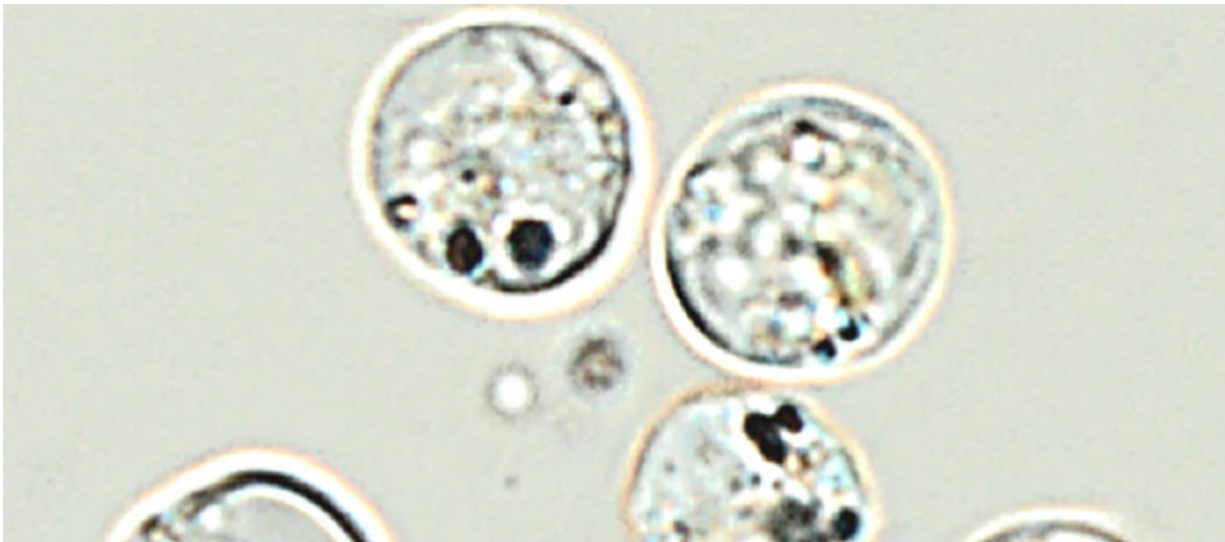


# Phytoplankton disturbed by nanoparticles

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Optical microscopy image of nano-Ag uptake by golden-brown alga *Poterioochromonas malhamensis*. This nanoparticle disrupts the metabolism of algae. Credit: UNIGE/Wei Liu

Products derived from nanotechnology are efficient and highly sought-after, yet their effects on the environment are still poorly understood. A research team from the University of Geneva (UNIGE), working in collaboration with the University of California at Santa Barbara, have investigated the effects of nanosilver, currently used in almost 450 products for its antibacterial properties, on the algae known as *Poterioochromonas malhamensis*. The results—published in the journal *Scientific Reports*—show that nanosilver and its derivative, ionic silver,

disturb the alga's entire metabolism. Its membrane becomes more permeable, the cellular reactive oxygen species increases and photosynthesis is less effective. The Swiss-American team was able to demonstrate for the first time the metabolic perturbations induced by nanosilver following its uptake in the food vacuoles of freshwater algae, paving the way for early detection of the metabolic changes before they express themselves physiologically.

The nanosilver is used for its antibacterial properties and is employed in textiles and cosmetics, inter alia. In addition, the agro-food, biomedical and biopharmaceutical industry is interested in it for developing drugs, devices and pesticides. "Since nanosilver is designed to destroy, repel or render harmless noxious organisms such as bacteria, scientists have realized that it might also be harmful to organisms that are crucial to our environment," says Vera Slaveykova from the Department F.A. Forel for Environmental and Aquatic Sciences in UNIGE's Faculty of Sciences. To assess the influence of nanotechnology products on phytoplankton and to evaluate the impacts on [aquatic environment](#), the researcher team conducted a study on the alga *Poteroiochromonas malhamensis* as a model phytoplankton species. "The phytoplankton are everywhere, in lakes and oceans," continues Professor Slaveykova. "As a whole, phytoplankton generate almost half of the oxygen we breathe. And they have a second essential role, since they are at the base of the food chain. If they accumulate nanoparticles, these will be integrated into the aquatic food chain."

## **Multiple disturbances**

The study led by Professor Slaveykova shows that treating the algae with nanosilver disrupts the metabolism of the amino acids that are vital for producing cellular proteins, the nucleotide metabolism that is important for genes, and fatty and tricarboxylic acids making up the membranes, as well as the photosynthesis and photorespiration elements.

The study results suggest that the silver ions released by the silver nanoparticles are the main toxicity factor. "The nanosilver is internalized in the algal cells by the phagocytotic mechanism used to supply cells with organic matter," continues Professor Slaveykova. The study is the first to demonstrate that nanoparticles can follow such internalization path in a species of phytoplankton. "These measurements were carried out in Geneva by Dr. Liu using transmission electron microscopy. This entry mechanism is only known in *Poteroiochromonas malhamensis*; it is still unknown if other phytoplankton species express it," explains the Geneva researcher.

To finish demonstrating [nanosilver](#)'s toxicity, the international research team highlighted the fact that metabolic disturbances induce physiological dysfunctions. Professor Slaveykova observed [lipid peroxidation](#) leading to membrane permeabilization, increased oxidative stress and less efficient photosynthesis—and, it follows, reduced oxygen production.

## **An Approach That Needs to Be Implemented**

The study underlines the full potential of metabolomics geared towards the molecular basis of the disruptions observed. "It's a fundamental contribution to the field: although the metabolomics approaches are properly in place in medical and pharmaceutical sciences, it's not at all the case for environmental toxicology where [phytoplankton](#) metabolomics is still in its infancy. The metabolomics is, therefore, a technique that offers the possibility of early detection of changes induced by a toxin, upstream of more global effects such as the alga growth inhibition and their impact on oxygen production. As it's never easy to demonstrate the relationships between cause and effect in complex environment, it is now essential to use approaches like these."

**More information:** Wei Liu et al, Metabolomics for early detection of

stress in freshwater alga *Poteroiochromonas malhamensis* exposed to silver nanoparticles, *Scientific Reports* (2020). [DOI: 10.1038/s41598-020-77521-0](https://doi.org/10.1038/s41598-020-77521-0)

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