Diverse AAAS Converges in Atlanta

Bringing presentations on biochemistry, geology, genetics, and a host of other disciplines, about 4100 researchers came to Atlanta, Georgia, last week for the 1995 meeting of the American Association for the Advancement of Science (AAAS) and Science Innovation Exposition. The theme was "Unity in Diversity," and AAAS, the publisher of *Science*, put on a diverse show. The wide range of research reported includes news of a new DNA probe, drastic science funding cuts, the abundance of greenhouse gases, and humanity's African origins.

DNA Goes Electric

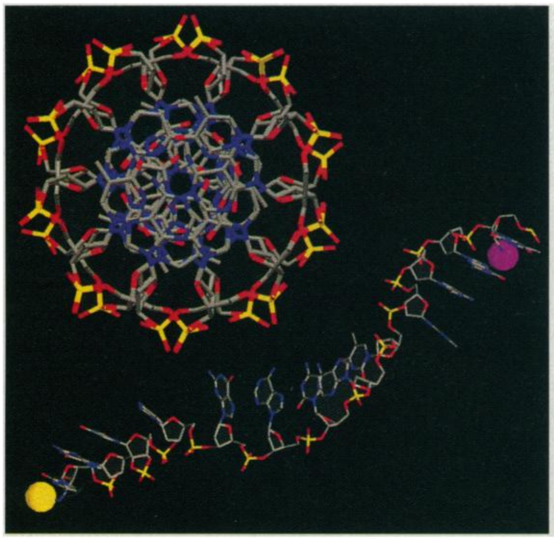
DNA is a remarkable molecule, but researchers have long debated its talent for conducting electricity. An electron moving from bond to bond along one of DNA's helical backbones, many assumed, would follow a slow, circuitous path. That's a pity, because technologies exploiting DNA's ability to carry information and probe for other molecules would be easier to develop if DNA could also transmit electrons fast. But in Atlanta, chemist Thomas Meade of the California Institute of Technology demonstrated that it does not pay to underestimate the double helix.

Meade and his colleague Jon Kayyem found that the molecule can carry electrons efficiently after all—and believe that electrons take a straight shot down a central channel. By setting up an electron detection system at either end of this channel, they found that electrons shoot through DNA like bullets. "The rate we found was very fast," says Meade.

Their work should open the way to exploring DNA's basic physics by testing the effect of different strand lengths or combinations of DNA bases on conduction speeds. "It's a nice model system, and it will allow them to make stronger statements about distance dependence," says electron transfer theorist David Beratan of the University of Pittsburgh. Moreover, say Meade and his colleague, this work may point to a simple DNA-based diagnostic device.

DNA researchers have long known of the channel, which runs down the center of the ring-shaped molecules formed where the complementary bases on DNA's two strands meet. And some guessed that it might have conducting properties because the joined bases have electron bonds called π orbitals that stick up perpendicular to the ring, forming what is known as a π-stack—a high-speed path for traveling electrons. Proving the existence of the π-stack has been a dicey chore, however.

In 1993 Caltech chemist Jackie Barton's group made a stab at measuring the rate of electrons through DNA and found it to be very fast for a biological molecule, supporting the π-stack theory (*Science*, 12 November 1993, p. 1025). Barton slid an electron donor molecule into the helix near one end of a DNA strand and a receptor molecule near the other end. By exciting the donor with laser light, she caused it to eject an electron into the strand. Because the loss or gain of an electron affects the ability of these molecules to absorb light, she could time the departure of the electron with laser spectroscopy. But the electron transfer rates she reported were so high—over a billion per second—that they prompted suspicions that some other mechanism may be taking place.



THOMAS MEADE

Straight shot. Electrons may be shooting down the middle of a DNA molecule, seen in an end-on view and as a single strand.

Meade and Kayyem took a slightly different route. They constructed a short length of DNA made up of 8 base pairs and firmly bonded a complex organic molecule containing the metal ruthenium to each end. Using a similar spectroscopic method to Barton's, they reported in Atlanta and in the March issue of *Angewandte Chemie* [International English Edition **34**(3), 1995, p. 352] that they had measured a rate of just over a million electrons per second.

