impacts.

Scientists have grappled with the ion–nanoparticle question over the past few years as nanomaterials—silver and other kinds—have emerged as a topic of environmental concern. Hypothetical mechanisms of action include the direct interference of clumps or particles of nanosilver that settle on the surface of cells, disrupting cell behavior merely by making contact. Or silver particles might also act as a Trojan horse, entering a cell by bypassing its barriers to “normal”-sized silver, and then releasing silver ions that damage cell machinery.

But showing exactly how nanosilver might work in a living system has been problematic. In the new *ES&T* research, scientists from the Swiss Federal Institute of Aquatic Science and Technology (Eawag) seem to have found a way to look at nanosilver’s mechanisms in live algae, which can be a stand-in for many plants.

With a clever experimental scheme, the team used cysteine ligands that bind free silver as a tool to separate the exposure to nanosilver or free ions. The researchers then exposed algae—Chlamydomonas reinhardtii—to silver ions (using silver nitrate as a source), to silver nanoparticles (from 10 to 200 nanometers [nm] in diameter and characterized as mostly at 25 nm), or to both kinds of silver with cysteine present.

In the first hour or so, silver ions from silver nitrate alone inhibited the algae’s photosynthesis about 18 times more than nanosilver did. But after 2 hours, the nanoparticles continued to be even more toxic than the ions alone, the team reports. Adding cysteine to the algal bath removed many of the original silver ions as they interact with algae, says Renata Behra, a coauthor of the research. “Without these [nano]particles, you wouldn’t have as much damage,” Behra says. Exactly where the nanosilver releases ions, the team concludes, remains to be seen and could hinge on as-yet-unknown biological interactions with the algae.

“The fact that they use cysteine to differentiate the nanoparticle response through time is the really novel part,” comments Ron Turco of Purdue University. The chelating tool allowed the researchers to separate the possible mechanisms, he says, from contact with silver ions right away or later on. “What they’re showing is it’s a little bit of both: nanosilver comes in with ions and then bleeds silver ions,” he explains, in what may be a slow-release model of action. Turco adds that the experiments were “well done.”

Geochemist Sam Luoma, formerly of the U.S. Geological Survey and who recently joined the John Muir Institute of the Environment at the University of California Davis, says he interprets the results to show that nanosilver is “delivering ions to the cell membrane more efficiently,” but even the authors are cautious on this point. Luoma would like to see evidence of nanoparticles inside the algae—something the team is working on now, Behra says.

But when it comes to understanding nanosilver, “we’re just beginning,” underscores Luoma, who recently authored the Woodrow Wilson International Center for Scholars’ Project on Emerging Nanotechnologies report, *Silver Nanotechnologies and the Environment: Old Problems or New Challenges?* Luoma says that “baseline risk comes from the amount of silver that’s in the environment—the amount of silver ions. Nanoparticles can then add to that risk,” whether by facilitating ions’ behavior or disrupting cell activity on their own.

---NAOMI LUBICK