The Journal of The New Alchemists

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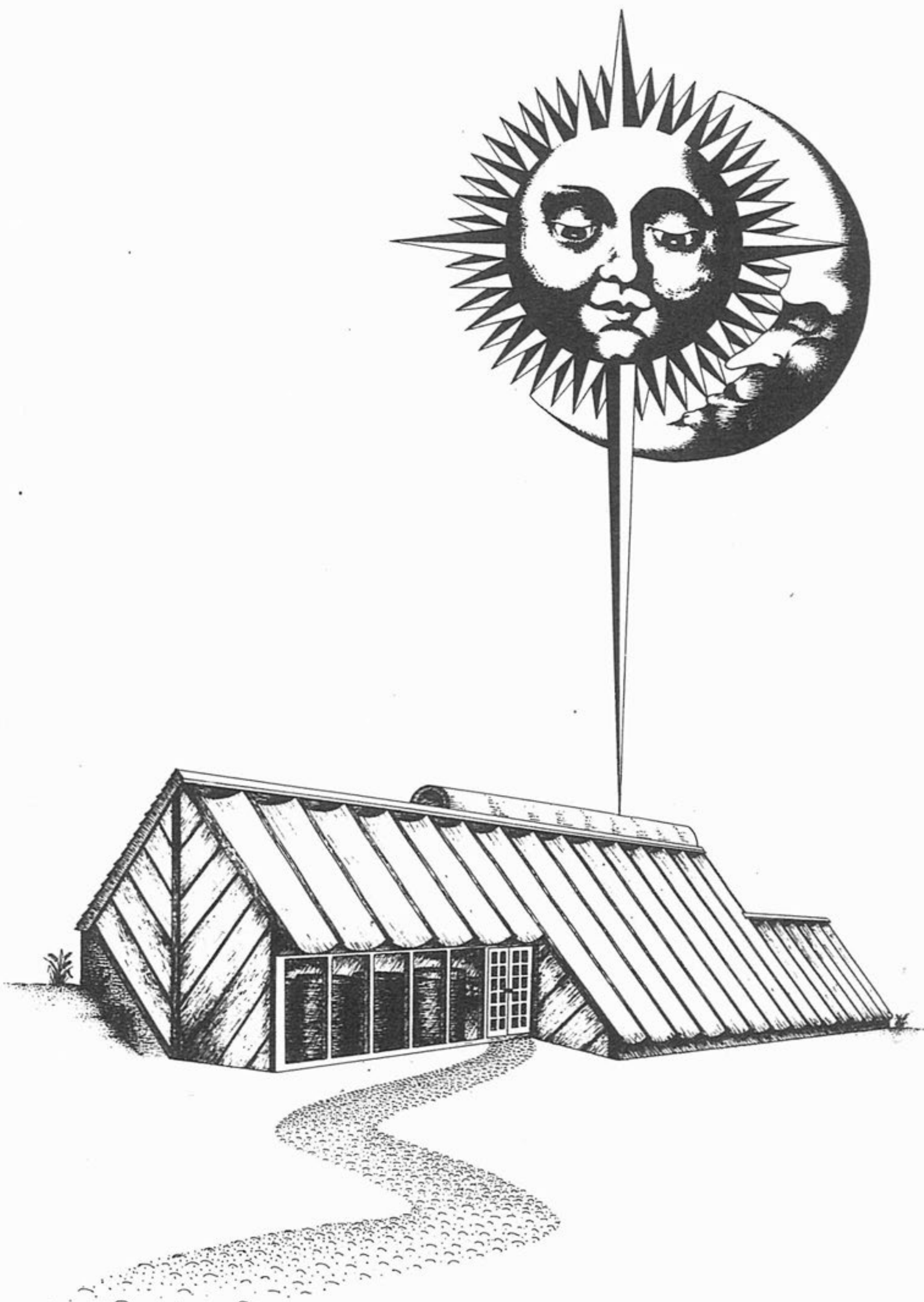

Journal of the New Alchemists 4

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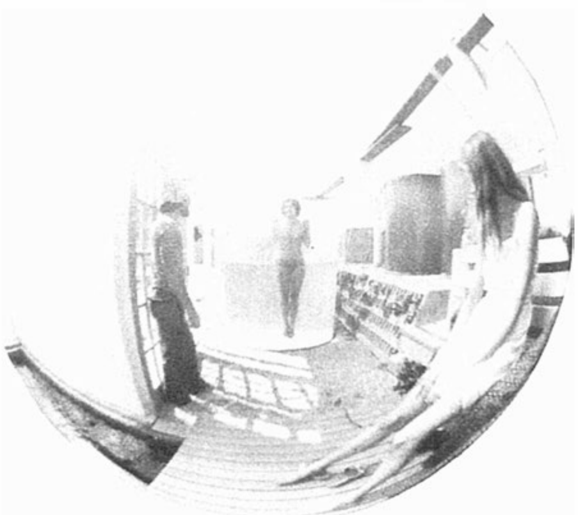
For E. F. Schumacher

Photo by Hilde Maingay

The rule of no realm is mine, but all worthy things
that are in peril as the world now stands, those are my care.
And for my part, I shall not wholly fail in my task
if anything passes through this night that can still
grow fair or bear fruit and flower again in days to come.
For I too am a steward. Did you not know?

Gandalf, *The Return of the King*
– J. R. R. Tolkien

We learned of E. F. Schumacher's death just as this Journal was in its final phase of printing. We share with everyone in our small but beautiful movement a sense of personal and collective loss. It has sometimes seemed to me that in our struggle we are not unlike Tolkien's ragged and assorted fellowship and, if that is so, then Fritz was our wise and gentle wizard. His leadership and guidance, the directness of his thinking will not easily be replaced. Dedicating our Journal to his memory is part of a larger and renewed dedication to all worthy things that were his care.

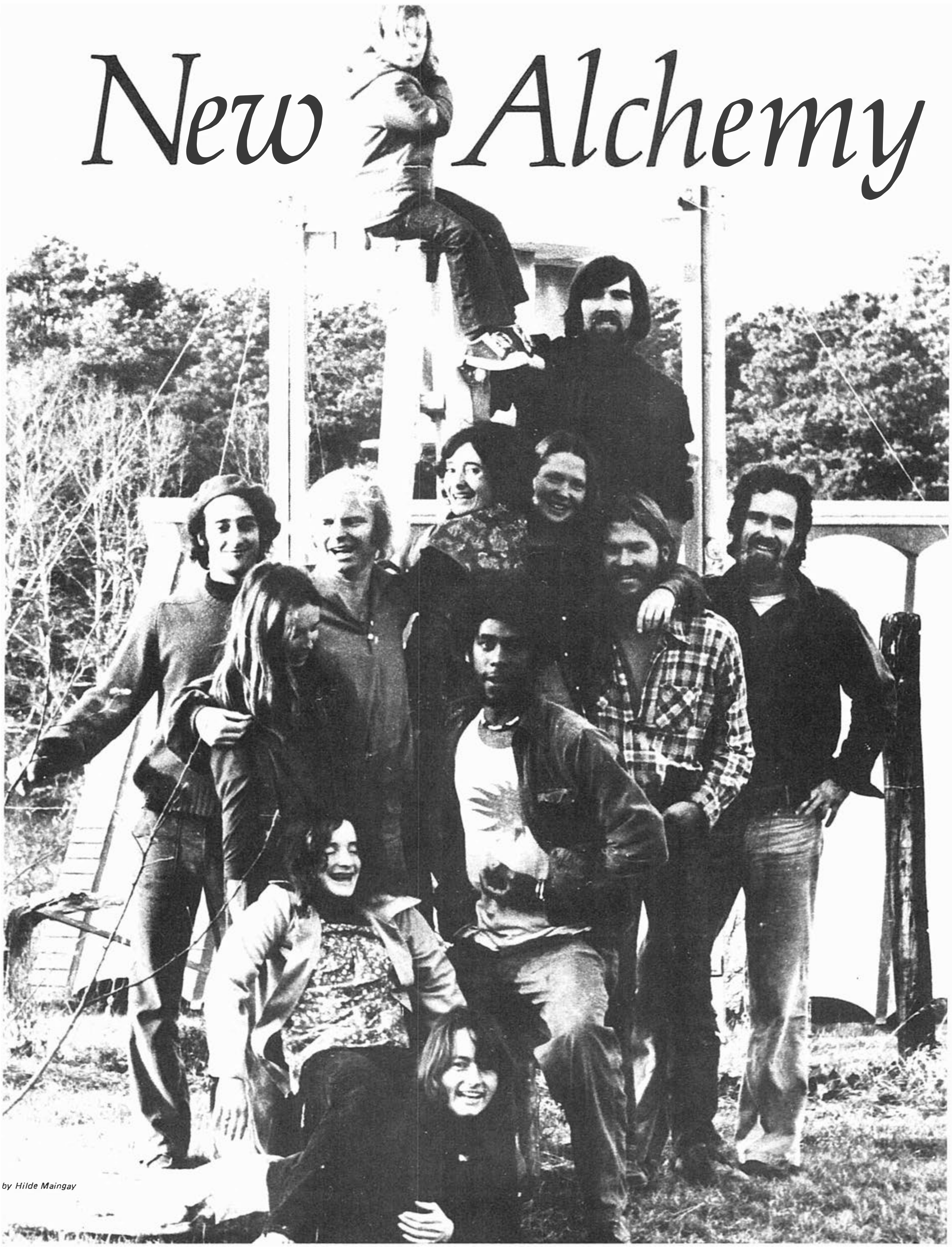


The interim between the publication of this and the previous Journal has been one of transition for New Alchemy. In the outside world, the severe winter of 1976/77 with resultant fuel shortages gave greater numbers of people a more intimate acquaintance with the reality of their dependence on finite resources than they had been previously inclined to recognize. Those who, like ourselves, had been sounding the knell of dwindling resources began to sound slightly less like voices crying in the wilderness. In public life, the heightened respectability of alternatives was personified by the attendance of Prime Minister Trudeau and Premier Alec Campbell at the official opening of the Prince Edward Island Ark in September, 1976. In the United States as we go to press, President Carter's Energy Policy is still news and still controversial. While absolutely opposed to his advocation of nuclear power, we are encouraged by his strong statements in favor of a drastic change in life style and his urging of serious efforts in conservation.

Apart from a less limited or less esoteric public reception, the year has been a turning point within New Alchemy as well. Although we have come to articulate it more succinctly with time, the underlying purpose of New Alchemy has always been the search for an answer to a very basic question — one we now refer to as the biological analogue. What the question asks is, "Are there biologically and ecologically viable alternatives to the capital-intensive, highly industrialized methods and technologies by which human populations currently sustain themselves?" Can we find ways in which, in Gary Snyder's often quoted phrase, we may live lightly on the earth? This was and is, when we

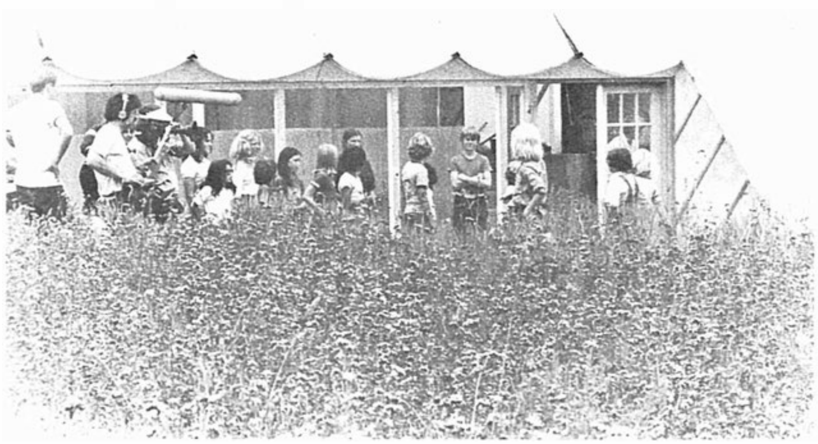
put aside all the complications of being and running an Institute, what we wanted to know. We were optimistic, but we were not certain. We hoped, by turning to natural models for guidance, by becoming increasingly attuned to the lessons of biology and natural systems, that we might, like karma yogis, gain in understanding through our work. This year, with the high productivity of the solar algae ponds and the unexpectedly successful weathering of the winter by the bioshelters, our question is slowly beginning to be answered in the affirmative — to be an affirmation. The hard path — the path of ongoing industrial expansion, of exploitation of landscapes and people and of nuclear power is not the exclusive or even most desirable one. We are beginning to accumulate knowledge that broadens our options for the future and offers the opportunity of a choice. If our early, modest successes are regarded as prototypes, as the the model Ts and biplanes of the possible, then the options open to us widen markedly. This is all the more so in view of the emerging information of transitional technologies advocated by Amory Lovins in his article entitled "The Road Not Taken " in the Fall, 1976, issue of "Foreign Affairs." Such strategies could ease the changeover to a culture based on the use of renewable resources, appropriate technologies, and on an attitude of stewardship toward the natural world. It is unlikely that it is too late for us to opt for such a course, should we elect to do so. Should we be wise enough — or lucky enough — to choose this path, we should find ourselves, to quote Amory Lovins quoting Pogo, "confronted with insurmountable opportunities."

New Alchemy



by Hilde Maingay

Photo by Hilde Maingay



Also in this section is the realization of at least tl beginnings of a project that has been percolating among us for a long time. As a rather earthy, basic l of people, we spend quite a bit of time working wit and thinking about food. We are, as Eeyore was of l tail, "fond of it" – not that in itself that is particul ly worthy of note. But on the occasional crowded Farm Saturday, as we set out our usual rice and bea kale soups, garden salads and homemade yogurt, th is the odd remark or snigger about the peculiar fooc Mutters of weird! – and so on. Peculiar or otherwis we have fairly strong ideas on the subject of food. V favor using things that are seasonal or readily availa in one's local area and avoid as much as possible expensive or prepared foods. The general drift of ou common modus operandi can be found in the Cook Book of the New Alchemists in this section.

With the publication of this issue, the New Alchemy section of the Journal has had to extend itself to cover events, not only at the center on Cape Cod, but on Prince Edward Island and in Costa Rica as well. Because the opening of the Arks, both on the Cape and on the Island, were landmark occasions of the past year, the stories of each are related. From Costa Rica, Bill McLarney gives the first detailed account of the establishment of NAISA and of the work in progress there. His article on the Herb Tea Project is concerned with New Alchemy's first attempt to integrate some of our ideas with the needs of an indigenous community. Earle Barnhart spent some time in Costa Rica with Bill and Susan Ervin in 1976 and, in his capacity as New Alchemy's briccoleur at large, devised some much needed strategies and tools to further the work there. His sketches and descriptions are in the article, "Technology Appropriate to the Gandoca Region of Costa Rica."

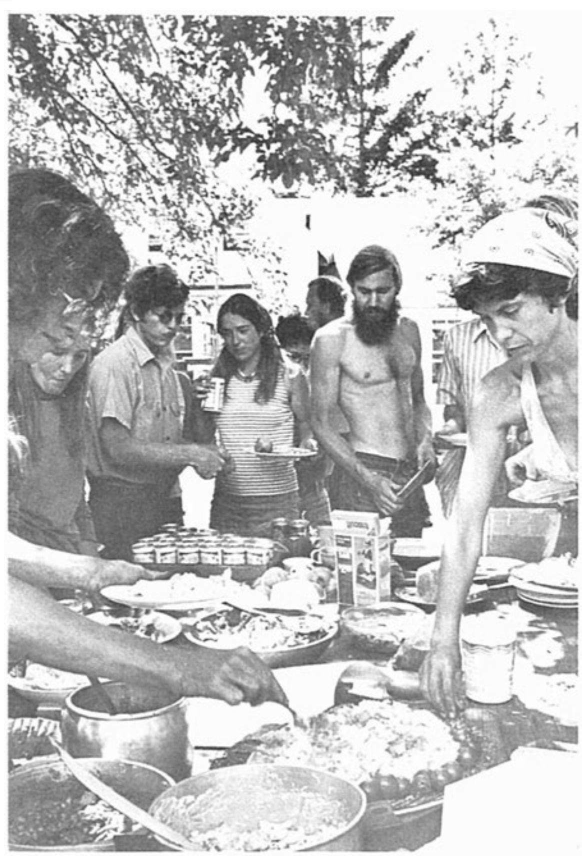


Photo by Joan Pearlman

Photo by Hilde Maingay

In this section, in preceding Journals, there have been descriptions of some of the day-to-day and seasonal aspects of the activities that revolve around the center on Cape Cod. Over the past year, our work has continued much as before, centering on food-growing and fish-raising, windmills and bioshelters, and on the administration, correspondence, data collecting and recording that the work with living systems, which is really the primary focus, engenders. The most recent developments in these areas are reported throughout this issue. In many ways, our work has remained basically unchanged, with active outside summers, only now we have far more visitors. With gradual transitions through spring and fall, the winters are more withdrawn. The physical work is largely confined to the bioshelters and we spend much of our time writing, reporting, assessing data, questioning and planning. In other ways, there have been changes that have occurred with such dizzying speed as to give the less pressured earlier years an almost nostalgic, distant quality — a time when we played more and didn't work quite all the time.

It is still gratifying and exciting to share our ideas with increasing numbers of people. Before we opened in May a year ago, because of a number of articles that had appeared about us, we anticipated an influx in the number of visitors for Farm Saturdays. We decided that we needed a format that would make Saturdays more informative and useful to the people who stopped by. Old hands will remember that Farm Saturdays began as an open, community sort of day when a few people dropped by and we would all work for a while, break for a great feast at noon, then stagger, replete, back to work again. By sometime during the summer of 1974, there were too many people to make informal exchanges over lunch or work sufficient explanation of what we were trying to do. It was then that we instituted the "tour", which consisted of one or several of us giving a fairly lengthy description of our work, conducting people to and through the various points of interest as we did so. But even before last summer, it was becoming clear that there were too many visitors to be squeezed through the Dome without losing several to the Tilapia, or to be led through the other structures without sacrificing the plants. In our deliberations before the opening of the '76 season, we hit upon the tactic of giving workshops.

To date we are pleased with this solution and plan to continue with it. We feel it gives people a general background and then frees them to pursue particular interests in greater depth and to have more questions answered than would be possible in a single extended talk. We do ask those planning to come to arrive by noon. At this time, there is a general introduction on the background, paradigm and ideas underlying New Alchemy's work. After this, everyone revives with lunch. We ask our visitors to bring food with them — a bit more than they are likely to eat themselves and, preferably, something like bread or fruit or cheese that is easily shared. This way there is almost always enough and people get a chance to meet each other as they serve the food.

The workshops proper begin at one-fifteen to one-thirty, after a clean-up. There are usually two, sometimes three, taking place at once. The topics cover our basic areas of research and, accordingly, are on various aspects of agriculture, aquaculture, energy and bioshelters. The specific subject for each of these varies from week to week. Pest resistance or agricultural forests may be discussed under "agriculture", cage culture or semi-enclosed systems under "aquaculture." There is usually an additional workshop on the social and political implications of alternatives which can range from feminism to the opposition of nuclear power. It is our intent that these sessions be genuine discussions and not lectures on our part. An exchange seems to us a more genuine and rewarding form of communication.

Photo by Joan Pearlman

We have never written in the Journal about the Woods Hole community which forms the larger social fabric with which our lives as individuals and as New Alchemists are interwoven. Our degrees of attachment to it are as varied as we are as people, but, over the years, strong bonds have grown up between many of us and some of the people in the community of which we feel ourselves to be a part.

One of those dearest to many of us was Peter Kaplan, who ended his life on February 25th this year by jumping from the Newport Bridge. He was nineteen. He was a poet and a publisher, a waiter and a cook, brash, brilliant and loving, endearing and complex. He embraced life with the same compulsive enthusiasm with which he, in turn, embraced his death.

Last fall he gave me the poem below which he wrote for Don Esty, another poet who was with us for a while and who also died very young.

REMEMBERING DON ESTY (1951-1975)

— Peter Kaplan

The old man sitting at the cafe table
forks his food
gingerly, with sidelong
glances at the kitchen,
at the suspicious waiter.
Under furrowed eyelids
he hatches plots,
remembers unsolved
mysteries.

His hunched movements
bring back your own,
your wizened face straining for comprehension,
towards the end,
when it was never
automatic.

I look up from the counter
and see you sitting there.
A shaft of yellow-moted
sifting sunlight
has caught you by the shoulders
and you do not
shrug it off,
grateful for a moment
to be so sharply outlined.

This is your celebration,
to be alone with light;
whether this flood of definition
or the moon's fiber
sifting over New Alchemy.

Alone with light,
yet always stooping
to form shadows ——
the shadows you found
beneath the wings of mountains,
the shadows owls make
in the brittle moonlight
zeroing in
on the prey that flees
suspicious
unresigned
but finally

imprisoned.

The day we held the service for Peter in the Community Hall in Woods Hole, the following note was pinned to the door of the hall.

Dear People,

The hardest thing to bear about death is the thought of all we did not say or do and all the reasons, so weighty at the time, that we did not say or do them. We could not keep the dark away from Peter, he swallowed it as it was swallowing him. But we are all here, closer in many ways than we would have been if he'd lived. We must nourish this closeness, water it and make it grow ——. It takes a lot of warmth to keep away the dark and we must not go to our deaths or let others go towards theirs leaving so much unspoken, leaving our loves unloved.

Counterpointed against our losses through death has been the birth of a son to Laura and David Engstrom. Both Laura and David have been around and part of New Alchemy almost from the beginning. Now, as all of our children have grown leggy and independent and laps are largely empty, there is a new baby to watch grow. Born at home and delivered by his father, blessed with an old New England name, Ivory Ben has joined us.

opening the arks

— *Nancy Jack Todd*

Another reason — or reasons — for the pressured pace we have experienced over the past year has been the building and completion of the Cape Cod and Prince Edward Island Arks. Taken separately either of these structures or bioshelters, which are described in detail in the section entitled Bioshelters, would have qualified as the biggest single project we had undertaken. Not even Noah was cavalier enough to attempt to launch two Arks at once and his backing was fairly solid. To do so was a stupendous effort particularly on the parts of architect/builders Ole Hammarlund and David Bergmark. Bob Angevine and John Todd had almost equally demanding jobs in administering to the work in progress and, in the case of the Canadian Ark, meeting the deadline of last September 22nd.

Photos by Hilde Maingay

The Cape Cod Ark is a smaller, more modest structure than its Canadian counterpart. Seen from a distance, it has something of the air of a boat beached in a meadow, sitting low and snug. It was opened last August, informally and even somewhat inadvertently. Toward the end of the summer, Hilde, who is definitely the best New Alchemist at celebrations and at honoring the special times that the rest of us might let slip by, proposed an end-of-summer party to which we would all invite our favorite people. We would have it on the lawn and everyone would bring food and musical instruments, if they had them, and we would feast and sing and dance. The Sunday we had chosen turned out to be cloudy and ominous. As we were beginning to set out the tables and people were beginning to arrive, the rain started. We were far too numerous to retreat to the house and the barn had been completely taken over by hydrowind construction. There was the Ark, not yet entirely finished nor too given over to seedlings that it could be devastated by a throng of festive people. So we snatched food, dishes and wine bottles and relayed them across the field to the Ark. There, throughout the intermittent rain, neighbors and old friends, adults and kids feasted and danced to their friends' music and, without quite intending to, opened the Ark.

Photo by Hilde Maingay

Photo by Tom Mignone

Photo by David Bergmark

Photo by Hilde Maingay

The opening on Prince Edward Island was completely different. In the first place, we had a deadline set by the Canadian Federal Government who had funded it. Secondarily, it was expected that Prime Minister Trudeau would officially open it, and a date had been set to coincide with a scheduled trip he was to make to the Island. Unlike the impromptu Cape opening, this was a race, ultimately a feverish one, with time. Jay Baldwin described the whole adventure aptly and well in the Fall '76 issue of the *CoEvolution Quarterly*. But, because it was such a singular event in the lives of so many of us, perhaps it won't seem redundant to tell the story once again from another point of view.

The idea of an Ark for Prince Edward Island has been around for quite a while. The original proposal was mailed to the Canadian government in late November, 1974. The early design work was done by Hilde Maingay and Earle Barnhart. Their plans were passed on to Ole Hammarlund and David Bergmark who, together, in the guise of Solsearch International, are Architecture's answer to New Alchemy. They evolved the final design over the period of the next year. Because negotiations are always a lengthy business, the ground for the foundation of the structure was not broken until October, 1975. Construction began immediately. Before the snow began, there was just enough framing up to

Photos by Hilde Maingay

which plastic could be tacked to provide enough shelter to keep going. David Bergmark worked with an Island crew all that winter, with Ole dividing his time between the Island and the Cape. By spring and an initial government inspection in May, the building had taken shape. In fact, to the unitiated, it didn't seem there could be that much left to do. The rooms had been enclosed, much of the built-in furniture was in place and the living room had been panelled. But a bioshelter is a complex structure. In addition to the wiring, plumbing, flooring and painting need-

Photo by Robert Todd

ed to complete a standard house, there are such extras as installation of solar collectors and the building of heat storage chambers. The physical systems have to be fairly well complete before the living systems are added. With the coming of summer, the pace increased and was made no less frantic by the unending stream of visitors, both tourists and well-wishers, authorized and otherwise. The very real courtesy of Nancy Willis and David Bergmark, who managed to receive people with trowels and hammers in hand, was the main reason that the project continued to progress throughout the summer. The influx of help in terms of numbers didn't really begin until the first week of September, although people had been commuting between both centers much of the time. But from that week until the opening, the number of people that turned up and the intensity and dedication of the work was remarkable. Toward the end, many of us were working twenty-hour days and subsisting largely on caffein. There were periods where I'm not sure whether David or Ole ever found a chance to sleep. Most of the time, it seemed preposterous that we should ever be ready on time.

As it has always been with New Alchemy gatherings, the people who arrived, for whatever reasons, were varied and wonderful. Many of the long-haired young appeared in vans, on foot or with packsacks. Of these, a few really wanted to be part of things enough to work. They stayed, some of them proving invaluable. Others watched for a while, then left. Old friends came and neighbors from the Woods Hole community, summer people, relatives, families and long-time fellow travellers like Steward Brand and Kathl and Jay Baldwin. Academics wielded hammers and paint brushes beside poets and homesteaders. Island neighbors gave up their Sundays to stay on the job.

