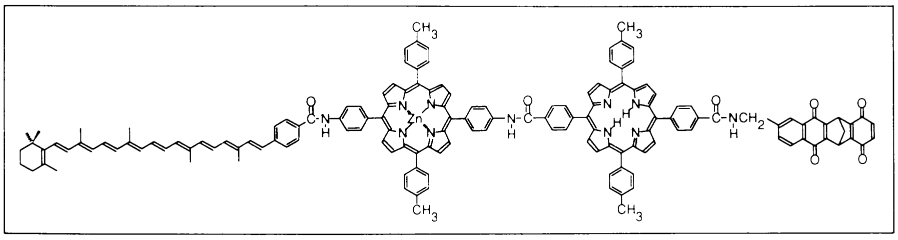
Lab-made molecule taps light's energy



Gust et al.

Starting on the left, the pentad comprises a zigzagging carotenoid polyene, a zinc-centered porphyrin, a hydrogen-centered porphyrin and a bridged pair of quinones.

Thanks to photosynthesis, a planetful of life eats and breathes. For decades, scientists have been unraveling the chemistry and physics woven into this biochemical *tour de force.* Some use the findings as a guide for making synthetic molecules that harvest sunlight in much the same way as the photosynthetic machinery of plants and bacteria.

In the latest step toward artificial photosynthesis, chemists at Arizona State University in Tempe have assembled a five-component molecular machine, or pentad, that harvests light energy and uses it to segregate positive and negative charges on opposite ends of the pentad.

In natural photosynthesis, ensembles of proteins and smaller molecules pull off a similar feat, but then tap the potential energy associated with the separated charges to drive chemical reactions that produce such crucial items as carbohydrates and oxygen.

The 12 chemists, led by Devens Gust and Thomas A. Moore, describe their work in the April 13 SCIENCE.

Gust says his group is already using the pentads to study natural photosynthesis. In the future, they hope to use molecules like these for such applications as harvesting solar energy, driving chemical reactions, making fuels and building molecule-scale electronic devices, he adds.

To make the pentads, the researchers use chemical components similar to ones found in plants and photosynthetic bacteria. Two chlorophyll-like porphyrin molecules, one with a zinc atom in its center, form the light-harvesting antennae of the pentad. A bridged pair of electron-hungry quinone molecules flanks these on the right. A long, zigzagging molecule containing a series of alternating single and double bonds — known technically as a carotenoid polyene — flanks on the left and accepts a positive charge. Like the quinones, these polyenes have counterparts in natural photosynthesis molecules.

"This whole thing works because of a multistep electron transfer strategy," Gust says. Initially, the zinc-centered porphyrin absorbs light energy and concentrates it into one of its electrons, which in turn dumps its energy to an electron in the adjacent hydrogen-centered porphyrin. Then, in a series of lightning-fast steps, the electronic energy transforms into a positive charge, which zips to the pentad's polyene end, and a negative charge, which zaps to the rightmost quinone.

"You want to get the charges as far apart as you can as quickly as you can," Gust says. Otherwise, the charges recombine, surrendering their potential for driving chemical reactions. The charge-separated pentads store more than half the original light energy, the chemists report.

"What you have is an energy source, and you could power virtually anything with it," Gust told SCIENCE NEWS.

"It's time to start trying to use these things [pentads and related molecules] to drive reactions," adds chemist Michael R. Wasielewski of Argonne (Ill.) National Laboratory. Wasielewski assembles molecular triads that also mimic initial steps of photosynthesis. — *I. Amato*

Home-wrecking beetle: Who'll pay the piper?

Donald Feener/University of Utah

Inside the petiole of a Costa Rican piper tree, a beetle larva (left) that has already killed several adult ants munches on an ant larva. Round, white "food bodies" line the petiole.

It's a match made in ant-plant heaven: What one partner lacks, the other provides. But when an unwelcome houseguest arrives, the relationship falls apart.

The drama unfolds in Costa Rican tropical forests, where *Pheidole bicornis,* a species of brown ant, makes its home inside young piper trees, also known as piper ant-plants. Entering through the petioles — hollow chambers connecting leaves to stems — the ants bore tunnels through the tree without harming it. At mealtime they feast on white, swollen "food bodies" — nutrient-packed cells specially produced by the petioles while the ants are in residence. In turn, the ants protect the piper tree from predators, casting off or devouring the eggs and larvae of opportunistic insects that attach to the leaves or stems.

But sometimes a group of beetle larvae horns in on the ants' turf, infiltrating the piper and rapidly destroying the symbiosis between ant and plant. When *Phyllobaenus* larvae worm their way into the petioles, they wedge their soft bodies in protective crevices, snacking on ant larvae and using their tough, jaw-like mandibles to crack the heads of the adult ants. Though the intruders damage leaves and offer no protection against other predators, they nevertheless manage to keep the piper producing the same swollen food bodies long after the ant colony's demise.

Parasites that upset or destroy a symbiotic relationship are not uncommon among plants and insects. Consider, for instance, the ability of nectarless flowers to lure bees away from other plants by mimicking the coloration of nectar-producing blossoms. Similarly, the viceroy butterfly mimics the colors of its inedible relative, the monarch butterfly, to fool predators.

But the beetle differs from these and other symbiosis-meddlers in that it manages to freeload without imitating the color or shape of its rival, asserts ecologist Deborah K. Letourneau of the University of California, Santa Cruz. "No one knows how the ant or the beetle triggers [food] production," she says. But Letourneau suspects the beetle larvae use a chemical trigger, possibly similar to one the ants may use, to trick the piper into manufacturing more food.

Letourneau found that even ant-free piper trees produce food bodies when the beetles invade — another indication the beetles have cracked the ants' food code and usurped it for their own purposes, she reports in the April 13 SCIENCE. In addition, Letourneau told SCIENCE NEWS she has recently identified a related species of *Phyllobaenus* that infiltrates Costa Rican piper trees with similar success.

Understanding the mechanism behind the beetle's behavior might alter the way scientists view other parasites that sever symbiotic relationships, she suggests. "Every time we think we have understood a system, nature suggests we must have overlooked something. The interactions [in other systems] may be more complex than we think," she says. But to this conjecture she adds: "I can't tell for sure. I've been too engrossed in this project for the past 10 years." — *R. Cowen*