for example, but the Survey, Sheldon notes, has aimed for relatively "price-free" figures that include a larger measure of speculative resources than most. All in all, he told *Science*, "the [Academy] report did an excellent job of establishing a floor on resources, but it didn't pay much attention to the ceiling, which is much harder to estimate."

The Survey and the Academy committee would probably agree on at least one point: that the art of resource estimation is, in Sheldon's words, "in a very unsatisfactory state of affairs right now."—ROBERT GILLETTE

New Alchemy Institute: Search for an Alternative Agriculture

Falmouth, Massachusetts. The new alchemists are a small group of people who consider that modern American agriculture is a mighty edifice built on sand. They expect it to collapse, maybe within the next 10 to 20 years, either from intolerable price increases in the fuel and fertilizer needed to sustain it, or because of the accumulating weight of biological damage caused by agricultural chemicals.

While others may dispute the analysis, the new alchemists are acting on it by trying to develop an alternative, and radically different, mode of food production. They want their style of agriculture to depend on renewable sources of power, such as sun and wind, instead of on fossil fuels; on natural biological cycles, not on biocides and chemical fertilizers; to be based on a diversity of crops and varieties, not on genetically vulnerable monocultures; to select plants for their taste and nutrition, not for trucking and packaging qualities; to require little capital investment and encourage people to come back to the land instead of driving them off it.

Such an idyll may not be possible outside the Garden of Eden, but the new alchemists' endeavor to attain it will be important even if it fails. In fact the group has already made quite substantial progress, considering the scantiness of its resources. Greenhouse complexes, solar heating devices, and windmills with brightly painted allegorical suns on their tails are evidence of an unusual experiment in progress at the New Alchemy Institute's 12-acre farm near Falmouth on Cape Cod. The institute is supported by more than a thousand associate members, each subscribing at least $25 a year, as well as by grants from the Rockefeller Brothers Fund and other foundations. It is likely soon to be awarded a contract worth several hundred thousand dollars from the Canadian government to set up an "ark"—a new alchemical food producing system—on Prince Edward's Island.

The New Alchemy Institute was founded in 1969 by two marine biologists, John H. Todd and William O. McLarney. The choice of name implied not a rejection of modern science but a harking back to a time when science, art, and philosophy did not have to be practiced as separate, mutually exclusive realms of knowledge. Todd has a broader training than most scientists—a B.Sc. in agriculture, an M.S. in parasitology and tropical medicine, and a Ph.D. in comparative psychology and ethology—yet he and his associates found, he says, that "with all our scientific training, we could not make any little piece of the world work."

A focus of the group's concern was the damage being done to nature by modern agriculture, and the fact that no one seemed to be tackling the problem at its roots. People in universities seemed to be concerned only with patch-up operations, trying to make the existing system less harmful instead of replacing it altogether.

The group pooled their savings to administer the institute and work on a small ranch in Southern California, where Todd and McLarney held teaching posts at San Diego State University. The goal of developing ecologically derived, low cost, low energy food production continued at Cape Cod when Todd and McLarney transferred to the Woods Hole Oceanographic Institution in 1970. Since early last year they have been working full time at the New Alchemy Institute.

One of the early design goals was to see if it would be possible to raise enough food to support a small group of people on a very limited area. For sufficiently rapid growth, it was necessary to consider tropical systems, which led the new alchemists to experiment with the hot environments created by geodesic domes and greenhouses.

Although these structures trap heat during the day, they lose it at night. Water, however, is an effective storer of heat, which suggested the idea of raising fish.

We brag of being a nation where food is relatively cheap and agriculture efficient, yet ignore the fact that most measures of food prices and farm efficiency fail to take into account the endangerment to such valuable resources as soil fertility, water, wildlife, public health and a viable rural economy. When we stop to consider the full impact of the agricultural tools that have replaced the people who crowded into the cities, it is clear that "modern" agriculture is causing more problems than it is solving. . . . In recent years, conventional science has come under increasing attack for the moral implications of its basic inquiries and the long term significance of its applied tools. There has been relatively little criticism of the agricultural sciences along these lines since the external costs of farming are just beginning to surface with a broad impact.
—Richard Merrill, in The Journal of the New Alchemy Institute, *No. 2, 1975.*

Commercial aquaculturists nurture their fish with fishmeal, grains, and other foods that, as with feedlot cattle, could be fed directly to humans. To avoid such "agricultural imperialism," the new alchemists have tried to devise less wasteful means of production. Their contribution is not so much of no biocides, no high-energy requirements, and no technical solution where a biological one can be devised instead. Their contribution is not so much in terms of uniquely new ideas, though

there are some of these, as in the reintegration of existing knowledge and the rediscovery of precepts forgotten since the advent of modern agriculture, such as how to deal with pests by methods other than pesticides.