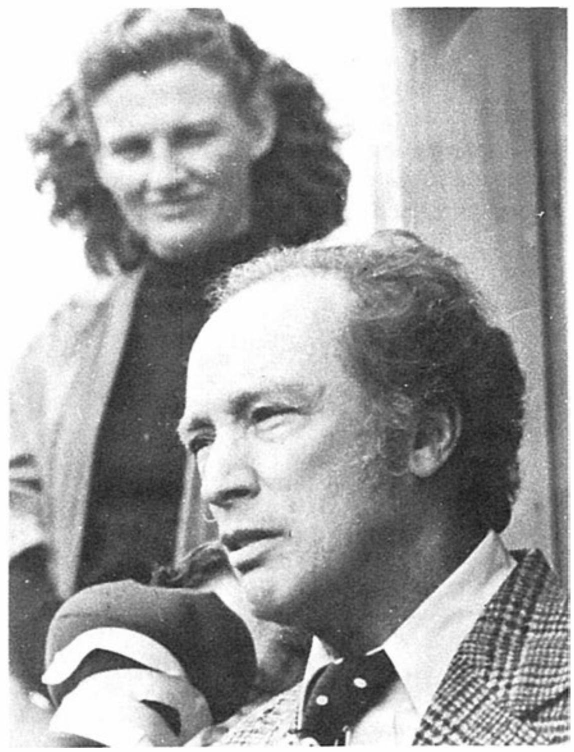
With the number of days dwindling to less than a week, the intensity seemed to increase exponentially. In ways, it was the closest experience any of us are likely to have to participating in an ant colony. Definite patterns began to emerge. People were greeted exuberantly on arrival. They would spend an hour or so looking around and then were absorbed into the dynamic, becoming contributing members of the humming, ordered pattern, the organization of which was not discernible to the casual eye. It was not uncommon to see an undone but essential task undertaken, carried out and completed almost as one watched, rather like time-lapse photography. Forty-eight hours before the opening, virtually no landscaping had been done, beyond an earlier seeding of the immediate area to grass, which was just beginning to germinate. The Ark was surrounded by rutted mud. In the intervening time, the front walk was gravelled and smoothed, shrubs were dug up from the fields and transplanted, rocks were hauled from the beach for walkways, paths were laid out and lined with stones and a seaweed mulch was spread over the exposed ground. Solemn industrious lines of people raked or trekked seaweed or lugged rocks. Another crew painted window frames and venting hatches. The biologists and their assistants worked with the solar-algae ponds, fending off enthusiastic children who had slightly different ideas about the purpose and flow of aquatic systems. The only major failing in managing such goal-oriented yet diffuse operations was that we had made no provision for meals — leaving individuals or groups to fend for themselves. People often worked until they were exhausted before they took a break to eat. A food crew could as easily have been organized as any of the others and, should we undertake a similar extravaganza, it will not be without some organization for food.

In spite of sporadic meals, the hours ticked by and one by one the jobs were completed. Complicated ones, like installing the sprinkling system in the greenhouse, which kept Jay and Kathl aloft on the scaffolding for several days, were eventually finished as well as more domestic ones like sanding and polishing the living room floor, which was done between one and four on the morning of the fateful day by Michaela Walsh, Ole, a large unidentified bearded fellow who knew how to do everything, and myself. By ten that morning the living quarters were declared ready for interior decorating. In the same final hours, the hydrowind crew, consisting

Photo by David Bergmark

of us were careful not to display our hands or gesticulate too lavishly. If he noticed turpentine to be the predominant perfume, he was too polite to comment.

More or less ready, more or less dressed, somewhat cleaner than we had been in some time, with the Ark functional and gleaming, the lot of us, New Alchemists and friends, in the company of several hundred Islanders and the inevitable swarm of media, were clustered and gazing skyward by the time the two helicopters bearing Mr. Trudeau and Premier and Mrs. Campbell of Prince Edward Island appeared in the sky. The children shrieked and surged in the tornado of the landing. The dignitaries disembarked, made their way through the throng and across the field, and the official opening began. Mr. Trudeau, Mr. Campbell, Arthur MacDonald and John Todd



of Ty Cashman and Vince Dempsey, who had spent several weeks being buffeted on the windmill tower, made their final adjustment while Al Doolittle monitored the controls and in a final burst of glory – or effort – the hydrowind pumped electricity into the Island utility grid for the first time.

Mr. Trudeau's arrival was scheduled for one-thirty. At twelve-thirty, we pronounced ourselves finished and scattered to change. In addition to inadequate food arrangements, there were virtually no washing facilities for the group, which now amounted to a hundred or so. We had all been living in tents or vans and were thoroughly coated in paint, dirt, fire smoke, grease, or any combination of the above. The nearest available showers were at Brudenell, the provincial camp grounds, and those of us who did not descend on Nancy Willis and her household (by then more than twenty) gathered kids and went off to wash there. It probably wasn't the first time Mr. Trudeau has been greeted by people with paint-encrusted fingernails, and most

spoke briefly and appropriately on the meaning of the occasion. It was clear that Mr. Trudeau understood the implications of what we are trying to do. He read aloud the words on the plaque that dedicates the Ark and in doing so placed it into time. The bioshelter became a reality – another possibility open to us should we choose to make use of it.

With the formalities over, Mr. Trudeau and the Campbells were given a fairly detailed tour and explanation of the Ark and its workings. Because

Photos by Hilde Maingay

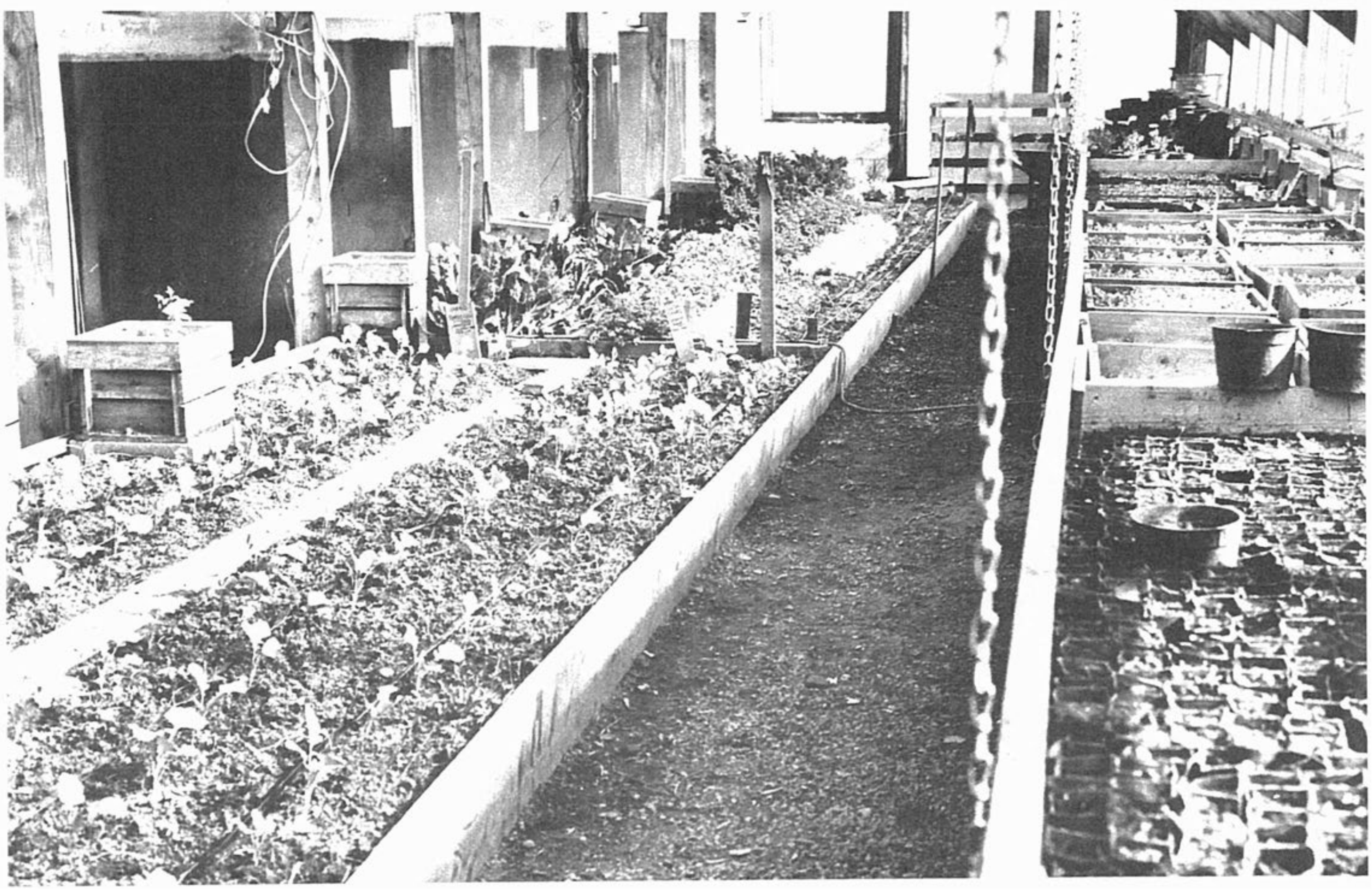
there was not enough space for everyone to come through at once, our neighbors Ethyl Blackett and Tommy Banks sang and played for everyone. Others of our neighbors had prepared refreshments – all the more welcome for the recent dearth of food among us. Mr. Trudeau snacked and chatted with the Islanders who had come to see him before his aides whisked him away and he was whirled off into the sky again. Our friend, Bill Thompson, has said that, by opening the Ark and thereby acknowledging the possibility of an alternative course for the future, Mr. Trudeau performed the most significant act by a major political figure in the last decade. It is impossible for any of us to be objective, but to have been there and noted Mr. Trudeau's flexibility and his grasp of the ideas embodied in the Ark was heartening.

The opening did not end with the departure of the helicopters. That night brought a celebration by Island neighbors, the visiting work crew and the rest of us in fine New Alchemy tradition. Our neighbors provided the music and everyone danced with everyone – kids and government officials, hippies and farmers and professors – all jounced about the packed living room until after midnight. Such was the height of the cheer that conversations could be maintained only by shouting or retiring. It was a glorious catharsis.

There had been something else planned to round out the opening ceremonies which, to many of us, was the most important part – a silent sunrise vigil on the morning of the autumn equinox. But dawn that morning brought the rain that we had been holding at bay by sheer will all the preceding day. It slid off the sides of the tents in sheets. It was wet and dismal and most of us were too tired to move. We waited and later that day, after we had restored the Ark from the ravages of the previous night, we gathered again to finish the opening. David Spangler of the Lorien Association had been asked to come for this part. We sat in a circle in the living room and he spoke quietly and simply, articulating, as few of us could have, what we hoped the Ark and ideas like it might come to mean – of a dream of a renewed understanding of the larger patterns of life and of the human place within such patterns.

With this, our house was consecrated and the opening was complete. People began to pack and to leave, rather quietly. I don't think that anything quite like those few days, either in the intensity of the preparations or of the headiness of the celebrations, is likely to happen to us too often.

Photo by David Bergmark



New Alchemy-*Costa Rica*

– Bill McLarney

A New Alchemy farm in Costa Rica has been on our minds since our very earliest days in San Diego – prior to the incorporation of the Institute. In the earliest discussions among John and Nancy Todd, Doug Evans and myself, we repeatedly touched on the attractions and problems of the tropical world – how very different they were from those of the temperate zone, but yet how appropriate (to our minds at least) a New Alchemy presence in the tropics would be. Since that time, all of the New Alchemists have thought and talked about the tropics and many of us have worked and traveled in tropical countries – Belize, Mexico, Nicaragua, Colombia, Haiti, Jamaica, India, Thailand and, of course, Costa Rica. But it would be dishonest to say that the responsibility for our presence in Costa Rica falls on anybody but myself. When people ask me "Why New Alchemy in Costa Rica?", one of the first reasons has to be that it is an outlet for my lifelong interest in the tropics.

Still, there are less personal reasons for being in the tropics. Rather than list problems, possible solutions, and the ways in which New Alchemy can participate in finding and applying solutions, I would like to present an essay on the history and present status of New Alchemy in Costa Rica, along with a very few specific goals and fantasies, and hope that a clear picture will emerge.

There is another question people ask: "Why Costa Rica?" One can begin by explaining the logistic difficulties of working in tropical Africa or Asia. But still some people point out that Costa Rica is one of the most fortunate of Latin American countries. If one were really interested in the *problems* of Latin America, they say, one would work in Haiti or El Salvador or Bolivia, countries where ecological, economic and social crisis is a daily fact of life. It is true that, in terms of such conventional measures as health, literacy, crime rate, educational level and governmental stability, Costa Rica is ahead of most of its neighbors. So why work there?

Again there is a personal answer interwoven with the practical and circumstantial. Costa Rica is the country where I had my first tropical experience and where I have spent the most time. The country has been good to me, and I admit there is, for me, some of the irrational attraction of a love affair. But the attraction has its practical side. For a Gringo, there is no Latin American country easier to work in; the generally positive attitude of the people and the lack of legal and political encumbrance permit one to get on with the work.

And there *is* work. Most of the negative trends which can be observed in other tropical countries have started there – runaway population growth, massive deforestation (a national emergency, according to President Daniel Oduber), the push toward monoculture crops, unthinking use of agricultural chemicals, replacement of the small farmer by the absentee landholder and the corporation, shortage of basic foods, migration to the cities, etc. It is these trends we are concerned with – wherever they occur. Finally, we are there simply because we feel that it is where we can do the most good. If we succeed, our successes can be passed on to others throughout the tropics.

My first visit to Costa Rica was in 1968, before there was a New Alchemy. In 1970, Doug Evans made an exploratory trip there, and the following year, John Todd and I went down with the goal of locating a site for a New Alchemy center. Since then I have spent three to six months of every year in Costa Rica, and a number of other New Alchemists have spent time there. But the goal of finding a home there proved more difficult than we had foreseen originally. In the years between 1971 and 1975, while we were travelling and talking and counting our pennies and deliberating, some people became impatient with us or lost faith in New Alchemy-Costa Rica.

There were a lot of people that helped, too. For several years our home away from home was at Bob Hunter's farm in the Sarapiqui region, and our first small tropical projects were realized there (McLarney, 1973; McLarney and Hunter, 1976). Many other people, in and out of Costa Rica, gave us ideas, inspiration, logistic support and education which have been invaluable to our tropical efforts. I would particularly like to mention Eugene Anderson, Don Jose Maria Arias R., Bob and Peggy Brown, Werner Haghauer, Walter James, Alexander Skutch, Peter Van Dresser, Glodaldo Williams Hall, and Jorge Zamora. Another important step was the incorporation, in 1971, of New Alchemy in Costa Rica, where we are known as NAISA.

Finally, in 1973, Shelly Henderson and I made the trip which eventually resulted in the purchase of our present fifteen-and-one-half acre farm. The purchase was made possible by generous gifts and loans from Tyrone Cashman, John and Peggy Elter, Richard Etheridge, Stephanie Hancox, Dorothy Todd Hénaut and Mr. and Mrs. Robert McLarney. Subsequently, Bill Haveland and Bob McCullough have made donations specifically earmarked for our tropical work.

The NAISA farm is located in rural Limón province. Limón, the Atlantic coastal province of Costa Rica, is physically and culturally distinct from the rest of the country. The low elevation of much of the province and the moderate to heavy rainfall make it an emphatically tropical place. Until 1971, there was no highway, and only one railroad connected Limón with the rest of the country. A majority of the relatively small population was composed of bilingual (English-Spanish) Black people of Jamaican and West Indian origin. The substantial Spanish minority and the Chinese shopkeepers mostly were born and raised in Limón. The greater part of Costa Rica's tribal Indians lived in the isolated Talamanca mountains, but they were scarcely noticed, and few outsiders ventured into their wilderness.

Today, much has changed.The road has facilitated immigration from the densely populated Central Plateau. The appointment of Hernan Garron, a Limónense, as Minister of Agriculture in this highly agricultural country, has helped to put Limón on the map, and the government is encouraging all sorts of development in both the coastal and highland regions of the long-neglected province. At the same time, Limónenses are developing a greater awareness of themselves as Costa Ricans, and political consciousness is on the rise. All of these changes have good and bad aspects; the least debatable thing that can be said about them is that they have resulted in greater integration of Limón into the Costa Rican mainstream.

Still, to a Gringo, Limón looks and feels very different from the rest of Costa Rica. It is more of a Caribbean than a Central American place. Life in Limón is, as the locals often remind a visitor, "muy tranquilo".

If that is true in the city of Puerto Limón, it is multiply true at the NAISA farm. We are located in one of the more remote coastal areas. There are continued rumors of a road, but for the next few years at the very least, the only access will be by foot or by sea. Every Saturday, weather permitting, a merchant from a nearby town (also without roads) brings goods in his dugout canoe to sell at his little shack on the beach. There we, like everyone else, buy coffee, salt, sugar, and such essential household items as flashlight batteries and razor blades. For the rest of our food supply, we are forced to be self-sufficient or to trade or barter with our neighbors. To post a letter, visit a medical clinic or drink a cold beer means a minimum three hour hike.

Our Black neighbors live mostly along the beach while the Spanish live along the single foot road which leads into the interior. The Blacks are the old settlers; the Spanish population is a relatively new phenomenon. Curiously enough, virtually none of our Spanish neighbors are native born Costa Ricans. Mainly, they are Nicaraguan and Panamanian, with a sprinkling from other Central and South American countries, trying to provide for their families here in a region where there is still land to be homesteaded.

All of our neighbors are what I would call "hard-core campesinos" — people who have chosen not to live in the city, whatever the financial inducements. Their only cash crops are cacao and copra, but our area is not prime cacao land and coconut palms do best along the beach. Any number of salable crops — bananas, citrus, pineapples, yuca, etc. — do well here, but the lack of transport facilities renders it impossible to get perishable crops to market. A few people specialize in turtle hunting. There is a small local trade in meat, fish, eggs, beans, dairy products, and coconut oil but, apart from the sale of cacao, people get by mainly on subsistence agriculture, hunting, fishing and gathering. They do well at it. Although their diets seem high in starch to our tastes, there is no evidence of nutritional health problems.

Many non-food needs are also provided locally. Houses are constructed in whole or in part with materials from the local forest. The only boats are dugout canoes. The majority of families cook on wood fires. The Blacks make coconut oil for cooking. Forest vines are cut for clotheslines.

Government, too, is a do-it-yourself affair. There are two schoolhouses, with schoolmasters from outside, but virtually no other "official" presence. There may not be much law, but order prevails.

It is this self-sufficiency and capacity for survival that is, in my view, the region's greatest asset. There is something similar to that which drew Peter Van Dresser to northern New Mexico (Van Dresser, 1972) – a functioning *local* economy. At this time, there is danger of its being swallowed up by the national and international economy. But there is also the possibility of intelligent diversification – of reinforcing self-sufficiency while at the same time building appropriate links with the outside world, thus improving the standard of living in an atmosphere of stability. We hope that the latter will happen, and that the NAISA farm will be a center for this sort of development.

Before we could function in the community, it was necessary to render the farm functional. The previous owner had had ambitious plans for raising livestock, but left the property when he got the opportunity to convert a nearby, abandoned airstrip into a pasture. The place had been virtually abandoned at the time we acquired it. About half of it is in virgin forest. We plan to preserve this. The remainder was "bush" and overgrown pasture. The principal food resources were somewhat less than an acre of neglected plantains and a few producing coconut and banana trees. There was a large stand of wild cane and a magnificent bamboo grove to provide construction materials. The only amenities were a barely habitable shack, semi-enclosed cooking area, and a marginal well.

In 1975, Susan Ervin and I set out to see what could be made of the place. The first few weeks in the area were devoted to getting red of a "parasito" (squatter). When Susan had to leave, it looked as though I would have to face the prospect of establishing a farm singlehandedly. It didn't work out exactly that way. I had some help from three visitors from the States, Mel Baker, Susan Malcolm and Alvin Stilman. But I especially want to thank the local people.

I was fortunate in that the first person I met in the area was John Holder, one of the most self-sufficient persons I have ever known. He introduced me to the man who sold us the farm, gave us food and lodging during the parasito episode, and helped in a thousand small ways. When it came time to build a house, I hired John to direct and assist with the construction, which began with felling a gavilan tree and hauling heavy timbers out of the woods. He recommended another man, Miguelito, to help in clearing land. I was somewhat concerned over spending our meagre NAISA funds on labor, but there was no other way; I had neither the time nor the skills. Then one day John refused his pay. Soon after, Miguelito showed up for work with a friend. They settled for a cup of coffee.

Since that day, we have had any number of helpers. A man may walk five miles in the rain to chop bush. Two children I had never seen before have arrived. Their first question was "How many machetes do you have?" Others may bring gifts – a sack of beans, a pumpkin, seeds, baby fruit trees with neatly balled roots, a jar of guava jam. I haven't been able to pay one of them.

I don't mean to give the impression that all of our neighbors are saints. There have been problems, too: cows in the pineapples because a neighbor refused to fix his fence; coconuts we wanted to eat spirited away, presumably for sale; a man trying to sell us nearby land with phony papers. But by being in the position of needing help, I found out who would help. I had little to offer besides "thank you" and an occasional fish, but once the seriousness of our farming venture and my own willingness to work had been established, that was enough.

By late May, when I started back for the States, the farm looked pretty good. The frame and roof of a new house were up. All the plaintains and coconuts had been cleaned out and a substantial number of young fruit trees reclaimed in the process. Sizable plantations of pineapple and yuca, a vegetable garden, and a fruit tree nursery had been started.

Unfortunately, there was no one to look after the place during my absence. Various plans involving friends from the States had fallen through, and the best of the local people had their own farms, leaving me only the drifters and drinkers to choose from. The neighbors would be glad to look in on the place occasionally, but it would be out of the question to ask them to do the daily maintenance which is a must for a tropical farm.

In desperation, I hired a young man who passed by, claiming he was from Belize. (I am too fond of that country to want to believe it.) He was a disaster. He wrote New Alchemy regularly, explaining how he was cleaning the yuca, putting walls on the house, planting corn and beans, etc. He signed his letters "Farmer Man." Farmer Man did none of the things his letters claimed. Worse, he stole from the neighbors; there is not much lower than someone who steals a poor man's boots. Eventually, the local "legal system" worked in the customary manner. After at least one attempt on his life, Farmer Man was driven from the community.

Susan and I returned in February, 1976, to find all of our plantations in yard-high bush, termites in the new house, rats in the yuca and dead crabs in the well – total desolation. Some of the work could be salvaged. Other parts could only be done over. What worried us more than the cost in labor and money was the harm done to our neighbors and how that would affect our position in the community. To our amazement, not one person has held the Farmer Man fiasco against us. Everyone has a story about him, but to them it is, to use the local phrase "una cosa de vida" — a mistake anyone could have made.

So we started again. The vegetable garden was almost a total loss, since nothing had been replanted, but there were twelve-foot high gongo beans (a local legume very similar if not identical to a pigeon pea) yielding well, and a few scraggly tomato plants. A substantial minority of the baby fruit trees had survived and were transplanted. The yuca and pineapple plants had survived in spite of neglect. The yuca, in particular, buoyed our spirits. Rats notwithstanding, I estimate that there was something close to a ton of edible yuca in our field of less than an acre. Apart from eating the yuca, it is more than a little satisfying to grow singlehandedly a ton of anything on your first try. And the yuca has helped in another way; local people are stopping by for yuca, to eat and to plant — our first chance to return substantially the many kindnesses we have received.

One of our first tasks was to dig a new well. Since Farmer Man had sold all the farm tools, we had to borrow a shovel. With the shovel came a neighbor, Geronimo Matute, who started to dig waving aside my offers to take turns. In half an hour he had an almost perfectly circular well about five-and-one-half feet deep, and in another fifteen minutes of furious bailing, we had clear water to drink. From that point on, our volunteer labor force has returned as if nothing had happened.

Up to this point in the story, I have made no mention of specific New Alchemy projects, which reflects what actually happened. In 1976, we have launched our first project and local people are beginning to realize that an Institute is involved. For the entire first season, I had never mentioned it — the impression was of another farmer trying to get started. In the long run, I think this may prove to be a wiser tack than coming in with the Institutional banners flying and promises of great projects for the community.

Before discussing present and future projects and problems, there is a little more about the farm in 1976. I was on the farm from late January through mid-May, Susan was there for the first half of that period and Earle Barnhart made his first working visit. In April, Barbara, Tony and Michael Lavender came to help and stayed on until mid-July; they will be back in the fall. (Meanwhile John Holder is caretaking the farm.) We all favor different kinds of work, so there has been a nice balance, and things have gotten done.

With the lack of certainty as to who would be on the farm and when, we emphasized perennial vegetables — gongo beans, chayotes, yuca, yampi, malabar spinach, and a beautiful and delicious native perennial sweet pepper. But we also planted native or imported tropical varieties of cucumbers, squash, peanuts, tomatoes, eggplant, melons, onions, okra, green beans, mung beans, and ayote (a sort of native pumpkin) in the hope that someone would be here to eat and replant. We have also planted various local spices, including turmeric, ginger, thyme, oregano and coriander.

The ornamental hibiscus I planted last year have bloomed and are forming a hedge by the main entrance. They have been joined by dozens of other flower varieties planted by Susan — mostly native flowers donated by the local ladies.

The plantains, bananas, and coconuts have been chopped out and are bearing well again. Our one-hundred-and-fifty pineapple plants should be bearing by now, as should our largest breadfruit tree. Among the surviving baby fruit trees were oranges, lemons, grapefruits, sweet limes, naranjilla, cas, guava, nispero, nutmeg, tamarindo, stinkin' toe, monkey head, carombola, manzana de agua, avocado and zapote. A nursery has been re-established for some of these as well as for others which succumbed to the onmarching bush — breadnut, akee, mango, pejibaye, caimito and guanabana.

The house, which is what our neighbors call an "Indian house", with walls made of sections of the wild cane which stands between us and the ocean, was seventy-five per cent completed when I left. The first job on the house in 1976 was a prolonged battle against the termites. We should have listened to our neighbors. Their first advice was "smoke". When our first smudge failed to eliminate the pests, we turned to poisons. These were partially effective, but the termites always came back full force within a few days after poisoning. Finally, when we moved into the house, termites and all, the termites left. They couldn't tolerate our twice-daily cooking fire.

We still haul firewood in from the beach, but maybe this year we will be able to afford a small kerosene stove. Our staples are yuca, plaintain, coconuts and gongo beans (from the farm), rice, beans, breadfruit, citrus, sweet peppers, eggs, cheese, malabar spinach, and purslane (from our neighbors), and fish (from the sea and rivers), plus bread, coffee and a variety of herb teas.

Earle, who is by nature a builder, did a lot of building when he was with us. Thanks to him, we now eat at a table pleasantly situated in the shade of the bamboo, overlooking the surf. He also constructed an elegant well cover, a shower stall made of cane and coconut fronds, an eight-foot high trellis for chayotes, a wash stand, a special box for growing papayas elevated in loose soil, as they don't like our rather clayey soil, a prototype tea dryer, and scores of handy tools and gadgets (Barnhart, 1977).

Barbara's particular interest is aquaculture, so I undertook to teach her aquaculture "from the ground down". It turned out to be more of an experience in engineering than aquaculture, but we now have a small pond stocked with fish. It doesn't look like much, but it is a start, and when I recall the spectacle of Barbara of Tony literally covered from head to toe with mud, racing against the rainy season with nothing but a constantly breaking shovel and the most primitive of homemade pumps, it seems like a great deal. Practical fish raising in the pond was delayed by the invasion of a small crocodile, but we have hopes for this year.

Tony, when he wasn't immersed in the swamp, was researching bat behavior. Perhaps his pilot studies will lead to the first scientific study to be based at the NAISA farm.

