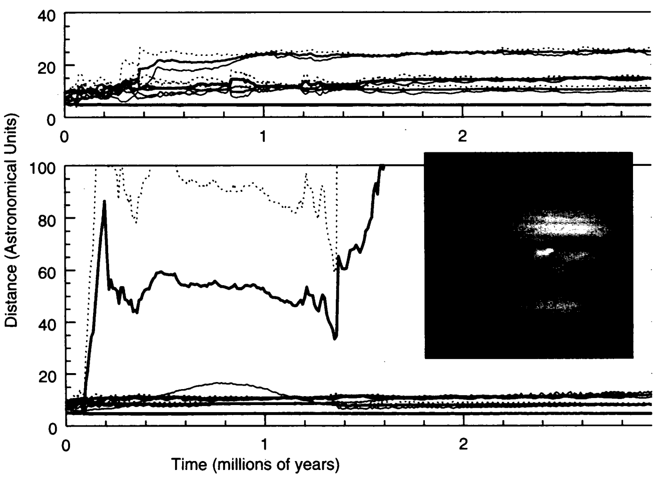
PLANETARY SCIENCE

Shaking Up a Nursery Of Giant Planets

What are Uranus and Neptune doing so far from the sun? The question has puzzled theorists for decades. Unlike the closest six planets, which orbit the sun inside of 10 astronomical units (AU)—that is, less than 10 times farther out than Earth—Uranus and Neptune orbit at 19 and 30 AU, respectively. Theorists don't believe they could have formed so far out; there, gas and dust were too sparse to coalesce into planets. Now, a new computer model suggests that sibling rivalry might be to blame for their banishment. Runty Uranus and Neptune may have grown up in tight quarters much closer to the sun, only to have the big bruisers Jupiter and Saturn fling them into the outer reaches of the solar system.



Mere chance. In computer simulations, Jupiter (pictured) and Saturn sometimes rearrange Uranus and Neptune (purple and red) to resemble the solar system (top) and sometimes not (bottom).

"It's a fascinating result," says planetary dynamicist Brett Gladman of the Observatory of Nice in France. "I think it's marvelous it works." Forming Neptune and Uranus where it's practicable and then having them thrown outward "seems dynamically plausible," adds Stuart Weidenschilling of the Planetary Science Institute in Tucson, Arizona. "It certainly comes out ahead of any previous explanations."

The nine planets formed in a nebular disk of dust and gas, where chunks of primordial matter collided to form bigger and bigger chunks and eventually planets. For the next several million years, the resulting ice-rock cores of the outer planets grabbed gas from the nebula until the gas was all taken up or blown away by the sun. But out on the nebula's fringes, matter was spread too thinly for anything like planets to form. In the best simulations of the process, cores for Uranus and Neptune fail to form at their present positions in even 4.5 billion years, the lifetime of the solar system. "Things just grow too slowly" in the outermost solar system, says Weidenschilling. "We've tried to form Uranus and Neptune at their present locations and failed miserably."

Apparently, Uranus and Neptune formed somewhere else, presumably closer to the sun where the nebula was far denser. But how did they move outward billions of kilometers without disrupting their nicely circular orbits, which are in the same plane as the rest of the solar system? In this week's issue of *Nature*, planetary dynamicists Edward Thommes and Martin Duncan of Queen's University in Kingston, Ontario, and Harold Levison of the Boulder, Colorado, branch of the Southwest Research Institute demonstrate a two-step method that works, at least in their model. They assume that not just two but four or five ice-rock cores formed where Jupiter and Saturn now reside, between 5 and 10 AU—an assumption most theorists are comfortable with.

Conventional thinking also has it that once a core reached a critical mass—about 15 times that of Earth—it would grow faster and faster as its increasing mass gave it greater and greater gravitational pull on the gas. By chance, in Thommes and Duncan's scenarios, Jupiter hit runaway growth first, letting it grab 71% of the total mass of the outer planets; Saturn came in second with 21%, but late bloomers Uranus and Neptune got only about 3% and 4% of the mass, respectively, leaving them at the mercy of nearby Jupiter and Saturn. In the first 100,000 years of many of the simulations, Jupiter and Saturn gravitationally fling their nursery mates into steeply tilted, highly elongated orbits that can carry them 30 or 40 AU outward.

That's a dangerous situation for an undersized giant because the big guys could, and in some of the simulations do, eject a planet from the solar system entirely. But the debris remaining in the disk, which extends to 40 AU and beyond, can step in to defend the bullied planets. In a process called dynamical friction, innumerable gravitational interactions with bits of disk debris push Uranus and Neptune around as they pass through and over the disk. The dynamical friction eases the wildly orbiting planets once again into circular orbits in the plane of the other planets but beyond the disruptive influence of Jupiter and Saturn. Further planet-disk interactions can move the relocated planets even farther out. Of the 24 simulations Thommes and his colleagues have run, about half produced an outer solar system resembling ours. Most runs also leave a disk of debris beyond 40 AU that closely resembles the Kuiper Belt of icy objects discovered in 1992, beyond the mean orbital distance of Pluto.