Several of the new alchemists' concepts are embodied in a polycultural food-producing system called an "ark" —so named in part because of its biological diversity and autonomy and in part because it would serve as a lifeboat if conventional agriculture goes under. The ark consists of three greenhouse-covered ponds built one below the other on a slight incline. It is essentially a chain with the first two ponds growing food for the fish in the third. The bottom-most pond holds edible species of fish, chiefly the tropical tilapia or St. Peter's fish. Water from the pond is pumped up by a windmill to the top pond, passing through a solar heater en route if the sun is shining.

In the top pond the water is shunted through a bed of crushed shells permeated with bacteria which detoxify wastes and degrade certain growth-inhibiting chemicals excreted by the fish. The bacteria convert the ammonia in the fish wastes to nitrites and nitrates, which are used as nutrients by the algae in an adjacent compartment of the pond.

Algae-laden water from the top pond flows into the middle pond, inhabited by the small, algae-eating crustaceans known as water-fleas or daphnia. The water arrives in the bottom pool completely purified and laden with algae and daphnia which provide a complete diet for the fish. (Tilapia are mostly vegetarian, but the young require animal protein for rapid growth.)

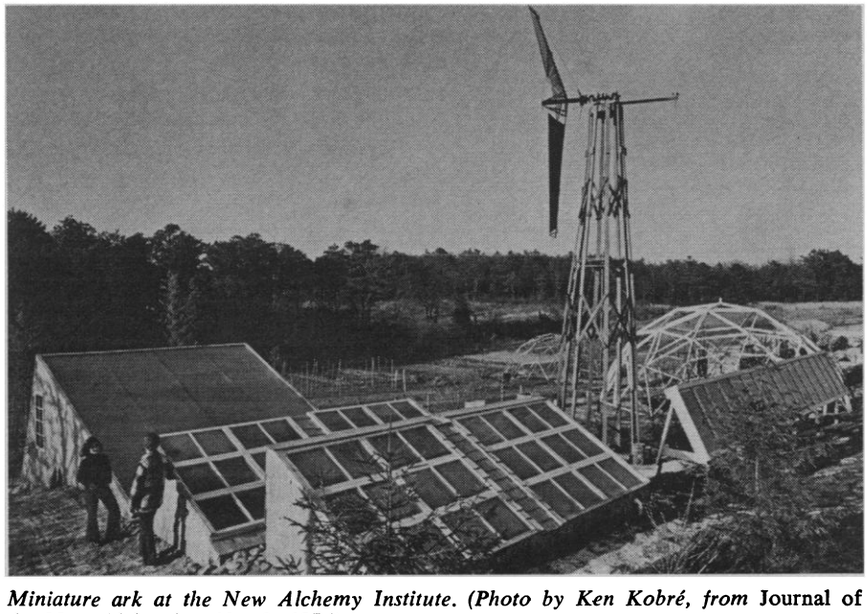
The greenhouse space above the pools is used to grow vegetables which are fertilized with fish water and kept free of pests by frogs and spiders. An early problem with the system was that the oxygen-requiring bacteria in the filter bed tended to die during calm periods when the windmill ceased to maintain circulation. The technological fix would have been to install a back-up electrical pump; the New Alchemists' solution was to grow oxygenating water plants next to the filter bed.

The system is one of undeniable elegance, providing in principle a no-cost method—labor and capital apart —of raising edible fish. A pilot scheme —the "mini-ark"—was constructed last year and was successful in validating the theory. The maximum yield of the system has yet to be determined, but last year the 5000-gallon tank produced two crops each containing about 50 pounds of edible fish. According to Todd, this exceeds the yields obtained in the most intense forms of Chinese aquaculture, as well as proving that the various species of plants and animals introduced into the system have already come into productive association. Construction costs, according to an article in the institute's journal, amounted to some $2300 for materials alone, even though some components, such as the automobile crankshaft used in the windmill, were obtained from scrap.