No description of the farm would be complete without mention of some of the natural delights which make us glad to be there: the one-hundred-foot-high ceiba tree which towers over the yuca field; the scores of other giant trees (some of them with twelve-foot-high prop roots) in our forest, the surf, visible from our porch; the incredibly ferocious sounding howler monkeys; the parrots, carrying on like a yard full of school children; the banana birds (a brilliant yellow and black oriole), who light just a few feet away in the bamboo and sing complicated and beautiful duets; the huge electric blue morpho butterflies; the smell of what we have christened the "cotton candy tree"; the little possum who sometimes visits us at night.......

A lot of our time is spent on an herb tea project funded by the Arca Foundation. It has involved starting nurseries and experimental plantings of "soril", securing seed, visiting and exchanging ideas with our experimenting neighbors..... The project is described in detail on page 23 (McLarney, 1977).

Here I would like to emphasize just one point about it. It originated as much in the minds of the local people as in ours. That is, it was designed with the needs and wants of the local people, as expressed by them, in mind. In our way, we have applied what the Peace Corps and other voluntary service organizations have learned – that the only projects which have a high probability of success are those which people ask for. In the framework of a large institution, the policy of waiting for requests has one drawback – the voices reaching it are usually those of people acquainted with bureaucratic channels of communication.

In our case, communication has been more direct. In my first season on the NAISA farm, I talked with dozens of local people and listened, as one farmer to another, to their desires for the area. Almost invariably we talked of the lack of a road. Everyone allowed that a road would permit them to grow and sell a far greater variety of crops. Most people hoped for the road, but everyone acknowledged the problems it would bring, and a minority were firmly opposed to it. More than anything else, the road is equated with the chance to diversify. The tea project is really only another way of facilitating economic diversification. It is not an "answer" for Latin America. But it is wanted and, to our minds, it fits in this particular community, where nutritional levels are high, but cash income is low. (An average full-time worker earns about $50 U. S. per month.) (Ashe, 1975), and prices of essential goods are only slightly lower than in the United States.

Other possible projects (pending funding) which have arisen from our contacts with the people here:

1. Our tea dryers are based on the cacao and copra dryers ("barbecues") which are a fixture on most local farms. Their use could be expanded to drying food products. For example, pineapple, which grows splendidly in the area, is excellent dried. As with the teas, all that is needed is the knowledge that it is salable in quantity.

2. We would like the farm to become a source of seeds and planting materials for the community. In a small way this has already happened. I have mentioned the visitors who ask for yuca sticks. Another example is malabar spinach. This little-known plant, available from Burpee, is, to my mind, the best pot green to grow in the lowland tropics or during hot summer months in the States. It produces well, withstands the hottest weather, and unlike native tropical greens such as calalu and jaboncillo, there is no need to throw off the cooking water. We introduced malabar spinach to the region in 1975, and already a number of people are planting and enjoying it.

Having established a minor reputation as a source of seed, we should like to expand into distributing many types of vegetable and fruit seeds. There is in Costa Rica a national shortage of almost all types of seed. It is a cliché that the people of Latin America are not very interested in vegetables, but we have received many requests for such seeds as squash, peanuts, watermelon, cantaloupe, green beans, cucumbers, tomatoes, eggplants and okra. People ranging from ten-year-old children to old men have planted the few seeds we were able to spare.

This year we plan to expand our gardening activities. One of our neighbors, Casimiro Dosman, has given us a substantial piece of his farm to use for this purpose. There, Susan and John Holder, who have experience in small-scale commercial vegetable growing, will be trying to put together a combination of the best of native food-growing methods and applicable North American techniques, such as composting. In addition to providing a needed source of vegetables for the community, we want to be able to give seed to others in the area, and to offer informal instruction in vegetable gardening. If anyone has seed of varieties they believe would be well suited for this project, or knows of sources of such seed, we should love to hear from you.

There is even more demand for good fruit tree seed, largely due to the commercial potential of some types of trees. As one local man put it: "I want to plant fruit trees now, because some day we will have a road, and, when it comes, my trees will be bearing already."

But perhaps more important is the nutritional role of fruits. A common sight in Costa Rica is that of children throwing sticks at a guava or mango or stinkin' toe tree. It is my impression that, in the areas of Latin America which are above par nutritionally, this sort of casual fruit consumption is a critical factor. At present, most of Limón Province is well supplied with fruit. But most of the trees the children harvest were planted by their grandparents and there is a tendency to take them for granted.

We would undertake to secure stock of local or superior new varieties of whatever fruits are in demand, plant them, and distribute seedlings free, for yard and garden planting, and at a nominal cost for small commercial scale plantations. There is a local man with skills in fruit tree propagation who could be hired to tend such an operation, if funds permitted.

3. A worldwide agricultural problem receiving increasing recognition is the loss of local varieties of food plants. Our region is not without outstanding local varieties and we would like to secure stocks of these varieties adequate to preserve them. We are just beginning to learn the local cultivated plants. Among those which seem significant are the perennial sweet pepper mentioned above, a small, round and incredibly delicious avocado, and a hardy local cucumber.

4. An alternative to the possibility of the road would be a launch which could pick up produce at points along the coast. Prior to World War II, such a launch existed, but it was owned by a German company and, at the start of the war, it was nationalized and moved to the Pacific coast. We have not defined what role NAISA could play in the re-establishment of a launch service, but it would certainly be a valuable service and we are ready to cooperate.

5. A long-term goal for the area would be the establishment of forest farming as described by Smith (1929) and Douglas and de J. Hart (1976), as a dominant agricultural mode. Should we be able to expand the farm or work out a cooperative arrangement with one or more of the local farmers, we would be ready to begin.

6. Although the farm is in a coastal area, there is not an overabundance of fish, and the supply is very dependent on the seasons and the weather. The small fish pond constructed on the farm is a start, but we would like to see a larger aquaculture system, designed to supply the community. We have been circulating a proposal to build a system similar to the one set up by Prof. Anibal Patiño in Colombia and described in the third *Journal of The New Alchemists* (Patiño, 1976). Such a system would be set up on one of our neighbors' farms, and some member of the family could be trained to operate it.

There are, in all, three functions which we hope the NAISA farm would serve. The first two have already been mentioned – a center for community oriented programs and a functional subsistence farm, organized along the lines of a Samaka farm (Hoskins, 1973) for the use and enjoyment of whoever is living here. Interwoven with these is an educational function. Certainly the farm has already contributed to the education of the Gringoes who have worked there. We would like to extend this; we think that the farm could accommodate a few students without creating too large a foreign presence. Students in biology or ecology would find a great diversity of habitats in the vicinity – virgin forest, second growth, agricultural land, swamps, rivers, beaches and the ocean. We believe that, in the long run, tropical countries will benefit as much from basic understanding of tropical ecology as from grandiose "development" and "aid" projects. The potential of the farm for students in Latin American studies is obvious, and there is also much to offer students of agriculture, economics, sociology and other disciplines.

It is possible that a student program of some sort could contribute to the solution of our caretaker problem, as at present none of us are able to be here all of the time, nor does this seem possible in the near future. A six month or one year stint caretaking the farm could be a tremendous educational experience, and having at least one non-local person there throughout the year would strengthen our position in the local community.

We should also like to be in a position to pay salaries. In the last two years, New Alchemy personnel from the States have received air fare only, with no pay whatever for the time spent in Costa Rica. As mentioned, in 1975 a small amount of local day labor was hired. In 1976 the Arca grant paid stipends to seven Costa Rican farmers participating in the tea growing experiment. We should like to be able to pay a subsistence wage to New Alchemy personnel who travel to Costa Rica to work, but it is more important to be able to continue being a local employer. It is our policy always to give preference to a Costa Rican person for any job in Costa Rica. If the idea of a student caretaker works out, it will be necessary to hire a local person to train, advise and oversee the student. If it does not work, we shall need to hire a caretaker. If the fruit and vegetable nursery becomes a reality, we will need additional labor to maintain it.

Expansion of the farm is a virtual necessity, especially if we are to preserve our small piece of virgin forest. Currently there is land, some of it not in use, in the vicinity of the farm which might be purchased, had we sufficient funds.

There are, of course, a number of items of equipment we would purchase or construct if funds permitted. I have already mentioned a kerosene stove. There are definite limits, though, to the accumulation of equipment; it is our policy never to exceed the limits of what one of the more prosperous campesino families might own. A kerosene stove or an outboard motor would be permissible; a gas refrigerator or an electrical generator would not. (Exceptions could be made for equipment specifically related to our institutional function, for example, a typewriter, but not for items primarily for home or farm use.)

More money would help us, but as long as we can manage a couple of round-trip tickets to Costa Rica annually, and somehow arrange for a caretaker, we will be there. We are there because we want to be, and we think our presence will continue to be a valuable one.

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Herb Tea Project

– Bill McLarney

I hope that all readers of this report first will have read my longer piece in this *Journal* (page 17), describing the progress of the New Alchemy farm in Costa Rica which explains why New Alchemy has become involved in the development of a cash crop in Costa Rica. Whereas overemphasis on cash crops for export has contributed to the problems of tropical "third world" countries, each environment should be considered individually. This project seemed an appropriate undertaking in our particular case.

In a decision reached mutually with our Costa Rican neighbors, it was felt that it would be socially healthy to diversify the cash crop basis of our community. In attempting to do so, we are handicapped by the fact that the region lacks roads, which limits the export of perishable crops. Our first clue as to what to do came from examining the crops which are successfully exported from other such regions in the lowland tropics – cacao, copra, rice – *dry* products. Some of all three are grown in our area, but none seems ideally suited. What new crops could we try?

The first answer to that question came from my experience as a Gringo living in Limón Province. Perhaps nowhere in the world do people utilize such a variety of herb teas – "bush tea" they call it – as in the Caribbean coastal region of Central America. Some bush teas, such as lemon grass and various mints, are widely drunk in other parts of the world as well. Others, like cowfoot and Mary Shakewell, are virtually unknown outside the region. Some are drunk only for the taste, others are reputed to have medicinal value. None of them are grown commercially to any extent. People may plant a bush in the yard and keep the weeds away from it, but that's about all.

Currently the herb tea business is one of the more rapidly growing agriculturally-based businesses in the United States. If people are growing bush tea commercially, why shouldn't the Central American farmer get in on it? With that thought, and a small grant from the Arca Foundation, New Alchemy went into the tea trade.

The first step was to contact potential buyers in the States. I sent out letters to sixty some packagers and distributors of herb teas, explaining that we were working on behalf of a farming community in Costa Rica and that we hoped our letter would interest them not only as a business proposition, but as a way of doing something really useful. It is a sad commentary on the state of small "counterculture" businesses that only three of those letters received replies. Of the replies, by far the most encouraging came from Celestial Seasonings of Boulder, Colorado. They encouraged us to proceed and agreed to send representatives to Costa Rica to discuss the matter further.

In January 1976, at the start of my annual Costa Rican stint, I began discussing bush tea with the farmers in our area. The first response was usually a rapid-fire demonstration/lecture of different teas, including exotic-sounding medicinal teas like "jackass bitters" and "piss-a-bed." Eventually I was able to explain the nature of the project: Gringoes were beginning to learn about bush teas and would pay well for certain good tasting kinds. The problem was to decide which kinds we could grow in commercial quantities and then to work out how to do so.

Again, the response was enthusiastic. Foreign aid people I meet often complain about the "conservatism" of the Latin American campesino and his resistance to new ideas. Conservatism there is, but much of the resistance to new ideas is really a resistance to being told what to do by someone who doesn't know any more than you do. "Experts" are often not popular, even when they happen to be right. Certainly they are not popular among the Central American country people, who are developing a minor mythology around the misadventures of the bumbling "tecnico." I was in the psychologically fortunate position of really wanting to help but, at the same time, needing to ask for advice and assistance with something the local people knew far better than I. The response was generous and enthusiastic. All I had to offer was one piece of information: "If you can grow enough of this stuff, you may be able to sell it."

We still had not settled on which tea to grow, but that was resolved during the course of a two-day visit from Carolyn MacDougall and John Elstrott of Celestial Seasonings. Part of our "work" was to spend an afternoon sampling delicious herb teas. The result of that, and a lot of talking, was to settle on one tea, locally known as "soril" to test plant in our first year. "Soril" is the name favored by the English-speaking Black people in Limón, but Spanish speakers call it "jamaica" or "vinillo." In the tea trade it is known as "hibiscus." It is the red, fruity component of Celestial Seasonings' popular "Red Zinger" tea. Botany books usually call it "roselle" and if you want to be precise it's *Hibiscus sabdarifa.* It is classified in the same genus as the ornamental hibiscus, *H. manihot* (known as "shoeblack" in Limón, where it is the most common ornamental plant, and it is in fact used to polish shoes) and okra, *H. esculentus,* but its appearance is quite different from either of these.

The soril plant is a shrub which grows to a maximum height of about eight feet. In season, which is December or January in Limón, it bears a profusion of "flowers" which have somewhat the shape and texture of an okra pod although they are much smaller and are the deep red color of the hibiscus flower. It is the thick, leathery outer coat of this "flower" which is used to make the tea. At this time the principal sources of commercial soril are Egypt and the Sudan, and they cannot meet the demand.

In Limón, soril may be drunk hot or cold, plain or with ginger, as a soft drink or an alcoholic one ("soril wine", made by mixing the tea with rum). It is drunk traditionally around Christmas time. Levi Bryant, one of the farmers working with us, recalled how the Black farmers used to ship soril to the city of Puerto Limón. "First time, they grow plenty soril this side, but when they carry to Port Limón, the Spaniards dash it in the harbor. Because when the people get that bush, they don't want to buy the Spaniards' wine." Apart from its use in making drinks, the soril leaf is a very palatable green.

The soril plant was not designed with our convenience in mind. By the time we had settled on soril as the crop for our experiments, the harvest season was over and seed was scarce. We managed to locate a few late-bearing plants, but it was going to be a small experiment indeed, until Levi turned up several thousand seeds his brother had been saving.

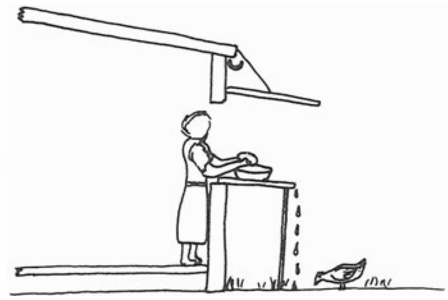
With the seed secured, the attitude of the farmers was once again enthusiastic. I must say that the "conservative" campesinos showed a better grasp of the concept of an "experiment" than most lay people I have dealt with in the States. There was no "Gee, Mister Science, what do we do next?" Rather, each farmer offered his own ideas for planting two different ways, or in two different types of ground, and comparing yields.

The major part of the Arca grant money was spent on stipends to the farmers who would be working with us. I felt it was unfair to ask people who are constantly close to the line economically to invest their time in a project which possibly would bring no return. As of my departure for the States in May, seven Costa Rican farmers – Levi Bryant, Willie Barnett, Casimiro Dosman, Pablo Rojas, Miguel Herrera, Isaiah Vallejo and Jeronimo Matute – were participating, along with one American resident of another part of Limón Province, Todd Scotlant. In addition, there are about ninety plants coming along nicely on the NAISA farm, where they are interplanted with pineapples. The soril plant makes very little shade, and so is good for interplanting with low-growing crop plants.

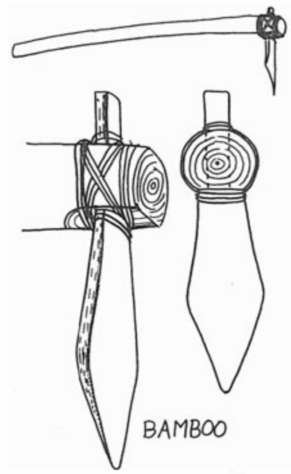
I will probably miss the harvest this season, unless it is very late, but Tony Lavender will be on hand to take notes on cultivation techniques used by each farmer and to determine yields. We can then decide whether commercial scale cultivation would be feasible. Assuming the answer is affirmative, we will dry the crop, using the dryers described in the article below. We expect a token crop at best this year, but Celestial Seasonings has agreed to buy the crop. however small, which should give the participants a large psychological boost.

We hope that 1977-1978 will mark the first season of commercial soril growing in Limón. If it does, our farmer/experimenter neighbors will be able to point with pride at their own creative contribution to solving the economic problems of their community.

Standard Water Supply



Window-Sill Dishwashing and Drainage



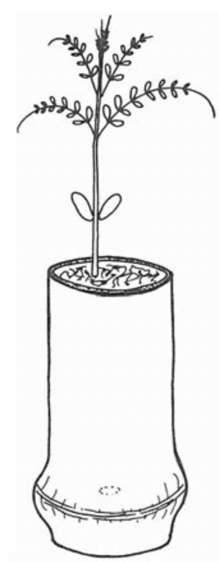
Simple Bamboo Hoe

Technology Appropriate to Gandoca, Costa Rica

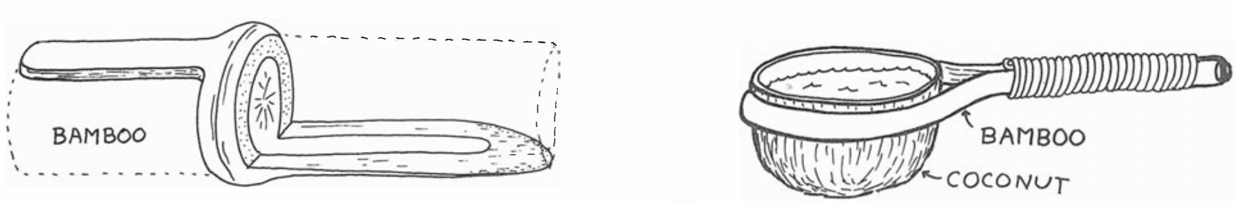
—Earle Barnhart

Local Cooking Stoves

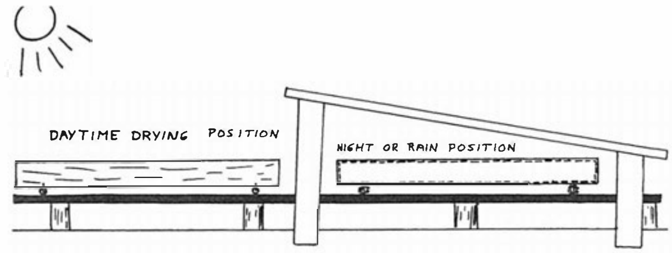
The Gandoca area of Costa Rica, where the New Alchemy center is located, is a remote tropical rural community. It is described in more detail in Bill McLarney's articles on our Costa Rican farm and on the Herb Tea Project. Transportation of people and materials to the nearest road is limited to walking, horseback or small boat and any of these requires at least several hours of travel. Overland, the trails are arduous and can be impassable at times in the rainy season. By sea, dugout canoes and larger motorized dugouts which are used have a limited capacity and are often restricted by rough seas. These conditions of transportation have played a major role in local technology by restricting the size and quantity of transported items, in and out. This partial isolation has many other social consequences and should be kept in mind in the following discussion.



Bamboo Segment as Seedling Pot



Custom-made Implements



Local Method of Drying Copra and Cacao

Indigenous materials available in the vicinity are:

Forest Plant Products – hardwood logs and saplings, vines suitable for cord, palm leaves for thatching.

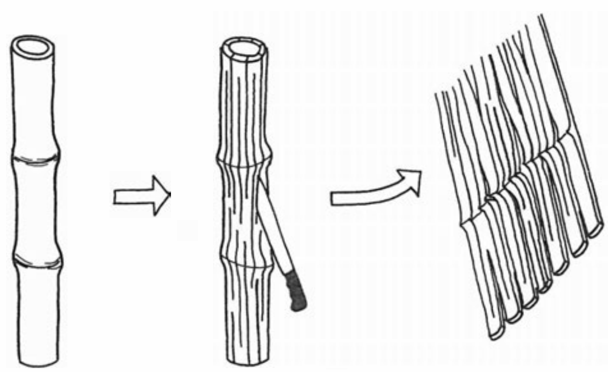
Domestic Plant Products – bamboo, cane, calabash gourds, coconuts.

Driftwood and Debris – bring some lumber, bottles and miscellaneous plastic items.

Clay – from local deposits, not used.

Stones – very scarce, except for coral fragments.

The most common tool is the machete, which has a diversity and quality far above any other tool used. Most daily tasks can be performed by a machete and a short hooked cane which is also usually carried. There are special shapes of machetes for special jobs. The standard long one is often used in lieu of a variety of other basic tools. A skilled person can use the same machete to chop down a good-sized tree, clear brush, mow grass, dig holes, plant crops, open coconuts, peel oranges and cut fingernails. An entire house can be built with this one tool, using material from the forest. Other metal tools are used, but much less often. Axes for felling large trees are often shared among neighbors. Most farms have hammers, nails and screwdrivers. Some craftspeople have planes and adzes. It is important to keep in mind that there are virtually no machines to maintain, any unprotected metal rusts very rapidly, and most hand tools available regionally are unfortunately of low quality.


Bamboo Board for Walls and Floors

The most basic needs of families are met as follows:

Water – shallow hand-dug wells from four to twenty feet deep are most common, with a bucket and rope for lifting water. In most cases these wells have a raised rim made from a steel drum and have a loose cover to keep out leaves and animals. Some households collect rainwater from roofs and store it in steel drums for washing and drinking.

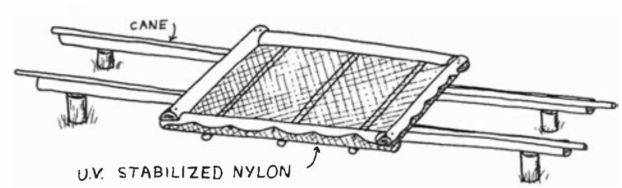
Agriculture – food supplies are a combination of tropical fruits and vegetables, dairy, poultry, pigs, fish, beans, and purchased staples such as rice, flour, sugar, and spices. The technology of agriculture is limited primarily to the machete, but wire fencing, bamboo pig pens, and cacao drying racks are also used. The drying racks roll on small railroad rails salvaged from a long-gone banana plantation nearby.

Human Waste – hand-dug outhouse holes, sometimes enclosed, are most common. Mass-produced cement privy floor plates and seats can be seen leaning unused against many houses, apparently part of some sanitation program.

Shelter – houses range from simple thatched shacks of loosely fitting boards to fairly elaborate, large two-story houses with porches. Most houses are raised on pilings, made with sawn lumber, and have tin or fiber-asphalt roofing. Termites are combated with liberal annual doses of DDT. Cooking is done on open wood fires, or occasionally with kerosene. Lighting is by kerosene lamps and candles. Washing is done outdoors, and dishwashing on a window sill draining outside. Storage of food includes smoked fish, jars of coconut oil, tins of beans, rice, flour, salt, sugar, and other staples. Most fruits, vegetables, and animal products must be eaten within a few days.

Transportation – many families have one or more horses for hauling heavy objects, such as cacao, to market, or lumber from the mill. Part of any journey involves rugged and steep hills and streams must be forded along the beach. There is an inland route to Panama. A motorboat comes once a week from the nearest store with supplies. Arrangements can be made to have special items brought from Limón by this boat, but the waiting period may be many weeks. It takes occasional passengers.

Communications – most homes own transistor radios, which supply welcome music, news, and weather information. Mail delivery and a wireless telephone is

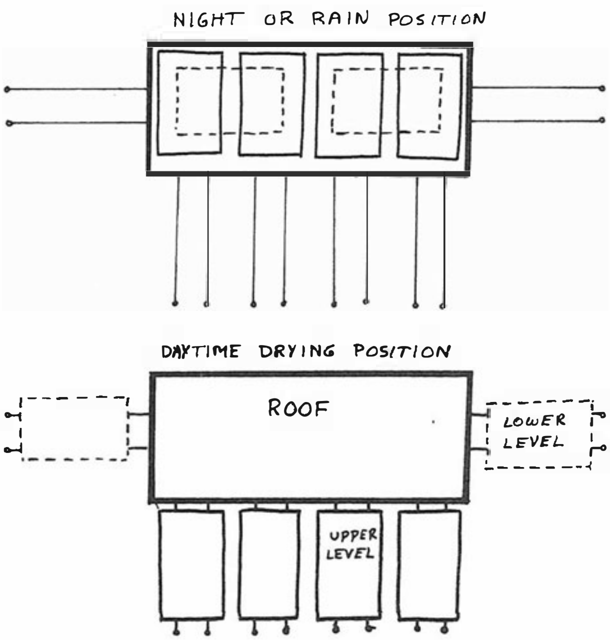


HERB DRYING TRAY
Showing Construction Details and Tracks (Roof not Shown)

many hours away at the closest town. The pace of living is slow enough that traveling neighbors and Saturday markets keep most people in contact.

The utilization of local plants for materials and services is quite advanced and often elegant. Outstanding examples are:

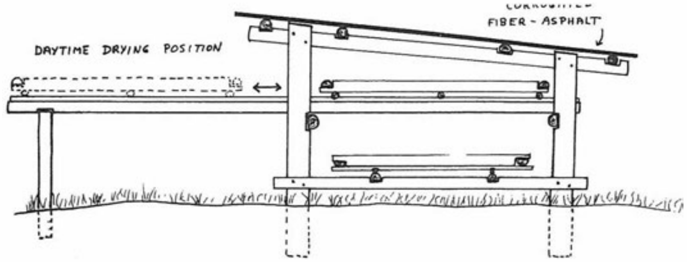
Living Fences. There are several tropical trees that form living fence-posts if cuttings are rooted in straight lines. The living posts slowly thicken and strengthen, requiring only periodic pruning of sprouts. Common plants for this purpose are madera negra, guava, and calabash. Calabash is especially appropriate, as it produces large, durable gourds useful for water containers and food storage.



SOLAR HERB DRYER
Upper and Lower Trays Slide Out in Three Directions

Pipa. Pipa is a special variety of small coconut, whose fruit, when green, is filled with clear, sweet water. In some places, pipa is grown near trails as a convenient source of pure water for travelers. Such an inexpensive luxury should be more widely adopted, especially as it will grow on hot, salt-water beaches.

Bamboo. Bamboo grows to a large size and can be used for innumerable structural purposes, such as peat pots for tree seedlings, bamboo boards for floors and walls, trellises, pig fences, and many others. Unfortunately the number of species is quite limited. Considerable benefit could result from introducing a type suitable for mats and baskets.

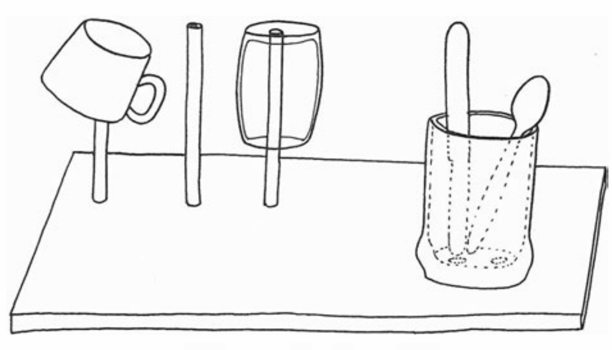


SOLAR HERB DRYER
Drying Trays Slide on Rails. One Roof Covers Two Levels of Trays.

