inherent ability to be expressed may have gotten into bacteria and thus wouldn't require integration through an integron. But there is plenty of evidence that, somehow, such gene transfers do take place. For example, at the Conference on Microbial Genomes, which was held in February in Hilton Head, South Carolina, geneticist Fred Blattner reported that his team at the University of Wisconsin, Madison, has found that the pathogenic *E. coli* strain 0:157 has a million extra base pairs of DNA compared to a laboratory strain. This extra DNA includes a few genes that are quite similar to genes that code for toxins produced by *Yersinia*, the flea-borne pathogen that causes bubonic plague.

And Dieter Söll, Michael Ibba, and their colleagues at Yale University have discovered the gene for an enzyme that seems to have escaped from a microbe that lives in hot environments and taken up residence in the spirochetes that cause Lyme disease and syphilis. Although the gene is not directly related to virulence, its enzyme product might still be a good target for therapy because it is not found in most bacteria. This could lead to a spirochete-specific antibiotic, Söll says.

As researchers decipher more and more microbial genomes, the transfer of virulence genes by integrons may become a common theme, says Stokes. His prediction: "What we're seeing is the tip of the iceberg."

–Elizabeth Pennisi

CLIMATE PREDICTION

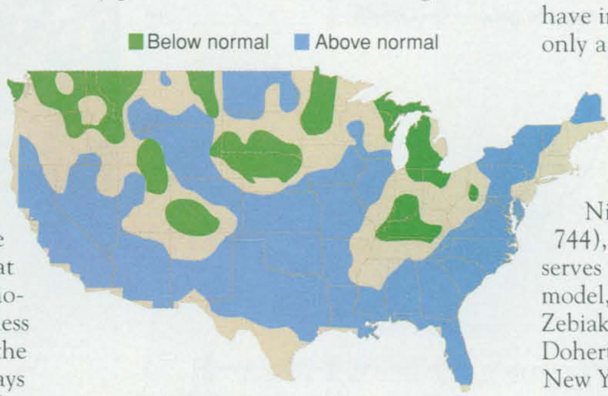
Models Win Big in Forecasting El Niño

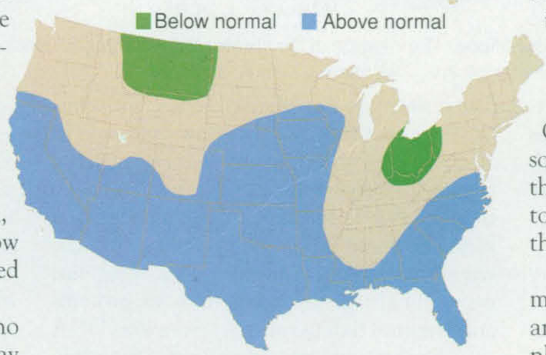
Predictions of the most recent El Niño were widely regarded as a stunning success: Forecasters warned of torrential rain in California this winter and drought in Indonesia, and they were right. But if meteorologists had dared to rely more heavily on their computer models, those predictions could have been even better—and next time, they may be. That's because this year's El Niño, one of the strongest in a century, was a proving ground for the models, showing which types do the best job at predicting this warming of the tropical Pacific and its effects on global weather patterns. When it comes to models, forecasters learned this year, bigger is better.

In a recent ranking of predictive efforts, the most ambitious models—which chew up hours of supercomputer time simulating how winds, water, and heat shuttle among land, ocean, and atmosphere—all came in near the top, while less sophisticated models often faltered. "For the first time, the big models got it right," says tropical meteorologist Peter Webster of the University of Colorado, Boulder. As meteorologist Eugene Rasmusson of the University of Maryland, College Park, puts it, "the more bells and whistles, the better." Knowing which models to trust, says Jagadish Shukla of the Institute of Global Environment and Society in Calverton, Maryland, "is a big breakthrough. We now have confidence in 6-month forecasts based solely on a model."