That more modest speed sounds more realistic to some researchers. "I'm more comfortable with Meade's numbers," says biophysicist José Onuchic of the University of California, San Diego. Barton, however, stands by her results: Her experiment revealed higher rates, she says, because her donor molecules injected electrons straight into the π-stack, while Meade's electrons have to wind through the ruthenium complex before reaching the start of the stack. Chemist Brian Hoffman of Northwestern University believes both techniques will make a contribution to the field: "The two sets of results will end up adding, not canceling," he says.

Meade and Kayyem are not contenting themselves with just answering a few questions of chemistry, however. "We set out to study electron transfer in biomolecules and came across an application," says Meade. The boosted conductivity of the π-stack, they realized, would make their system a dandy biological sensor to detect precise sequences of DNA in blood, for instance, or pathogens in watercourses. Meade and Kayyem's idea is to fabricate specific single strands of DNA with attached electron donor and receptor complexes, fix them to a substrate, and hook it into an electric circuit to measure the rate at which electrons pass through. The single strands have no π-stack, and so current through them will be slow. But if the substrate is dipped into a solution, such as blood, containing complementary strands of DNA, these would bind onto the attached strands to form DNA helixes, and conduction speeds would shoot up.

In theory, that is. "They need to demonstrate a significantly different rate of electron transfer between a perfect match and a single-base mismatch," says David Barker, vice president for scientific development at Molecular Dynamics of Sunnyvale, California, which is funding research on the sensor. Most rival DNA sensors are not very accurate at picking up single-base mismatches, so if the new scheme passes this test, it would find a good market niche. The researchers are currently working with strands of different lengths and different base pair sequences to test length and mismatch dependence. "If it's really sensitive to mismatch, then we start celebrating," says Meade.

–Daniel Clery

Painting a Grim Funding Picture

Now that Republicans are in power in Congress, scientists can blithely ignore Democrats' insistence that basic research be linked to specific national goals and expect a return to the good old days of no-questions-asked funding. Right? Wrong, says Representative George Brown (D–CA), former chair of the House Science Committee. In a grim speech to AAAS members on 17 February, Brown offered two reasons why the Republican agenda spells much bigger trouble for the scientific community than Democratic efforts in recent years to link basic research with applied efforts, a policy influential House Republicans promise to reverse.

First, there is the budget picture, which Brown says is far gloomier now. "The magnitude of cuts that are looming boggles the mind," says Brown. He forecasts a 25% cut in government spending for research and development over the next 5 years to help balance the budget and pay for tax cuts. Even though there are science advocates among the Republican leadership, the congressman says these larger forces inevitably will dominate the political scene, leading to "deep and broad" cuts, especially at research universities.

Second, scientific research is likely to run head-on into the conservative Republican social and political agenda, and the collision could endanger funding still further, according to Brown. Fetal and genetic research are obvious examples, but much of the scientific agenda is also at risk, says Brown. "Environmental research discovers environmental problems that might lead to regulation. Global warming would be a good example. And biological research may lead to the discovery of additional endangered species," he says. That means Republican lawmakers could meet funding requests with concern and skepticism. "And, unlike public television, you don't have Big Bird to help defend yourselves before Congress," Brown adds.

This political threat, coupled with budget pressures, means scientists will have to lobby harder for their funding, something Brown criticizes academics for having been reluctant to do in the past. He blasted academia for not using the political muscle latent in the extensive U.S. university system—a system that employs nearly 2.5 million people, more than the auto, textile, and aircraft industries combined. And by not tying scientific research tightly to national priorities, Brown warns that scientists leave themselves open to the charge that their work is a luxury the country can no longer afford.

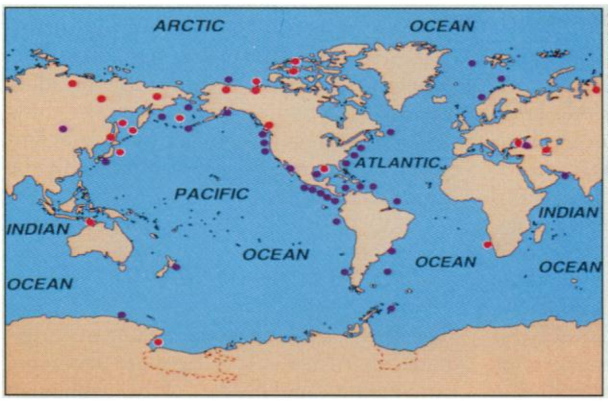
In the past, scientists at the National Science Foundation and the National Institutes of Health have countered that such strategies only increase applied research efforts at the expense of basic research. And in Atlanta, scientists again reacted coolly to Brown's alarm. Richard Zare, a chemistry professor at Stanford University, said government had such a poor record of directing research into specific areas that could benefit industry—the approach rejected by Republicans—that it wasn't worth defending. And Ernest Moniz, chair of the physics department at the Massachusetts Institute of Technology, said Brown's doom-and-gloom scenario seemed overblown. "This is more of a readjustment than a revolution," he noted.