Two members of the institute, Todd and Robert Angevine, a former lieutenant-colonel in the Army who serves as the institute's business manager, have plans to set up a larger version of the ark on Prince Edward's Island in Canada. (Todd was born in Canada and still holds Canadian citizenship.)

Interest in tropical agriculture has lead the institute to purchase a small piece of land in Costa Rica, where McLarney, coauthor of a textbook on aquaculture, is now searching for native species of fish suitable for ark life.

The Green Revolution has not been shaped by an ecological ethic and its keenest enthusiasts are usually manufacturers of chemicals and agricultural implements backed by government officials, rather than farmers and agricultural researchers. . . . A number of biologists and agricultural authorities . . . foresee environmental decimation which will offset the agricultural gains before the turn of the century. Amongst some of them, there is the disquieting feeling that we are witnessing the agricultural equivalent of the launching of the Titanic, only this time there are several billion passengers.—John Todd, in The New Alchemy Institute Bulletin, *No. 2, 1971.*



Miniature ark at the New Alchemy Institute. (Photo by Ken Kobré, from Journal of the New Alchemists *No. 2, 1974).*

Another foreign venture is the development by Marcus Sherman of a water-pumping windmill for use in India. A prototype has already been built in Tamil Nadu state. The machine is constructed from materials readily available to an Indian farmer, such as a bullock cartwheel, an automobile axle, bamboo, and cloth for the sails.

Sherman's Indian windmill has been redesigned with American materials by Earle Barnhart, with sails of a shape specified by racing yacht sail designer Merrill Hall. Barnhart, a biologist who grew up in a religious farming community in Ohio, chose the institute at which to do alternative service to the draft because of his interest in the combined study of low energy systems and aquaculture.

Hilde Atema Maingay, another member of the institute, raises vegetables on the farm without the use of pesticides or fertilizers, a method otherwise known as organic gardening. Although not trained as a scientist, Maingay last year undertook a careful

experiment to test the interaction between the marketability of 20 varieties of cabbage and their resistance to the Small White butterfly (*Pieris rapae*). Earlier studies had measured resistance simply by the number of caterpillars per cabbage. Maingay found that the varieties with the least caterpillars also tended to produce the fewest marketable heads. True resistance is the ability of a variety to produce marketable heads in the presence of caterpillars, her study indicates. Maingay says she found the agricultural research literature of little assistance—"Research on the life cycles and other aspects of insect pests came to a halt when DDT was invented."

The use of biocides has triggered a vicious cycle; soils decline in quality, which in turn makes crops more vulnerable to attack by pests or disease organisms. This creates a need for increasingly large amounts of pesticides and fungicides for agricultural production to be sustained. . . . A modern agriculture, racing one step ahead of the apocalypse, is not ecologically sane, no matter how productive, efficient or economically sound it may may seem.—John Todd, in The New Alchemy Institute Bulletin, *No. 2, 1971.*

