Biotechnology Reaches Beyond the High-Tech West

A common criticism of modern biotechnology is that it has produced products only for the rich—at about $4,500 per dose (current market price of tissue plasminogen activator), a genetically engineered bloodclot buster won't save many lives in the developing world. But proponents of the new biotech industry told an audience at last week's AAAS annual meeting that such criticisms are no longer valid: The fruits of biotechnology, especially in agriculture, are increasingly finding their way into impoverished areas of the world. "The progress in using agricultural biotechnology in developing countries has been remarkable," says Robert Fraley of Monsanto, who spoke with *Science* after his presentation in Chicago. And Fraley predicts that insect- and disease-resistant rice, as well as several entirely new crops, could be commercially introduced into some developing nations "by the middle to end of this decade."

If so, one of the keys to success will have been the mapping of genomes of economically important species. With a genetic map in hand, plant and animal breeders can learn in days or weeks, instead of months or years, whether a genetic cross produced a desired trait.

ROGER N. BEACHY

Improved roots. *Cassava* (above) *is just one of the crops helped by biotechnology.*

James Womack, an animal scientist at Texas A&M University in College Station—and another speaker—is putting this kind of selection into practice. Together with researchers at the Commonwealth Scientific and Industrial Research Organization Laboratories in Australia, the International Laboratory for Research on Animal Diseases in Nairobi, Kenya, and the International Trypanosome Tolerance Center in The Gambia, he is probing the genome of African N'Dama cattle. Compared with Western cattle, the N'Dama is a bovine runt, producing only a small fraction of the milk and meat of Holsteins and Herefords. However, N'Damas are resistant to the lethal parasitic disease trypanosomiasis, endemic to much of western Africa. Womack expects to have a genetic map of N'Dama by 1996. With that in hand, Womack says, he can examine newborn calves for the presence of the gene for trypanosome tolerance and only continue breeding those that have evidence of it. This way, he expects the 6 to 8 years normally needed to breed more productive N'Damas can be cut in half.

Success stories are cropping up for plants, too. About 5 years ago, researchers discovered that expressing the coat protein gene of a virus in a genetically transformed plant protected that plant against viral disease. In the United States, genes for viral coat proteins have been successfully inserted into tomato, alfalfa, tobacco, and melons. Now, Mexican researcher Louis Herrera-Estrella, working with the Rockefeller Foundation and Monsanto, is using this general strategy to genetically engineer viral resistance into potatoes, and Kenyan researcher Florence Wambugu, working with the U.S. Agency for International Development, is using the same technique to incorporate viral resistance into sweet potatoes, yams, and cassava, a starchy root crop that is a food staple in the tropics.

Another promising strategy for protecting valuable crops against losses is to genetically engineer them to express the *Bacillus thuringiensis* toxin, a biocontrol for select predatory caterpillar insects. Cotton growers in Mexico, India, Egypt, and some of the republics of the former Soviet Union are planning field trials of cotton seed that has been transformed to express the *Bacillus thuringiensis* toxin.

Agricultural biotechnology may have had its roots in the wealthy, industrialized nations of the world, but Fraley predicts that by the middle of this decade farms in the developing world will also be benefiting from products developed by recombinant DNA technology.

■ ANNE S. MOFFAT

Do Parasites Reproduce by Clone Alone?

For years, scientists have been designing vaccines and drugs to fight protozoan parasites without taking into account the actual genetic variability of these deadly organisms. Now two biologists have shown that parasites can make clones of themselves—without mating. The bad news is that there are lots of different clones, making the job of finding effective therapies much harder than anyone thought.

French population geneticist Michel Tibayrenc stumbled onto this unfortunate truth while he was in Latin America, studying *Trypanosoma cruzi*. That's the protozoan parasite that causes Chagas' disease, a common and often fatal illness in the region. *T. cruzi* literally strikes at the heart of its human or animal host, weakening its cardiac muscles. Early studies of the culprit's enzymes indicated that different strains were extremely varied genetically. But when Tibayrenc, of the French Institute for Cooperative Development in Montpellier, France, and his collaborator, University of California at Irvine evolutionary biologist Francisco Ayala, took a closer look at certain DNA markers, they decided that the variation in the different strains was far too large to be the result of mating between organisms sharing the same gene pool. They also saw signs that the parasites seemed to be inheriting most of their genes from just one parent—instead of two. And that's when the two scientists came to what, for many, would seem a counterintuitive notion: The parasites got their uniqueness by reproducing clonally!

Yes, clonal reproduction implies perfect copies of one organism—with no chance for a second parent to insert its genes and add variation. That is true, but the fact is that if there were several different strains of a parasite living millions of years ago, they could give rise to genetically distinct lineages, each making copies of itself in isolation and evolv-

ing its own set of characteristics. There is so much variation in *T. cruzi* today that different lineages must have been isolated from each other for 40 million to 50 million years. That means, says Ayala, that "these lineages are as different from one another as we are from whales."

