ECOLOGY

Can Basic Research Ever Find A Good Home in Biosphere 2?

John B. Corliss recently landed a job that sounds like a scientist's dream. The 56-year-old biologist is now in his third week as research director of a vast ecology project in the Arizona desert—a far cry from his former desk job, formulating computer models of evolution as a visiting scientist at the National Aeronautics and Space Administration's (NASA) Goddard Space Flight Center. But there's a catch: The project Corliss is heading is Biosphere 2, the glass-encased ecosystem in Oracle, Arizona, that many researchers deride as a scientific joke. Corliss' daunting mission: making this odd hybrid of commercial tourist attraction, New Age venture, and research project scientifically respectable.

PETER MENZEL

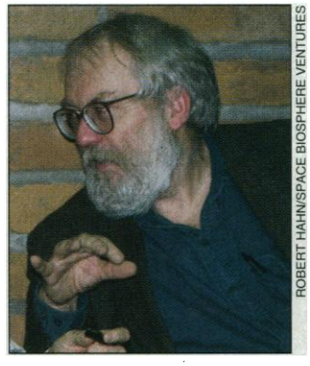
Fallen from grace. Beauty belies a tarnished reputation.

That task grew a bit more difficult last month, before Corliss' arrival, when the 11 members of Biosphere 2's independent scientific advisory committee resigned en masse. Committee members say that they've been left out of key decisions and kept ignorant of important information—indications, they argue, of Biosphere 2 managers' reluctance to accept scientific advice. But the committee's departure may not be the blanket condemnation of Biosphere 2 that it seemed at first blush: Even the most critical committee members admit that the prospects for basic research at Biosphere 2 have improved over the past 8 months as the project's managers became more accommodating. "We did make some progress," admits Thomas Lovejoy, the committee's chairman and assistant director of external affairs at the Smithsonian Institution. Adds committee member James Arnold, a geochemist at the University of California, San Diego, "I'm reasonably optimistic. I think there is the will there to get [research projects] done."

A few biologists and geochemists have seconded that verdict by starting their own studies at Biosphere, and many others still hope to take advantage of what they see as unique scientific opportunities. "There's still the chance of seeing some really interesting work come out of it," says Daniel Vogt, an ecologist at the Yale School of Forestry and Environmental Sciences who is conducting basic research on Biosphere's soils and plants. But the outcome, researchers agree, hinges on Corliss' success at organizing the research program and convincing the Biosphere 2 management to give scientists free rein.

In its early days, the $150 million Biosphere 2 seemed an Eden of scientific possibilities: the largest enclosed ecosystem in the world, containing 3800 species in five diverse habitats, from desert to rain forest. Eight "biosphereans," who sealed themselves into the enclosure in September 1991 and vowed to stay for 2 years, are collecting data on how these species interact with one another and with Biosphere's soil, atmosphere, and miniature ocean.

But the scientific appeal soon wore off as the managers of the privately funded project displayed an unnerving penchant for secrecy and control. In late 1991, officials with Space Biospheres Ventures (SBV), the private company that owns Biosphere, admitted that they had installed a chemical scrubber inside Biosphere 2 to clean the air of excess carbon dioxide, despite earlier claims that the system would balance itself. Scientists reported that Biosphere 2 officials—because of proprietary concerns—were refusing to allow publication of some data and, to ensure that Biosphere 2 remained a closed system, had banned the removal of most research samples. And a former employee accused SBV of installing computer systems that allowed data to be doctored.



ROBERT HAHN/SPACE BIOSPHERE VENTURES

Redeemer? The new scientific director, John Corliss.

What science was being done at Biosphere 2 was mostly the work of paid consultants, who have had to devote much of their time to solving technical problems and collecting data about how the habitats are changing. "It's not a lot of experimental work," says Biosphere 2 primate adviser Kay Izard, a private consultant. And it wasn't enough to prevent the project from losing its scientific credibility. In early 1992, SBV asked Biosphere 2's independent scientific advisory committee for advice about how to rehabilitate it. Last July, the committee released a blunt report calling for the appointment of a scientific director to coordinate research and recommending major changes in Biosphere 2 operations.

In the past 8 months, managers have followed many of the committee's recommendations. Scientists now receive soil, air, and water samples through Biosphere 2's airlock. Researchers say they are now much freer to publish their work than before the report came out. Although SBV still wields the power to review all papers before they are submitted, consultants and independent scientists insist the requirement causes no trouble. "We've never had any problems getting authority for anything we wanted to do," says consultant Scott Miller, an entomologist at the Bishop Museum in Hawaii. So far, however, SBV's openness has not been tested much; to date, only two papers have appeared based on research in Biosphere 2—one about changes in the biosphereans' health and one about the Biosphere 2's potential as a tool for studying restoration ecology.

More papers—and a clearer verdict on whether Biosphere really has changed its ways—are in the offing. For example, geneticist John Avise of the University of Georgia, an independent collaborator, has been studying genetic drift in two species of mosquito fish released into Biosphere 2's estuary and streams when it was sealed. A group of geochemists led by Wallace Broecker of Lamont-Doherty Earth Observatory, meanwhile, is tracing the cycling of elements among plants, soil, and air. Along the way, Broecker and his colleagues hope to solve the puzzle of Biosphere's missing oxygen: Oxygen levels inside the dome had dropped nearly 30% by mid-January. One candidate explanation the group is now pursuing is that the oxygen is reacting with iron in Biosphere 2's rich soil.

So far, says Broecker, he has few complaints about the Biosphere management. To do their studies, for example, he and his collaborators rely on SBV to give them accurate reports on the operation of the facility—how much air

is leaking in and out, for example, and how much carbon dioxide is being scrubbed from the atmosphere. Broecker says he's convinced that managers are now running the facility as advertised. "If they had big sins to cover up, they would never have let us in," he argues.