There are other interesting uses of plants. Banana leaves can be informal plates or food wrapping, jungle vines which are as strong and pliable as cord are used as such, and palm leaves of various types can be thatched to form waterproof roofs and walls.

We are trying to base our technology in Costa Rica on the successful experiences of people who live there. We have constructed a house, furnishings and a herb dryer mainly from local materials. In fact, we are using local material to a larger degree than is the present trend. In most situations, local custom provides patterns which can be adapted. This coastal region has been settled only recently. In a few instances, such as termite proofing, simple local strategies had often not had time to evolve before modern solutions such as DDT became available. In such cases, ideas from other tropical regions such as Southeast Asia or the South Pacific should be considered. Now that the basic housing and other living requirements at the New Alchemy center have been completed, we are eager to investigate several routes of technical experimentation to discover their appropriateness.

(1) From an architectural view, there is great need for specialized bamboos and reeds suitable for wall and floor mats and basketry. Attractive flat surfaces for covering walls and floors currently are difficult to construct. The best solution would be a structural bamboo which also produces edible shoots.



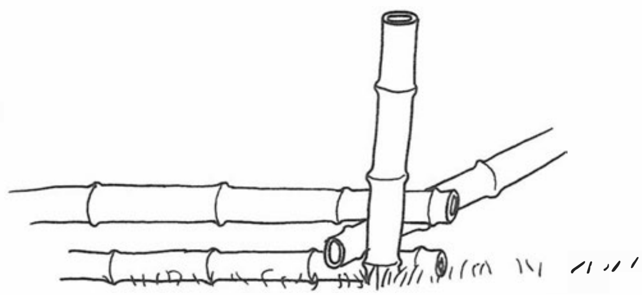
Custom-made Dish Rack

(2) A test should be made of a living fence of Cassava posts interwoven with bamboo slats. Such fences are used in the Philippines as pig and chicken enclosures and, being continually fertilized by the pigs' wastes, produce Cassava tubers and edible leaves on both sides of the fence.

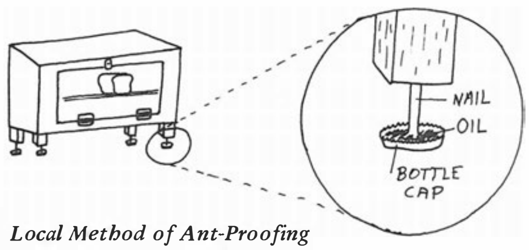
(3) An important unused local resource is an outcropping of fine clay on the beach. This clay can be formed into bricks or containers, dried on the beach, and fired with driftwood. Containers for storage are relatively scarce in the area, and few, if any, households have any type of oven for baking. If the clay is suitable and the products are acceptable, pottery would be a good local craft to initiate in the community.

REFERENCES

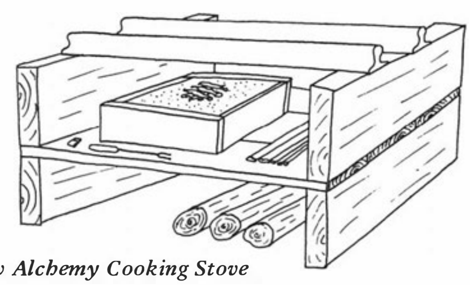
McLure, F. A. May, 1953. Bamboo as a Building Material. Reprinted by Peace Corps Division of Volunteers Support, Washington, D. C. 20525. 49 pp.



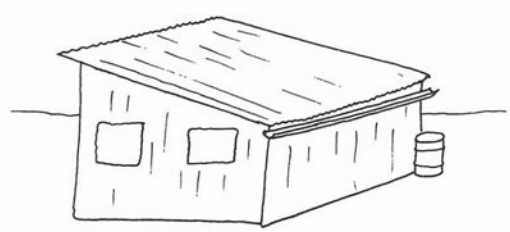
Construction Detail of Pig Pens and Compost Box



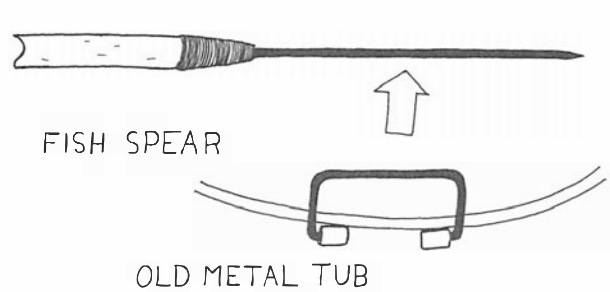
Local Method of Ant-Proofing



New Alchemy Cooking Stove



Rainwater Collection



Book Reviews

— *Bill McLarney*

Dekorne, James B. 1975. *The Survival Greenhouse: An Eco-System Approach to Home Food Production.* The Walden Foundation, P. O. Box 5, El Rito, New Mexico 87530. 165 pp.

Our work at New Alchemy would have little meaning if no one attempted to adapt our ideas to their own situation or to apply the things we learn in other contexts. Among our earliest "fellow travelers" was the Dekorne family. Before there was a *Journal of the New Alchemists* or an Associate Membership program, the Dekornes were planning their own research and exchanging ideas with us. They have tried some things we haven't such as hydroponics, beaten us at others like the wind generation of electric power, and failed at some where we have had some success, particularly aquaculture. In other words, they are different people, in a different place, doing their own kind of New Alchemy.

Now Jim Dekorne has brought out a book, describing their continuing effort to build a small food-producing ecosystem for their own survival and enjoyment. He is totally candid about their successes and failures: "You won't find here a blueprint for the construction of a one hundred-per cent efficient free lunch machine, but instead the description of an experiment in progress, including some educated opinions on how it might be improved." If you, like me, have had a surfeit of "experts" on the one hand and gushing "New Age" visionaries on the other, you will welcome this down-to-earth description of a piece of the real world.

After a philosophical and historical introduction, which will introduce nothing new to most readers, but should make you like the author, the book goes on to describe the design, construction and operation of the Dekornes' 12' x 24' solar-heated, wind-powered greenhouse-cum-aquaculture system. There are also appendices on "do-it-yourself wind generators" and greenhouses attached to dwellings.

The word "ecosystem" is central to the Dekornes' approach, and it is a refreshing change from the standard works on greenhouse management. Among their discoveries are a really effective *organic* hydroponic system and the use of rabbits as "carbon dioxide generators" for the plants. The book is loaded with other discoveries, tips and insights that will prove valuable to many readers.

But I like the book for reasons other than its usefulness. Jim's approach to science and technology is of the healthiest imaginable sort: "We have even progressed to the point where we can accurately estimate the number of amperes being generated by our wind-electric system, just by feeling the wind on our faces and observing how the trees bend. Technology need not estrange us from nature — it can put us in tune with it."

The Walden Foundation *is* the Dekorne family and the book (available for $7.50 by mail only) is part of their survival kit. The last page gives us a clue as to the do-it-yourself nature of their operation: "This book was typeset on an old and very used IBM Executive Typewriter. Layout was done during October and November, 1975, in a 61 year-old adobe farmhouse. Any unexplained marks on these pages are probably photocopies of soot specks from the wood-burning heater." And that is perhaps the strongest recommendation I can make — not just that the Dekornes have done interesting and useful research, described and illustrated it well and published it, but that they have lived it, in the difficult environment of northern New Mexico. It gives us renewed confidence in our concepts.

I think any readers who are interested in New Alchemy's bioshelters in more than a theoretical way will want to read *The Survival Greenhouse.*

We get inquiries about just about every aspect of aquaculture. We try to handle these questions, particularly from our Associate Members, but we are not always the best source of information. A recent issue of the *Commercial Fish Farmer* listed the following sources of aquaculture information. Bearing in mind the basic "agribusiness" bias of most "establishment" information sources, you should feel free to contact them with general aquaculture questions. (We, of course, are free of all biases.)

Commercial Fish Farmer Magazine
P. O. Box 2451
Little Rock, Arkansas 72203

Fish Farming Experimental Station
U. S. Fish and Wildlife Service
P. O. Box 860
Stuttgart, Arkansas 72160

U. S. Fish and Wildlife Service
John Giudice, Fishery Biologist
P. O. Box 4389
Jackson, Mississippi 39216

National Marine Fisheries Service
Number One, Union National Plaza, Suite 1160
Little Rock, Arkansas 72201

One of the specific subjects we get the most questions about is trout culture. If you are in a position to go into trout culture, you are one jump ahead of many other prospective aquaculturists; trout culture is one of a very few forms of aquaculture which is well developed in North America, and there are a number of how-to-do-it books on the market. So far I have seen two which I like:

Sedgwick, S. Drummond. 1976. *Trout Farming Handbook.* Seeley Service and Co., London, distributed in the U. S. A. by Scholium International, Inc. 130-30 31st Avenue, Flushing, New York 11354. 163 pp. $13.50.

McAdam, Paul. B. 1972. *How to Make Money Trout Farming.* Jumping Rainbow Ranch, Box 848, Livingston, Montana. 139 pp. $5.95.

One of the first problems facing many prospective trout farmers in the U. S. is that virtually all the literature, and especially books, starts from the assumption that the reader is interested in competing with the giants of the trout culture industry. The same criticism applies to the catfish farming literature. I am acquainted with any number of successful trout farmers who grow fish for their own tables or for small, specialized commercial markets, but from the literature one would never believe they existed.

Of the two books reviewed here, Sedgwick's suffers most from this bias toward bigness. But the basics of trout culture are the same at any scale, and Sedgwick presents them more clearly and concisely than any other author I am familiar with. He covers all the subjects of major concern to a trout farmer, starting with the biology of trout and on through water supply and pond construction, fry rearing, diseases, hygiene, feeding, brood stock, economics, and trout farm equipment. There are also sections on matters which, while not of universal concern, will be important to some farmers, such as hatchery operation, cage culture, salt water trout farming, and fish for angling.

Sedgwick has taken care to weed out material which is theoretical, incidental or anecdotal and get down to the real meat of his subject. As a result, he conveys more information in a pocket size book than other authors have done in tomes. The disease chapter is especially noteworthy in this respect; much of the literature on fish diseases is difficult to read for anyone but a trained pathologist, but Sedgwick's treatment is usable by any trout farmer.

There are flaws; most of them minor. The most serious omission in terms of content is in the feeding chapter. Sedgwick (in common with most trout culturist-authors) leaps directly from the dietary requirements of trout in terms of protein, amino acids, vitamins, etc., to a discussion of commercial feeds. The implications are that there is no alternative to commercial feeds and that natural foods have no value in trout culture. (See Cage Culture, page 77, for this writer's feelings on that subject.)

The other major flaw is the complete lack of reference material. Reference is made to other publications in the text. For example, on page 67 we learn that "Halver (1964) has suggested certain minimum amino-acid requirements for salmonid fish," but nowhere in the book is there any clue as to the title of whatever paper Halver published in 1964.

Sedgwick writes with a calm authority which bespeaks his many years of experience in trout and salmon culture. North American readers should not be put off by the fact that most of that experience is in the British Isles. Our rainbow trout, *Salmo gairdneri,* is virtually the only trout grown for food anywhere in the world, and basic techniques are the same the world over. His conservatism should keep the merely enthusiastic from running off and losing their shirts. I would like to see more sentences like "It (trout farming) is a hard and often dirty job, which must go on in all weather and at all times." Yet he is out of touch with the needs of the non-commercial and small-scale grower when he advises all prospective trout growers first to take employment on a fish farm "for a minimum period of one year, and preferably for not less than three years."

Paul B. McAdam, like S. Drummond Sedgwick, is an experienced trout farmer, but he seems to be a very different person and he has written a different book. Literarily, he definitely takes a back seat to Sedgwick. His anecdotal, rambling, poorly organized and sometimes grammatically confused prose makes his book much less of a "handbook." And, as McAdam's frequent use of italics and exclamation points indicates, he is an enthusiast: "Become a pioneer Trout Farmer. You're needed today!"

McAdam's enthusiasm is perhaps the greatest virtue of the book. He seems to be the only author to recognize the existence of *small* trout farmers and to encourage them. In the Preface, he makes this distinction: "With the descriptive words 'Trout Farming' we distinguish a new industry from that of the Commercial Trout Growers. Commercial Trout Growers have trout hatcheries, supply fingerlings, then grow the trout in raceways. 'Trout Farming' generally indicates the use of the natural environment to raise trout." In the book, he attempts to treat both aspects and to help the reader decide which approach to take. The large commercial grower will have little further use for the book, but the small grower will find many ideas and tidbits of information.

In general, McAdam covers the same subjects as Sedgwick but you will have a harder time finding the subject you want in McAdam. Easily the weakest section is on disease. McAdam advises Malachite Green for "fungus" and Terramycin for everything else. This is not enough for the modern trout farmer to know.

There are fairly useful lists of reference and equipment suppliers, as well as recipes, conversion tables and other helpful but not essential items.

For the prospective or beginning trout raiser, Sedgwick's is the basic work, while McAdam supplements it as an "idea book", particularly for the small farmer in North America.

The last book to be reviewed here is not an aquaculture book, but it should be:

Gaddie, Ronald E., Sr., and Donald E. Douglas. 1975. *Earthworms for Ecology and Profit, Vol. 1:* Scientific Earthworm Farming. Bookworm Publishing Company, 1207 South Palmetto, Ontario, California 91761. 176 pp.

The title lacks something in grace, but that is about all that is wrong with this book, one of the most thorough and best organized "how-to-do-it" volumes I've ever seen on any subject. The authors, like the authors of the trout culture books reviewed above, are experienced commercial growers of their animal. They have covered every facet of their field I can imagine, from basic earthworm biology right down to how to advertise worms for sale.

All that's missing is an index, but this is largely compensated for by the exhaustive table of contents. A few minutes scanning the table will get you to the right page to learn about any aspect of worm culture.

Why do I say this should be an aquaculture book? Because here is not only the archetypal fish bait, something fish obviously like to eat, but also one of the few invertebrates for which there are well-developed methods for mass culture at home. Yet the earthworm has not been "discovered" by fish farmers looking for an alternative to commercial feeds. The possible use of worms as fish food is accorded one paragraph under "Miscellaneous earthworm markets."

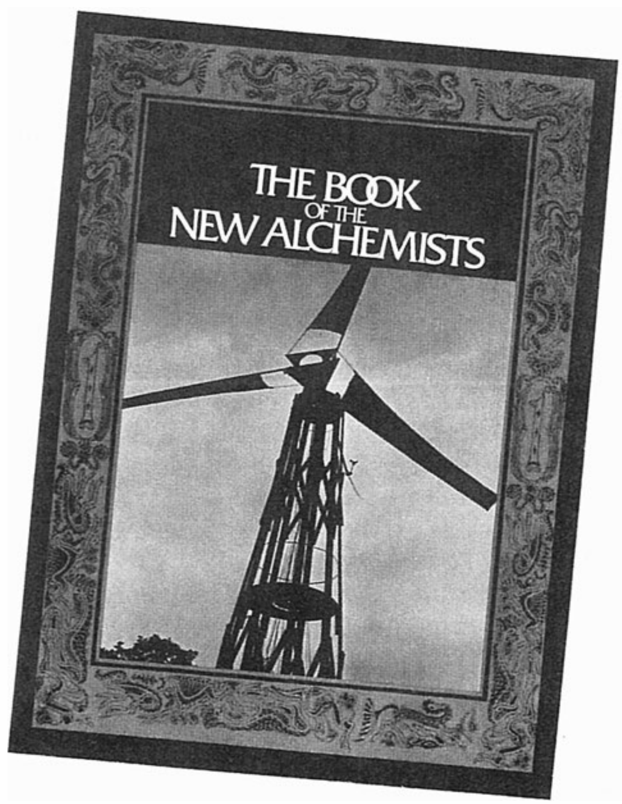
There are of course other reasons to grow earthworms which may interest our readers. Their value in farm and garden soils is well known, they are marvelous converters of most kinds of organic "wastes", earthworm "castings" make fine fertilizer or potting soil and, as the title acknowledges, some of you may be looking for a way to make a living. According to the authors, "The raising and selling of earthworms is approaching a billion-dollar-a-year business."

Gaddie and Douglas discuss all these and other uses of the earthworm. The how-to-do-it sections include construction diagrams and tables that are really helpful and photographs that are more than decorative. The usefulness of the book as a reference is enhanced by the authors' practice of breaking the chapters down into numbered sections and providing extensive cross-references. For example, in Chapter 3, Paragraph 3-6.3 on "Preparation of Bedding" is the note "Earthworm beds may be watered as stated in Paragraph 6.8." Potential pitfalls and how to avoid them are presented in bold-face sections, inset and headed "CAUTION."

This book should enable any competent person to grow earthworms for whatever purpose.

THE BOOK OF THE NEW ALCHEMISTS

John Holt is a long-time friend and Associate of New Alchemy. A while ago, he showed our *Journals* to Bill Whitehead, a senior editor with E. P. Dutton & Company. Bill Whitehead contacted us and, as a result of the subsequent collaboration, Dutton is publishing *The Book of The New Alchemists*. It is a compendium of articles from *Journals One* through *Four* and should appear in the fall of 1977.



Somehow, in the whirlpool of issues in which so many of us are caught by virtue of living at this time and in this culture, our attitudes toward some very basic and straightforward questions often have come, symptomatically, to reflect our confusion. Typical of this is the welter of conflicting ideas that center around the issue of food. As a culture, we are vastly overfed, while millions of people are malnourished, go hungry or starve. Yet our leviathan economic structure mades it difficult for us to share our abundance. We are wasteful beyond belief. We tolerate the production of foods that have been processed to be almost without nutritive value, that are extravagantly, even unnecessarily, packaged and are priced without regard for their real worth.

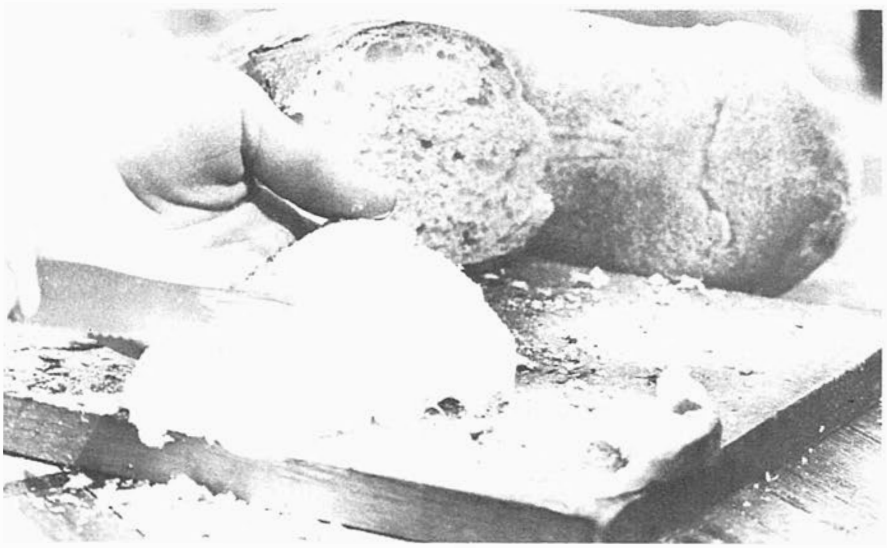
With the resurgence of feminism, the preparation of food has become a symbol of the oppression of women by men, perhaps because of differing interpretations over the question of power. That life=food =power, as Erich Neumann says, is understood by everyone. But it is a masculine conception of power, although one to which women are becoming prey, to see it as meaning domination and hierarchy or "power over." In our attitude to the growing and preparation of food, we are choosing to think of its inherent power as immanental or "power in being" and, as such, power to sustain life. At New Alchemy we have always felt that work with food is work to be honored. To have enough food in a hungry world, to have access to land and to grow one's own food in a commercialized culture is to be privileged. To nourish people one cares for and yet to leave the soil undepleted is a gratifying and a fulfilling aspect of human existence.

It is in this spirit that we offer our cook book. We make no pretensions as to its being entirely based on self-sufficiency. It is rather the reflections of the experiences of a group of seasoned, mainly seat-of-the-pants cooks who are fond of eating and are trying to make the best use of what is available under varying seasons and conditions. Hilde and Susan are both first-rate examples of this type of cook. Hilde reduces the wasting of food to a degree that would be considered almost impossible by most North American cooks. Susan grows, gathers and preserves a great deal of what she and Bill McLarney eat. Sterling as these practises are, as a partially weaned Francophile, I should be able to muster only theoretical enthusiasm if what they come up with wasn't almost always good. This is, of course, a matter of opinion. Susan and Bill, being highly principled, maintain the same dietary practises in Costa Rica where "what's there" is obviously very different. Both Bill and Susan return after their time there looking undiminished, but Earle, during his visit, shed a great deal of weight and did not think too highly of the diet on which he had been subsisting. In general, however, the attitudes and recipes we have included are fairly representative of what might very loosely be called our philosophy of food.

The following recipes are not particularly precise, but more ideas or suggestions for meals when confronted with surpluses at one time and shortages at another. We offer them in the hope that the very real pleasure we have had in working with food will extend outward to be shared by many others.

Photo by Hilde Maingay

The Cook Book of the New Alchemists



shadow bread
sky oven
cloud snow
fire smoke

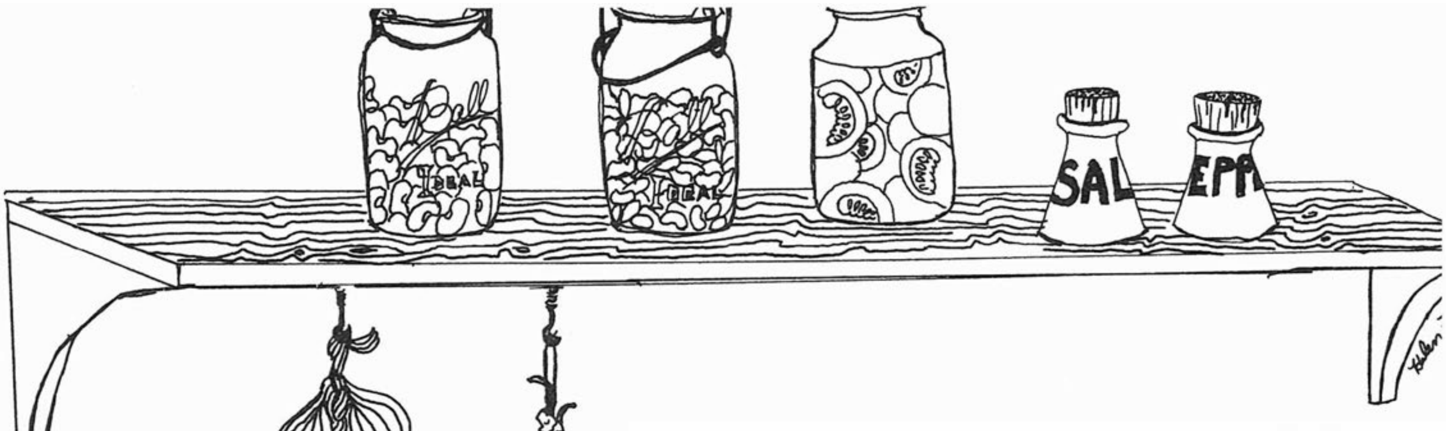
feed us
who saw
your fusion

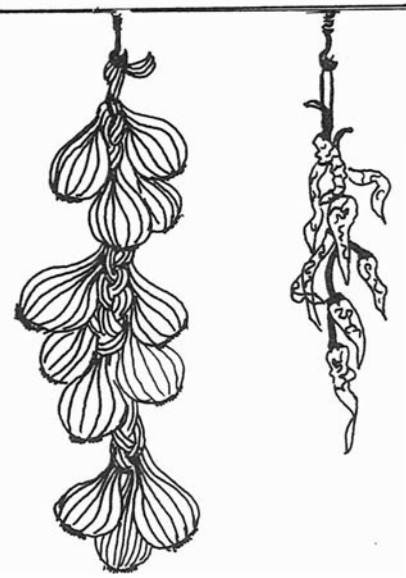
bread oven
snow smoke
fire cloud
sky shadow

feed those
who recall
the vision

— Meredith Fuller-Luyton

Photo by Hilde Maingay





In the third *Journal,* we included a section called the *Trash Fish Cook Book*. This year we want to share some of our other favorite things to do with food. If we called it the "Trash Food Cook Book", you'd get the wrong idea – it's about good food – mainly food we grow ourselves, but like the "trash" fish, these good foods are often little known or underutilized. We have found that growing the food is only the first step. In living both more economically and more ecologically, people have to learn to change their food preparing habits and their eating habits. In too many cases, the need for food triggers the foot to push the gas pedal to go to the store. I have seen store-bought lettuce in a friend's refrigerator when there was much better available in the garden or, more subtly, rice on the table night after night when the garden could supply a variety of starchy foods that didn't have to be grown somewhere else and shipped.

I think the main thing in learning to use food properly is to take stock of what you've got and use that rather than to think of some particular dish you want or are used to having and then buying whatever you need in order to make that. It's creative, it's fun, and it's an important step in trying not to be a drain on the rest of nature.

It's late fall now and I am beginning to rely on stored and preserved foods with a few hardy things still coming from the garden and fresh treats from the greenhouses. Each season offers different foods but, if you respond to the changes, you can provide for yourself in all seasons. A big pot of soup made with preserved vegetables will make better lunches than endless cheese sandwiches. Baked pumpkin or squash pudding is as good as cereal for breakfast.

As important as not wasting it or taking unnecessary energy from somewhere else to get it, appropriate use of food means making it taste *good.* As Dr. Samuel Johnson said many years ago:

> "Some people have a foolish way of not minding or pretending not to mind, what they eat. For my part, I mind my belly very studiously and very carefully, for I look upon it that he who does not mind his belly will hardly mind anything else."

Here are some of the good things we make.

BEANS

Beans aren't just beans – the three dishes I describe are as different as can be. Encouraging note: If red beans cause belly disturbances for you, try some other color, such as black or white beans. Many people find these much less aggressive.

BLACK BEANS AND RICE

This recipe is for about two cups of uncooked beans. They should cook three hours, more or less, depending on whether you soak them before cooking, how large they are, how hard, etc. It is better, of course, to save time and energy and soak them overnight. Cover the beans with water and, if they get dry any time during the cooking, add more water. After about two hours, chop and add a couple of garlic cloves, an onion and as much hot pepper as you like. Season with at least a teaspoon of cumin and a little oregano and sage. Add a couple of tablespoons of coconut oil if you have it (it's very common in Costa Rica and we always bring a bottle back) or some grated coconut. Serve the beans on just plain buttered rice or for a really special dish, rice cooked in coconut milk. Make a hot sauce by soaking minced hot peppers in warm oil for twenty-four hours. For a different taste, season black beans with bay leaf and cloves instead of cumin.

An orange sauce is good on any variety of simply cooked dried beans. Chop a hot pepper and two garlic cloves finely and simmer them in a little white wine – a half cup should be enough, but add more if it cooks away. Meanwhile, squeeze the juice from two oranges, add two tablespoons of vinegar and mix a tablespoon of cornstarch into the liquids. Stir this into the wine and peppers and simmer until it thickens. Thin with boiling water if necessary.