"It's a very interesting idea," says Jack J. Lissauer of NASA's Ames Research Center in Mountain View, California. "They've shown it's not as unlikely as I would have thought." But he and others question the realism of the model and note that no one is sure what the earliest solar system was actually like. Lissauer wonders, for example, if the modelers haven't put a bit too much debris in the outer solar system. Renu Malhotra of the Lunar and Planetary Institute in Houston believes cores would have interacted with gas and ice-rock bodies in the giant planet nursery where they formed. Such interactions, which don't appear in the model, would "tend to damp this violent physics" of throwing Uranus and Neptune out. "Whether the modeling reflects what happens in nature is not demonstrated," she says.

More realism will require more complicated modeling and more computing power, says Duncan. In the meantime, astronomers are pushing their telescopes to the limits to catch a glimpse of more-distant Kuiper Belt objects. In many of Thommes's simulations, Neptune scatters these objects high and low before settling down itself. Like debris from a brawl, scattered Kuiper Belt objects would be a strong sign that the giant planets had an early falling out. —**RICHARD A. KERR**

ANTHROPOLOGY

Proto-Polynesians Quickly Settled Pacific

The ancestors of the Polynesian people settled the islands of the East Pacific only a few thousand years ago, but anthropologists have long debated where they came from. Even after detailed scrutiny of bones, blood, DNA, pottery, and languages, researchers have remained divided. One camp, chiefly geneticists, argues that seafaring proto-Polynesians originated in Southeast Asia and quickly island-hopped eastward, sweeping through Melanesia in the West Pacific along the way. The other, chiefly archaeologists, argues that Polynesian ancestors originated in Melanesia itself, a hotbed of human diversity with a 45,000-year record of habitation. Now geneticists have combined DNA and linguistic data from Melanesia to make a new case that the archipelago was only a way station.

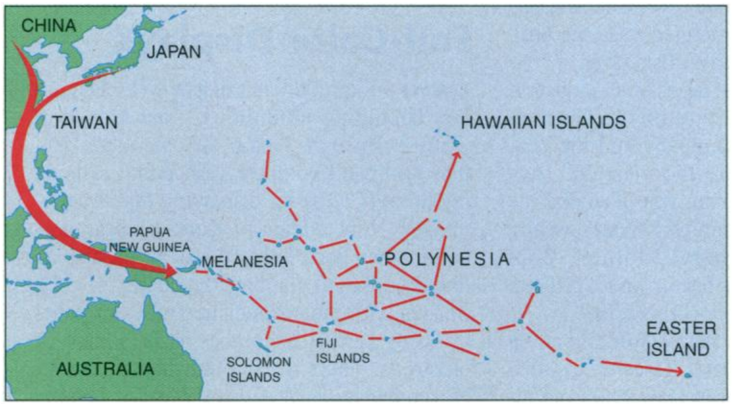
The study, in last month's *American Jour-*

CREDITS: (TOP TO BOTTOM) THOMMES ET AL.; JPL/NASA *nal of Physical Anthropology*, "adds important new primary genetic data" and is "strongly consistent with" a rapid intrusion, sometimes called the "express train" model, says Patrick Kirch, an archaeologist at the University of California, Berkeley. "This is important work," adds geneticist Rebecca Cann of the University of Hawaii, Manoa. "We have the history of evolution in our bodies. If we decipher that, we have an independent and useful record of human history."

Still, not everyone is convinced the patterns are so simple. Although he praises the accumulation of data, archaeologist John Terrell of The Field Museum in Chicago says he's mystified "that people try to reduce 45,000 years of prehistory down to a story as simple as two peoples [Melanesians and Southeast Asians] and two migrations. It's a lot more interesting, complicated, and significant than that."

D. Andrew Merriwether of the University of Michigan, Ann Arbor, chose to examine Melanesian DNA and language more closely because, he says, "the islands are a critical crossroads to explain where everyone in the Pacific passed through or came from." The languages spoken reflect that complexity: Some Melanesians speak Austronesian languages, as do all Polynesians, but other Melanesians speak non-Austronesian languages, dozens of which can be heard on the island of Bougainville alone.

Merriwether and Jonathan Friedlaender of Temple University in Philadelphia, Pennsylvania, opened up lab freezers in the United States and Melanesia and resurrected blood samples taken from Melanesian islanders in the 1960s and '70s. They extracted mitochondrial DNA (mtDNA) from the blood and searched its nucleotide bases for a genetic signature shared by all Polynesian and many Southeast Asian people—a nine–base pair deletion that was presumably part of the genetic heritage the Polynesian forebears carried eastward.