Still, he and his collaborators, like other scientists doing work at Biosphere 2, were shaken by the advisory committee's resignation last month. "Originally, we thought it was a very bad omen," says Jeff Severinghaus, a graduate student of Broecker's. Now that he and Broecker have spoken to a committee member and learned some of the background, says Severinghaus, "we think it's not such a big deal."

But the committee's rocky tenure shows that Biosphere 2's management is still a long way from being a model of openness. Committee members and scientists say that SBV, as a private company, has had trouble adapting to the scientific culture and its free-wheeling exchange of information. Collaborating with researchers is "an educational process for SBV," says Phillip Dustan, a biologist at the University of Charleston who is working as a consultant and doing basic research at Biosphere 2. "They're used to working in secret—[it's] that corporate mentality."

For example, says committee member Gerald Soffen, director of university programs at NASA-Goddard, the committee heard about the oxygen problem only after SBV had decided to relieve it by pumping in fresh oxygen. "They didn't really need us to do more than bless" the decision to add oxygen, Soffen says. In January, SBV even added three new members to the committee without consulting the original eight members. Most upsetting of all, say some committee members, SBV ordered the search firm looking for a scientific director not to talk to Lovejoy and justified the ban as necessary for preserving the search's integrity.

Predictably, some committee members doubt whether Corliss, who had been working on a model of Biosphere 2's biogeochemical cycles while at NASA, is up to the job of directing research at Biosphere 2 and mediating between scientists and management. Though a respected scientist who helped pioneer the study of life at deep-sea hot springs, Corliss has never held an administrative position. "I just do not see Jack running anything like that," Soffen says.

Corliss, for his part, thinks he'll manage just fine—and he seems unconcerned that he won't have the full committee's advice. "The people who couldn't work with us left," he says, and he's not looking for replacements. Though he will continue to receive advice from a few committee members, "we won't have any more committees. I think we know what we're doing." All decisions, he adds, will be made "within the organization"—including the selection of the scientists who have access to Biosphere 2 data. The many scientists who still see bright possibilities within Biosphere 2's dome can only hope that "the organization" takes their interests to heart.

–Traci Watson

MALARIA

Controversial Vaccine Shows Promise

Manuel Patarroyo is used to marching out of step with the international malaria research community. Ever since the Colombian immunologist burst onto the scene in 1987 with a paper in *Nature* describing a synthetic vaccine that seemed to protect monkeys from the disease, his claim to have produced a new weapon in the war against malaria has been viewed with intense skepticism. Many researchers argued that Patarroyo's vaccine couldn't be all it was cracked up to be—particularly as there seemed to be no correlation between antibody responses to the vaccine and protection against malaria. And when Patarroyo launched straight into a huge program of testing his vaccine in thousands of Colombians, that initial distrust soon turned to open criticism of the design—not to mention the ethics—of Patarroyo's trials. "His initial data and the studies that generated them were obviously flawed," says Ripley Ballou of the Walter Reed Army Institute of Research.

The gulf between Patarroyo and the malaria research establishment may be about to narrow, however, with a paper scheduled for publication in the 20 March *Lancet* that Patarroyo believes will silence his critics. The paper describes a new Colombian trial—designed in consultation with a former skeptic—involving more than 1500 people. It shows the vaccine reduced the risk of malaria by 39% in immunized volunteers. Indeed, with a Walter Reed group now planning a clinical trial in Thailand using a U.S.-made version of Patarroyo's vaccine, and an international trial in Tanzanian children already under way (*Science*, 9 October 1992, p. 207), 1993 could be the year in which the maverick Colombian scientist—and his controversial vaccine—finally come out of the cold. "There's no question about it," says malaria vaccine pioneer Ruth Nussenzweig of New York University School of Medicine. "He's coming back into the mainstream."

In from the cold. Manuel Patarroyo hopes to gain credibility by publishing his results in the *Lancet*.

For Patarroyo, the skepticism he's encountered until now is easy to explain: "I knew it would not be easy for people to swallow the fact that I had made the first...vaccine against a parasitic disease," he says. But to most malaria researchers, it has been Patarroyo's consistently unorthodox approach that has posed the greatest barrier to acceptance. The conventional wisdom is that to be effective, a malaria vaccine would have to mobilize the cellular component of the immune system in addition to generating antibodies. Yet Patarroyo made his vaccine from peptides more likely to produce an antibody response. What's more, many researchers in the mid-1980s were pinning their hopes on a vaccine to attack the parasite in its sporozoite stage, the form in which the organism is injected into the bloodstream by a biting mosquito. But Patarroyo targeted mainly the merozoite form, which develops from the sporozoite and causes the fevers and chills typical of the disease. Although his initial attempts to find a merozoite peptide that would completely protect monkeys from malaria were unsuccessful, he eventually came up with a cocktail of three peptides that showed promise, and then by a deft stroke of chemical legerdemain used two sporozoite peptides to link them in a stable form.

What really drove a wedge between Patarroyo and the malaria research establishment, however, was the speed with which he then rushed into the field. Even at the time of his second *Nature* paper, in 1988, describing a preliminary trial showing the vaccine to protect two out of five immunized human volunteers, questions were being asked about the ethics of Patarroyo's research. In an accompanying article, malariologist Louis Miller of the National Institute of Allergy and Infectious Diseases in Bethesda wrote that Patarroyo's "failure strictly to follow the protocol [of his study] placed some volunteers at excessive risk" of a dangerously high parasite load. And concerns were voiced more and more loudly as the numbers of people