international fund dedicated to preserving agricultural biodiversity. The requirement applies only to varieties that are unavailable to other researchers because they are covered by patents or treated as trade secrets.

African nations pressed for a total ban on patenting of plant genes obtained from public gene banks, while the United States rejected any restrictions on patenting that would contradict U.S. law. In the end, in wording that many negotiators admitted was ambiguous, the treaty outlawed patents that would restrict the ability of gene banks to distribute "genetic parts and components" in their original form.

U.S. negotiators felt that this still might block patents on genes that an inventor had isolated and purified from plant seeds. European delegates, meanwhile, were angered that so many crops remain subject to national restrictions, potentially crippling efforts by nonprofit plant breeders to develop improved varieties.

Despite such disagreements, the final vote triggered a spontaneous celebration. "There was half a day of wild emotion," says Pat Mooney of the ETC Group, a Canadian-based advocacy group that has followed the negotiations. "People were hugging each other. The U.S. negotiators were partying, too."

The treaty will go into force when 40 nations ratify it. Mooney says that the U.S. abstention will not cripple the effort and that the United States is expected to abide by most of its terms. **–DANIEL CHARLES**

Daniel Charles is a science correspondent at National Public Radio.

SPACE STATION

Science Comes First, Panel Tells NASA

NASA has been told to revamp its current plan for the international space station and put greater emphasis on science. A new report by an independent panel led by former aerospace executive Thomas Young says NASA must come up with realistic costs for building the orbiting lab, pay more attention to its research components, and adopt a new management structure before finishing with construction.

The 20-member panel, which delivered its blunt report on 2 November, was set up in July by the White House and NASA to analyze the station's costs, which have nearly doubled to $30 billion in the past 4 years. The task force unanimously concluded that even its plan for a scaled-down version "is not credible." But the panel, which could not even guess at what the current price tag is, offers the agency a reprieve. If NASA can fix the station's problems in the next few years, then the government could consider enlarging the station to accommodate a crew of six. That recommendation marks a political middle ground between White House officials who don't want to spend any more money on the program and agency managers, researchers, and international partners who want a top-of-the-line facility.

The high-powered team of financiers, engineers, and scientists also went beyond its limited charter to tell NASA to emphasize research and to put biology at the top of the research agenda. "The space station needs to be looked at differently; it's a science mission," says Young. Some members want the Bush Administration to see the station as the first step toward future human space exploration. "The space station with nothing to follow it is worthless," says one. Adds panelist Rae Silver, a Columbia University research psychologist: "What's needed is strong leadership and clear vision."

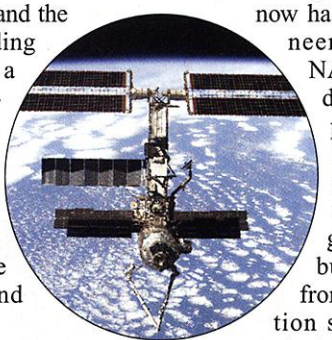
Such qualities may be hard to come by. Longtime NASA Administrator Dan Goldin steps down this month, at a time when the White House Office of Management and Budget is openly hostile to additional funding and Congress is skeptical of NASA's ability to deliver on its promises to provide a worthwhile laboratory. The fiscal constraints caused by a lagging economy and the focus on antiterrorism spending will hinder development of a long-term space strategy, Administration officials say.

The current station crisis, simmering for years, came to a boil this spring after the White House ordered NASA to trim costs. The agency cut the planned crew size in half and abandoned a living-quarters module and a rescue vehicle, sparking an outcry from potential users. But even those cuts are not enough to keep the station within the $8.3 billion spending limit between 2002 and the scheduled completion of the core U.S. portion in 2006.

The report doesn't tot up the bill, but panel members say privately that more than $1 billion extra is needed. The panel recommends that NASA find the money by limiting shuttle flights and other aspects of its human space-flight budget. Halting work on the core station, however, would have "significantly adverse impacts on the science," Young warns. The primary international partners—Canada, Europe, Japan, and Russia—also fear that a three-person crew would limit their access and capabilities.

If NASA can demonstrate they can complete the core program in a credible manner, then the Administration should consider adding the hardware necessary for a six-person crew, the panel concludes. But neither the panel nor NASA would estimate how much that additional hardware would cost. In the meantime, Young's group suggested boosting research dividends by docking two Russian Soyuz vehicles for at least 1 month out of six at the station. The arrangement would allow a six-person crew to conduct more experiments.