CHILI BEANS

If you soaked the beans, cook them in that water plus a jar of tomatoes. Add lots of onion and garlic and hot pepper after an hour of cooking. Season strongly with oregano, sage, paprika and parsley. Serve with cornbread or tortillas.

MIDDLE EASTERN BEAN PUREE

Cook white beans until they're tender. Strain off most of the liquid and save. In a blender, puree about two cups of beans with a garlic bud, about three tablespoons of oil, the juice of a lemon, salt and pepper. Vary amounts according to taste. I sometimes add a little vinegar for extra tartness. Add bean cooking liquid to achieve the consistency you want. You can dip bread into the puree. Syrian bread is especially good, but I wouldn't complain about homemade whole wheat. You can also serve it on tomato quarters or lettuce. I've made the same sort of puree with overly mature green peas, the seed part of green beans, and dried limas.

FISH CURRY

You can use left-over baked or fried fish or your less desirable frozen fish. Left-over rice is fine, too.

For two people: Chop a large onion and a handful of parsley. De-bone the cooked fish and break into small pieces. Three-quarters of a cup is plenty for two people. Fry the fish, onions and parsley until the fish is slightly browned. Add more oil and put in as much rice as you'll eat. Season with lots of good curry powder, a little sage and oregano and garlic. Stir fry until the rice is a little browned, too. It's good served with cold yogurt or cranberry sauce or pickles.

COSTA RICAN RUN-DOWN

We learned to make Run-Down from a lady in Limón who cooks on a crooked stove, in a frying pan with an iron stuck under one side to level it out. We asked her why the dish is called "Run-Down" and she said, "Because it's made with coconut milk..... "

For two people who eat a lot, grate one coconut. Through this pour about two cups of water slowly, squeezing out the milky liquid. This is the coconut milk as opposed to the watery liquid inside the coconut, which is coconut water. The remaining coconut meat should have had all its goodness removed by this process if you've squeezed enough and so should be thrown away. (Ed. Note: i. e., either composted or fed to the chickens). Cook the milk down while you get the rest of the things ready.

Cut into pieces and fry unbattered fish fillets or steaks. A large hand-sized piece cut into one-inch chunks should be enough for each person. Also fry a chopped onion and a small hot pepper and, when they're ready, add a cut-up tomato. Put the fish, onions, etc., into the coconut milk, simmer a few minutes and serve over rice.

CABBAGE AND SOUR CREAM PIE

Shred four-and-one-half cups of cabbage. Steam it just a few minutes, not so much that it's done. Drain the cabbage and mix with a cup of sour cream, a tablespoon of flour, a tablespoon of caraway seed, some dill and salt and pepper. Put the filling into a regular two-crust pie and bake.

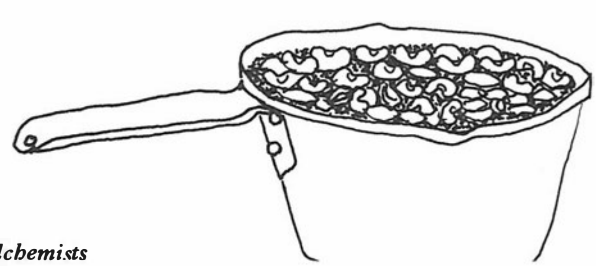
VEGETABLE CURRY

Another flexible favorite is vegetable curry. Use any mixture of fresh or frozen vegetables you like, but be sure to include a chopped onion. I particularly like green beans, crookneck squash and broccoli together. Cut all the vegetables into small pieces and simmer until each is the appropriate doneness. When the vegetables are done, drain off the juices and stir in yogurt to make a thick sauce. Heat through. You can stabilize the yogurt by stirring in a little cornstarch while it's cold, if you want to make sure it doesn't curdle. Season with good curry, garlic and fresh parsley.

ZUCCHINI CASSEROLE

This recipe is adapted from Claudia Roden's *A Book of Middle Eastern Food* (Vintage Books, 1974), my very favorite cookbook. The book is very well suited to mostly-vegetarian cooking – full of lovely things like eggplant cream, carrot soup, spinach cheese pie and Jerusalem artichokes with tomato sauce.

For the casserole, slice a couple of medium-sized zucchini, enough for two people. Steam or simmer until barely tender. Drain and put it into a buttered casserole with a fried onion, salt and pepper. Beat an



egg or perhaps two and mix with a cup of grated cheese. We like a combination of parmesan and cheddar. Pour over the zucchini. Sprinkle the top with nutmeg or fenugreek or both and bake for twenty to twenty-five minutes. The egg mixes with the juice from the zucchini and forms a custard. Of course, crookneck or scalloped squash are fine, too.

Frozen squash is often spoken of harshly, but I think it's fine if you simmer it in its own water, squeeze out the water and proceed with the casserole above or a good tomato-cheesy-spicy one.

ARMENIAN YOGURT SOUP

This is another one adapted from Claudia Roden's Middle Eastern cookbook.

This summer we had a lot of goat's milk at the farm, which led to some interesting milky things. This is an excellent recipe to use if your yogurt, like mine, isn't exactly thick. It's an excellent recipe even if you can make thick yogurt.

Beat two eggs with four cups of yogurt. Bring slowly to a boil, stirring frequently. The eggs should keep the yogurt from curdling, but you can stabilize it with cornstarch to make sure. Stir in two cups of water and about two cups of noodles. I prefer spinach noodles. Simmer until the noodles are done. Salt and pepper. Meanwhile, fry a chopped onion and three tablespoons of crumbled dried mint in four or more tablespoons of butter. Pour the mint butter on top of each bowl of soup. Sounds strange but it's good. Really, it is.

VEGETARIAN MOUSSAKA

Slice a couple of eggplants, salt the slices and, after fifteen minutes, dry them. Flour and fry until brown. Also fry a chopped onion and a couple of garlic cloves. Make a couple of cups of thick white sauce, beating in an egg for a richer sauce. Layer the eggplant with the sauce, seasoning generously with cinnamon, nutmeg, fenugreek and coriander, or whichever of them you have. Top with a thin layer of cheese and bake. (You can cover the eggplant layers with an inch-thick layer of mashed potatoes for a more substantial dish.)

IMPROVED STIR-FRY

I guess everybody stir-fries vegetables, but a few things can make a stir-fry really special. I always sauté lots of garlic and fresh ginger root before I put in the other vegetables. A little soy sauce, sherry and cornstarch added at the last improves things too. Put a few fried cashews or peanuts on top. A really nice thing is a hot peanut butter sauce mixed in with the vegetables when they're done. It's good on a single vegetable too.

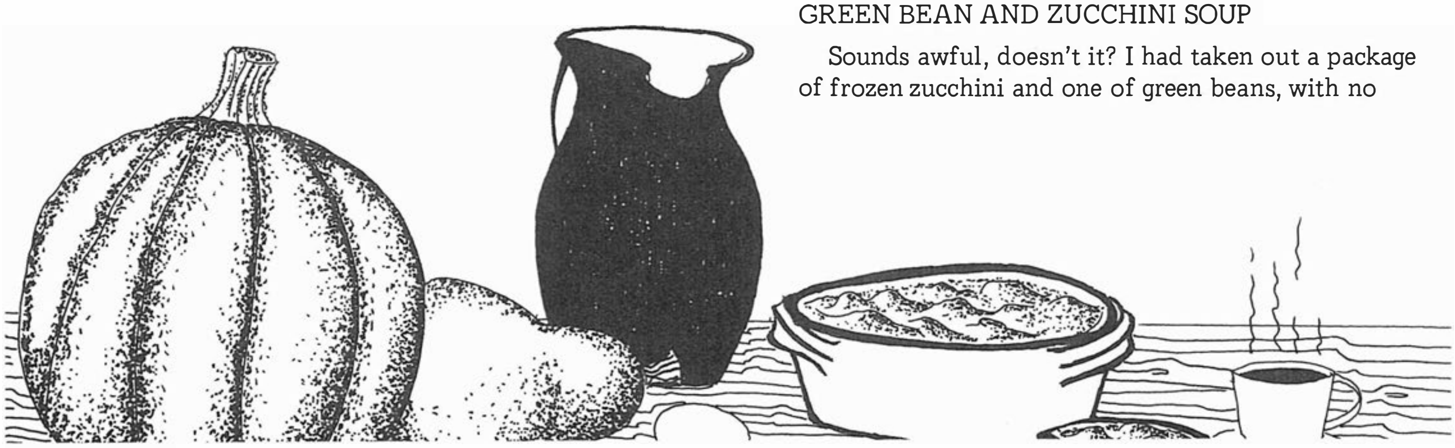
Mix: Three tablespoons peanut butter, two tablespoons oil, two tablespoons soy sauce, two tablespoons dry sherry, two tablespoons sugar, four tablespoons water, a little bit of hot pepper and two tablespoons tomato paste (or use cooked-down tomatoes and leave out the water). Beat everything together and serve over vegetables. (Adapted from *Chinese Vegetarian Cooking* by Kenneth H. C. Lo, Pantheon Books, 1974.)

BREAKFAST IDEAS

We've come up with some good breakfasts, using the foods we've grown. You can make a squash or pumpkin pudding by following any recipe for pumpkin pie filling or just by mixing two to three cups of squash with an egg, a cup of milk, sugar, butter and spices, and baking it. Or you can just cut the squash in two and bake it with butter, spices and brown sugar or maple syrup. It's fine to cook it the night before and heat it up for breakfast. We also like to make tortillas and put hot homemade fruit sauce (apple, pear, mulberry) on them and melt a little cheese on top. Corn can be mixed with an egg, a little milk and just enough flour to hold it together and then fried like pancakes. In Latin America, leftover rice and beans are often fried together for breakfast and served with a fried egg on top. A lovely thing that's good at any meal is to stew fruit, fresh or frozen, in a big pot with spoonfuls of biscuit dough dropped in to make dumplings. (Keep the lid on during cooking.) Strawberries are perfect. Serve with butter and cream or milk.

GREEN BEAN AND ZUCCHINI SOUP

Sounds awful, doesn't it? I had taken out a package of frozen zucchini and one of green beans, with no



particular plan. At dinnertime, I came up with this and it was so good I decided to serve it to Nancy Jack, who does not speak fondly of frozen beans or zucchini. She has relented.

Thaw and simmer, with very little liquid, frozen zucchini and green beans - a couple of cups of each. (Of course, fresh would be even better.) Chop and fry a few spring onions, including the green tops for color, and two garlic cloves. Purée everything in a blender, adding two eggs, salt, pepper, a little butter, and spices – I used rosemary and savory, lightly. Return to the pan and simmer for a few more minutes. It's good with fried bread and cheese.

FRIED BREAD (Chapattis)

Mix one cup of water with four cups of flour and ½ teaspoon salt. Knead well – at least five minutes. You can make the bread immediately or store the dough several days in the refrigerator. Take small lumps of dough and roll out into ¼" thick circles six inches across. Fry these in one-inch-deep hot oil until browned. This is a chewy crisp bread, quite different in texture from a baking powder bread.

– *Susan*

NECESSITY IS THE BREAD OF INVENTION

This bread is created from piles of this and that left in the cupboard such as tablespoons of oatmeal, barley, rice, brown rice, cream of wheat, wheatena, wheat germ, etc. Gather these grains and grind them to a rough powder. Cook them in 2 cups of water as you would hot cereal.

It usually takes the better part of a day for the whole process.

1 package of yeast
1 cup warm water
2 Tbsp. honey — Allow to grow.

1 envelope powdered milk, dissolved in
2 cups warm water
3 Tbsp. oil
2 Tbsp. salt
3 Tbsp. strong molasses or 1/3 cup regular molasses
2 cups cooked wheat berries
¼ cup honey
2 cups cooked ground grains
2 to 3 cups rye or whole wheat flour
2 Tbsp. chicory
5 cups white flour

Mix well. Allow to rise until double. Knead very thoroughly with a little white flour. Separate into two or three loaves. Allow to rise again. Brush with beaten egg. Bake at 300° for one hour.

– *Tanis*

SOUP AND SALAD

To me, soup and salad is such a lovely combination. Since salad makings are plentiful in the summer, I began combining garden vegetables to make some really excellent soups. This recipe, adapted from Claudia Rosen, makes an unusual use of eggplant. It's become a favorite of mine.

Grill the eggplants over a naked flame or under a broiler until their skins are black and blistered all over. Peel them carefully, removing all the charred particles.

Melt 5 tablespoons butter in a saucepan. Add 3 tablespoons flour (more if you want an eggplant cream) and stir over very low heat till well blended. Remove from heat.

Drain the eggplants and mash them or put them in the blender. Purée with butter and flour mixture. Return to the heat and gradually add two to two-and-a-half cups of milk, stirring constantly until it thickens and the taste of flour is gone. Season with salt and pepper. Add ½ cup Parmesan cheese. Stir till melted. Chop lots of parsley to add before serving.

Another excellent soup that is thick and creamy but uses no milk is this potato soup.

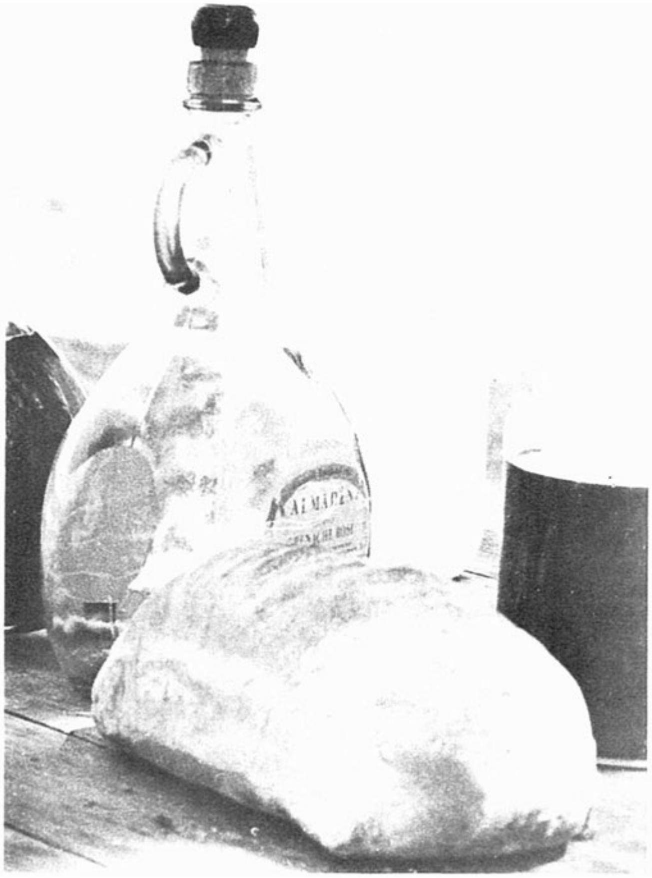
In 5½ cups water, cook a combination of onions, carrots, celery and potatoes. When tender, remove, saving a cup of the water. Purée the remaining mixture in the blender. Dissolve a chicken boullion cube in the reserved cup of water to make a stock. Add this to the puréed mixture. Return to the heat. Season with salt and pepper and lots of chopped parsley.

Although this idea came to me too late in the season to try it, I'm very pleased to know that one can make use of sunflower heads.

Take the whole head of the sunflower and clean the seeds off it. Put it in a pot with water and boil it until brown in color or until the outer skins can be peeled away easily. You now have a white mass that tastes like mushrooms. Season with salt and pepper.

Here's an interesting use of the milkweed which grows abundantly around here. You can use it for pokeweed.

When plants are young, take the whole plant, minus the roots, and place it in boiling salted water. Boil until soft and serve with butter. It resembles spinach.



BREAD RECIPES

This is a recipe we have used over and over again. When Marsha Zillis introduced it to us years ago, it was said to be an old Grange recipe. It's a bread or, with one addition, a cake. Both are moist, tasty and rich. Makes 1 loaf.

Mix into a bowl: 2 cups flour, 2 cups sugar (1 cup of flour may be whole wheat and the sugar may be cut down. Honey can be used in place of the sugar but it alters the consistency) , 2 teaspoons baking powder, 2 teaspoons cinnamon, 1½ teaspoon soda and 1 teaspoon salt. Beat in 1½ cups oil and 4 eggs, one at a time. Then add 6 cups grated carrots. Vanilla and nuts will heighten the flavor and texture. You can add 1 cup crushed pineapple to it, which adds a lot of moistness and makes it more like a cake. When I add the pineapple I usually make the cream cheese frosting.

For a voluptuous icing, beat together 1 cup butter, 1 8-ounce package of cream cheese, 1 teaspoon vanilla and a 1 pound box powdered sugar. This recipe makes more frosting than I need, so you may want to cut it in half.

The abundance of winter squash and pumpkin we had this winter resulted in this excellent bread. The general commentary was that it is a whole meal in a piece of bread!

Mix 1½ cup sugar with ½ cup oil, and add 2 slightly beaten eggs, 1 cup pumpkin or squash (I usually use a bit more) and 1/3 cup water.

Sift together 2 cups flour, 1 teaspoon soda, 1 teaspoon salt, ½ teaspoon each of allspice, cinnamon, cloves and nutmeg, ¼ teaspoon baking powder. Add to the squash mixture and blend well, then throw in some raisins and nuts and bake the bread in a loaf pan at 350° for an hour or until it's done.

– *Kathi*

There is a small but stubborn caucus of New Alchemists who have not submitted to the charms of some of your sturdier greens. Kale, for instance. Acknowledging its marvelous nutritional qualities we remain sullenly obstinate. Yes, Portuguese Kale Soup is lovely, but look at the quantities of Linguica necessary to discipline it. We look upon it with disfavor when it is sprung on us in a salad. However, when Hilde puts it in a soufflé it becomes not only palatable but delicious. The following recipe should be taken seriously if for no other reason. One never knows when one might be confronted with ominous green waves of kale.

– *NJT*

SOUFFLÉ

Cook a batch of greens such as broccoli, kale, spinach, beet greens or swiss chard and chop them very fine – you should wind up with about the amount in a 10-ounce package of frozen greens. Drain them thoroughly and add 2 tablespoons butter or margarine. Stir in a saucepan over high heat until the butter is melted and any excess moisture has evaporated. Then add chopped onions and parsley to taste and blend in 2 tablespoons all-purpose flour, ½ teaspoon salt and some pressed garlic. Add ½ cup milk all at once (you may need more depending on how many vegetables are used).

Cook all over medium heat, stirring until mixture thickens and bubbles, then stir in ½ cup grated cheese.

Beat 4 egg yolks until thick and lemon-colored - to these, add the cooked greens mixture, stirring constantly.

Beat stiff 4 egg whites and fold them thoroughly into the mixture and pour all into an *ungreased* 1-quart soufflé dish. Bake in a moderate oven (350°) for 35 minutes or until an inserted knife comes out clean. This should be served and eaten *immediately.*

Here's another method for keeping exuberant greens at bay:

QUICHE LORRAINE

Use regular or whole wheat pie dough – spread it in a pan with sides at least 1½" high. Sprinkle a layer of grated cheese on top of the dough (Optional: you can

add, if you are inclined, a layer of cooked, spiced, crumbled hamburger meat, or a layer of cooked, thin-sliced, finely chopped ham or bacon crumbs). Then add a layer of slightly cooked, finely chopped greens (broccoli, kale, beet greens, swiss chard or spinach). Sprinkle a layer of grated cheese on top. Another layer of either meat or tomato or green pepper slices is optional. Now make the milk mixture: ½ cup white flour and ½ cup whole wheat flour, some salt, pepper, paprika powder. Add 4 cups of milk slowly to this to make a smooth sauce and stir in 6 beaten eggs. Now, pour the mixture over the other layers in the Quiche and bake it in a moderate oven about 30 minutes (or perhaps a bit more, if there are many layers). This is good eaten hot or cold.
(You may arrange strips of dough on top of milk mixture and then bake).

–Hilde

GREEN BEANS (or SPINACH) with EINBRENNE (German Recipe)

Here is a way to make green beans (either fresh or frozen) more interesting. Cook 1 pound fresh green beans or 1 package frozen green beans (not too long – they should still be green and slightly firm) in water to just barely cover. Meanwhile, chop a small onion and cook it in butter in a skillet until transparent - not brown. Add about 1½ teaspoons flour, stirring well. Now, drain the liquid from the cooked beans into the onion-flour mixture, stirring till smooth. Taste for salt and pepper and add the green beans, then heat through.

You can treat spinach the same way. Cook fresh spinach (about a pound) and chop it (an old-fashioned wooden chopping bowl and chopping knife are good for this) or you can use a package of *chopped* frozen spinach.

COLCANNON (Irish Recipe)

This can be made at any time of the year, but it is especially useful when potatoes and cabbage are harvested at the same time. Cook as many small potatoes as you want (the little red ones are very good) with their skins. Peel them when cooked (let them cool a little or you'll burn your fingers) and mash them very coarsely into a couple of tablespoons of butter in a skillet (You can use oil, but butter really tastes better).

Chop a small head of cabbage (actually, shred it) and add it to the potatoes. Cook potatoes and cabbage together about 5 minutes, stirring often. Cabbage should not be limp, but still nice and crispy.

– Claire

Mushroom

A mystical air
Clings to your
Waxy, mellow
Skin

You are the
Magical potency of
A wizard's
Brew

And often macabre
Eerie food of
Corpus delicti

Yet you can
Be the satisfaction
Of a
gastronome
Uncanny...

The Trash Fish Cook Book  Rides Again!

CHAIN PICKEREL

The pickerel, one of the commonest predators of weedy waters east of the Appalachians, from New Brunswick to Florida, is a fish I hadn't thought of as a "trash fish." For years, I've been having too much fun catching and eating them. But this summer we witnessed a couple fishing a small pond, alternately catching largemouth bass and pickerel. They kept the bass and put back the pickerel which, I have discovered, seems to be the general practice. The pond was small, so we didn't reduce our own harvests by enlightening them. But I trust our readers don't fish in the same small ponds, so I will share this secret. Those pickerel would have been a whole lot better on the table than the bass. I am especially partial to the texture of pickerel, fried or baked. On this count, it has few equals among fresh water fishes.

I don't know why pickerel are not more accepted. Before I ever lived within their range, I was told that most of the pickerel one catches are small and skinny (true) and therefore terribly bony (not true). Massachusetts law stipulates a minimum length of fourteen inches for pickerel and I would take home smaller ones if I could. Even the fourteen-inchers are less bony than most panfish.

Sometimes pickerel taste "lakey." This taste appears to be characteristic of certain bodies of water, particularly shallow ones with a lot of water weeds (other than lily pads) and algae. But I have yet to meet the pickerel too "lakey" to be made delicious; just lay on the herbs a little more heavily.

PANFRIED PICKEREL

There's nothing unusual about panfrying a pickerel but here are details in case you don't know how to panfry anything. I cut the fish in several pieces about six inches long. If the fish has gotten excessively slimy, rinse it off, and then roll each piece in flour seasoned with salt and pepper and a little dill, if you like. Fry the pieces in about three-quarters of an inch of hot oil until nicely browned. Cook it well – underdone fish is not good fish. We like fried pickerel for breakfast.

BAKED PICKEREL WITH HERB STUFFING

This is a fancier method for cooking large pickerel. The proportions I give are for a single fish large enough to feed two hungry people.

Melt a couple of tablespoons of butter in a pan and fry a chopped onion in it until it's soft. Then mix in about a cup of bread crumbs. Add *lots* of herbs. I like a mixture of thyme, rosemary and sage, about a tablespoon of each. Fill the cavity of the fish with the stuffing and bake at 375° until the fish is flaky in the thickest parts – probably forty-five minutes. A few minutes before the fish is done, make a cup and a half or so of white sauce. Mix a little of the sauce with the juice of a lemon (or two) and then slowly stir the juice and sauce mixture into the rest of the sauce. Salt and pepper. When the fish is done, pour the sauce over it and serve. The same sauce is lovely on broccoli, so I like to make enough to have sauce on everything.

FRESH WATER BLACK BASS

Having maligned the largemouth bass in the above section on chain pickerel, let me clarify my position. I realize that very few people will classify the black basses (largemouth, smallmouth and spotted) as "trash fish", but I submit that they, and particularly the largemouth, are greatly over-rated as food fish. I suppose their table status is related to the high regard in which they are, rightly, held as sport fish. I spend a fair amount of time fishing for bass, and there are times when I feel foolish looking several pounds of food in the face, thinking about putting it back in the water. So, I make the best of a good situation by applying a tip from my erstwhile co-author and ol' fishin' buddy, Bryce Butler: Fillet the bass and fry it fast in deep oil, using your choice of breading, oil and spices. Bryce uses a mixture of flour and, of all things, Ralston, a breakfast cereal. I don't know why this is so, but I have found filleted and deep fried bass to be far superior to bass prepared any other way.

BULLHEADS

Bullheads are one of the chief fish in our diet; see the first installment of the TRASH FISH COOK BOOK in the third *Journal* for basic bullhead recipes. This summer we tried a couple of new ways of preparing them. The first was a different smoking method contributed by a visitor from Holland, Jacques Visser. Jacques' method worked well with other fish, too, but the bullheads were everyone's favorite. This is a very soft smoke with no preservative value, but wonderful to eat.

Jacques constructed a simple smoker with an old oil drum. He cut a hole about nine inches square near the bottom of the drum and made a piece that was used as a damper over the hole. Two holes were drilled about six inches from the top of the drum so that a skewer could be run across it.

The fish should be gutted but not skinned or beheaded, then salted and allowed to sit for a couple of hours. Meanwhile, burn enough wood to get a good bed of coals. When the flames have almost died down, dry the fish thoroughly and run a skewer through the gills. Put the skewer through the holes provided in the drum, suspending the fish down inside, put a cover over the drum and close the damper. When the fish are good and hot, dip several handfuls of fresh cedar needles in water and throw them on the coals. Keep an eye on the fish. If you've got the right amount of fire, you can just let the coals burn themselves out, by which time the fish should be done. But don't let them burn or dry out.

We have also smoked bullheads conventionally, with good results. This summer we were invited to contribute to a wedding feast and, having caught forty some bullheads the night before the wedding, decided to smoke them. Smoking is not something you can rush and, as the hour drew near, we could see that our bullheads were going to be "almost done", which is *not* satisfactory for a wedding feast (or any meal, for that matter). Susan solved the problem by putting butter and rosemary on the almost-done fish and broiling them for just a few minutes.

The next two creatures are not fish, but they do live in the water and are often encountered or even accidentally caught by anglers.

FRESH WATER "MUSSELS"

These are actually not mussels, but fresh water clams, of which there are many species, found in all North American waters except the smaller creeks and brooks and those waters which are severely polluted. They are especially numerous in large rivers, but here in New England we find them in abundance in ponds. To collect fresh water clams, look for shells on shore or in the shallows, then look a little deeper, probing in the sand and mud.