Even veteran El Niño forecasters who have seen the models fail in the past now say that this year's success has won the models a larger role in forecasting. "My guess is that next time we will rely much more heavily on the [big computer] models than we did this time," says Ants Leetmaa, director of the Climate Prediction Center (CPC) at the U.S. Weather Service's National Centers for Environmental Prediction (NCEP) in Camp Springs, Maryland, and co-developer of one of the most sophisticated models. That next test—predicting whether El Niño will linger through the fall or switch to its mirror image, La Niña—is already looming. By Christmas, this more difficult test will provide even more convincing proof of the models' mettle—or expose their weaknesses.

The value of the more complex El Niño models emerged when climate forecaster and statistician Anthony Barnston of the CPC rated a dozen different methods on how well they predicted the Pacific warming, which peaked at the end of last year. As he describes in a paper in the proceedings of the October 1997 Climate Diagnostics and Prediction Workshop, Barnston looked at the predictions each model was offering in February and March of 1997 for the coming fall. Six of the models were so-called empirical models, which make no attempt to simulate the real-world interplay of winds and currents that actually leads to an El Niño. Instead, these models are in essence automated rules of thumb, doing what human forecasters do but in a more objective way. They compare current observations of the tropical Pacific Ocean and atmosphere with comparable data for the periods leading up to El Niños of the past 40 years and issue predictions based on the resemblance. But as a group, these models did poorly this time, as they often have in the past. Three of the six called for only a moderate El Niño by the fall, while three predicted weak warmth or normal conditions.





It's a match. Complex computer models helped forecasters last November to predict a wet winter for the southern United States and dryness in spots in the north *(top)*. Actual precipitation *(bottom)* fell much as predicted.

SOURCE: CLIMATE PREDICTION CENTER / NWS

Even a more complex model, which won fame in 1986 by being the first to successfully predict an El Niño (*Science*, 13 February 1987, p. 744), "fell flat on its face" this time, observes Barnston. This so-called dynamical model, run by Mark Cane and Stephen Zebiak of Columbia University's Lamont-Doherty Earth Observatory in Palisades, New York, does simulate ocean-atmosphere interactions, although only in the tropical Pacific. This time the model predicted only a gradual warming to near-normal conditions rather than intense warming. Cane can't say exactly why the model failed so spectacularly, but it seems to have something to do with the wind observations used to get the model started, which are sparse in the southeast Pacific.

In contrast, the most sophisticated modeling efforts rated by Barnston scored an impressive success. These more complex models also couple ocean and atmosphere but do so worldwide, like the large-scale models that scientists have developed over several decades to forecast global warming. Researchers have been struggling to construct these "coupled" models for much of this decade by cobbling together parts of weather and climate models; their creations perform millions of calculations and have insatiable appetites for computing time.

In early 1997, all four of the bigger

coupled models Barnston rated called for at least moderate warming in the tropical Pacific by the fall of 1997. The NCEP model, perhaps the most sophisticated of the group, predicted the strongest warming of any model, empirical or dynamical, albeit still only half the strength of the real-world event. A fifth sophisticated coupled model, run by the European Center for Medium-Range Weather Forecasts (ECMWF) in Reading, England, didn't fit Barnston's scoring because it offers predictions only 6 months ahead. But it did exceptionally well in calling for a rapid warming relatively early in 1997—a hallmark of this El Niño—and by June the ECMWF model had correctly predicted the eventual end-of-year peak temperature.

Not only did the big coupled models successfully predict El Niño's timing, they helped human forecasters do their best job ever of predicting its dramatic effects on regional weather patterns. Using their coupled model as a starting point and adding their experience with past El Niños, CPC forecasters predicted in November that in December, January, and February precipitation would be heavy coast to coast in the southern United States and light in the Ohio Valley and Montana—and generally they were right. They also predicted unusual warmth across the northern third of the United States, and again they were right. On a scale of forecasting skill that runs from 0 (no better than chance) to 100 (perfection), the precipitation forecast scored 36. That's a major accomplishment, for precipitation forecasts by the current long-range forecasting program have been stuck at 0 since they began in 1995 (*Science*, 23 December 1994, p. 1940).

Worldwide, the models also helped weather forecasters get it largely right. Dry weather struck Indonesia, northern South America, and southern Africa, and heavy rains hit East Africa, Peru, and northern Argentina. The only major failed predictions were those of a weak Indian monsoon and drought in northeast Australia.

