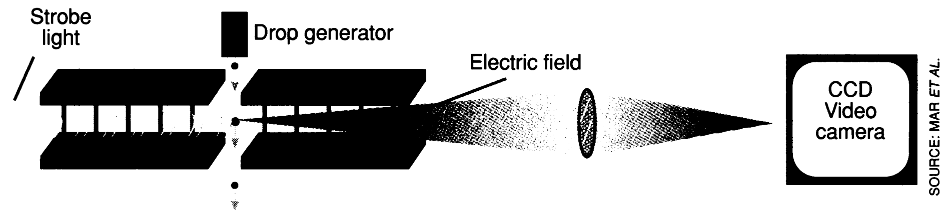
Alamos physicist George Zweig: "Every theory needs to be checked out thoroughly. Compared to general relativity, which has been tested over and over again, QCD is relatively untested." Still, the prospect of a payoff is so small that "a younger scientist trying to make a reputation would be well-advised to avoid this line of work," says Roger Bland, a physicist at San Francisco State University who has conducted quark searches himself.

Searches for free quarks got under way soon after Murray Gell-Mann and Zweig published papers in 1964 independently proposing the quark model. On the off chance that an unconfined quark could somehow have survived the cooling since the big bang, either attached to an atom or flying through space on its own, investigators have employed a number of methods—the oil-drop technique, magnetic levitation, particle accelerator experiments, and cosmic ray searches—and combed through materials ranging from metals to moon dust and even oysters. All these efforts have turned up empty-handed, save for a Stanford project headed by William Fairbank, who claimed in the late 1970s and early 1980s to have found evidence of fractional electric charge in niobium spheres—results that were never substantiated.

Every other research group except for Perl's has since called off the search. Bland's team quit a decade ago for the same basic reasons others have given up: the lack of positive results and the lack of funding. "Not finding anything means you either have to search more matter or search in a very clever way in just the right places," Bland says. "We didn't know where to look, nor did we see a way of measuring much more than a few milligrams of matter with our technique."

Perl and his collaborators have improved the oil-drop method used by Bland's group, making the droppers more reliable, automating the measurement process, and reducing measurement error to a fortieth of the charge of an electron—the best charge resolution ever achieved in such experiments. When the SLAC team conducts its second run later this year, these and other modifications should enable them to examine 100 times more material than has ever been sifted through before, at a cost of a few tens of thousands of dollars a year.

Perl and company are no further along than their predecessors are in determining the right places to look for free quarks, however. Perl suspects that metallic substances like mercury may offer the best prospects, as unbalanced charges tend to be attracted to metal surfaces. He also thinks that primordial solar-system material might be a good hunting ground, which means looking at meteorites. For now, though, "we're working with silicone oil because it's easy and we know how to do it," Perl says. After establishing the methodology with silicone oil, he plans to check out other candidate materials.



Slow leak. The speed at which droplets of silicone oil fall through a changing electric field reveals any unbalanced charge—including the fractional charge that would signal a free quark.

"It takes a certain type of personality to pursue projects with such a low chance of success and little glory if you don't find anything," Zweig notes. Yet Perl, as a tenured Nobel laureate, has the "luxury" of continuing the search. "I like the technique, and I like watching the experiment run and improve," he says, adding that he means to quit before he becomes obsessed—within 3 or 4 years at most. He still holds out some hope that free quarks exist and that his group might be lucky enough to find some. "Life is easier for theorists if there are no free quarks," he says. "But it's more interesting if there are, because that means there's more work for all of us to do."

–Steve Nadis

Steve Nadis is a writer living in Cambridge, Massachusetts.

BIODIVERSITY

Focal Species Offer Management Tool

BRISBANE, AUSTRALIA—Patches of untouched vegetation are scarce in this vast country, where the rural landscape is dominated by a mosaic of cropland and pastures. But these patches are prized by conservationists because they often provide the only suitable habitat for a significant number of endangered plants and animals. Unfortunately, it's not always clear how to rebuild this highly degraded and impoverished landscape and to stem the rates of extinction. And because the land is not public, preservation efforts must also benefit the farmers that own it.