Cruising the Pacific. New data suggest that ancestral Polynesians came from Southeast Asia and swept rapidly through Melanesia.

SOURCE: (LEFT) D.A. MERRIWETHER; (RIGHT) DIANA WALKER/GAMMA LIAISON

The researchers found that throughout Melanesia, the nine–base pair deletion is most common near the coast and absent in remote, hilly areas. And it is present in all Austronesian speakers, but only in some non-Austronesian–speaking groups. This pattern fits the idea of a rapid, relatively recent migration of ancestral Austronesian speakers through the area, Merriwether says. As the newcomers arrived on the already-inhabited islands, they settled along the coasts, introducing their languages and their genes. But these seafarers were slow to penetrate into the rugged, volcanic interior.

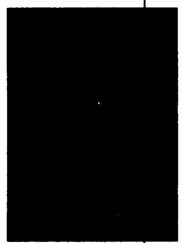
Merriwether and Friedlaender found more evidence for a recent, rapid migration through Melanesia when they examined the sequence of some 500 bases in a hypervariable region of mtDNA known as the d-loop. The number of nucleotide differences in the d-loop sequences of any two individuals in a population provides evidence for how much time has passed since a small population began expanding—the more differences, the longer ago the population began to grow. Polynesians share a nearly identical d-loop sequence, varying by perhaps one nucleotide base. The same is true for Melanesians who have the nine–base pair deletion, indicating that both Polynesians and Melanesians who carry the deletion are recent descendants of the same small population. On the other hand, Melanesians who lacked the deletion had an average of seven to nine d-loop differences, evidence of a much older population that remained on Melanesia while the ancestors of Polynesians cruised the Pacific.

Other researchers approve of combining genetic and linguistic data, but even some geneticists say that the results don't rule out other scenarios of settlement. Henry Harpending, a population geneticist at the University of Utah, Salt Lake City, says, "It's a lot of data that doesn't … consider other explanations such as migration from South America or genetic drift," in which some genetic variation, lost by random chance in small populations, led to apparent genetic similarities today. More convincing would be data from "around 100 genetic loci," he adds.

As the Polynesian picture becomes clearer, researchers are probing other ques-

ScienceScope

Converted Energy Secretary Bill Richardson has gotten religion on science. He pledged last week to create a "vigorous plan" to recruit and retain scientists at the Department of Energy's (DOE's) national laboratories, and promised to make science and technology a more central concern next year on Capitol Hill.



Richardson has had relatively little to say about science since he took over DOE in 1998. But at a 1 December briefing for Washington science writers, he said he wants to boost funding for the new neutron source planned for Oak Ridge National Laboratory in Tennessee and for fusion, a program that has received little attention from DOE chiefs in the past decade.

Richardson also plans a recruiting drive to address department fears that the espionage scandal and resulting furor—including threats to submit more than 1000 scientists to polygraph testing—are scaring away talented young researchers. He is considering a package that would include increasing pay rates and freeing up slots via early retirement. Better salaries could help stem a mini–brain drain from the labs: "We're losing people to the private sector," he says. Late last week, Richardson also said he would grant waivers to some foreign scientists from sensitive nations barred from doing certain kinds of research at DOE labs.

Polio Push Two of the world's richest men have joined the crusade to rid the world of polio by the end of next year. The Bill and Melinda Gates Foundation, a charity founded by Microsoft CEO Bill Gates, will put $50 million into the campaign, while the United Nations Foundation, which administers the 1997 $1 billion gift of CNN founder Ted Turner to the UN, has pledged another $28 million. The money will be used to strengthen vaccine delivery efforts in countries like Angola and India, where the disease is still a scourge, and to boost polio surveillance. "This is wonderful," says Bruce Aylward, coordinator of the World Health Organization's polio eradication initiative. "Having big players like Turner and Gates involved really raises the profile of the campaign."

Contributors: Dennis Normile, David Malakoff, Andrew Lawler, Martin Enserink

tions—such as why Melanesia is so incredibly diverse. "We are talking about very complex relationships ... that reflect the influence of different migrations" at different times, Friedlaender says. And the right genes can continue to tease apart that history, he says.

–BERNICE WUETHRICH

Bernice Wuethrich writes from Washington, D.C.

SCIENCE EDUCATION

Science Fairs Pump Up The Rewards of Talent

If you can't run the nation's most prestigious high school science fair, start your own—and make it even more lucrative for the winners. That's the genesis of the Siemens Westinghouse Science & Technology Competition, which announced its first winners this week in Washington, D.C. In doing so, Siemens prompted Intel, which last year beat out Siemens for sponsorship of the venerable Science Service Talent Search, to raise its prize money as well.

