Iowa State scientists demonstrate first use of nanotechnology to enter plant cells

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[摘要] 16-May-2007, AMES, Iowa -- A team of Iowa State University plant scientists and materials chemists have successfully used nanotechnology to penetrate plant cell walls and simultaneously deliver a gene and a chemical that triggers its expression with controlled precision. Their breakthrough brings nanotechnology to plant biology and agricultural biotechnology, creating a powerful new tool for targeted delivery into plant cells.
[关键词] plant cells;agricultural biotechnology;plant biology

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A team of Iowa State University plant scientists and materials chemists have successfully used nanotechnology to penetrate plant cell walls and simultaneously deliver a gene and a chemical that triggers its expression with controlled precision. Their breakthrough brings nanotechnology to plant biology and agricultural biotechnology, creating a powerful new tool for targeted delivery into plant cells.

The research, "Mesoporous Silica Nanoparticles Deliver DNA and Chemicals into Plants," is a highlighted article in the May issue of Nature Nanotechnology. The scientists are Kan Wang, professor of agronomy and director of the Center for Plant Transformation, Plant Sciences Institute; Victor Lin, professor of chemistry and senior scientist, U.S. Department of Energy's Ames Laboratory; Brian Trewyn, -doctoral scientist in the Center for Plant Transformation and now a scientist with Biogemma, Clermond-Ferrand, France.

Currently, scientists can successfully introduce a gene into a plant cell. In a separate process, chemicals are used to activate the gene's function. The process is imprecise and the chemicals could be toxic to the plant.

"With the mesoporous nanoparticles, we can deliver two biogenic species at the same time," Wang said. "We can bring in a gene and induce it in a controlled manner at the same time and at the same location. That's never been done before."

The controlled release will improve the ability to study gene function in plants. And in the future, scientists could use the new technology to deliver imaging agents or chemicals inside cell walls. This would provide plant biologists with a window into intracellular events.

The Iowa State team, which has been working on the research in plants for less than three years, started with an Iowa State University proprietary technology developed previously by Lin's research group. It is a porous, silica nanoparticle system. Spherical in shape, the particles have arrays of independent porous channels. The channels form a honeycomb -like structure that can be filled with chemicals or molecules.

"One gram of this kind of material can have a total surface area of a football field, making it possible to carry a large payload," Trewyn said.

Lin's nanoparticle has a unique "capping" strategy that seals the chemical goods inside. In previous studies, his group successfully demonstrated that the caps can be chemically activated to pop open and release the cargo inside of animal cells. This unique feature provides total control for timing the delivery

The team's first attempt to use the porous silica nanoparticle to deliver DNA through the rigid wall of the plant cell was unsuccessful. The technology had worked more readily in animals cells because they don't have walls. The nanoparticles can enter animal cells through a process called endocytosis - the cell swallows or engulfs a molecule that is outside of it. The biologists attempted to mimic that process by removing the wall of the plant cell (called making protoplasts), forcing it to behave like an animal cell and swallow the nanoparticle. It didn't work.

They decided instead to modify the surface of the particle with a chemical coating.

"The team found a chemical we could use that made the nanoparticle look yummy to the plant cells so they would swallow the particles," Torney said.

It worked. The nanoparticles were swallowed by the plant protoplasts, which are a type of spherical plant cells without cell walls.

Most plant transformation, however, occurs with the use of a gene gun, not through endocytosis. In order to use the gene gun to introduce the nanoparticles to walled plant cells, the chemists made another clever modification on the particle surface. They synthesized even smaller gold particles to cap the nanoparticles. These "golden gates" not only prevented chemical leakage, but also added weight to t

The biologists successfully used the technology to introduce DNA and chemicals to Arabidopsis, tobacco and corn plants.

"The most tremendous advantage is that you can deliver several things into a plant cell at the same time and release them whenever you want," Torney said.

"Until now, you were at nature's mercy when you delivered a gene into a cell," Lin said. "There's been no precise control as to whether the cells will actually incorporate the gene and express the consequent protein. With this technology, we may be able to control the whole sequence in the future."

And once you get inside the plant cell wall, it opens up "whole new possibilities," Wang said.

"We really don't know what's going on inside the cell. We're on the outside looking in. This gets us inside where we can study the biology per se," Wang said.

The interdisciplinary research collaboration was funded and facilitated by Iowa State's Plant Sciences Institute. The institute sponsors Wang's work to develop a male -sterile, biopharmaceutical corn - the corn contains a therapeutic protein but does not produce pollen. The materials development and synthesis of the nanoparticles in Lin's laboratory was funded by the energy department and the National Science Foundation. Wang and Lin intend to continue their collaboration to further develop the technology and its applications in plants.

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