Forecasters concede that the overwhelming power of this El Niño—one of the two strongest of the past 120 years—probably accounts for much of their success at predicting how it would alter regional weather; effects that might have been lost in the noise during a milder event stood out clearly. But they also point to signs of surprising predictive power in the coupled models. Tim Stockdale of the ECMWF notes that their model successfully predicted heavy summer rains in southern Europe and a mild winter across Europe, even though El Niño's effects there were thought to be subtle and unreliable. "The model seems to give us not just the standard El Niño," he says, "but also the difference between this event and others."

Forecasters will soon have the chance to test their models again. El Niño is only one-half of the climate cycle in the equatorial Pacific; its less famous sibling is the unusual cooling of tropical waters dubbed La Niña. It too has effects on weather in the tropics and around the world, although they are the opposite of El Niño's and are therefore less dramatic; parching South America's coastal deserts is not as devastating as is drowning them with torrential rains.

REED SAXON / AP PHOTO

Making waves. El Niño's force crashed into California beachfront homes last December.

"We've got a test ahead of us: exactly when La Niña may start," says meteorologist Kevin Trenberth of the National Center for Atmospheric Research in Boulder, Colorado. In the past, La Niña has proved even more difficult to predict than El Niño, notes Trenberth, and moderate events, which the next one is expected to be, are harder to predict than big ones.

So far, it looks like the NCEP coupled model will either win big or suffer an embarrassing defeat. All the other models—both empirical and coupled—are predicting a return to normal ocean temperatures by late summer and a continued chilling into a full-fledged La Niña by the end of the year. But the NCEP model calls for the current tropical Pacific warmth to decline but linger through the fall. The models may have turned a corner in prediction, but their creators are still anxious about their performance. "There's still a lot of nail biting going on," says Leetmaa, noting the unexpected collapse of the Lamont model. "There are still some unknowns out there."

–Richard A. Kerr

Current El Niño forecasts from many models can be found on the World Wide Web at: www.ogp.noaa.gov/ENSO/forecasts.html

ASTRONOMY

Spying on Solar Systems in the Making

Want to see how our solar system formed? Take a ride on one of the sensitive new cameras that astronomers have been pointing at young stars. These instruments are giving scientists unprecedented views of swirling disks of dust surrounding the stars—probably the nurseries of planets like our own.

A crop of new images unveiled this week shows several disks with mysterious bulges—perhaps dust-cloaked giant planets—and others with holes torn in them, apparently by the gravitation of planets. "What we see is almost exactly what astronomers orbiting nearby stars would have seen if they had pointed a ... telescope at our own sun a few billion years ago," says Jane Greaves of the Joint Astronomy Center (JAC) in Hawaii. In one case—the youngest disk ever seen around a full-grown star—astronomers may be spying on the very moment of planet birth.

These views come courtesy of a new generation of electronic detectors, sensitive to the midinfrared and submillimeter wavelengths in which the disks are brightest. Greaves and her colleagues on a British-American team led by Wayne Holland of JAC and Benjamin Zuckerman of the University of California, Los Angeles (UCLA), used a camera called SCUBA, mounted on the 15-meter James Clerk Maxwell submillimeter telescope at Mauna Kea, Hawaii, to observe the stars Vega, Fomalhaut, and Beta Pictoris. Fifteen years ago, the American-Dutch Infra Red Astronomical Satellite had shown that these three stars (and a handful of others) emit more infrared radiation than expected, probably because they are ringed with disks of warm dust.

The Beta Pictoris disk has already been photographed in visible light. But the SCUBA images, which appear in this week's *Nature*, offer the first direct views of the dust disks around Vega and Fomalhaut. The images of Vega and Beta Pictoris also show the mysterious bright blobs, at distances from the star several times greater than Pluto is from the sun. The view of Fomalhaut shows that the disk peters out close to the star. The missing dust, says Holland, "might have formed rocky planets like the Earth."

The stars that host those disks are all several hundred million years old—well past prime planet-forming age. But two other groups of astronomers have now made a similar finding around a much younger star, HR4796A, in the southern constellation Centaurus. Last month, using a midinfrared camera called OSCIR on the 4-meter telescope at the Cerro Tololo InterAmerican Observatory in Chile, Ray Jayawardhana of