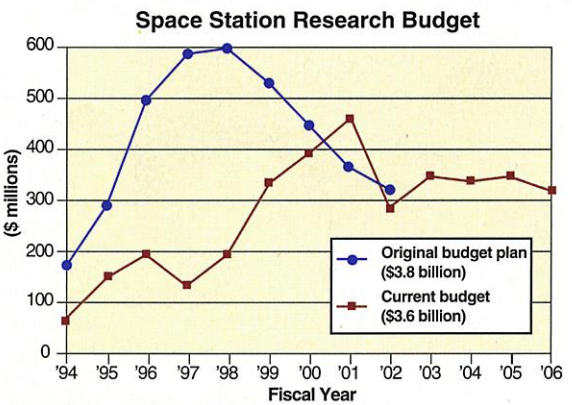
The panel also urges NASA to turn the massive engineering project into a realistic science program. "NASA has not been good at prioritizing its research" for the station, Silver says. "The whole program until now has been controlled by engineers." The panel calls for NASA to create a science deputy in the space station program and to coordinate better the research and space-flight offices. Planners must also come to grips with the 40% loss of buying power that resulted from diverting into construction some of the $3.8 billion promised in 1993 for research.



CREDIT: NASA/JPL

One victim has been the station's centrifuge, initially the responsibility of NASA and now being built by Japan. The 2008 launch date for a large centrifuge is "unacceptable," the report declares about a facility needed to test the effects of microgravity on living organisms. "If you are going to do the kind of science that gets published, you need a centrifuge," says Richard Roberts, panel member and Nobel laureate at New England Biolabs in Beverly, Massachusetts. And biology should be king, panelists add, if NASA hopes to obtain the sort of knowledge needed for continued human exploration of space.

A clearer idea of what NASA wants to accomplish is critical to a successful science program, say panelists. "You have to know



Research delayed. NASA's original research budget, adopted in 1994, has been stretched out and shrunk to make room for rising construction costs.

the purpose of the station and view it as a way point toward something else," says Robert Richardson, vice president for research at Cornell University in Ithaca, New York. "The vision issue was the most heated part" of panel discussions, recalls Silver. Before they can focus on the long term, however, NASA's new leaders must first survive the current national crisis and the resulting tight fiscal constraints. **–ANDREW LAWLER**

QUANTUM PHYSICS

Spooky Twins Survive Einsteinian Torture

It's a nagging truth that all physicists must face: Relativity and quantum mechanics don't mix, and when they square off, Einstein loses. Now Swiss physicists have brought the two great theories into the arena again. In an experiment that turns commonsense notions of causality on their head, the scientists showed that relativity's tools for dealing with the flow of time are irrelevant in the submicroscopic realm of quantum processes.

The experiment, conducted at the University of Geneva, explored the properties of pairs of particles whose fates are linked through a mechanism called entanglement. As long as physicists don't examine them, such so-called Einstein-Podolsky-Rosen (EPR) pairs enjoy a wishy-washy existence, not committing themselves to any particular states of properties such as polarization. But jolt one of the particles into choosing—say, by noting its existence with a detector—and the other instantly feels the tweak, even if it's millions of light-years away. If one particle is detected with horizontal polarity, for instance, the other might instantly assume vertical polarity.

Lab experiments have repeatedly confirmed that this "spooky action at a distance" operates faster than light, although physicists have shown that it doesn't violate relativity because it can't be used to send faster-than-light messages. In the mid-1990s, however, Swiss physicists Antoine Suarez and Valerio Scarani realized that EPR pairs pose a different sort of relativistic problem, because it's not always clear which particle is tweaking which. The reason is that according to Einstein, observers in different reference frames can disagree about the order in which events occur.

In a classic thought experiment, for instance, physicists like to imagine a person with a 15-meter-long pole running into a 15-meter-long barn at four-fifths the speed of light (see figure). To an observer looking down from the rafters of the barn, the streaking pole seems to be contracted to 9 meters, so it fits entirely within the barn. This means an electronic sensor can (a) shut the front door and then (b) open the back door. But from the pole's point of view, the *barn* is moving. It shrinks to 9 meters long, while the pole retains its full length of 15 meters. Why doesn't it smash into the barn door? Because the order of events is different from the runner's point of view. The pole carrier clearly sees (b) the back door open before (a) the front door shuts, the opposite of what a stationary observer sees.