While scientists debated the accuracy of the Democratic congressman's predictions, there was silence from the one group that might be able to provide more concrete answers. No Republican lawmakers or congressional staff turned up at the Atlanta conference. AAAS organizers say that new House Science Committee chair Robert Walker (R–PA) and his staff declined invitations. House Speaker Newt Gingrich—a dues-paying AAAS member—offered to do a videotaped speech, but organizers preferred a live appearance. The closest they got was spotting the speaker at the Atlanta airport during the meeting—his home district is right next door to the city.

–Andrew Lawler

Putting Methane Worries on Ice

A decade ago the late Roger Revelle came up with a prediction that sparked a hot debate among climatologists. Some 640 million metric tons of methane gas, he estimated, trickle out of icy ocean sediments into the atmosphere each year, feeding a buildup of greenhouse gases that—like extra coals shoveled onto a fire—could drive average global temperatures higher. But new measurements presented in Atlanta—apparently the most direct measure yet of hydrate-released methane—suggest the renowned atmospheric chemist was wrong: Oceanic methane appears unlikely to provide much fuel for the global furnace.



Methane map. Known *(red)* and presumed *(blue)* oceanic reservoirs of the gas lie only in shallows, damping worries that methane could escape and add to the greenhouse effect.

Revelle was worried about methane coming out of gas hydrates, an ice-like lattice of frozen water and gas molecules buried in sediments hundreds of feet below the ocean floor. The U.S. Geological Survey (USGS) estimates that about 13 trillion tons of methane are trapped in oceanic gas hydrate deposits, says Keith Kvenvolden, an organic geochemist at USGS in Menlo Park, California. Oil companies, which used to view hydrate as a sludgy nuisance, are now looking for ways to exploit these abundant deposits as an energy source (*Science*, 28 June 1991, p. 1790).

Revelle, however, had thought hydrates were even more abundant. He had assumed gas hydrate could form anywhere beneath the ocean floor, because two conditions necessary for its formation—high pressure and low temperature—were present whether one looked in shallows or in the ocean abyss. In the late 1980s, however, geochemists began paring down Revelle's estimates after studies suggested that gas hydrates formed only in organic sediments near shore, where bacteria in the sediments produce the methane. Until recently, the best guesses for releases of oceanic methane worldwide had shrunk to less than 5 million metric tons of methane per year.

Now comes Kvenvolden with a more direct measurement—and an estimate that is even lower. During the past 2 years, Kvenvolden has measured methane levels in the Beaufort Sea off the coast of northern Alaska, which is thought to harbor some of the more volatile hydrate deposits. His team, which published data from its 1993 Arctic field season in *Geophysical Research Letters* (19 November 1993, p. 2459) and presented additional data from last year's field season in Atlanta, sampled methane concentrations in the Beaufort Sea's water columns. It appeared to be the kind formed by sediment-dwelling bacteria, because it is richer in light isotopes of carbon than is geothermally produced methane, although Kvenvolden admits there is still some room for doubt.

What was very clear was the tiny amount of the gas in the water samples: less than 20 parts per million. If that rate is similar worldwide, Kvenvolden says, then gas hydrates are releasing no more than 130,000 metric tons of methane per year. That's barely a hiccup compared to the estimated 720 million metric tons belched annually by terrestrial sources such as cows, rice paddies, and coal mining. "The stuff Kvenvolden's doing is right on the money," says Charles Paull, a marine geologist at the University of North Carolina, Chapel Hill. "His data are very relevant for putting into better perspective some of the estimates of methane's impact on global warming."

The key to a more solid conclusion will be to get more data on the hydrates themselves, says Paull. He will participate in a 2-month expedition run by the international Ocean Drilling Program, set to begin in November off the Carolina coast. This will be the first expedition ever geared to look exclusively at hydrates, says Paull. Only a detailed look at hydrate structure—and a better assessment of how much actually exists—will let scientists finally put the older hydrate worries on ice.

