AAAS MEETING
GENETICS

Becoming a Symbiont Is in the Genes

Some couples enjoy a harmonious intimacy that many people can only dream of. Such is the alliance between certain bacteria and plants, in which each partner provides an essential gift, with the microbes nestled comfortably within the plant. At the meeting, molecular biologist Sharon Long of Stanford University described several new genes that may play key roles in a bacterium's transition from independence to symbiosis. Although the lessons offered by these cross-kingdom pairs are unlikely to enhance human relationships, they may someday open the door to improved crop production.

After infecting legumes, *Rhizobia* fix nitrogen by grabbing the gas from pockets of air in the soil and converting it into ammonia, which the hosts use to make protein. In return, the plant provides the bacteria with nutrients and private quarters in root nodules. Researchers know how legumes and *Rhizobia* first catch each other's attention, but the pas de deux after the sparks fly and before the microbes have settled into their new home remains largely a mystery. Long's team is catching the first glimpses of this courtship's middle stages. "We're looking at a step that's largely unknown, and we may uncover unanticipated things that will help us understand what makes symbiosis succeed or fail," she says.

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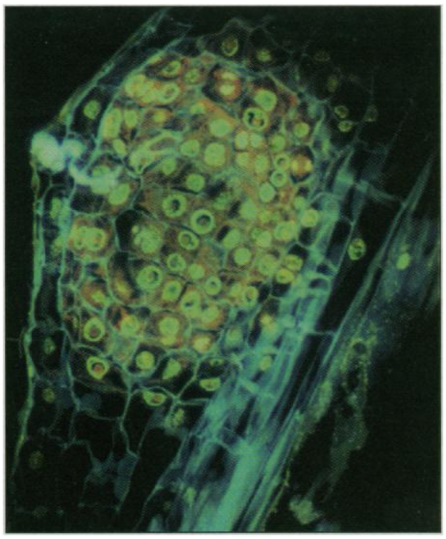
This collection of stories captures the breadth of science, from new genes involved in symbiosis to insights into monogamy, featured at the American Association for the Advancement of Science Annual Meeting in Anaheim, California, 21 to 26 January.

To figure out what molecules are involved, Valerie Oke, a postdoctoral fellow in Long's lab, set out to look for bacterial genes that turn on at some time in the interval after a bacterium latches onto the tip of a root hair and before it starts fixing nitrogen. Already, Oke has uncovered several surprises. One gene encodes a protein that resembles fasciclin I, which in insects glues nerve cells together and guides them during embryonic growth. The researchers don't know how the bacteria use this protein, but they have shown that plants infected with rhizobial strains lacking the gene fix nitrogen inefficiently. Further evidence that the gene plays a role in symbiosis comes from Daniel Gage, a microbiologist now at the University of Connecticut, Storrs, who independently isolated it when he was a postdoc in the Long lab during a search for proteins that *Rhizobia* secrete when infecting host plants.

Another of the genes Oke identified appears to produce a protein similar to ones that disarm destructive oxygen molecules in a variety of organisms. This suggests that the bacteria encounter such harmful molecules after infecting the plant, says Long, which hints that the legumes might at first consider *Rhizobia* enemies. The presence of the gene, she says, raises questions about where to draw the line between pathogen and symbiont. On the other hand, she says it's equally plausible that the plants are not mounting a defensive response, and that the gene's presence may simply reveal "something basic about plant physiology."

"I'm very impressed and excited by this new work," says R. James Cook, a plant pathologist at Washington State University in Pullman. Exposing the intimate details of the plant-bacteria relationship could help researchers such as Cook find ways to improve the efficiency of nitrogen-fixing bacteria and even transfer some of their abilities to other species. For instance, strains of *Pseudomonas* and *Bacillus* make antibiotics that help protect plants from root infections, but these bacteria live "casually" in the vicinity of the plants, says Cook, and thus are at the mercy of fluctuations in soil conditions and other environmental whims. *Rhizobia*, meanwhile, have a safe haven. "I don't know if these genes are what we're waiting for," he says, "but it would be exciting to find out if they can enhance the ability of these antibiotic-producing bacteria to associate with roots."

In another fantasy, scientists would figure out how to introduce nitrogen-fixing bacteria into crops that aren't cozy with helpful microbes, such as wheat and corn. This arrangement could make it possible to grow those plants in nitrogen-poor soil without fertilizer—a boon to farmers. Such a project would require more detailed information about the genetic contributions to the symbiotic relationship from both plants and bacteria. Long says she's pessimistic that the endeavor will succeed anytime soon, but "we're gathering the tools to test the idea. I wouldn't have said that 2 years ago." Even if scientists can't figure out how to spark romance between every crop and nitrogen-fixing bacterium, they seem to be well on their way to figuring out what makes certain plant-microbe pairs click. –EVELYN STRAUSS



Warpath. Gene finds shed light on how nitrogen-fixing bacteria (whitish blue) invade a root nodule (green-orange).

CREDIT: MARK DUDLEY AND SHARON LONG

AAAS MEETING
LINGUISTICS

Grammar's Secret Skeleton

It's been more than 3 decades since scientist-dissident Noam Chomsky hit his colleagues with a controversial theory: that babies learn how to speak so easily because they're born with a sense of grammar that transcends individual languages. Chomsky, a linguist at the Massachusetts Institute of Technology (MIT), challenged researchers to find simple rules that govern all languages, from Arabic to Zulu. Now some linguists claim to have at last uncovered key elements of this universal grammar—and their findings, presented at the meeting, are rekindling a debate over whether grammar is innate.

Guglielmo Cinque got the fireworks started at a packed symposium with his description of common grammar elements spanning dozens of cultures. Cinque, a linguist at the University of Venice in Italy, recalls being struck several years ago by how certain adverbs—"always" and "completely," for example—appear in the same order in a sentence in languages as disparate as Italian, Bosnian, and Chinese. Looking more closely, Cinque realized the same was true for auxiliary verbs, particles, and other parts of speech.

He and his students then set out on a linguistic odyssey, surveying word order and meaning in some 500 languages and dialects. After more than 4 years of sifting through grammatical analyses and querying native speakers, the researchers found that every language consists of sentences based on a verb phrase surrounded by modifiers in predictable patterns. Because this core structure does not vary, Cinque concludes that "our human species imposes these rules on language as part of our genetic endowment." Cinque, who lays out his argument in a new book, *Adverbs and Functional Heads: A Cross-Linguistic Approach* (Oxford University