Enter Robert Lambeck. An ecologist for the Commonwealth Scientific and Industrial Research Organization (CSIRO) Division of Wildlife and Ecology, Western Australia, Lambeck has adopted an approach that makes the very complexity of the problem part of the solution. Rather than focusing on what's needed to protect a single species, say the spotted owl in North America or the Australian numbat, a banded anteater, Lambeck has begun to gather data on a range of "focal" species to help define the attributes of a viable landscape. Once that landscape is defined, scientists and public officials can work with private landowners to preserve both biodiversity and the value of the enterprise.

Ecologists find the notion an attractive one. "The main value of his model is that it helps break the single-species mindset of Australian ecologists," says ecologist David Goldney from Charles Stuart University, New South Wales. And Dan Simberloff, a leading conservation biologist from Florida State University in Tallahassee, says the idea may actually work. Species sometimes have conflicting requirements that make it hard to form a single conservation plan for a single habitat, he says, citing the "nasty" legal battles over water-level regulation in the South Florida Everglades based on the differing needs of two endangered species, the snail kite and the wood stork.

Imperiled patch. This mix of wheat fields, grazing lands, and nature reserve in western Australia highlights the need for a unified approach to biodiversity.

Lambeck, who presented his model at a conference here last month,* hails from southwestern Australia, where wheat fields dominate the landscape. Thirty percent of the native mammals are extinct, populations are declining in half of the bird species, and 24 plant species have disappeared from the wheat belt.

To conserve as many species as possible, conservationists would prefer to set aside large tracts of pristine land. Unfortunately,

* "Conservation Outside Nature Reserves," 2 to 5 February, University of Queensland.

wildlife conservation was rarely a priority for private landowners, who simply cleared the land to make room for crops. As a result, the remaining wildlife habitat now exists as widely scattered patches of remnant vegetation. Furthermore, on most farms little is known about what species are present and how these species are using the existing landscape.

So Lambeck took a different approach. He begins with a field survey of existing species and those likely to occur in the region. Experts then review the list and eliminate species whose survival is not threatened. Vulnerable species are put into subgroups based on the kinds of management strategies and interventions needed to ensure their protection. Some species—a plant called the acorn banksia, for example—may only require fencing to exclude cattle from browsing, while other species, such as the yellow robin, may require more drastic reconstruction of the landscape.

The species with the most restrictive demands—those limited by area, by movement within the area, and by the availability of resources—are used to identify the critical elements of the landscape. The single species with the greatest area requirement, for example, becomes a "focal" species and sets the minimum area for patch size in the landscape design. Similarly, the species with the least mobility defines where in the landscape the patches are located and how they can best be connected, through corridor paths or other means. And looking at which species are absent from a region could suggest which native plants should be added to the landscape.

That, at any rate, is the theory. And while it's a plausible one, other conservation biologists note that reality can be more complex. Some worry that Lambeck's model does not pay sufficient attention to climatic variations over time within a single region. "He is taking a snapshot," says Steve Falconer, project officer for Rural Nature Conservation of the World Wildlife Fund, New South Wales. "I question whether it takes enough into consideration to ensure long-term viability of the ecosystem."

The focal model includes continuous monitoring of resident species populations, Lambeck responds, a strategy that should yield data on natural fluctuations and allow for appropriate readjustments of the conserved area. Any strategy "based on the needs of the focal species [that] is found not to be true" must be modified, he says.

Lambeck's model must also stand up to fiscal realities. Conservationists are concerned about the lack of money available in Australia to fund large-scale projects, such as buying land for habitat preserves. Nor do farmers receive any tax deductions for setting aside land for conservation.

But Lambeck says that farmers have shown interest in his plans as long as such plans don't conflict with their own. On the large wheat farms where Lambeck has worked, for instance, the land suffers from salinity due to high water tables. To lower the water table, farmers can devote marginal land to exotic trees or native vegetation or both instead of wheat. CSIRO ecologist Denis Saunders says this indicates that preservation and profits are not mutually exclusive. "Farmers use economic and planning models to increase production," he says. "We are now trying to integrate Lambeck's model with [existing strategies] so that both farm production and wildlife conservation can benefit."