–Richard Stone

Languages' Last Stands

When Edna Campbell Guerrero died at age 87 last month in Potter Valley, California, the language of her people—the Northern Pomo tribe of Mendocino County—moved a giant step toward extinction. Guerrero was one of the last speakers of Northern Pomo, one of 50 American Indian languages in California no longer learned by children. Now the only known speaker is another woman in her 80s who was a friend of Guerrero's. They had what may have been the last conversation in Northern Pomo on New Year's Day.

Last word? Alaskan Marie Smith Jones is the last known speaker of Eyak, one of the world's endangered languages.

"At least once a year, a California language goes extinct," says linguist Leanne Hinton of the University of California, Berkeley. And according to linguists who spoke at a AAAS session on endangered languages, the same thing is happening all over the world. As many as half of the world's 6000 known languages are dying because they are not being taught to children, researchers say. In their place, children are being taught the 600 most common languages, including English, Spanish, and Arabic, and those behemoths are swallowing up their smaller counterparts. "By the year 2000, we may be left with only 5% to 10% of the languages we still have," says University of Alaska linguist Michael Krauss. "I call this a catastrophe."

Language loss is a disaster, says Massachusetts Institute of Technology linguist Kenneth Hale, because most of these languages are essential to the cultural identities of the small ethnic groups that are losing them. Marie Smith Jones of Cordova, Alaska, the last speaker of Eyak, recalls the pain of such a loss. "We were forbidden in school to talk it," she says. She grew up speaking Eyak at home, but few of her classmates followed suit. "It hurts," she says. "I feel as though I lost someone in my family."

Linguists also feel pain, although of a different kind. Their ability to develop a theory of human language—including the understanding of the range of words, sounds, and grammar the human mind is capable of—is damaged by the loss of diversity. During his career, Hale has seen eight languages he studies go extinct. These losses, says Krauss, are most severe in the three regions where the number of native languages still left is the highest: Australia, the polar North (including Alaska), and California. While prehistoric people spoke 10,000 to 12,000 languages, that number has been declining steadily—partly because many native tongues have been suppressed by government policy. In Australia, the government's suppression of the Lardio language on Mornington Island in Queensland "was exactly like dropping a bomb on a museum or a university. Their wealth was intellectual wealth," Hale says. Today, most languages are threatened less by governments and more by global communications, such as e-mail, cellular phones, and satellite television, which all allow people to converse instantly—most often in English.

Even among native languages, however, all is not necessarily lost. Linguists at the meeting argued that by encouraging bilingualism, native speakers can preserve their own languages and still participate in mainstream culture—as is done in many nations of the world. "By spreading English we don't have to wipe out everything in its path," says Krauss. But the tide of language dominance is clearly running in the opposite direction.

–Ann Gibbons

Out of Africa—at Last?

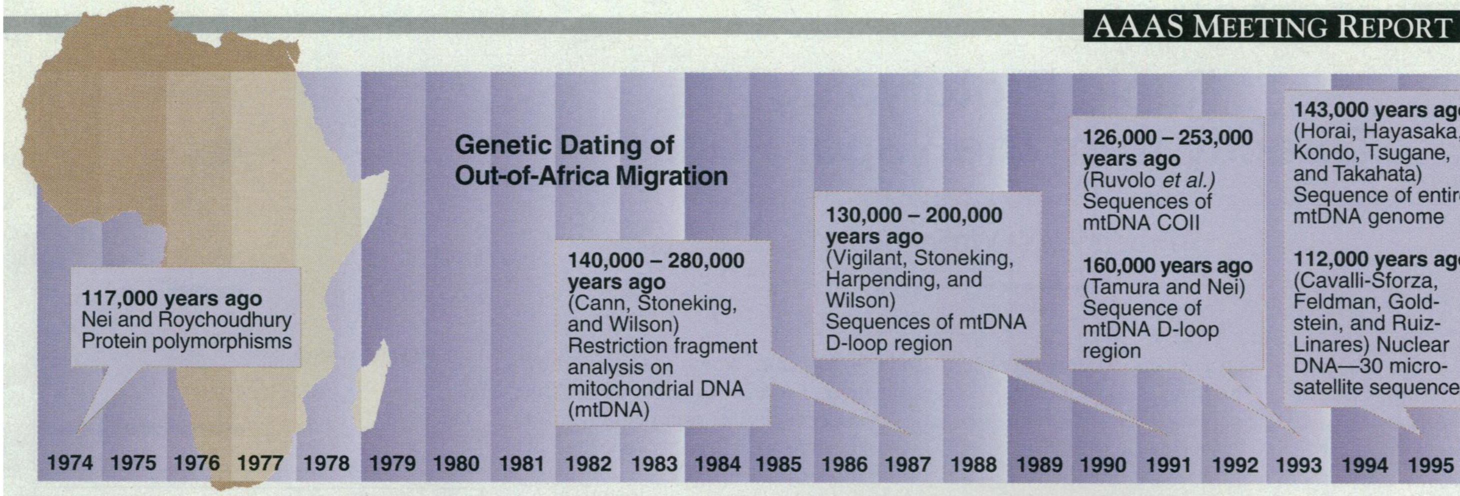
The theory that all modern humans originated in Africa is looking more and more convincing—and the date of the first human exodus from Africa keeps creeping closer to the present. The controversial "Out of Africa" theory, which originally postulated that the common ancestor of all modern humans lived in Africa about 200,000 years ago, has had its ups and downs over the years. But new genetics research presented in Atlanta, which traced two types of gene lineages from the far reaches of the globe back to Africa, is likely to remove many lingering doubts. And the research has also provided new dates for the African exodus, one as recent as 112,000 years ago.