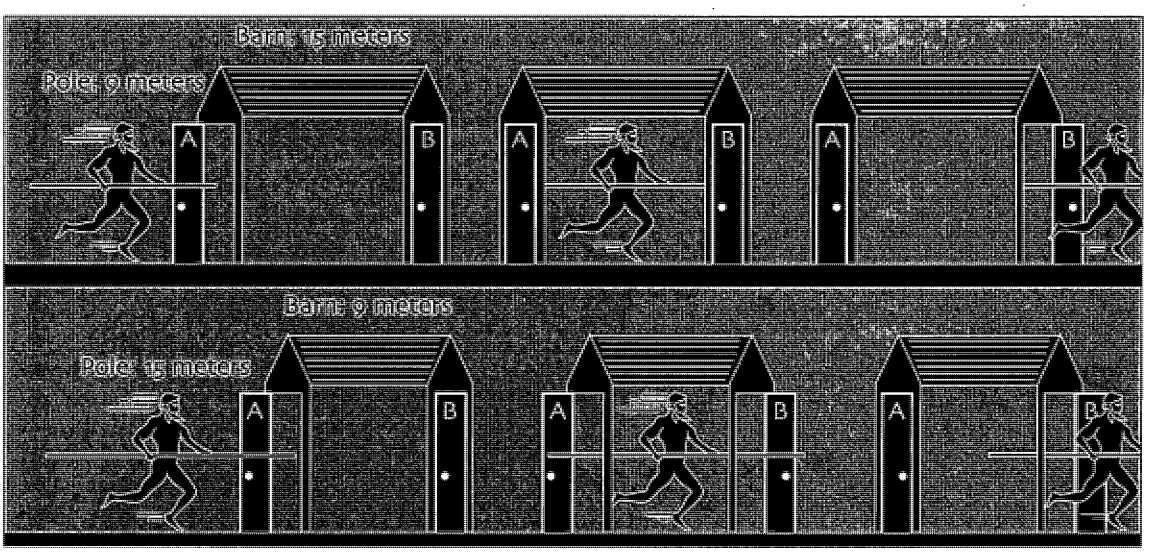
Likewise, if two scientists are moving with respect to each other when they measure each half of an EPR pair, they might disagree about who measured the particle first. How could the twins be "communicating" if both scientists think that their twin is the sender and the other is the receiver? In such a "before-before" situation, Suarez and Scarani argued, the two particles can't be communicating at all. The spooky action must fall apart.

The Suarez-Scarani theory suffered a setback last year, when Nicolas Gisin of the University of Geneva and his colleagues put it to an ingenious test (*Science*, 17 March 2000, p. 1909). They set up an experiment in which a laser spat out entangled pairs of photons. After zipping through fiber-optic cables, each entangled photon struck a beam splitter, which gave the entangled photons a "choice" of paths leading to different particle detectors.

To bring relativity into play, Gisin used a whirling drum as a stand-in for one of the device's stationary photon detectors. The drum's motion created an Einsteinian before-before situation, in which each detector thought that it had measured the photon before the particle's twin struck the other detector. Contrary to Suarez and Scarani's theory, the particles stayed entangled. The refutation wasn't quite airtight: Skeptics pointed out that the Suarez-Scarani interpretation could still be true if the particles made their "choices" of path before they struck the detector—at the beam splitters, for example.

The new experiment closes that loophole by showing that the particles still communicate even if they make their choice at the beam splitters. Using nearly the same setup, Gisin's team—with Scarani added—replaced the moving detector with a stationary one and made the stationary beam splitters into moving ones by pumping sound waves through crystals. In a paper submitted to *Physical Review Letters*, Gisin and his team describe how they set the speeds of the beam splitters to create a before-before situation. As in the earlier experiment, the particles remained entangled. Although each particle hit the beam splitter "first," and thus thought it was the sender rather than the receiver, the particles were communicating just as well as when the beam splitters were stationary.

The results, Suarez says, leave the theory he and Scarani proposed no wiggle room. "The notion of time makes sense only in Einstein's world," he says. "It doesn't make sense in the [quantum world]. It cannot be described in terms of before and after." And for those who prefer to live in a world of cause and effect, spooky action at a distance just got even spookier. **–CHARLES SEIFE**



What next? Quantum experiment's relativistic quirks resemble those of a pole moving through a barn at near the speed of light. An observer in the barn would see a short pole and both doors closed at once, but the runner carrying the pole sees a foreshortened barn with at least one door always open.

ILLUSTRATION: A. STONEBRAKER