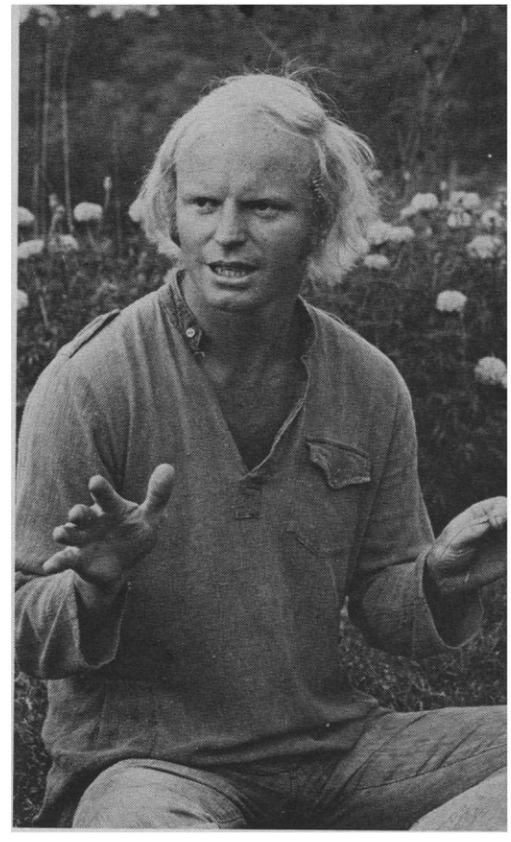
New alchemist Richard Merrill is the co-editor of *Energy Primer*,* a do-it-yourself guide to renewable forms of energy such as solar, wind, water, and biofuels. Proceeds from the sale of the book will help support the operations in California of New Alchemy West. These will parallel activities at the Cape Cod institute, but with emphasis on raising shrimp instead of tilapia. Merrill earned his Ph.D. in population biology at the University of California, Santa Barbara. His book *Alternative Agriculture* will be published by Harper & Row later this year. Traditional agriculture, he believes, is generating not only the wrong answers but the wrong questions. "The tools of liberation—chemicals, machinery, monocultures, hybrid crop strains, etc., while they have alleviated scarcity and one kind of work, at the same time have precipitated mounting economic and ecological problems which . . . threaten the sustaining potential of our farmlands."

The New Alchemy Institute has been through some hard times financially but seems now to have proven its ability to attract support. In its early years funds were donated by such maverick institutions as the Rodale organic gardening company, the Stern Fund, and the Point Foundation (which distributes the profits of the Whole Earth Catalog). More recently the institute has been able to attract money from more established sources, such as the Rockefeller Brothers Fund. The proposal for the mini-ark was turned down by the National Science Foundation but found favor elsewhere.

The Canadian project aside, the institute will have a budget this year of about $135,000—enough to make ends meet but less, for example, than Todd received for his lab at Woods Hole. On the grounds that all jobs are essential, from writing grant proposals to mowing the grass, the institute is experimenting this year with an equal salary policy. Everyone gets a basic $9000, with $2000 extra for each dependent. The institute's farmhouse serves only as an office, and people have to find their own accommodations in the area. The full-time staff is about 12 people during the summer months, with numerous volunteers and visitors giving a hand each Saturday.

Public interest in the institute is remarkably keen, considering that its activities have been little publicized. The institute's elegantly designed journal, edited by Nancy Jack Todd, is distributed only to its membership. Sometimes up to a hundred letters a day are received. A single article in a Canadian newspaper brought in more than 300 subscriptions for associate membership. According to Angevine, the members are drawn from almost every walk of life, from scientists to schoolteachers to motel operators.

Part of the attraction may be the institute's emphasis on self-reliance, along with the message implicit in its name that modern science has led the world astray. While the new alchemists deny that they are part of an anti-science movement, they believe that science and technology have created a false confidence in man's ability to solve problems. "We have pretty much made the assumption that the world's problems won't be solved by the kind of technology being developed today," says Todd; "The longer we go after the technological fix, the worse the crash." According to Merrill, "The purpose of



John Todd

New Alchemy is to bridge the gap between anti-science and the esoteric, inhuman, specialized kind of science which is going on almost everywhere."

There is a tendency in some of the new alchemists' writings to justify their work in terms of an approaching apocalypse or "stormy times ahead." In a way, this rationale understates the importance of their experiment. Even if the economy and modern agriculture manage to muddle through, there may still be a viable place for the arks and other food producing devices created in the new alchemists' crucibles. Maybe of even greater importance is the theoretical significance of their attempt to design agricultural systems that are high on biology and low on chemicals. Such systems, if viable, would provide a reference point against which to judge the high yielding, chemically dependent, people displacing monocultures that are the essence of the present style of agriculture.

The new alchemists are not yet in a position to grow enough food for self-sufficiency, let alone a surplus. There is some way yet to go before they match their record to their rhetoric. But if fresh ideas and seriousness of purpose are any guide, they may soon be proving that they have something to teach the world.

—NICHOLAS WADE

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* Obtainable from The Whole Earth Truck Store, 558 Santa Cruz Avenue, Menlo Park, California 94025. Price $4.50.