Researchers hearing about these findings—one based on the first analysis of the entire sequence of DNA found in human mitochondria (tiny cellular organelles whose genes have often been used for tracing human ancestry), the other on a new technique for analyzing nuclear DNA—think they strike the strongest blow yet against a competing theory that modern humans gradually evolved in different regions of the world and then interbred to form a single species. "I think there is no genetic data that is consistent with the multiregional hypothesis," says Jan Klein, an immunologist at the Max Planck Institute for Biology, who led the AAAS session on human molecular diversity. John Clegg, a molecular biologist at the Institute of Molecular Medicine at Oxford University who spoke at AAAS, agreed that more and more genetic studies are lining up in support of the African exodus.

Molecular evolutionists have been using mitochondrial DNA (mtDNA) to probe human origins ever since 1987. That year, a group of researchers from the University of California, Berkeley, showed that Africans had more variation in their mtDNA than did any other geographic or ethnic group. Because variation is produced by mutations that accumulate over time, it indicated that African mtDNA was older than any other—between 140,000 and 280,000 years old, according to the Berkeley calculations. Those dates have been refined over the years, ranging from 130,000 to 200,000 years.

But the evidence has been far from conclusive. The early work, for example, was based on a less precise method that uses DNA landmarks rather than actual sequences. Critics also complained that different researchers were studying different parts of the mtDNA genome, which evolve at varying rates and thus yield disparate dates for the last common ancestor of Africans and non-Africans.

Geneticist Satoshi Horai and his colleagues at the National Institute of Genetics in Japan have now taken a major step toward overcoming those objections by sequencing all 16,500 bases in the mtDNA genome. In his work (*Proceedings of the National Academy of Sciences* **92**, pp. 532–536, January 1995), Horai analyzed the complete mtDNA sequences for three humans, one each from Africa, Europe, and Japan, and four apes (common and pygmy chimpanzees, a gorilla, and an orangutan). By comparing the differences in mtDNA sequences between the orang and the other apes, who are generally acknowledged to have split apart 13 million years ago, Horai was able to calculate the rate at which mtDNA mutations occur once populations split off from a common ancestor. Then, applying that rate to the three human lineages, Horai inferred that they last shared a common ancestor 143,000 years ago, plus or minus 18,000 years. And as the



Pilgrimage's progress. As scientists have developed new tools to reconstruct our genetic history, the date attached to the proposed "Out of Africa" migration that peopled the world—shown here in a partial list of research findings—keeps inching toward the present.

African lineage has the most diversity, Horai concluded that last common ancestor lived in Africa. Says Pennsylvania State University molecular anthropologist Mark Stoneking: "I think this is great—it's the maximum amount of information you can wring out of the mitochondrial genome."