Not surprisingly, these barely related creatures could differ dramatically in their ability to cause disease and resist drugs—something the two scientists have been testing on animal models in their laboratory. Indeed, *T. cruzi* isn't the only parasite skipping out on sex and causing havoc as a result. Tibayrenc and Ayala last week reported at the AAAS meeting that they have found a wide range of protozoan parasites that can reproduce clonally—including parasites that cause sleeping sickness, Leishmaniasis, amoebic dysentery, Giardia, and, probably, toxoplasmosis. Although these organisms may reproduce clonally most of the time, many also have sex on occasion—prompting Tibayrenc to say they have a "nearly clonal" population structure.

These findings should shake up the medical treatment of these diseases: Vaccines and drugs against parasitic protozoa may be ailing because they do not adequately take into account their genetic diversity. "Generally people studying and testing new drugs use one strain of a species, which is not representative of the actual genetic variability," says Tibayrenc, who adds that it is not uncommon for a patient to be infested with more than one strain of a parasite at once.

Or, how about 100 strains? *T. cruzi* has turned out to be a doctor's worst nightmare, partly because researchers have now identified more than 100 genetically distinct strains of the parasite, which is a major health problem in Latin America, where it has struck 90 million people. The parasite is spread by the ubiquitous blood-sucking bugs of the subfamily *Triatominae*, also known as the kissing bug.

While the prospects are grim for designing one vaccine that prevents infestation from so many different strains of the parasite, there is some hope for the victims of the disease. There appear to be four major strains that predominate, giving vaccinologists a reasonable target at which to aim their research. And it should help researchers to know the true nature of the beast they are fighting, even though it could be far more difficult to control than they first believed. Says Ayala: "It's as though lions and tigers are killing people but we're setting traps for mice." ■ ANN GIBBONS

A High Five From the First New World Settlers?

Bones, stones, and a palm print from a New Mexico cave could shake up New World archeologists

THE FASTEST WAY TO GET MANY ARCHEOLOGISTS' blood pressure to skyrocket is to suggest that Clovis, New Mexico, might not be the first prehistoric site in the New World. For the last 50 years, the received wisdom has been that the 11,500-year-old artifacts found at Clovis were made soon after the first Americans found their way across the Bering landbridge. Those who have dared question the consensus have met with harsh criticism, and they haven't changed many minds (see *Science*, 17 August 1990, p. 783). But in recent months archeologist Richard MacNeish has been telling his colleagues that the scientific ground beneath the Clovis partisans is about to crumble.

For the past 2 years MacNeish, a respected figure in New World archeology who is based at the Andover Foundation for Archeological Research, has been excavating in Orogrande Cave, a dusty limestone cave in southern New Mexico. In a presentation at the AAAS meeting, he described the results as "ten counts [of evidence] that will eliminate the Clovis-firsters." Bones, charcoal, chipped stones, and what he believes is an ancient human palm print prove, he says, that ancient hunters dragged their kill into the cave, butchered it with crude stone tools, and grilled it over clay-lined hearths on the cave floor, starting more than 30,000 years ago.

CHRISMANVFISH

Old hand? *Palm print at Orogrande.*

MacNeish's doubters—and there are many—do endorse one of his claims: that he has unearthed a remarkable 30,000- to 40,000-year record of the area's fauna. "It's a fascinating paleontological site," says Harvard University archeologist John Shea. "Mammal experts should be climbing all over each other to get at this." Bones of camels, extinct horses, and other prairie species litter the lowest strata in the excavation, giving way to woodland animals like tapirs and weasels at intermediate levels and dryland species—including antelope and llama—at shallower levels. The bones lie in a clear stratigraphic sequence, interleaved with charcoal layers that have been carbon dated.

All that makes for a paleontological treasure, but MacNeish thinks it's an archeological one as well. The charcoal, he says, comes from ancient hearths, and at least some of the bones were discarded by human hunters. That evidence is easy to attack as the work of wildfires and carnivorous animals, though. As MacNeish himself conceded, "The $64,000 question is: Do we have artifacts?"

His answer is an emphatic yes. The simple, chipped pebbles and rock flakes his team has unearthed look nothing like the beautifully worked points found at Clovis-era sites. But MacNeish says he and his co-workers have done tests showing that the patterns of chipping couldn't have been produced by animals trampling the cave floor or debris falling from the ceiling. And only human beings could have brought the stones into the cave in the first place, he says, since nearly half of them represent rock types found nowhere in the cave.

But other archeologists aren't convinced. "I have doubts about almost everything he showed me from the lower [pre-Clovis] levels of the cave," says Shea, who has examined some of MacNeish's finds. The chipping is