dependently by different groups of countries, not by the E.U. Busquin's idea is to get them working together, discussing funding sources, international cooperation, and access for non-E.U. scientists.

Initial reaction to this proposal has been positive. "A substantive council that could identify and follow up opportunities for cooperation with the E.U. and among the centers would certainly contribute to the dynamism of European science," says EMBL director-general Fotis C. Kafatos. Although the centers focus on widely differing fields, Kafatos says he foresees "the possibility of fruitful collaborations ... for example in informatics, in modeling complex systems, and in engineering tasks."

The council is the most visible of several proposals Busquin included in his white paper. He also wants to commission a "benchmarking" study of research efforts in all E.U. nations; find ways to network the best European research centers into "virtual centers of excellence"; help to create an "E.U. patent" that would be simpler and cheaper than the current European patent; encourage national research centers to give technical support to start-up companies; and attract outside researchers to work in the E.U. Busquin's vision also includes a "thorough rethink" of plans for the E.U.'s next flagship research program, Framework 6, focusing more on areas that should be tackled at a Europe-wide level. The current framework funds a large number of crossborder projects in many fields, but accounts for only about 5% of public research expenditure in Europe.

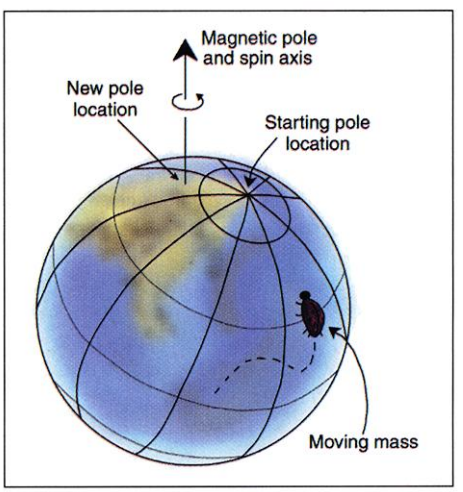
Busquin is hoping his white paper will spark a 6-month debate in European labs and the European Parliament over the best way to make E.U. research more cohesive. He must win the support of both the European Parliament and E.U. member governments to implement many of his proposals, but he aims to ask research ministers to endorse the plan in June. –ROBERT KOENIG

GEOPHYSICS

## Did the Dinosaurs Live On a Topsy-Turvy Earth?

Earth's surface is constantly on the move. Over tens of millions of years, the drift of continents carries land from tropics to poles, from poles to temperate latitudes. But another agent of change may be at work beneath our feet, occasionally jerking not just a continent but the whole globe into new climate zones. On page 455 of this issue of *Science*, two researchers report evidence that 84 million years ago the whole Earth rolled like a ball, turning 15° to 20° in a couple of million years. That would be enough to rotate Washington, D.C., into the tropical latitudes of the Caribbean today. To paleoclimatologists, such a rapid whole-Earth tumble would trigger climate shifts that seem to have come out of nowhere. This "true polar wander," so called because the geographic poles could actually travel across the globe, would move land and sea 10 times faster than continental drift ever has. And it may be symptomatic of unusual turmoil within the deep interior of Earth.

Earth's poles are a wobbly crew, as scientists have long known. The magnetic poles ramble around a bit with the vagaries of the churning core that produces the magnetic field. Averaged over tens of thousands of years, though, they stick close to the geographic poles marked by the spin axis, which wobbles predictably while remaining fixedly pointing to the same stars. But despite all this wandering, experts have disagreed for decades about whether the geographic poles ever rapidly shifted their position. "Virtually every test we've done in the past 5 years suggests true polar wander has been overestimated," says paleomagnetician John Tarduno of the University of Rochester, New York. But paleomagnetician Richard Gordon of Rice University sees something like the 84-million-year event in his own data.




**Try, try again.** Intending to crawl from equator to pole, a bug sees the pole wander away as Earth tumbles to keep the bug's mass at the equator.

The principles of true polar wander have been straightforward enough since physicist Peter Goldreich of the California Institute of Technology and mathematician Alar Toomre of the Massachusetts Institute of Technology applied some basic physics to the problem in 1969. A spinning Earth is most stable when its most massive parts, such as an ice sheet on its surface or a lump of particularly dense rock within it, are farthest from its spin axis as marked by the poles—that is, when the extra mass is at the equator. If the mass forms or moves elsewhere, Earth will roll to bring it to the equator, while the spin axis remains pointing at the same stars. In a classic figure (see above), Goldreich and Toomre likened the excess mass to an oversized bug heading from the equator to the pole. If it walks too slowly, the pole will wander away from it, keeping the bug forever near the equator.