But even Horai's work doesn't provide a complete picture. MtDNA is only one of 40,000 gene lineages in humans. Moreover, it is maternally inherited and can't reflect the genetics of fathers, and thus is an incomplete record of human population movements. A male hunting party, for instance, could become separated from a larger group, or a group of females and children could be carried off by invaders. Critics such as paleoanthropologist Milford Wolpoff of the University of Michigan, Ann Arbor, who has long advocated multiregional origins of modern humans, says it is possible that the ancestry for one part of the genome may not be the same as that of the entire species. Stanford University geneticist Luca Cavalli-Sforza agrees: "We've learned if we study a single gene we cannot get a reasonable conclusion for the human species. To get reproducible results, we have to study many genes."

Cavalli-Sforza and his colleagues told scientists in Atlanta they had done just that using nuclear DNA from 30 Africans and 120 people from four other continents. They looked at chromosomes 13 and 15, and they zeroed in on 30 different microsatellites, tiny stretches of nuclear DNA that are made up of a repeating series of nucleotides. As in the mtDNA, Cavalli-Sforza found more diversity within the African microsatellites, and he used that diversity to calculate how much time has passed since Africans separated from other populations. His conclusion was that Africans split from non-Africans 112,000 years ago.

These nuclear markers give scientists a good window into the past movements of populations of people, says Stoneking, because they come from different parts of the nuclear genome. "As more and more genetic lineages are looked at this way, the data get stronger and stronger against regional continuity," says Stoneking. Although critics like Wolpoff are still unconvinced, the evidence coming out of our genes, like the putative African founder population itself, seems to be sweeping the field.

–A.G.

Trouble for Planet Formation

For astronomers hoping to find planets outside our solar system, the traditional picture of how a new star forms has provided plenty of grounds for optimism. As a cloud of interstellar gas condenses into a protostar, theorists have assumed, a disk of gas and dust routinely forms around it—the raw material for planets. But in Atlanta, astronomer Andrea Ghez of the University of California, Los Angeles, presented a decidedly gloomier picture: Virtually all young stars are formed in multistar systems, she said, and these companion stars are in the habit of hoovering up most of the gas and dust that could form planets. If the disks are vital to planet formation, other planetary systems could be very rare indeed.

In a conference session mostly devoted to planet searching, you might expect some hostility toward such news. But as so little is known about other planetary systems and how they form, planet searchers weren't deeply discouraged. "It's very interesting, but it's not going to stop anyone looking for planets," says Robert Brown of the Space Telescope Science Institute (STScI) in Baltimore.

Ghez based her argument on a study of T Tauri stars, "the young counterparts of solar-type stars," she says, and the closest thing to the protostars posited by planetary theorists. Ghez examined a complex of three such stars that formed at the same time. If protostars routinely develop disks of gas and dust, all three stars should have disks that radiate similar amounts of infrared light. But Ghez found that two of the stars, lying especially close to each other, give off much less radiation than the third. This, Ghez suggests, means there is much less gas and dust around the close pair. "The close companion has a disruptive influence and depletes the dust," she says, adding that "such stars are unlikely to be able to form planetary systems."

And unfortunately for planet searchers, such stars seem to be all over the place. Several years earlier, Ghez had started taking a close look at nearby T Tauri stars using the 5-meter Hale telescope at the Palomar Observatory in California and another telescope in Chile. She sharpened the resolution of the telescope using speckle imaging, a technique in which computer processing filters out atmospheric blurring. Focusing on the two nearest star-forming regions—Taurus-Auriga and Ophiuchus-Scorpius—she counted how many of the T Tauri stars are actually multiple stars orbiting each other.

By now, Ghez has surveyed 110 T Tauri stars and found that around 60% of them are in multistar systems. And it's possible the news is even worse. Ghez's technique is only sensitive to binaries or multiples in which the stars lie from 15 to 250 astronomical units apart. (One astronomical unit equals the distance between Earth and the sun.) Some of the T Tauris that her survey marked as solo stars may in fact have companions, only at smaller or wider separations than she could detect.

That could mean that few stars are born with the wherewithal to make planets, but astronomers—an optimistic group—are not dismayed. "It doesn't need much mass to make a Jupiter. It's only one-thousandth the mass of the sun," says Todd Henry of STScI. After all, says Don McCarthy of the Steward Observatory at the University of Arizona, planets did incontrovertibly form around one star system—ours—and there are a few other T Tauri solos in the neighborhood, so star-making ability may not be as rare as Ghez claims. But "until we find a another solar system like our own, speculation will be wild," he says.

–D.C.