I was brought up to believe that fresh water clams are inedible, and I must admit that I have sampled some that would substantiate that claim. But I have also had some that were wonderful. The best I have ever eaten were the exotic Asian fresh water clam *Corbicula,* which has become established in much of the United States, but many of our native species can also be quite good. If you need to convince yourself of the gustatory potential of fresh water clams, stop by your nearest gourmet foods store and pick up a tin of "smoked baby clams", which are actually full-grown *Corbicula,* imported from Japan.

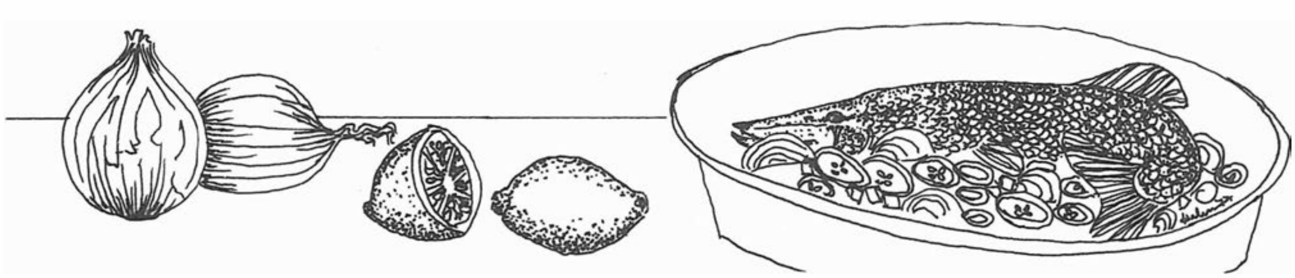
So far we haven't gotten fancy with fresh water clam cookery; we just put them overnight in a pot of water with corn meal (this is supposed to clean the sand from them; we aren't sure it is critical), steam them just enough to open the shells, and saute the whole animal in garlic butter. The results vary considerably, which apparently has more to do with the body of water where the clams were taken than anything else, though it may have something to do with the species as well. So far, we aren't able to look at a live clam or a body of water and predict the food quality. We welcome comments from readers on this or other aspects of preparing fresh water clams for the table.

One word of caution: Clams are filter feeders and thus concentrate whatever is in the water in their tissues. So be more careful about where you get them than you would with fish. Avoid any waters known to receive sewage or pesticide pollution.

SNAPPING TURTLE

One of the true gourmet treats of North American fresh waters is the snapping turtle. Anglers often see them and occasionally catch them (usually to everyone's dismay). They can be caught on set lines or with special traps, but the easiest way to get a snapping turtle is to look for one on land in the late spring or early summer, when the females leave the water to lay their eggs. The males seem to wander quite a bit at this time, too, and they can often be seen crossing roads near ponds and swamps. To capture a snapping turtle on land, simply pick it up *by the tail* and hold it *well away from your body. Don't do it any other way,* unless you have fingers to spare.

Before you go out and catch a snapping turtle, though, you should ask yourself, "Do I *really* want to eat one?" My father used to say "A snapping turtle has seven different kinds of meat, all good, and seventy different smells, all bad." That prepared me for only one aspect of the tedious and mildly disgusting task of dressing a snapper. There are a few who love snapping turtle soup more than I, and I do in about one turtle a year.



In one respect, turtle butchering is easy; there are few animals harder to love than a snapper. And your conservationist friends will applaud you; this superpredator eats just about anything that moves in the water, up to and including ducklings. It is *not* an endangered species.

So, having made a commitment to do the deed and set aside the better part of a day for it, the first task is to kill the turtle. This should be done the night before you plan to butcher and cook it and, if feasible, two days before you plan to feast on turtle soup. If your turtle doesn't turn up on a convenient day, don't worry, it will live for many days as long as you keep it damp and shaded. The standard instructions for killing a snapper say to chop its head off. To do this you will need to stretch the neck out. A variety of instructions have been given for this; in my experience they mostly don't work, and only result in much struggle for all and suffering for the turtle. I prefer to axe the turtle between the eyes, anyway. Snappers, unlike other turtles, cannot completely retract their heads into the shell. You can get a clear shot there, and there is a lot of meat in the neck and right on up over the top of the head, where the brain should be. However you proceed, use a *very sharp* axe – turtles are *tough*. Once the turtle has been killed, hang it up by the tail to drain overnight.

The next step is to open up the shell, which is easier than it sounds. Just bring a *large* pot of water to boil and put the turtle in, on its back. You will probably need to place a rock or brick on the belly of the animal to hold it down. At this point, try to overlook any left-over kicks and twitches. Just how long to boil the turtle depends on its size; about an hour will do for the average snapper. One of my more poetic colleagues says to boil it "until it looks like a horse with a head cold that sneezed in its nosebag." The point of boiling the turtle whole is to soften the under shell and loosen the skin, while retaining the fluids in the main shell. So don't overdo it; overboiling will cause the shell to break up and the fluids to be lost. You can make an occasional test poke with a knife at the point where the two shells, upper and lower, are joined.

When the turtle has boiled sufficiently, decant the water and allow it to cool. If you have done the job well, you should be able to remove the bottom shell with your fingers. Pour off and save the juice inside the shell. Now comes the hard, time-consuming part.

You have to pick out laboriously the seven different kinds of meat, while savoring the seventy different smells. This involves skinning out the legs, feet, neck and tail and poking around every cranny inside, including up next to the top of the shell. Turtles have muscles in the most amazing places. In the process you will discover not only various new odors, but more sticky fat than you ever dreamed of. Would you believe fat between the toes? I find it helps to make up disgusting songs about turtle fat. Soon you will discover more flies than you thought existed in your neighborhood. The job will take long enough that you will discover why I only do it once a year.

If you persist, you will end up with a surprisingly large amount of meat of a variety of colors and textures. Some real turtle connoisseurs save the liver and other parts; I don't like them. It is now up to you to make a gourmet dish to justify all that time, labor and stench.

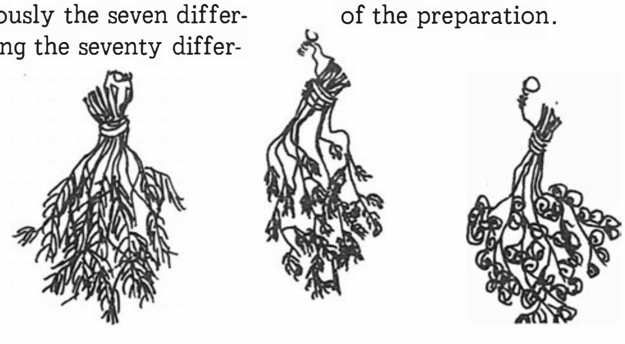
The classic snapping turtle dish is snapper soup, which we prepare as follows.

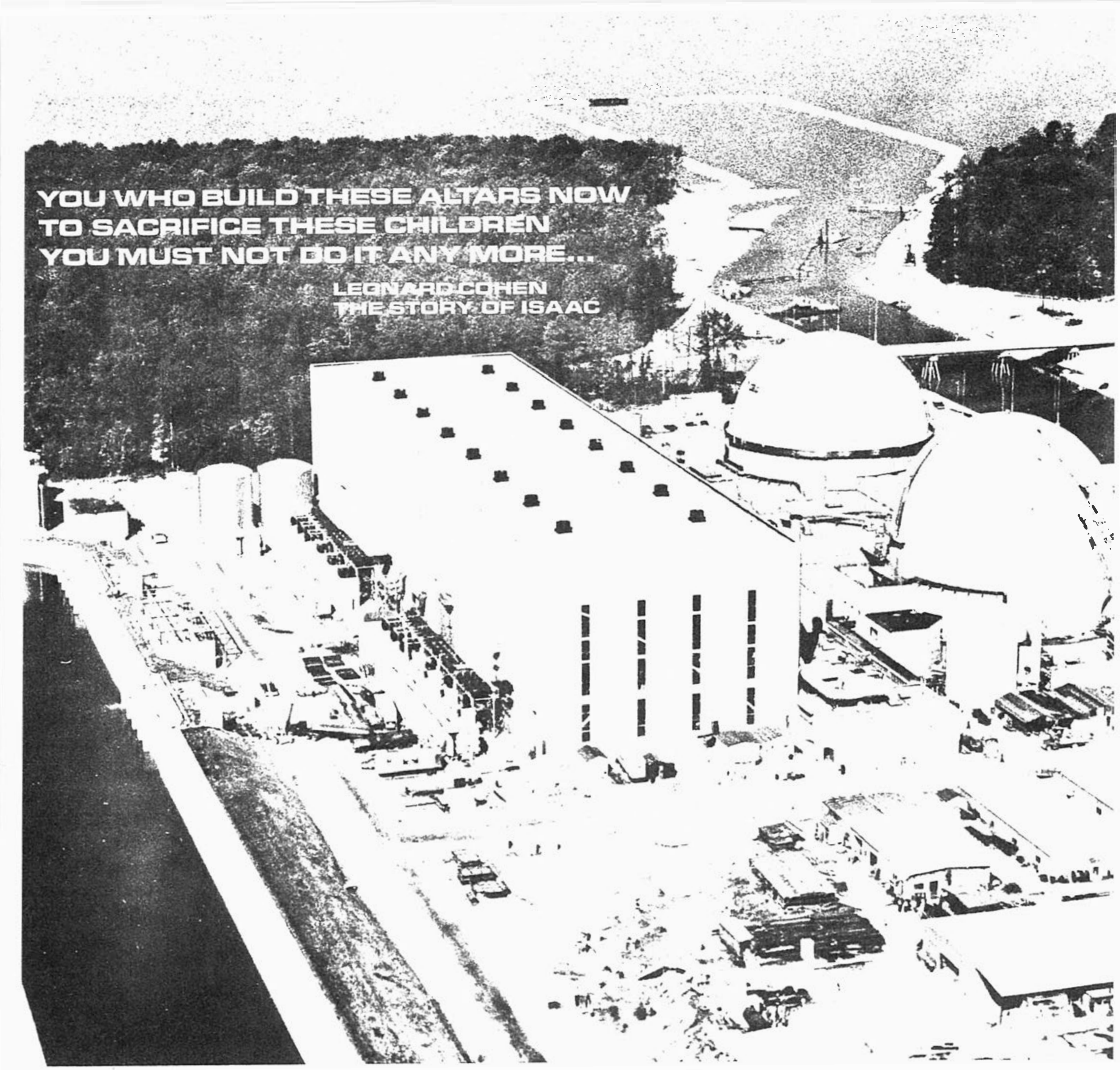
Simmer the turtle meat, cut into small pieces, until it is approaching tenderness. We use the liquid mess from inside the turtle shell but some people find our results distinctly funky. If you prefer less funk (or less taste, Bill would say) use tomatoes and water. Then we add onions, corn, celery, green peas and carrots (you can use any vegetables you like in soup), and simmer until they're tender, adding spices and seasonings to taste. The soup is better the second day.

A fancier dish which everybody liked, even those who didn't like the soup, was adapted from *The Joy of Cooking* recipe for terrapin. Follow the steps given above, ending up with clean meat and the broth from the shell. Melt several tablespoons of butter in a pan and stir in an equal amount of flour. Slowly add the broth from the shell and a cup of tomato sauce. Stir until the mixture is smooth. Add the chopped turtle meat and a chopped onion. Simmer until the turtle meat is almost tender, adding water if necessary. Turtle isn't one of your naturally tender beasts, so you should be content with a hearty chewy meat. At this stage, season to taste with thyme, basil, marjoram, bay leaf, etc., and add a couple of tablespoons of dry sherry. The sherry is important. Simmer a while longer and serve on rice.

These two recipes, and particularly the second one, should make your snapping turtle one of the most memorable meals of the year, and not only because of the preparation.

– Bill




YOU WHO BUILD THESE ALTARS NOW
TO SACRIFICE THESE CHILDREN
YOU MUST NOT DO IT ANY MORE...
LEONARD COHEN
THE STORY OF ISAAC

Energy

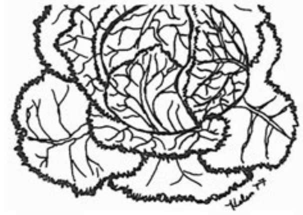
We are not including an Energy section in Journal Four. This does not reflect a lack of either interest or progress in this area. The success of the bioshelters testifies to the applicability of solar energy. However, we have always been cautious about publishing information on any of our projects without adequate testing. This is the case with the Hydrowind, the hydraulic, electricity-generating windmill that was designed as the accompanying power plant to the P. E. I. Ark. The mill is completed and is operational, but we intend to subject it to a battery of further tests before making definitive pronouncements to its workability. Our most successful windmill so far, the Water-Pumping Windmill that Works, described in Journal Two and updated in Journal Three in "An Advanced Sail-Wing for Water-Pumping Windmills" is currently being built by Ty Cashman for Green Gulch Farm in California. They intend to use it to pump water for irrigation.

There is another side to our work in this area. We have long been unalterably opposed to nuclear energy. New Alchemy itself is, among other things, an anti-nuclear statement. Last summer John Todd happened to be lecturing at Goddard College in Vermont at the same time as Margaret Mead. That redoubtable lady approvingly surveyed the various trappings of alternatives in evidence there, but added, "It's all very fine, but none of it will be any use at all if we don't stop nuclear power." As this only reinforced our own uneasy feelings on the subject, we have been making an attempt to cover this front as well. Christina Rawley, in particular, has managed to find time for anti-nuclear work. She is our liaison with the Clamshell Alliance and the anti-nuclear collective at Montague Farm, Massachusetts. Although our tangible contributions are minimal, we feel strongly supportive of the work of these and other such groups. As indicated in Australia with the Green Bans and in West Germany and France, the anti-nuclear issue has considerable potential for a genuine grass roots movement. As Ralph Nader has said, "It's like Vietnam, only this time we're all the peasants."

Land and Its Use

Our gardens seem to get better each year. Over the past few years, Hilde Maingay has incorporated the use of raised beds and sheet composting to our repertoire of general organic gardening practises. She has concentrated on intensive growing techniques and on high productivity. Hilde describes the work in her article entitled "Intensive Vegetable Production." Susan Ervin's attitude toward agriculture like that of her cooking reflects characteristic practicality in learning what crops are adapted to an area in terms of productivity, soil health and nutritive value. Her articles on "Experimenting with Growing Beans", "Mulching", and "Irrigating with Fertile Fish Pond Water" are the results of her attempts to achieve useful data in a field in which folklore and hearsay tend to predominate.

Photos on this and previous page by Hilde M



Intensive Vegetable Production

— Hilde Maingay

Introduction

Intensive vegetable production utilizing raised beds has proved suitable for both the small farmer and the backyard gardener. Unlike agri-business, it uses simple, low cost equipment, does not rely on non-renewable fossil fuels for fertilizers and pesticides, uses the soil area and the sun's energy effectively and recycles materials from the local community. Over the years the soil is improved and the production and quality of food is increased. The demand on materials from the outside and on labor remains stable or in some cases declines. This type of horticulture uses companion and succession planting, raised beds, mulching and composting, techniques which have been established over thousands of years in conjunction with the new understanding and knowledge gleaned from modern science.

Current American intensive gardening techniques are derived from a combination of two European horticultures; biodynamic techniques developed under the influence of Rudolph Steiner in Europe in the 1920's and French intensive techniques begun in the 1890's in the suburbs of Paris. Biodynamics contribute raised beds, companion planting and organic manures. The French intensive method includes close-spacing techniques which reduce weeds and hold water.

Eugene Odum has stated that agricultural scientists have repeatedly found that maximum productivity of broad-leaved crops occurs when the leaf surface area exposed to the incoming light from above is about four to five times the surface area of the ground. Average conventional agriculture falls well below this maximum efficiency. A great portion of the surface area of the ground is left bare to allow for mechanized farming. This, in turn, calls for increased irrigation and other energy-consuming practices to balance the adverse effects of barren soil and heavy equipment.

In an intensive agriculture using a complex planting scheme with variety and succession, maximum productivity of broad-leaved crops can be achieved while demands on water and labor requirements decrease.

Preparation of the Raised Beds

To prepare the beds in the New Alchemy gardens for intensive cultivation, a strip of soil one foot wide was dug to a depth of six to twelve inches. The soil was spread over an area four to five feet in width to form a planting bed. The strips that had been dug out became the pathways between successive raised beds. Twenty such beds were made, each approximately forty to forty-five feet long.

Tools: The garden tools used were a shovel to build the beds and dig the paths and a rake to smooth the surface. Auxiliary tools included a pitchfork to spread leaves, seaweed and other organic matter, a posthole digger for the bean posts, a trowel to set out the seedlings and string as a guide in making straight lines.

Labor: It took one woman of average size and strength two days to build these twenty beds.

Advantages: Raised beds are more convenient to work than those at ground level. There is less bending. A clear distinction is created between pathway and growing area so there is less chance of stepping on freshly seeded rows. Pathways can be a nuisance to keep weeded. With raised beds, a layer of top soil can be added where it is most needed without robbing another growing area.

The sides of the raised beds create more total surface area although the total amount of radiation received by them may be the same as with flat beds. It is distributed differently over the ridges, however. During the day, seeds and small plants, before they are big enough to alter the microclimate, gain sub-

Title Art by Helen Jacobson

Drawings by Hilde Maingay

stantial heat, especially in beds which run north and south as ours do. The plants respond to the extra heat by sprouting sooner and growing more quickly. Once established, the plants create a microclimate around and especially under the leaves, which protects the soil surface from becoming overheated, drying out or eroding.

The sides of the beds are still exposed to the weather, wind, sun and rain, and protection is necessary. This can be achieved by placing wooden boards against the sides. They are effective but costly and make a less flexible garden set-up. A thick mulch works well, but the slope of the sides of the beds must be gentle for the mulch to stay on, which takes a fair amount of space. The solution we adopted was that of sheet composting.

Sheet Compost in the Pathways

Sheet composting differs from a standard compost pile in that thin layers of organic materials are spread over the soil, rather than being piled in one heap. It has an advantage in that gathering and spreading can be done at any time whereas a regular compost pile must have all the material within a one or two day period. We were able to take all material except grass clippings from unknown sources, since they often contain residues of herbicides and other lawn fertilizers. When possible a layer of manure was added after two layers of green matter. Our manure is mainly from stable horses bedded on woodchips. The rest of the organic materials consisted of dry leaves, unwashed seaweed, garden wastes like weeds, vegetable parts and flowers, and once a few loads of straw from the local county fair with an exotic selection of elephant, tiger and goat manures.

As the season progressed, the pathways were filled, deterring the weeds and keeping the sides of the beds covered and cool. There were additional unanticipated advantages:

- Running back and forth with weeds and garden wastes was eliminated
- A single unloading of compost materials
- Improved absorption and retention of water in the beds
- Beds moister and cooler than with mulch

The composting materials absorbed more rainwater and run-off water from the beds than the same amount of materials in a compost pile would have. No additional water was necessary to decompose the materials. If irrigating is done by flooding the pathway ditches, the plants receive water enriched with leached out nutrients from the sheet compost and the decomposition of materials is hastened. We noted a large population of earthworms under the strips.

During the relatively slow decomposition process, CO_2 is given off. Insufficient CO_2 is one major limiting factor in plant growth. In pathway sheet composting, CO_2 is released slowly and constantly. Later, when the compost is buried, the CO_2 remaining is released into the ground, beneath the plants.

With all these advantages, sheet composting still does not completely replace the regular compost pile. In a well-built, balanced pile, the heat created during the first decomposition process can kill grubs, eggs and some pathogenic organisms. In the next steps of the breakdown process, the action of fungi produces antibiotics and growth hormones in higher concentration than is possible in regular soil.

Rotation of the Raised Beds

At the end of the growing season, all the beds were moved a third of their width by digging up part of the beds and putting dirt on top of the sheet compost filled pathways. At the same time new pathways were created.

Incorporating Organic Matter: All the organic materials were buried beneath a layer of top soil where further decomposition occurred over the winter, forming the growing medium for the next year's plants. Over a period of three years, a new layer of humus approximately six inches thick will have been placed under about six inches of top soil. Last spring, due to lack of snow in the winter and rain in the spring, the previous year's layer had not decomposed properly and a residual mat of dry leaves under the soil concerned us. It was decided to plant non-root crops like broccoli, brussels sprouts, eggplant and soybeans there and to seed carrots in plain dirt. All grew well. The leaves and the other organic material under the dirt decomposed fully over the summer.

Stimulating Soil Organisms: To maintain soil health, periodic addition of organic matter has proved to stimulate soil organisms. Earthworms play an important role in this process by stabilizing and even increasing soil fertility. Their numbers, appearance and vigor are good indicators of fertility. They improve the physical structure of the soil and produce nutritive materials for growing plants as well as being in themselves a food for a large variety of birds. Earthworms break down large quantities of leaves and other litter. They contribute to the nitrogen content of the soil as well as to its aeration.

Cultivation

Using the intensive raised bed method, we found little or none of the usual cultivation necessary.

Weed Control:

Mulch - Where and whenever possible, a mulch consisting in the main of a mixture of seaweeds and eelgrass was applied between the plants. Mulch helps retain moisture in the soil and helps prevent weed germination.

Intensive Planting - All plants in the beds were grown as close together as healthy growth would allow. The canopy of leaves produced once the plants have begun to grow shades out undesirable competitors and creates a beneficial microclimate for the plants themselves.

Fertilization

In our raised beds we used four methods of adding nutrients to the soil.

Compost: Several compost piles were built. Some were slow decomposing piles left over winter, others were quicker and decomposed fully in a few weeks. The same proportions of two to one of green and animal manures as in the sheet compost method were used. The finished material was used as a fertilizer, sprinkled around the base of each plant.

Mulch: Most of our mulch consisted of dry leaves gathered during the previous fall and piled up over winter or seaweed collected from the local beaches during the growing season. The seaweed is left unwashed to avoid leaching of nutrients. There is considerable precedence for this as a gardening practice. No tests have been done as yet to establish the salt content of our soil or the possible increase of salinity over the last five years. Depending on the time in the season as well as the year, our mulch consists on the average of 85% eelgrass which is not a seaweed and 15% a mixture of codium and other seaweed species. In the fall it is dug in or covered over by top soil to trigger decomposition.

Rock Minerals: Small amounts of commercial rock minerals were used including glauconite greensand which is an iron potassium silicate and an undersea deposit. Dolomite was applied to raise the pH of the soil.

Sheet Compost: See previous discussion.

Irrigation

To achieve maximum plant growth, water should be available constantly to plant roots. A heavy rainfall can saturate the soil, but even when it fulfills the moisture requirements of the plants it is not consistently available. Most of the water drains away below the root zone or evaporates into the air, making it necessary to replenish water between rainfalls.

Hose Sprinkling: Most of our watering was done by hand with a garden hose and tap water. Each bed received three minutes for a light watering and five minutes for a heavy watering. Hand irrigation has many drawbacks including the expense of tap water, and the application of chlorine and other possible additives with adverse side effects. It is time-consuming. It is also inefficient use of water in that distribution is uneven. There is loss through evaporation and high water pressure requirements. To alleviate some of these problems the following system was tried.

Because soils with a high percentage of organic matter and good water holding capabilities have a profile of underground water seepage that extends horizontally before it drains down, we hoped that by flooding the pathways with water a significant percentage would penetrate the beds. This proved true. Up to one foot on each side of the paths was replenished with water in this way.

Two wooden boxes, formerly used as fish tanks, 4' x 4' x 4' in size, were placed at the end of the beds (Fig. 1). Each was filled with tap water and left to stand for at least 24 hours to release the chlorine. Flexible black plastic tubing 1½" in diameter and at least 20' in length was attached to the bottom of the box. The tubing was placed along the pathway. In five to ten minutes the contents of the box drained into the pathway. Slowly the water soaked into the beds as well as draining into the ground. We were pleased that the soil had the capacity to hold the water for long enough to fill the 40' pathway ditch and to retain it for a while. The preceding summer, water in a trench would not flow further than three feet before draining straight down.

We found this watering system to be quite satisfactory. The plastic tubing was moved easily from one path to another. The low pressure, gravity-fed application is gentle and evenly distributed. Loss by evaporation is kept to a minimum. In late summer when the paths became increasingly filled with mulch, the need for irrigation lessened. The next step is to gain direct access to water, either from the water table or a nearby pond. We shall most likely use wind power as the energy source.

Drip Irrigation: We tried making seeping hoses from black plastic pipe. We placed the small holes in the hose at the base of each plant. The hose was fed by gravity from one of our cement fish ponds. Even the slightest unevenness in the ground, however, affected the water flow.

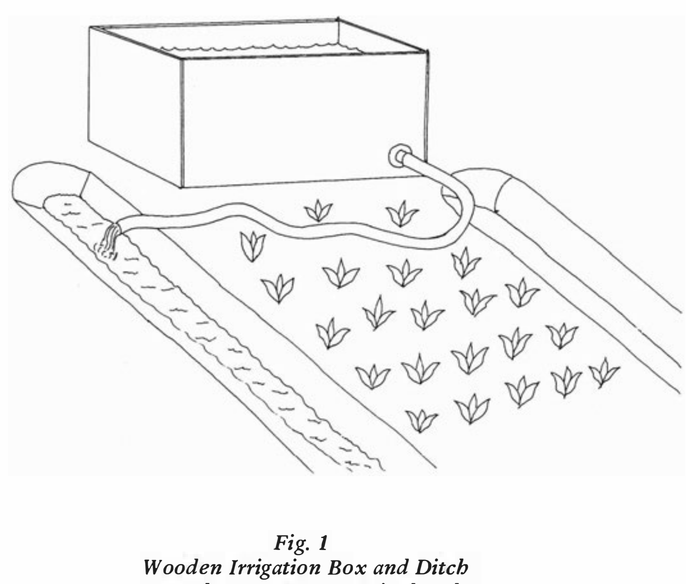
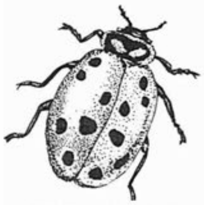
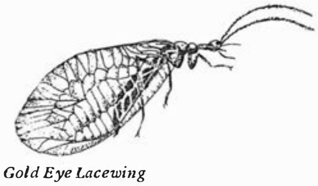


Fig. 1
Wooden Irrigation Box and Ditch or Pathway Between Raised Beds

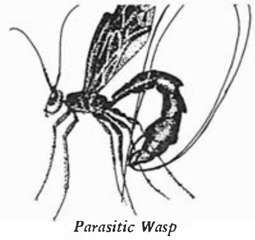


Convergent Ladybird

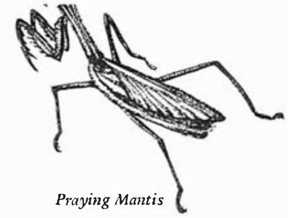


Gold Eye Lacewing

Robin



Parasitic Wasp



Praying Mantis

Pest and Disease Control

Insects Observed: The following is a list of the most significant insect pests observed in the intensive gardens, the problems they represented and what was done about them:

Pests

White Flies, Aphids, Flea Beetles: no significant damage
Cabbage Worms, Squash Borers: hand picked, minimal damage
Corn Borers: no picking or other control, damage in about 1/3 of the ears, limited mostly to tips
Cucumber Beetles: no control, resulting in cucumber wilt which killed at least 75% of the plants
Mexican Bean Beetles: decreased production, all plants eventually killed, extensive hand picking done

Beneficial Animals Observed

larva and adult of Lady Bird Beetle
praying mantis
toads: created cool, muddy places to attract them, but they found their own favorite places elsewhere between the vegetables
birds: many types of bird houses tried, as well as fences and posts, and sunflowers as a food source

Responses

Cultivation Methods: Traditional methods were used. No extreme methods such as flooding or burning were necessary.