The physics worked, but it fell to paleomagneticians to show whether true polar wander has ever happened. They got the nod because they can track ancient magnetic poles, which coincide with the spin axis poles in the long run. The magnetic field is frozen into rocks as they solidify from lavas, recording the pole location. Paleomagnetician William Sager of Texas A&M University in College Station and geochronologist Anthony Koppers of Scripps Institution of Oceanography in La Jolla, California, have compiled 27 ancient pole locations dated to between 120 million and 39 million years ago by radiometric argon-argon dating. They assumed that each of the Pacific Ocean seamounts—mountain-sized piles of lava—had locked in a single magnetic field whose orientation points to the pole's location at the time the lava solidified.

After weeding out the lower quality or undated pole positions, Sager and Koppers found an odd situation about 84 million years ago. Seamounts from that period, give or take 2 million years, yield two pole locations 16° to 20° apart. Plate tectonics couldn't have operated quickly enough to shift the poles that far in the few million years allowed, says Sager: "It looks like there was a rapid polar shift 84 million years ago." By their analysis, the area of the Atlantic Ocean would have moved as fast as 110 centimeters per year southward compared to the top speeds of plate tectonics today of 10 centimeters per year.

Not everyone finds the data convincing. Sager and Koppers "call it true polar wander," says paleomagnetician Dennis Kent of Lamont-Doherty Earth Observatory in Palisades, New York, "but maybe it's something else. Maybe it's bad data." "I think they underestimated the effect of data selection," adds Tarduno: In Sager and Koppers's study, the 84-million-year event is defined by just four poles, he notes.

Gordon, on the other hand, thinks something unusual happened in the Pacific around 84 million years ago. He also sees a large, although less abrupt, polar shift about that time in Pacific paleomagnetic data of a different sort: paleopoles derived from the magnetic field locked into long stripes of Pacific Ocean crust. For complete confidence, true polar wander should appear worldwide, by definition. However, the shift is far less obvious in paleopoles determined

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from lavas elsewhere around the world, Gordon concedes. Tarduno and Kent see that as a serious problem, suggesting a solely regional phenomenon like a redirecting of Pacific Ocean plate motions, but Gordon suspects the data from beyond the Pacific may just not be good enough yet.

If so, he, like Sager, looks to Earth's interior for the driver of true polar wander. Perhaps a pile of ocean plates that had sunk 700 kilometers down finally broke through into the lower mantle, abruptly shifting the planet's mass distribution and triggering true polar wander. Then plate tectonics would lie behind Earth's tipsiness.

–RICHARD A. KERR

REMOTE SENSING SATELLITES

## The Promise of All Weather, All the Time

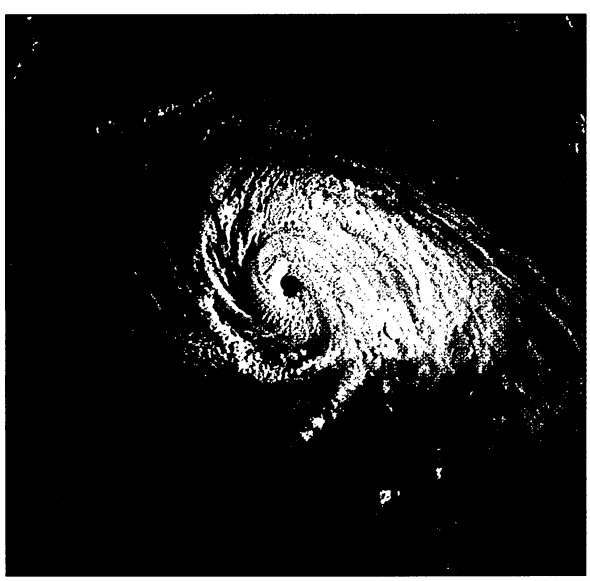
Want to watch the weather unfold on your home computer or TV? Next year a Mississippi company called Astro Vision Inc. hopes to launch the first in a series of small satellites that would provide live, high-quality color videos from space of storm fronts, hurricanes, forest fires, and other natural disasters. The satellites have piqued the interest of NASA officials, who hope that the data will be useful to researchers, and they have caught the attention of venture capitalists, who see an opportunity to feed the Internet's insatiable demand for material.