Lisa Harris of Dalton High School in New York City won this year's top Siemens prize for individuals—a $100,000 college scholarship—for developing a new method to detect carriers of a gene responsible for cystic fibrosis. Daniar Hussain of Richland High School in Johnstown, Pennsylvania, and Steven Malliaris of New Trier High School in Winnetka, Illinois, won the team competition and will divide a $90,000 scholarship for their method of generating computer programs to store data more efficiently. A total of 12 individuals and teams chosen from six regional competitions competed for the top prizes; combined with awards to students who score well on advanced placement tests and their teachers, the total Siemens pot comes to nearly $1 million.

Young stars. High school seniors Daniar Hussain, Steven Malliaris, and Lisa Harris win the first annual Siemens Westinghouse Science & Technology Competition.

Last year was tumultuous for the world of U.S. high school science competitions. Westinghouse ended 57 years of support for the annual Science Service Talent Search, which has been a scientific launching pad for five Nobel Prize winners and 30 members of the National Academy of Sciences. In a competition for a new sponsor, Siemens—which bought Westinghouse after it dropped its support—was one of 75 companies vying for the honor. After Intel won, Siemens decided to start its own contest.

"It was enlightened self-interest," says Albert Hoser, head of the Siemens Foundation, a corporate charity created in 1998. "We need employees at the cutting edge of science and math. We want to inspire students to give those subjects top priority." Not to be outdone, Intel has doubled the prize money awarded to Science Service Talent Search winners, including $100,000 to be awarded in March for first place among 40 finalists, and is offering a total pool that exceeds $1.2 million. "We like to think we're serving as a catalyst for other corporations to raise the bar," says Siemens spokesperson Esra Ozer.

Indeed, one Nobelist urges other industrial giants to follow the lead of the German telecommunications company and the U.S. chipmaker. "The more the merrier," says physicist Leon Lederman, who attended the Siemens awards ceremony. "What's wrong with General Motors? Why don't they have a prize, or Ford, or any other corporation?"

Harris started working at the Public Health Research Institute in New York City at 16 and already is a co-author of a paper classifying the virulence of different strains of tuberculosis. For the competition, she used a fluorescent marker to tag blood samples that harbor a mutation in the cystic fibrosis gene, producing a test that is simpler and faster than current techniques. "I hit a wall over the summer," she says about a project that took 11 months. "The most exciting thing for me was to make it work." She finished the latest experiments just in time to write them up for her poster session at the awards ceremony.

Hussain and Malliaris took a computer science class together in Illinois before Hussain's family moved to Pennsylvania earlier this year. "We knew the distance wouldn't be a problem," says Malliaris, who collaborated with Hussain via the Internet. The students used evolutionary principles to improve polynomials that direct the storage of items from large data sets. They introduced random mutations in a population of techniques and then repeatedly eliminated the ones that were unfit and selected ones that distributed data most efficiently.

The Siemens competition focuses on the quality of the student research projects, whereas the Intel talent search also judges contestants on creativity and their knowledge of science. In addition to these competitions, the National Science Teachers Association (NSTA) hosts three national contests that focus on a student's imagination—some are entirely conceptual—and don't require them to work in a lab outside school. "The Intel competition is for students already definitely going into science, who are already interested in science," says NSTA spokesperson Cindy Workosky. "We're trying to turn them on to science."

For Lederman, every science competition "is another opportunity for the kids in America to excel."

–LAURA HELMUTH

TECHNOLOGY

Nanotubes Generate Full-Color Displays

TOKYO—Liquid crystal displays (LCDs) are fast becoming ubiquitous—just glance at your wristwatch, laptop, or calculator. But they still can't compete with bulky cathode ray tubes (CRTs) for displaying high-quality images. Now, a team of Korean researchers at Samsung has produced a working display that promises to combine the quality of CRT images with the convenience of a flat panel by using carbon nanotubes as its source of electrons. Their work, published in the 15 November issue of *Applied Physics Letters*, gives Samsung a small lead in a heated race to commercialize the technology.

The CRT is a dinosaur in the fast-changing world of electronics, surviving because of its brightness, resolution, and ability to show moving images. But it may be driven to extinction by a technology called field emission, which like the CRT uses electrons to light up colored phosphors on a glass screen (*Science*, 31 July 1998, p. 632). Instead of a single electron gun at the far end of a bulky and heavy cone-shaped tube, however, field-emission displays use thousands of tiny pointed electron emitters arrayed within a flat panel. An electric field pulls a stream of electrons from each point. Field-emission displays can be built as thin as LCDs, yet consume less power and promise to produce images comparable to a CRT. The problem to date has been finding materials that are easily fabricated into pointed shapes yet can hold up to the intense stream of electrons.

Carbon nanotubes, which conduct electrons freely, could fit the bill—if researchers can find a way to control their fabrication and place them in a precise pattern. The Samsung group has done just that. The result, reported by Won Bong Choi and col-

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