Planting Schemes: Plant varieties were chosen for disease and pest resistance. When possible they were grown from purchased seeds produced in climatic conditions similar to ours, without chemical fertilizers and pesticides. A wide range of seed varieties was used for each type of vegetable.

Companion Planting: This was used extensively to optimize space in relation to incoming sunlight and available nutrients and water. Many combinations of plants have been suggested as beneficial in pest control because of their ability to attract or repel certain insects by color, taste, smell or by chemical excretions from the roots. For example, marigolds are thought to control nematodes for as long as three years.
Meadow nematodes are microscopic worms which feed on roots of many different plants. For maximum effectiveness marigolds should be rotated with food crops. This has been a problem for us as we have an aesthetic preference for flower borders around vegetable plots. Most companion planting is not scientifically documented but is based on the collective experience of gardeners over many years.

Even less well documented are the ratios in which companion plants should be grown together. One study has shown that planting one onion to every five or ten cabbages promoted growth in cabbages, but that more onions inhibited growth.
The aromatic powers of the food and companion plants have to be synchronized for effectiveness. Other flowers particularly those of the Compositae family, like the sunflower and many herbs, are helpful in pest control by providing shelter and nectar for predators or pests. We used them for this purpose.

Biological Sprays: In general, our focus has been on improving the soil rather than experimenting with home-made or commercial biological sprays. This cautious approach is not without reason. In the past, our experiences with home-made garlic and pepper type sprays were never sufficiently successful to continue their use. Any successful techniques known to our readers would be welcome.

Because there is little extensive long-term knowledge of the effects of so-called natural insecticides like pyrethrum and rotenone on animal life in general and of their residues in the soil in particular, it is difficult to accept these natural insecticides as harmless on the basis of their ability to break down in a short period of time. Because of this, all natural insecticides were avoided in the intensive beds although rotenone was used elsewhere in the gardens.

Since the Cucumber Beetle and the Mexican Bean Beetle were our major pest problems and could not be controlled by hand picking, an effort was made to grow those vegetables affected by them elsewhere in the gardens with the help of rotenone. In these cases the vines were hand picked as soon as the beetles appeared, which is always when the first flowers show, no matter when the seed is planted. Even with extensive picking, the numbers of beetles seemed just as high the following day.

After hand picking, rotenone dust was sprinkled on the leaves by hand. Insect damage was halted. Less than two weeks after the first application, the beetle population had again reached a proportion damaging to the plants. A similar application was made and no more was needed. Using this combination of hand picking and natural pesticide, two 30' rows of green beans provided us with green beans for fresh food and for winter preservation as well. For unknown reasons, the beetles were more persistent on the dry beans than on the green bean plants and more applications of rotenone were necessary.

CLOCHES

Introduction:

Extending the growing season is an efficient way to utilize the sun's energy. As our last killing frosts of the season on the Cape are in mid-May and our first often in mid-September, the growing season for many plants is considerably shorter than six months.

A cloche may be defined as a bell-shaped glass cover which is placed over a plant to protect it from frost and to force its growth. A modern plastic version is on the market under the brand name "Hot Caps." These are expensive and do not last longer than a season.

To maximize our growing period, we made modified cloches. They consisted of simple covers for the plants made from left-over pieces of Kalwall, the fiberglass material used on our greenhouse structures. In size and appearance they fall between a cloche and a greenhouse. They were made as follows:

Cloches with Frame

A rectangular frame of 2 x 4's was made for the base. Kalwall fiberglass was curved to form an arc and attached to the wood base. Doors were attached to the ends leaving space for free air flow and eliminating overheating problems (see Figures 2 and 3).

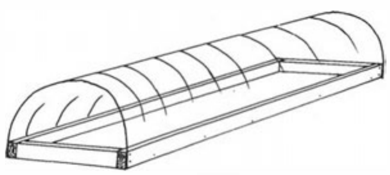


Fig. 2
First Cloche with Wooden Framework and Kalwall Permanently Attached to it

On April 19, 1976, five Savoy King Cabbage seedlings and five Broccoli de Cicco seedlings were planted in a row. Bloomsdale Spinach was seeded to the left, Ruby Queen Beets on the right. A cloche was placed over them. On April 19, 1976, five Broccoli de Cicco seedlings were planted beside the cloche as control plants. The cloche acted as a windbreak giving some protection against the winds and the cold air stream from the hill in a low spot of the garden valley.

Evaluation:

The difference in growth was striking. A month after setting out, the plants under the cloche were two to three times as big as the controls. Two months after the planting date, the first broccoli was harvested. The plants kept producing until the second week of October. The cabbages were ready for harvest by the last week of July. Vegetables planted a month early and placed under the protective covers of a cloche were mature a month earlier than had a cloche not been used.

Neither watering nor weeding a cloche this size created a problem. The watering was done with a regular garden hose and an accurately regulated spray. As it was very light, the cloche was easily lifted and put aside for weeding.

Cloche Without Frame:

Encouraged by our first success, a larger cloche was made. To avoid the storage problems of the previous model, this one was made to be disassembled (see Figure 4).

In late April, 1976, kohlrabi, eggplant, tomato, basil and Bibb lettuce seedlings as well as onion sets were planted under this cloche.

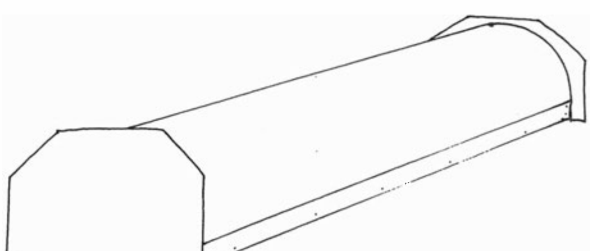


Fig. 3
First Cloche Showing Kalwall Cover and Ends

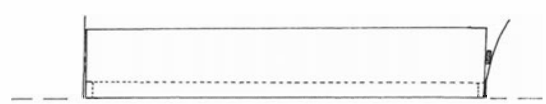
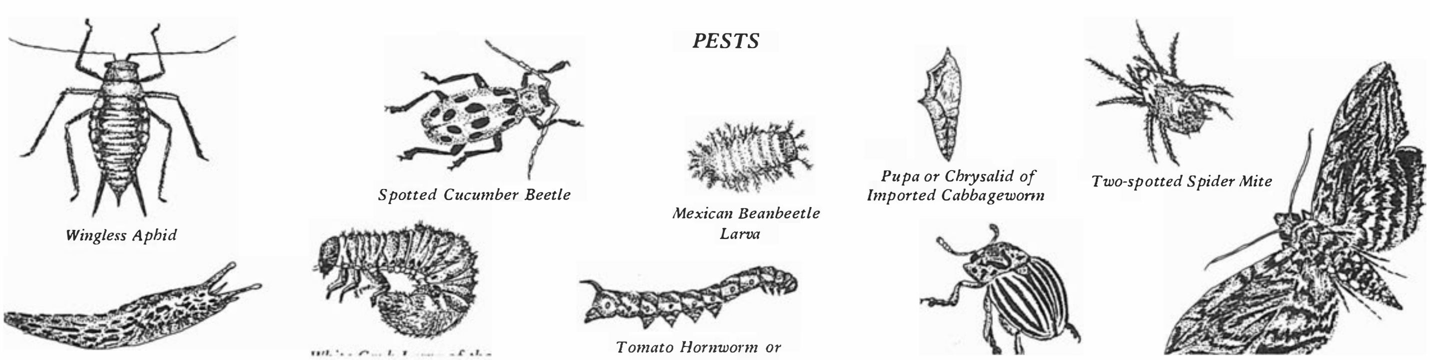


Fig. 4
First Cloche: Sideview Showing End Flaps Only Attached on the Bottom



Evaluation:

By May 4, all plants were thriving. Watering was difficult because of the length of the cover. On a calm day two people, by undoing the top bars, could take off all the fiberglass and put it aside or roll it up temporarily. This was necessary the few times weeding and/or mulching had to be done. A more practical design is needed which would enable one person to open and close it, yet would have sufficient strength to resist high winds. An untested prototype is included in the drawings (see Figures 5-7). In areas

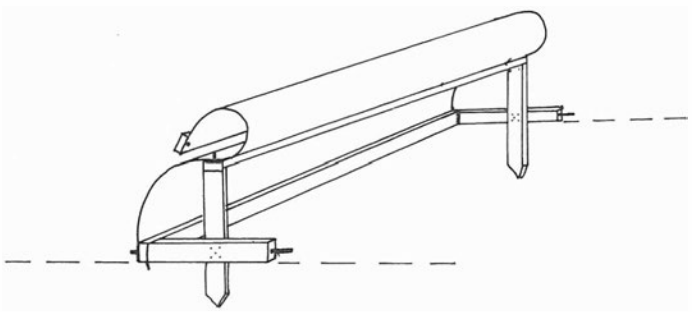


Fig. 5
New Cloche in Opened Position

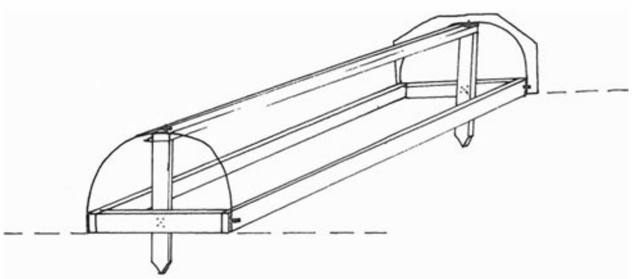


Fig. 6
New Cloche Showing Framework and Kalwall and One of the End Flaps

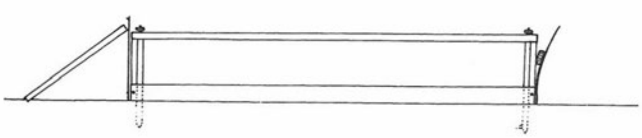


Fig. 7
New Cloche: Sideview Showing Basic Framework and Side Flaps Open and Closed

with strong winds, posts should be placed close together. In weighing the advantages of those with and without frames, the former are stronger and easier to lift but require some carpentry skill and are harder to store.

First harvest days of the plants tested were as follows:

Kohlrabi	July 1
Eggplant	August 1
Tomato	June 24
Basil	June 21
Bibb	June 21
Onion	August 20

Of the varieties tested under cloches and compared with those grown simultaneously in the open, the most successful were broccoli, cabbage, tomato and eggplant.

It is also possible to extend the season in the fall over small plants such as lettuce, parsley, kohlrabi, beets and many of the herbs. We were still picking vegetables from under the cloches in mid-November.

LABOR/TIME, WATER AND PRODUCTION ANALYSI

This year an attempt was made to record the number of hours spent working in the garden, the amount of water used for growing a certain quantity of vegetables and the total weight of vegetables harvested from these intensive beds.

Labor:

The number of work hours are somewhat inexact as such interruptions as a phone call, visitors or a dog chase made it hard to be precise. But a pattern is emerging.

The following activities were included in the recorded hours: seeding, weeding, unloading of organic materials, mulching and filling paths, watering, transplanting, bug picking, staking and stringing. Not included were: digging and building of beds (done previous fall), seeding flats and caring for seedlings before setting out, trucking in organic materials (manure, seaweed, straw), harvest time and winter storage of vegetables.

Time:

Number of work hours spent in the twenty intensive beds:

April	18½ hours
May	34 hours
June	78½ hours
July	86¼ hours
August	13 hours
September	5 hours

This totals 235¼ hours over a six-month period, an average of forty hours a month or one hour and sixteen minutes a day.

In October, the old plants were pulled and put in the pathways which by that time had become level with the tops of the beds. This time was not recorded. In November, the beds were moved, re-built, shaped, raked and made ready for the next season. This required a total of twenty hours or approximately one hour per bed.

Water Use:

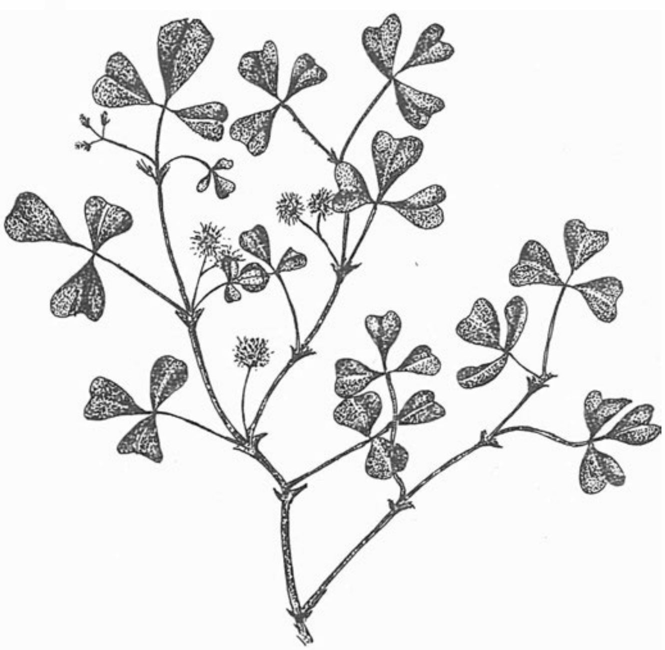
The amount of water used to irrigate the raised beds can only be estimated. The greatest variable may be the change in water pressure from day to day or hour to hour. Under constant water pressure, the average flow from a standard 5/8 garden hose was four gallons a minute. The number of beds receiving water and the approximate time per bed was recorded from April until October. A light watering took three to five minutes per bed, a heavy watering six to ten minutes. In the chart the upper limit of five minutes for a light watering and ten minutes for a heavy watering was used.

	Light Waterings			Heavy Waterings			Average	
Months	Number of Beds	Total Amount of Minutes	Total Number of Gals. of Water	Number of Beds	Total Amount of Minutes	Total Number of Gals. of Water	Min/ Day	Gal/ Day
April	None	---	---	None	---	---	---	---
May	30	150	600	46	460	1840	20	81
June	84	420	1680	86	860	3440	43	170
July	180	900	3600	55	550	2200	46	193
Aug.	20	100	400	20	200	800	10	40
Sept.	None	---	---	None	---	---	---	---
		1570	6280		2070	8280		

It took a total of 3640 minutes or 60 hours and 40 minutes to irrigate this area over the entire growing season. This represents almost one-fourth of the total amount of labor hours. 14,560 gallons of water were used. Light waterings of small areas or individual spots often done with a watering can have not been included in the previous chart.

Garden Size:

The total area of the intensive raised beds was 110' x 40' or 4400 ft^2 which is approximately 1/10 of an acre. Each bed had a width of four feet and a length of forty feet.



Medicago Hispida - "Bur Clover"

Only thirty feet of most beds were truly productive as plants in the last ten feet had to compete with the thick roots of the briar bushes, weeds and trees from the adjacent woods. Few plants survived or grew substantially there.

Production Figures:

The following table gives the total vegetable production from the intensive raised beds. It also estimates the total number of servings of each crop.

For a clearer idea of the quantity of food over the span of a year, certain vegetables were grouped together by type. This selection was based on our average eating habits, not on a rating of nutrients.

The total number of servings in each group was divided by 365 to determine the number of people who would have one serving per day per year of one or any combination of vegetables in that group.

Limitations on Productivity

Edible Greens; Some of these were not consumed and therefore not included. These were the greens of kohlrabi, parsnip, rutabaga and turnips, broccoli, cauliflower, brussels sprouts and the outer leaves of cabbage.

Frozen Ground: Some vegetables such as leeks, turnip and rutabaga were stored in the root cellar and others were left in the ground. The weights of those left in the ground are unknown.

Insects: Cucumber and bean plants were heavily damaged by cucumber and Mexican bean beetles. Had rotenone or a biological control been used the harvested weight would have been greater. In our area every year at the end of the season (October) kale and brussels sprouts are infested with aphids. As there is an abundance of food at that time, the interest in harvesting infested vegetables was less, affecting the recorded weights.

Lack of Picking: An effort was made to pick all vegetables as soon as edible size was reached. In some instances, however, it was almost impossible to keep up with the harvest.

Drought: The peas were unproductive due to lack of water. The corn did not germinate well. Seedlings were finally transplanted from shallow ditches that had been mulched with leaves in another section of the garden. Two beds were therefore unproductive for more than a month.

Other Animals: Several varieties of soybeans were grown. As soon as the plants were established, they were levelled by rabbits. Later in the season they left the bean plants alone. A few plants did mature, resulting in a small crop of soybeans.

TABLE 1.

		Total Edible Grams	Grams per Portion	Total Portions per Crop	Total Amount of Portions
Kohlrabi	cooked	23,027	98	234.9 *	
Parsnip	"	9,040	105.5	85.6	
Potato	"	167,316	81.5	2052.9	
Rutabaga	"	14,245	81.5	174.7	
Squash-Winter	"	2,913	122	23.8	
Turnip	"	13,123	98	133.9	
					2705.8
Parsley	fresh	not weighed			
Radish	"	not weighed			
Cabbage-Head	fresh	116,798	36.5	3199.9	
" Chinese	"	11,964	38.5	310.7	
Carrot	"	11,184	65.	172.	
Celery	"	12,874	60.5	212.7	
Chard, Swiss	"	12,021	38.5	312.2	
Cucumber	"	34,774	113.	307.7 *	
Kale	"	8,143	30.	271.4	
Lettuce	"	27,817	77.	361.2	
Spinach	"	13,260	27.	491.1	5638.8
Beans (Lima,Wax,Green)	cooked	14,492	62.5	231.8	
Broccoli	"	26,722	84.	318.1	
Cabbage-Head	"	116,798	73.	1599.9	
Chinese	"	11,964	95.	125.9	
Cauliflower	"	9,798	62.5	156.7	
Celery	"	12,874	77.	167.2	
Chard, Swiss	"	12,021	95.	126.5	
Eggplant	"	25,725	106.5	291.5	
Kale	"	8,143	95.	85.7	
Peas	"	1,065	81.5	13.0	
Pepper	"	1,474	83.5	16.6 *	
Okra	"	759	88.5	8.5	
Spinach	"	13,260	100.	132.6	
Sprouts, Brussels	"	9,189	77.5	118.5	
Squash-Summer	"	16,994	119.	168.9	
					3510.5
Beets	cooked	18,383	90.	204.2	
Carrot	"	11,184	80.	139.8	
Corn	"	226 ears	2 ears	113.	
Leek	"	6,473	88.5	73.1 *	
Onion	"	39,128	98.5	397.2	
Tomato	"	68,613	81.	847.	
					1674.3

Portion figures were based on *The Handbook of Food Preparation* published by The American Home Economics Association, 1964. Those marked with an (*) were not mentioned in this handbook and are our own estimates.

TABLE 2.

	Number of People - One Portion - Each Day of the Year	Significant Amount of Portions Unrecorded
Cooked Root Crops	7.4	x x x x
Uncooked Fresh Salad Vegetables	15.4	x x x x
Cooked Vegetables	9.6	x x x
Cooked Non-Green Vegetables	4.58	x x x x

The table shows that ten people would have at least one serving or the equivalent of raw, cooked green and cooked starchy vegetables every day of the year.

Discussion:

The preceding figures give some idea of productivity. The amount of harvest of one garden row of vegetables can be projected to a figure per acre, then compared with a state or national average.

Such comparisons have little validity unless differences in energy consumption with standard agricultural practices are considered in such areas as mechanization, irrigation, pest control and fertilization, as well as in attention and attitude toward the land. Where companion planting, interplanting and succession planting are practiced, comparing square footage or linear footage of growing area are nearly impossible. Comparing one garden with another is even less valid. Original soil structure, natural fertility, growing season, micro-climate and immediate environment all play an important role. Many of these are not easily controlled and differ from place to place.

Conclusion:

On a plot of less than a tenth of an acre, one serving each of a raw vegetable, a green cooked vegetable and a root or other non-green cooked vegetable was grown for ten people for each day for a year, with some surplus.

This took 235 work hours over a six-month period or an average of one hour and sixteen minutes a day for one person. Included are sixty hours and forty minutes of hand watering.

Approximate water use was 14,560 gallons over a period of six months.

No chemical or biological pesticides were used.

Only traditional non-commercial insect control methods were used, including companion planting and hand picking.

No chemical fertilizers were used.

Rock minerals, seeds, hand tools, garden hoses and black tubing were the only commercial items used.

No equipment requiring fossil fuels was used.

The only energy was human labor.

Future Projections:

It is our hope that the same twenty beds could produce the same combination and types of vegetables for fifteen people instead of ten next year. This is based on the fact that several crops failed or were severely damaged by rabbits, insects and/or drought, all of which could be controlled to some degree.

With improved soil and more effective growing space in the area closest to the woods, there is a possibility of growing all the vegetables for twenty people on this one-tenth of an acre two years from now.

Gardening intensively on a small acreage, using such practices as extending the season with cloches and solar-heated greenhouses, selecting local plant varieties for pest and disease resistance and for suitability to soil and climate, improving soil fertility, the establishment of food-producing forests and animal husbandry are all strategies within our reach to heal the earth and to secure the existence of future generations. All that is needed is people willing to tend the land and nurture the plants that in turn sustain them.

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Photo by Hilde Maingay

Experimenting with Growing Beans

— Susan Ervin

At New Alchemy, we are interested in the growing of dried beans, both for their nutritive value and because, as nitrogen-fixing legumes, they restore rather than deplete the soil. Our bean experiments are attempts to realize our conviction that adequate protein is a basic human necessity and that to produce protein ecologically is equally essential.

This past summer we grew sixteen varieties of beans for drying. In addition to the standard kidney bean, these included several old New England varieties, a Mexican black bean, a black bean which has been grown locally for many years by Delinda LaBeet, who is of Wampanoag Indian descent, two Oriental sprouting beans and a half-dozen of the many beautiful kinds of beans grown in Costa Rica. Rather than design a controlled experiment, we chose, at this stage, to do a pilot study relying mostly on observation, and a sampling and comparison of yields from the different varieties at harvest. The sixteen varieties grown were:

1. Dark Red Kidney
2. Light Red Kidney
3. Charlevoix Kidney
4. Trout (New England)
5. Soldier (New England)
6. Main Yellow Eye (New England)
7. Navy (New England)
8. Mexican Black Bean
9. Local Black Bean
10. Adzuki
11. Mung
12. Costa Rican Black
13. Costa Rican Red "Colorado"
14. Costa Rican Pink "Coloradito"
15. Costa Rican Yellow "Mantequilla"
16. Costa Rican Purple Striped "Tigre"

Each variety was harvested when the majority of the beans on the plant was dry. Before harvest, six plants were chosen at random from each row and the weight of the beans recorded. Also, the total weight of beans for each variety was recorded. All yields given below are for two 25' rows unless otherwise specified.

Throughout the season, the plants bearing the Light Red Kidneys were the largest and the healthiest green and were least damaged by rust or attack by Mexican Bean Battles with the exception of the Mung and Adzuki beans which received virtually no beetle damage, probably because of their hairy leaves. Consistent with their generally healthy condition, the Light Red

Kidney Beans had the highest yield of any variety at 8 pounds. The Maine Yellow Eye Beans had serious rust and some yellowing at various stages but gave the second highest yield at 6½ pounds. There was a general yellowing of most of the bean plants in early June, but the deep green color returned within a week. Rust was quite extensive on some varieties and persisted throughout the summer, causing premature loss of leaves in a few cases, the Navy beans being the worst affected. The Mung beans were the third highest in yield at 3 pounds from one 25' row. Early planting in their case is essential therefore. They were very slow growing and not all of the beans were mature by frost.

Of the three black beans, the local variety did the best (5 pounds). The Mexican Black Bean produced 4 pounds. Though neither was as high yielding as the varieties already listed, yields were in line with those predicted for a 50' row of beans by Johnny's Selected Seeds Company in Maine.

The Costa Rican beans did not grow as large as the same varieties do in Costa Rica and they were much smaller than the temperate varieties. However, the Mantequilla, at 4½ pounds, yielded nearly as much as the best temperate varieties.

Looking over the yields, all varieties were up to average with the exception of the Soldier beans which germinated poorly, the Tigre from Costa Rica (which are, however, very pretty), the Colorado, the Costa Rican Black and the Adzuki, which had many pods that were not fully mature by frost. Thus, even with some disease and insect problems, a number of varieties were average or above average in production.

Highest yield is not the only criterion for suitability of a crop. Light Red Kidneys happen to be my least favorite bean, because they are large and starchy. The small beans, which include all the Costa Ricans, and blacks, are in my opinion, a higher quality food. The cooking time tends to be shorter also. The small Costa Rican beans are tender in one hour, whereas the large kidneys may take three hours. So, although yields for small beans may be lower and shelling time longer, one saves fuel and can have cooked beans in a shorter time. We include recipes and suggestions for cooking dried beans in *The Cook Book of the New Alchemists* and further recommend *The Bean Book* by Crescent Dragonwagon from Workman Publishing Company. When eaten in combination with other protein-providing foods, beans add a high quality protein to the diet, as the amino acids which they lack are available in grains and some seeds and nuts. A cup and one-half of beans on their own provide usable protein equivalent to six and one-quarter ounces of steak; four cups of rice alone provide protein equivalent to seven ounces of steak. But the rice and beans together provide usable protein equivalent to nineteen ounces of steak, a 43% increase over the two eaten separately. *(Diet for a Small Planet,* Frances Moore Lappé, pp. 156-157, Ballantine). American Indians and Mexicans combine beans with corn, and the Caribbean and South American cultures combine beans and rice. Lentils and rice are combined in India, and soy and rice in China. Legumes have been a beneficial source of protein for many peoples for many thousands of years without upsetting the balance between the needs of the human population and the immediate ecosystem.

TABLE 1 - Bean Varieties and Yields

	Name of Variety	*Yield per two 25' rows*
1.	Dark Red Kidney	3 lb.
2.	Lt. Red Kidney	8 lb.
3.	Charlevoix Kidney	3¾ lb.
4.	Trout	5¾ lb.
5.	Soldier	1¼ lb.
6.	Maine Yellow Eye	6½ lb.
7.	Navy	2¼ lb. (one 25' row)
8.	Mexican Black	4 lb.
9.	Local Black	5 lb.
10.	Adzuki	Not mature at frost
11.	Mung	3 lb. (one 25' row)
12.	Costa Rican Black	1 3/8 lb.
13.	Costa Rican Colorado	1¼ lb.
14.	Costa Rican Coloradito	1¼ lb.
15.	Costa Rican Mantequilla	4¼ lb.
16.	Costa Rican Tigre	2¾ lb.

