Green genes blasted into chloroplasts

After years of failed efforts, scientists working with flowering plants have inserted foreign genes into chloroplasts — the tiny, chlorophyll-packed sacs that green plants use to convert sunlight into usable energy. Researchers say the newfound ability to genetically manipulate these solar-powered substations opens the door to a host of improvements in crops.

"It's a big hurdle, a very significant step forward," says Wilhelm Gruissem, a botanist at the University of California, Berkeley. "Many people are going to want to use this technique."

Most plant genes reside within the cell nucleus, but a few genes critical for photosynthesis remain cloistered in the 100 to 300 chloroplasts scattered through the rest of the cell. Molecular biologists have become reasonably adept at inserting and deleting nuclear genes, and in 1988 scientists succeeded in altering the genetic sequence of chloroplasts in primitive algae bearing only one chloroplast per cell. But until now, nobody had genetically altered the more complex chloroplasts in higher plants.

The new work, described in the November PROCEEDINGS OF THE NATIONAL ACADEMY OF SCIENCES (Vol.87, No.21), was performed by Zora Svab, Peter Hajdukiewicz and Pal Maliga of Rutgers University in Piscataway, N.J. Working with tobacco seedlings grown in culture plates, the team sought to insert two new genes into the chloroplasts. These genes enable plant cells to resist antibiotics that would otherwise inhibit photosynthesis.

The researchers blasted the seedlings with tiny tungsten pellets coated with multiple copies of the antibiotic-resistance genes. When grown on a special growth medium containing antibiotics, most of the seedlings turned white, indicating that they had not incorporated the resistance genes and that their photosynthetic machinery had succumbed to the drugs. But a few plants grew green, and DNA tests confirmed that their chloroplasts included the protective genes. The progeny of those plants inherited the new genes.

The insertion technique remains somewhat inefficient. One gene gets incorporated with every 50 blasts — only 1 percent the success rate routinely achieved with nuclear genes. But Maliga and others expect refinements of the method to yield a cornucopia of agricultural applications. By altering the blueprints for genes involved in photosynthesis, "we may make crop plants more efficient under environmental conditions like drought or low temperatures, which adversely affect photosynthetic reactions," he says.

Seedlings with ordinary chloroplasts appear white when grown in antibiotic-laden culture. Seedlings with chloroplasts engineered to contain genes for antibiotic resistance appear green. Variegated leaves (right) contain both gene-altered and ordinary chloroplasts.

Moreover, since chloroplast DNA never gets incorporated into pollen grains, Maliga suggests the technique could help ensure that newly inserted plant genes — such as those that make crops resistant to herbicides — don't get passed to surrounding weeds. "If you want to put a new gene in a plant, the chloroplast is a good target," he says. "It's an isolated compartment that's generating lots of energy."

Maliga envisions scientists someday blasting chloroplasts with genes that direct nitrogen fixation, reducing the need for fertilizers by allowing plants to derive nutrients directly from atmospheric nitrogen. "Right now that's science fiction," he concedes. But as evidenced by the little green leaves in his culture plates, "the chloroplast has now become a realistic target for gene manipulation."

— R. Weiss

Hubble still shaking despite software 'fix'

During each 96-minute trip around Earth, the Hubble Space Telescope suffers two bouts of uncontrolled jiggling. To compensate for these unsettling episodes — which last for about 6 minutes each and thus encompass one-eighth of the telescope's potential viewing time — engineers radioed up a package of new computer instructions on Oct. 15. But the software failed to steady the craft, and engineers deactivated the package two days later.

The jitters result mainly from oscillations of Hubble's electricity-providing solar panels. Each time the panels move between sunlight and darkness, their thermal expansion or contraction initiates a "solar twang," explains astronomer H. John Wood of NASA's Goddard Space Flight Center in Greenbelt, Md.

The telescope's other technical setback — a misshapen primary mirror — creates focusing problems that lead to fuzzy images (SN: 7/7/90, p.4). The jitters, however, interfere primarily with Hubble's ability to track guide stars — extraterrestrial "signposts" that help orient the telescope for observations. At times, the guide-star images jitter about so rapidly that the telescope loses sight of them.

Engineers at Lockheed Missiles and Space Co. in Sunnyvale, Calif., the telescope's principal builder, spent months working on a remedial computer program with colleagues at NASA's Marshall Space Flight Center in Huntsville, Ala. (SN: 7/14/90, p.21). When the "software patch" didn't dampen the vibrations, they headed back to the drawing board.

The problem is that Hubble oscillates on several different frequencies — primarily at 0.1 hertz but also at others between about 0.4 and 0.8 hertz. Ironically, when the remedial software performed its designated task of quelling the 0.1-hertz jitter, it also made the guidance system overly sensitive to the higher-frequency oscillations, says David J. Pine of NASA headquarters in Washington, D.C. And so, Pine says, "we have returned to the old software."

Hubble jiggles not only when its solar panels change temperature, but also on some occasions when its two tape recorders go on or off, or when researchers rotate the carousels that place different filters or prism-like diffraction gratings in front of various instruments. Moreover, the craft twitches slightly when a telescoping strut on a solar-panel mount sticks briefly and then releases, says Gerald S. Nurre, chief of the pointing-control systems branch at the Marshall center. The European Space Agency, which developed the solar panels, is considering using stick-resistant materials or lubricants in the new mounts for the replacement panels scheduled for installation in June 1993.

NASA officials now plan a "dynamics test" in which engineers will give the telescope's position-holding "reaction wheels" a precisely specified nudge and then measure the jitter response, Nurre says. The results should help researchers design a new software correction (or an adjustment to the previous one) to radio up to Hubble around Jan. 1. *— J. Eberhart*