Plastic plants may become plastics plants

For years, agricultural scientists have dreamed of sowing polyester as they do cotton. They've envisioned biological polyesters from transgenic plants providing a cheap, sustainable alternative to petrochemical plastics.

Early experiments produced plants that made plastics, but their properties couldn't rival those of polystyrene, polyethylene, and other traditional plastics. A crop of plants reported in the October NATURE BIOTECHNOLOGY, however, makes a polymer that's up to many of the roles that conventional plastics now fill.

"Before, it wasn't clear you could make a useful plastic in plants," says biochemist Kenneth J. Gruys of Monsanto Co. in St. Louis, which created the new plants.

While litter from petroleum products can persist for centuries, the plant plastic degrades rapidly to carbon dioxide and water. The plants make small amounts of plastic, though, and scientists see obstacles to molding them into cost-effective crops.

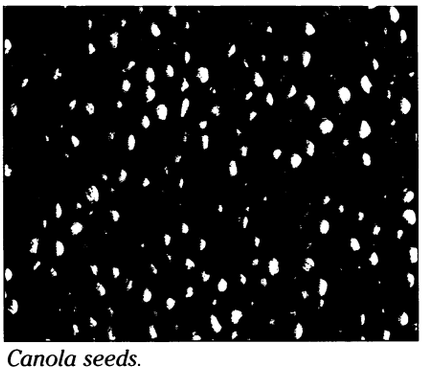
The biopolymer that the plants produce is not new. Synthesized by certain bacteria, which use it as a food store, the material has been made by bacterial fermentation and sold as Biopol by a succession of biotech companies. They've sold Biopol to be fashioned into golf tees, disposable razors, shampoo bottles, plastic cups, and credit cards in the United States, Europe, and Japan.

Bacterial synthesis of Biopol proved too costly, however, to lure many customers away from petrochemical plastics, says Steve Goodwin, president-elect of the Bio/Environmentally Degradable Polymer Society and a microbiologist at the University of Massachusetts at Amherst.

Before its current patent holder, Monsanto, stopped making Biopol last year, a team of its scientists began working to grow the polymer in plants. Because plants thrive in open air on just carbon monoxide and sunlight, they reasoned, plant plastic could be dirt cheap.

The plants that Monsanto scientists engineered represent about the most sophisticated transgenic strategy anyone has ever gotten to work, says Peggy G. Lemaux, a plant scientist at the University of California, Berkeley. They created two new biosynthetic pathways—in effect transplanting four enzymes from bacteria and making new use of one of the plants' native enzymes, the pyruvate dehydrogenase complex, or PDC. The researchers made the modifications to *Arabidopsis*, a favorite plant of laboratory scientists, and canola, a crop plant grown for the oil in its seeds. Both grew well with the modifications.

The amount of Biopol they made, however, was low: 3 percent of the dry weight of the *Arabidopsis* and 1.5 percent of the canola. A yield of 15 percent would be necessary to make the plants commercially viable, the Monsanto team says.



Canola Council of Canada

Canola seeds.

Such a yield will be hard to achieve, the team concludes. The native PDC makes Biopol's two building blocks in unequal amounts. So, the more plastic the plants make, the farther its composition strays from that of Biopol.

Calling plant biochemistry intricate and mostly unexplored, Lemaux says she's not surprised by the study's limited success. "This shows the power of biotech, but it also shows its weaknesses," she says.

Although the results have prompted Monsanto to discontinue its Biopol research, they're not considered a dead end. Tinkering with a plant's PDC, for example, could make the Monsanto strategy workable, says Lemaux. According to Simon F. Williams, vice president of Metabolix in Cambridge, Mass., his company plans to pick up where Monsanto left off. *—O. Baker*

Zip Code plan for proteins wins Nobel

Don't forget the Zip Code! That's a rule fixed in the minds of most people because they know their mail probably won't be delivered without this number.

The realization that the billion or so proteins within a cell bear molecular Zip Codes that direct them to appropriate destinations has won German-born cell biologist Günter Blobel this year's Nobel Prize in Physiology or Medicine.

Besides revealing a fundamental method by which cells organize themselves and carry out functions, Blobel's work has helped explain several rare diseases in which proteins travel to the wrong location. In their efforts to engineer plants and bacteria to synthesize drugs or other proteins, biotech companies have also made use of the molecular zip codes within proteins.

Blobel, a Howard Hughes Medical Institute investigator at Rockefeller University in New York, made his Nobel-winning discoveries in the 1970s. The original observation occurred when he was examining protein synthesis and the role of a ribbonlike compartment within the cell known as the endoplasmic reticulum.

This structure serves as a processing station for many proteins under construction, modifying the molecules before sending them elsewhere in the cell or placing them into the secretory pathway that will release them. Blobel noticed that a protein that normally moves through the endoplasmic reticulum was slightly bigger when it was made without the aid of that compartment.

From that observation, he speculated that extra amino acids on the larger protein act as a signal, subsequently removed, that direct it into the compartment. A series of experiments confirmed that premise and revealed a transport molecule that ferries proteins bearing the signal to the endoplasmic reticulum.

Inspired by those findings, Blobel developed his signal hypothesis, which holds that all newly minted proteins contain an amino acid string that determines their eventual home. Blobel and other scientists have since identified many such signals, including ones that guide proteins to mitochondria, the nucleus, and other locations.

"It's one of the early hypotheses in cell biology that really stood the test of time with very few modifications. It was visionary," says Danny J. Schnell of Rutgers University in Newark, N.J., who studied protein trafficking under Blobel.

Investigators are still trying to comprehend how cells use a protein's Zip Code to distribute the molecule. Schnell compares the uncertainty to knowing that envelopes must bear a zip code but not understanding how the postal service picks up, sorts, and delivers the mail.

Misplacing a protein is more serious than losing a letter, however. "There are diseases where proteins are mistargeted in cells," says Tom A. Rapoport of Harvard Medical School in Boston, who investigates how proteins directed to the endoplasmic reticulum cross its membrane.

In one condition characterized by frequent kidney stones, for example, mutations in the Zip Code cause a protein normally destined for a cell compartment called a peroxisome to end up in mitochondria. In another rare illness, cells mistakenly secrete enzymes instead of storing them in sacs called lysosomes.

So far, Blobel's work has not led to ways to correct such misplacements, but scientists have attached secretory Zip Codes to proteins that they plan to produce in yeast, bacteria, or plants. With this strategy, the researchers can engineer the cells to secrete valuable drugs or enzymes. *—J. Travis*

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