This week company officials said they have almost finished raising nearly $65 million in private funding for the first phase of their business plan, which calls for the launch of Avstar 1 in October 2001 and a twin 6 months later. The fund raising was aided by the prospect of some real income: Under a 1998 contract, NASA will buy $9.4 million worth of data on how tornadoes form. The company has a broader market in sight, however—the millions of people who watch The Weather Channel and monitor the Web site of the National Oceanic and Atmospheric Administration (NOAA). "We're going to change the way we view Earth's environment and weather," boasts Michael Hewins, the company's chief executive officer. NASA officials aren't willing to go that far, but they are complimentary. "It's a neat little project, and they've got a good shot at making it happen," says David Brannon, chief of commercial remote sensing at NASA's Stennis Space Center in Pearl River, Mississippi, who has worked closely with Astro Vision officials for the past 3 years.

Each Avstar satellite will cost between $20 million and $25 million to build and launch, says Hewins. It would carry both a wide-angle camera with a resolution of 7 kilometers and a second camera with a narrower field to spot objects as small as a half-kilometer across. Although its resolution is poor compared with military spy satellites, it is similar to the 1-kilometer resolution achieved by NOAA's Geostationary Operational Environmental Satellites (GOES) and well-suited for weather watching.

Astro Vision managers will be able to provide users with an image per minute, rather than the single image a government weather satellite typically produces every 15 minutes to a half-hour. That will enable Astro Vision to stitch together videos of hurricanes evolving, thunderstorms growing, and forest fires spreading. A customer interested in volcanoes could be alerted to an eruption, for example, or forest rangers could monitor the spread of fires. The second phase of Astro Vision's business plan calls for launching a satellite every 6 months or so, with a resolution down to 100 meters. In time, Hewins says, the company will operate a fleet of spacecraft "that can watch everything at once—eventually globally."

Fritz Hasler, a research meteorologist at NASA's Goddard Space Flight Center (GSFC) in Greenbelt, Maryland, says the Astro Vision approach could provide researchers greater flexibility than the GOES system, which must choose between viewing Earth from a wide angle or doing rapid scans of a smaller area. "Basically, we can only do one or the other," says Raymond



CREDIT: NASA/GSFC

**Eyeful.** Astro Vision satellites would provide clear view of storms like Hurricane Luis that struck the Caribbean in 1995.

## ScienceScope

**Academic Freedom** Japan's leading university has cautiously endorsed a government proposal to cut loose the country's 98 national universities (*Science*, 13 August 1999, p. 997). A University of Tokyo panel has declared that "denationalization ... could help invigorate research and education" by freeing universities from regulations on administrative matters. However, it says, serious questions remain about whether funding cuts are the price of freedom—or if the government really can let go.

The panel's stance is expected to influence the academic community during negotiations. The education ministry hopes to submit a plan to the Diet by late spring, for implementation no earlier than 2002.

**Chimp Deaths** The Coulston Foundation is in hot water again. According to allegations made by In Defense of Animals (IDA), six chimpanzees have died at the primate lab since last August, when Coulston and the U.S. Department of Agriculture (USDA) announced an agreement that resolved charges of animal-care infractions (*Science*, 10 September 1999, p. 1649). In its latest broadside, IDA asserts that a chimp named Donna died of an infection after carrying a dead fetus in her womb for at least 2 weeks. A USDA report from December notes that the causes of several other deaths were "not fully determined."

Coulston's Don McKinney says the foundation is formulating its response to the USDA report. As for Donna, he says, Coulston vets had delayed surgery to remove the fetus in order to allow her to gain strength after failed attempts to induce delivery. The NIH and USDA are investigating. Coulston could face sanctions if found negligent.

**Numbers Crunched** Indian Prime Minister A. B. Vajpayee's promise to boost research spending sharply by tying it to the country's GDP—initially 1% and rising to 2% over 5 years—assumed that the current spending level is 0.86% of GDP (*Science*, 14 January, p. 209). But the actual figure is 0.66%, Indian officials now admit.

The revision means the government must come up with an additional $500 million—and a total increase of $1.25 billion over a current $2.5 billion budget—to meet the PM's pledge in the 2000 budget. Although a sudden rise of such proportions is unlikely, the head of the Department of Science and Technology says it should be possible to reach the 2% figure in 5 years.

**Contributors: Michael Baker, Andrew Lawler, Laura Helmuth, Dennis Normile, Gretchen Vogel, Pallava Bagla**