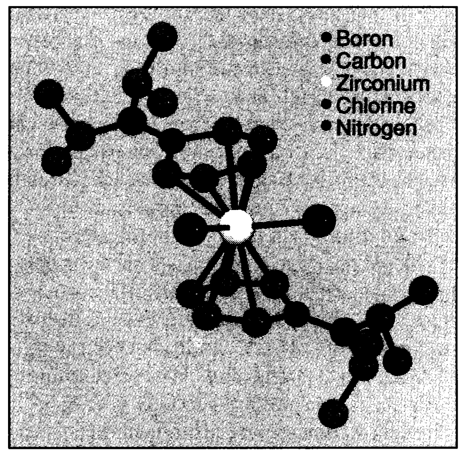
–William James Davis

William James Davis is a free-lance writer in Queensland, Australia.

MATERIALS SCIENCE

Tuning a Catalyst for New Plastics

If plastics are big business, the catalysts that create many of them are the keys. Indeed, without them, plastic production, currently worth hundreds of billions of dollars annually, would be hobbled because there would be no way to link the small chemical building blocks from which plastics are made. One breed of catalysts that link building blocks called alpha-olefins typically employ rings of carbons to do their jobs. But now researchers, by inserting boron atoms into the carbon rings, are developing a new class of catalysts—and possibly whole new classes of polymers, too.



G. RODRIGUEZ

New tune. Adding boron to carbon rings lets researchers "tune," or adjust, the electronic behavior of this catalyst.

In the 6 March issue of the *Journal of the American Chemical Society*, a group of chemists at the University of Rochester in New York and the University of Michigan in Ann Arbor report that boron atoms, in combination with different chemical groups attached to them, can change how electrons are distributed throughout the catalyst molecule. That should give scientists a new way to "tune," or change, the catalyst's electronic properties. Because those properties help determine which olefins the catalyst will link together and how they assemble, increased tunability should lead to new types of polymers, possibly with different molecular weights or densities, says Guillermo Bazan, one author of the report. Just what those polymers will look like and how they will behave "is impossible to predict," he says. But although the researchers have not yet created a catalytic choir, just one compound humming a single note, it performs as well as current catalysts, and thus is "a promising first step," says Francis Timmers, a catalysis expert at the Dow Chemical Company's Central Research Laboratories in Midland, Michigan.

Catalysts of this type, known as metallocenes, typically consist of a single metal atom, such as zirconium, surrounded by a pair of all-carbon rings, which are in turn linked to other chemical groups. One end of the growing polymer chain binds near the metal, while together the rings and dangling groups control access of the olefin building blocks to that interior complex, forcing them to bind in one preferred orientation to the end of the chain. Bazan and his colleagues found that adding boron atoms to the rings shakes things up a bit. Boron is electron-hungry and tends to borrow electrons from other atoms in the catalyst, atoms either in the surrounding chemical groups or the core atom itself. That change in the distribution of electrons in the catalyst molecule is what alters the catalyst's interaction with the olefin building blocks. Along with Arthur Ashe and his colleagues at Michigan, Bazan and his Rochester group found they could control this electron distribution by adding specific groups to the borons. The researchers linked the borons to nitrogen-containing amine groups and then inserted the borons into a pair of carbon rings surrounding a zirconium atom. As a result of this configuration, each boron grabbed a pair of electrons from the nearby nitrogen, leaving those around the metal undisturbed. That made the catalyst behave just like an ordinary catalyst with all-carbon rings and produce polyethylene and other polymers as effectively as conventional metallocene catalysts.

The researchers next plan to replace the amines with carbon-based phenyl rings. These rings should not give up electrons to the boron atoms, which should therefore scavenge electrons from the zirconium—altering the metal's electronic and catalytic behavior. If so, polymer catalysts may soon be singing some new tunes.

–Robert F. Service