Photo by Hilde Maingay

The Effects of Mulching with "Seaweed" and Azoll on Lettuce Productivity

— Susan Ervin

Mulching is a common gardening practice, used to control weeds, retain soil moisture and add organic matter to the soil. We have used it extensively in the New Alchemy gardens. In 1976 we conducted an experiment comparing the productivity of unmulched lettuce to that of lettuce mulched with "seaweed" (actually a mixture of eel grass and codium) and of lettuce mulched with azolla (probably *Azolla pinnata*). Azolla is a small aquatic fern on which grows the nitrogen-fixing blue-green algae, *Anabaena* sp. In experiments conducted in Denmark, it was found that the symbiotic algae on the azolla fix up to 95 kg/ha of nitrogen in small ponds in one season's growth.[1] Azolla is commonly grown in rice paddies in Vietnam, resulting in 50% to 100% greater yields.[2] We thought that the excess azolla from our fish ponds, used as mulch, might be a rich source of nitrogen for the garden plants. Seaweed was chosen for the trials because it is plentiful here and has been our primary mulching material at New Alchemy, as well as having been used traditionally on Cape Cod.

The 15' by 10' experimental plot was divided into six sections. On June 14, three 3' rows, consisting of fifteen (Bibb lettuce, Ferry-Morse) plants each, were set in each section and mulched. The seaweed mulch was approximately 4" thick but settled to a thin covering and had to be renewed several times to maintain a depth of about 1" to 1½". The plot was watered as needed, with each section receiving an equal amount of tap water. Plants were harvested and edible portions weighed on July 15 and 16. Contrary to our expectations, the unmulched plants gave higher yields than those receiving either of the two mulches (Table 1).

Table 1: Mean weights of lettuces — unmulched, mulched with azolla, and mulched with seaweed — Trial I.

	No. Plants	Total Wt.	Mean Wt.
Plot A (azolla)	45	941 g	20.9 g
Plot B (seaweed)	43	690 g	16.05 g
Plot C (seaweed)	44	836 g	19 g
Plot D (no mulch)	43	1125 g	26.6 g
Plot E (no mulch)	43	1217 g	27.66 g
Plot F (azolla)	45	805 g	17.89 g

The following pairs were compared using a Wilcoxon signed rank test:[3]

A (azolla) vs. B (seaweed)
C (seaweed) vs. D (no mulch)
E (no mulch) vs. F (azolla)

The respective values of T were 281.5, 216 and 105.5. In each case, there was a difference between the treatment effects significant at the 5% level or better.

On July 20 the rows were re-seeded with Great Lakes lettuce (Burpee) and on August 6 thinned to fifteen plants per row, again giving a total of forty-five plants per section. Mulching was done with seaweed and azolla as described in the first trial; however, as azolla was scarce at this time, the mulch was not as thick as before until a second application was made on September 2. To offset any possible inherent natural advantage in any particular section, treatment was rotated between the first and the second trials.

All plants were harvested on September 20 and the edible portions were weighed. In Plot E (azolla) nearly half the plants were damaged, with only roots and/or small leaves remaining so these were not considered in the analysis.

Table 2: Mean weights of lettuces – unmulched, mulched with azolla, and mulched with seaweed – Trial 2.

	No. Plants	Total Wt.	Mean Wt.
Plot A (seaweed)	44	1414 g	32.1 g
Plot B (azolla)	40	2496 g	62.4 g
Plot C (no mulch)	44	1963 g	44.6 g
Plot D (seaweed)	38	352 g	9.3 g
Plot F (no mulch)	44	603 g	13.7 g

Using the Wilcoxon signed rank test, the following pairs were compared:

A (seaweed) vs. B (azolla)

C (no mulch) vs. D (seaweed)

The respective values of T were 138.5 and 57, a difference, in each case, significant to the 5% level or better.

The results of the experiment are by no means clear. In the first trial, a lack of mulch of either type was advantageous for the plants. In the second trial, a light application of azolla resulted in the highest yields. The variability observed may have been due to the following variables: rainfall and water availability between the two trials, competition for oxygen and nitrogen between lettuce seedlings and mulches, particularly in Trial 1, and to the dynamics of soil and plant, mulch interactions which are as yet little understood.

Next summer we will continue our mulching trials, growing a root crop, a fruiting crop and a leafy crop. Unmulched plots will be compared to plots receiving several different mulches. Identical trials will be run with and without supplemental watering. We have observed that azolla can take root on the soil in the high humidity of the greenhouses, particularly in small planting boxes and pots. Perhaps further research should be done with these plants as a living mulch rather than a decomposing one.

Any observations from readers on the effects of mulches are invited.

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Fertile Fish Pond Water Irrigation Trials

–Susan Ervin

During the summers of 1973 and 1974, we conducted experiments comparing the productivity of plants irrigated with fertile water from fish ponds to that of plants watered with ordinary tap water. The most significant difference occurred with lettuce; collards showed some benefit from the fish pond water; beets, chard and zucchini showed no significan differences (the first and second *Journals of the New Alchemists*).

In 1976, we conducted further lettuce trials. Tomatoes were tested as a fruit crop. The lettuce trials were repeated not only in order to strengthen our findings by replication, but also because we planned to analyze and compare the ammonia content of the two types of water. Unfortunately, the water analysis equipment was defective on arrival and replacement arrived too late for adequate data collections. Water analysis results will be published next year.

The experimental plot was rectangular, 20' x 28', divided into four equal sections. Two sections were watered with tap water and two with water from aquaculture ponds. To prevent water run-off and mixing between sections, concave "nests" were dug for individual tomato plants and troughs made for the lettuce rows. A small amount of compost was mixed with the soil before planting. On June 6, each section was planted with ten tomato seedlings (Better Boy, Burpee) in two rows of five plants each, with thirty lettuces (Bibb, Ferry-Morse) planted in a single row. Watering was done at least once a week throughout the summer, more frequently when soil and weather conditions required. The 4' plots received equal amounts of water. At each watering, individual tomato plants received one gallon except during several very dry periods when they received two gallons each. At each watering, every lettuce trough received three gallons when the plants were small. This was later increased to four gallons, and to six gallons during dry periods.

The Bibb lettuce was harvested on July 6 and 7. Lettuce troughs were replanted with Prizehead lettuce (Northrup-King) on August 2 and harvested again on October 11. In both trials, raw weights of edible portions of the lettuce were recorded. Tomatoes were harvested and weighed individually when fully ripe until the first light frost when all remaining fruits were harvested.

Results of the experiments are show below (Tables 1 and 2).

Table 1. Mean weights of lettuces irrigated with fish pond and tap water

	No. Plants	Total Wt.	Mean Wt.
Trial 1			
-Bibb Lettuce			
Pond Water	56	1714 g	30.61 g
Tap Water	56	1184 g	21.24 g
Trial 2			
Prizehead Lettuce			
Pond Water	58	1823 g	31.43 g
Tap Water	58	1297 g	22.36 g

Statistical analysis of the data was carried out using a Wilcoxon signed rank test.[3] In the first lettuce trial, T = 367.5 indicating that the experimental plants were larger than the controls, significant at the 5% level. In the second trial, T = 559, which barely misses significance at the 5% level.

Even though the pond water produced larger fruits and the tap water a larger number and higher average yield per plant, there was no significant difference between the yields of tomatoes watered with pond water and those watered with tap water.

Table 2: Yields of tomatoes irrigated with fish pond water and tap water

	No. Plants	No. Fruits	Total Wt.	Mean Wt.	Aver. Yield per Plant
Pond Water	19	607	133.656 kg	220.9 g	7034.5 g
Tap Water	20	770	153.053 kg	198.77 g	7652.65 g

The results of these experiments are in accord with our earlier work. It appears that shallow rooted leafy crops are likely to benefit from irrigation with fertile fish pond water, whereas fruit crops are not as likely to benefit.

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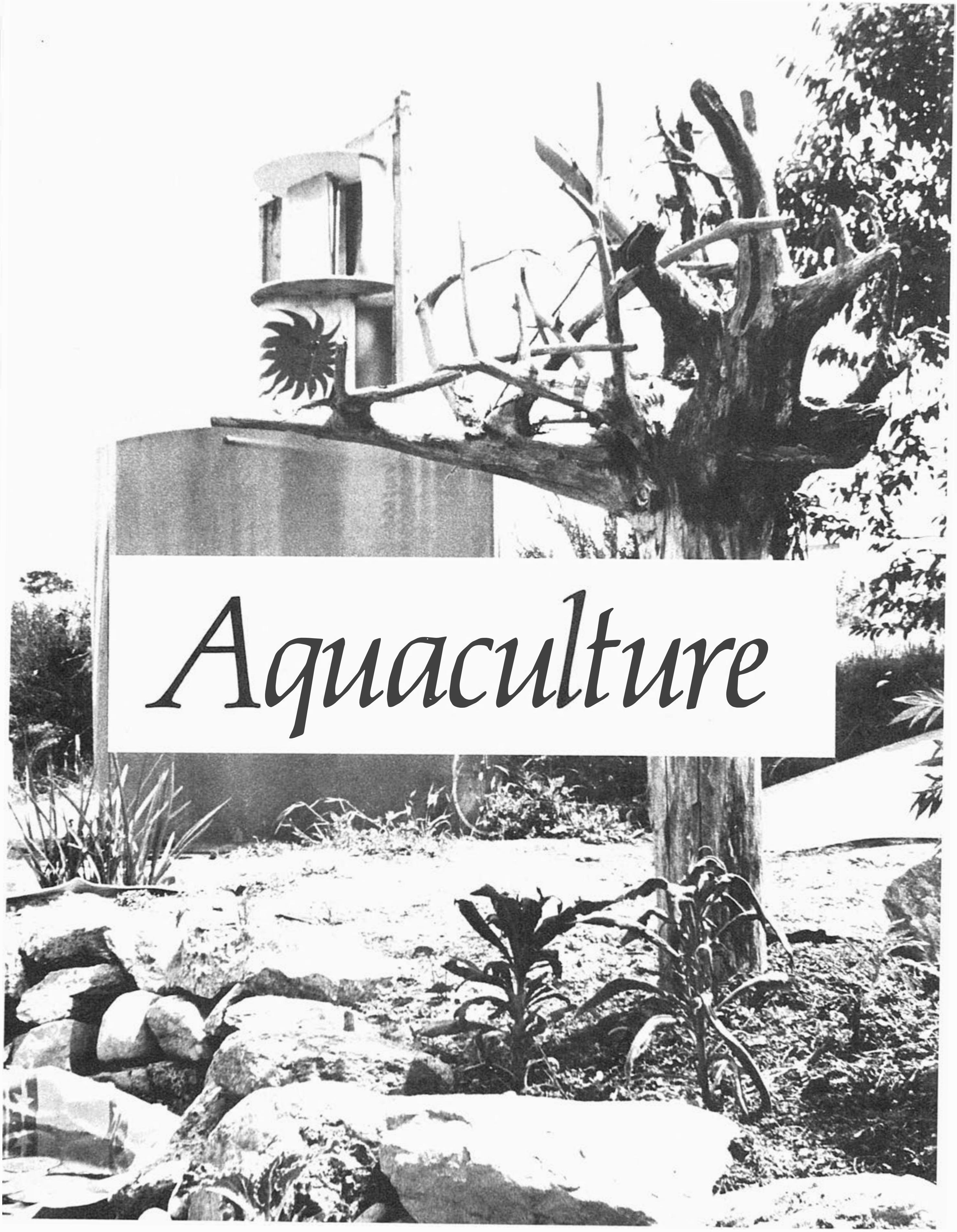
Photo by Joan Pearlman

Aquaculture



In spite of ongoing efforts on all fronts, our real news this year has come from the work in aquaculture and bioshelters. About two years ago, John Todd had an idea for the creation of what we have come to call "Solar-Algae Ponds." These are translucent cylinders which allow the interaction of algae with light on all pond surfaces except the bottom. They are proving far more productive of algae and consequently of fish than we had anticipated. Ron Zweig describes working with them in the article called, "The Saga of the Solar-Algae Ponds." We see potential applicability for them in the fact that the cylinders are economical in terms of cost and space and can be used inside and out, in urban, suburban and rural areas. Our other semi-closed aquaculture projects in established systems are described and contrasted in Ron's other articles.

Meanwhile, Bill McLarney, when he can be lured back from Costa Rica, is directing his attention to "Cage Culture." It seems, as he explains, a practical direction for people who have access to standing bodies of water. As a major limitation on fish raising is the high cost of fish feed, much of his effort and thinking is toward the search for alternatives to commercial fish food. His first summer's work is summarized in "Cage Culture."

The Saga of the Solar Algae Ponds

– Ron Zweig

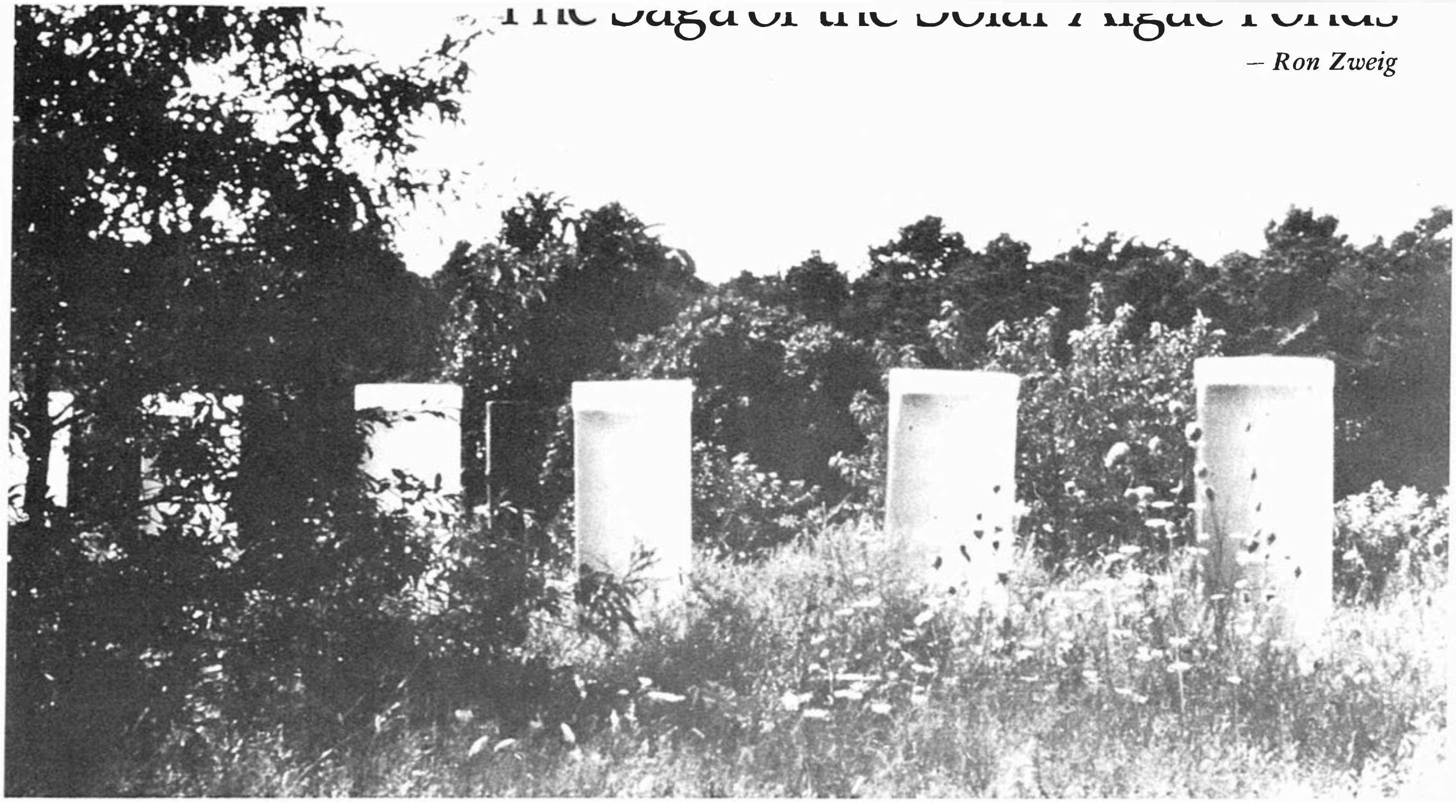


Photo by John Todd

The development and use of Solar-Algae Ponds is the latest innovation in New Alchemy's aquaculture. These ponds which are in themselves semi-closed ecosystems are cylindrical tanks made of highly translucent fiberglass. They have a depth and diameter of 1.5 meters (5 feet) and contain up to 2.78 cubic meters (734 gallons) of water. They were constructed by the Kalwall Corporation at approximately $150.00 per pond. We have also experimented with tanks of the same material, with a depth of 1.5 meters but having a diameter of approximately 0.45 meters. The fiberglass material is .06 inches thick and is expected to last twenty years.

Pond Theory and the Algae Component

The theory behind experimenting with these ponds was to increase the amount of pond surface area exposed to solar energy. With these tanks, not only is the upper surface exposed to light penetration, as in a conventional pond, the sides of the tank are as well. This has proved a most effective means of collecting and storing solar energy, especially in northern latitudes, when during the winter months the sun's position in relation to the horizon is quite low and the low angle rays can penetrate the water mass. The same would hold true for complementary southern latitudes.

The tanks can be used both outside and inside structures including ordinary houses. A number of tanks can be linked together to form a "Solar River." Both the Cape Cod and Prince Edward Island Arks have been designed with this in mind. Some of the linked ponds could be used as fish polyculture tanks, others as filtering components, and still others as zooplankton production ponds. Water can be transferred between them using an air lift pump. It has been found that air bubbled into a narrow tube can lift water one-half the depth of a pond. This air could be provided by an air compressing windmill and could be stored in pressure tanks. One-half pound of air pressure is required for each foot of depth. An initial pump of this type would be required and then the water would be cycled through the other ponds in the "river" by the use of siphons.

The phytoplankton population in these ponds can become extremely dense, due to the high quantity of light entering them. Last winter at Yale University, John Goldman used a small solar pond to experiment with Tilapia and the phytoplankton that grow in our systems. The predominant species was the Chlorococcales *Golenkinia* sp. This alga is a small spherical cell with thin spine-like structures extending in all directions, which give it pelagic capabilities. Since water movement within an independent pond is restricted to the stirring caused by the swimming of the fish, characteristics such as those of the *Golenkinia* sp. are necessary to keep the algae from settling to the bottom. In addition to *Golenkinia* sp., some *Scenedesmus* sp. and a few other algae species were also found. The functions of phytoplankton in these systems are listed in the description of the Miniature Ark.

Goldman found that the population densities of *Golenkinia* increased logarithmically in a proper nutrient medium. In some trials, bacteria populations were established prior to the algae, preventing the algae from blooming. This supports the hypothesis that bacteria compete with phytoplankton. When Tilapia were introduced into algae-rich systems, they were found to crop back the population through filter feeding. A transparent cylindrical culturing system has been used by Cook, consisting of a pyrex glass tube 4 inches in diameter and 6 feet in height. He cultured the Chloroccocales *Chlorella pyrenoidosa* which he calculated to be capable of using 2.5% of the incident solar radiation. He harvested his culture regularly, however, replacing it with nutrient-rich medium as desired densities were achieved. Both Goldman and Cook used artificial light to drive their cultures continuously.

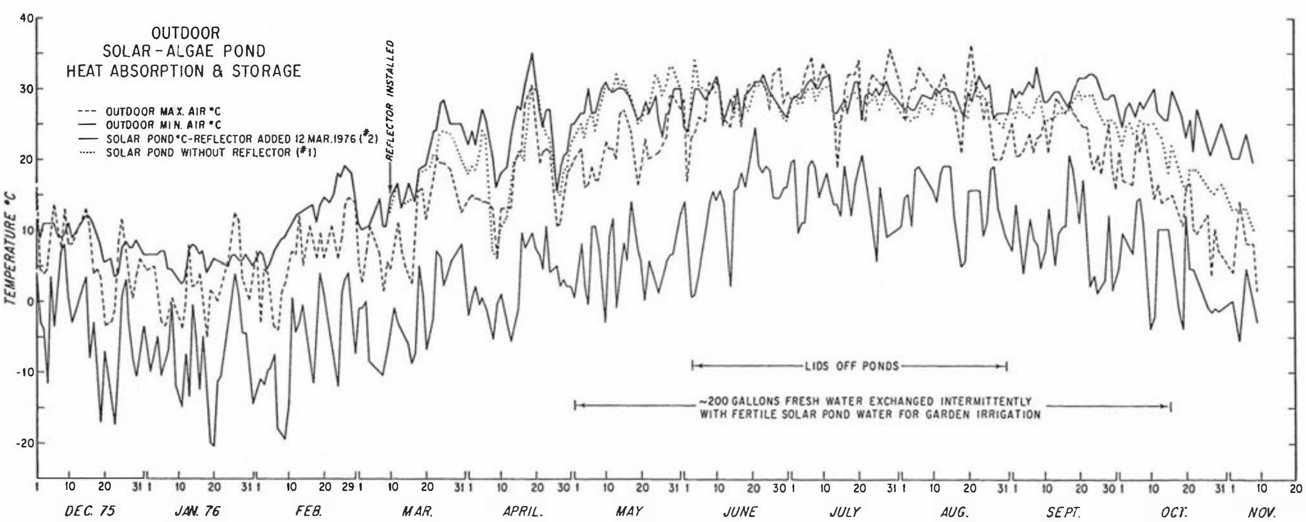
Goldman found that with his *Golenkinia* sp. cultures at an average temperature of 29°C, *Tilapia aurea* grew 0.1 grams per day. Phytoplankton alone does not provide optimal growth. It does provide enough food for maintenance and a little growth. Another alga such as *Spirulina platensis,* which is discussed in the Miniature Ark section, might improve production. For specific questions regarding Goldman's data, please write to us.

Winterization

The outside solar ponds required several adjustments for winter. A second layer of fiberglass was added to the outside vertical wall of the cylinder. This was done by winding garden hose 1.6 cm (5/8 inch) in diameter as a spacer around the top and bottom of the pond. Then a second layer of fiberglass was tightly wrapped around the spacer and sealed with clear silicone sealant, creating a thermal pane. Thick styrofoam insulation 5 cm (2 inch) cut in a 1.5 meter diameter disk was placed beneath the pond. A small, double-layer geodesic dome 1.5 meter-base diameter was placed on the upper perimeter of the cylinder. Insulated in this way, the outside tanks maintained the highest temperatures of all our aquatic systems including those within the other solar-heated structures. During the '75-'76 winter, the Miniature Ark, Dome and Six-Pack Ponds fell to freezing, whereas the Solar-Algae Ponds were measured at 4°C with the outside temperature at -21°C. A temperature profile of these ponds with maximum and minimum outside air temperatures is found in Graph 1. The '75-'76 winter was not particularly cold, however, there were short periods of intense cold for Cape Cod, as indicated by the chart.

On March 12, 1976, a parabolic reflector was installed behind Solar-Algae Pond No. 2 which was outside. It was focused on the center of the pond. The reflector was constructed of five vertical, ten-foot 2 x 4's, placed four feet apart and buried two feet in concrete. Four 4' x 8' quarter-inch reinforced sheets of plywood were bolted to the studs, long edge up and braced on the north side. The 128 ft^2 of surface area was covered with a reflective metalized polyester laminant attached with duct tape. This attachment method was used to allow for the possibility of detaching it, in the event of the loss of reflectivity, and turning it around to use the other side, as both sides are reflective. This has not been necessary. The first side is in excellent condition as of this writing (Winter '77). The material was made by the Hy-Sil Manufacturing Company of Revere, Massachusetts.

To construct the parabolic arc a line was defined equidistant from a given point and straight line (see Diagram 1). In this case, the point was the center of the pond and the straight line ran east and west, ten feet north of this point. During the spring, the difference in temperature between the pond with the



GRAPH 1.

SOLAR–ALGAE POND WITH PARABOLIC REFLECTOR

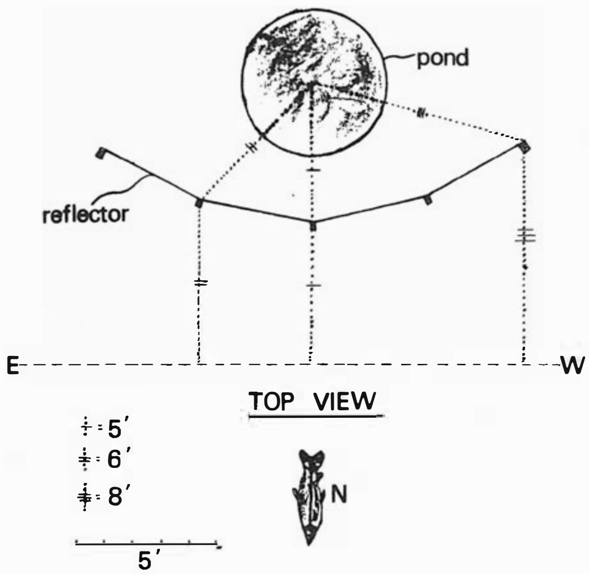


Diagram 1.

reflector (Solar-Algae Pond No. 2) and the one without (Solar-Algae Pond No. 1) was approximately 4°C. The reflector's position to the north of the pond provided a good wind break from the cold north winds. On a sunny day, Solar-Pond No. 2 was capable of an increase in temperature of 4.5°C) (≈ 8°F) which amounts to an increase of 12,510 Kcal (49,000 BTU's) for the 2,780 kg (6,123 pounds) of water in the pond. The tops were left on the tanks throughout this period. Energy studies are also being done with the solar ponds inside the Cape Cod and Prince Edward Island Arks.

There is an advantage to building a vertical reflector. It provides excellent reflectivity on the pond during the winter months when the sun is low in the sky yet less effective during the summer, especially around the summer solstice, when added heat is unnecessary. The sun is then very high in the sky and most of the direct sunlight striking the reflector is deflected to the ground on the space between the pond and the reflector. The intensity was very concentrated – strong enough to melt the styrofoam extending beyond the base of the pond. The ponds reached optimal Tilapia growth temperatures of 26° to 36°C during the summer with the tops removed.

The reflector became more effective as the sun sank in the southern sky during July and August. Overheating can become a problem, however. If so, the reflector can either be removed or masked with tall plants. This year, unintentionally, several plants, including lamb's-quarters, which usually grow waist-high, grew to two meters between the pond and the reflector. The phenomenal weed growth was probably because of the plants receiving light from all sides while being protected from the wind. Dwarf fruit trees in movable boxes could be used for selective shading when necessary. The outdoor solar pond design is being explored further and will be expanded to include about thirty solar ponds in a reflective courtyard adjacent to the Cape Cod Ark.

Outdoor Experimentation

Over the past year, we completed six fish production trials, using the larger 1.5 meter diameter ponds and one series of experiments using the 0.45 meter ponds coupled together.

Coupling and Density Experiments Using the Smaller Solar Ponds: The first trials with linked solar ponds were done last summer. Sixteen of the smaller ponds were used, connected in eight individual couplets. Water flowed between them continuously. It was pumped by a simple air pump device over into the adjacent tank (see Diagram 2) and flowed back through a siphon. The rate of flow varied because the screens on the ends of the exchange tubes became clogged with growing algae, necessitating repeated cleaning. The screens were necessary because the size of the fish used in the experiment was so small that they swam through the tubes to the adjacent pond. This experiment was designed to test the efficiency of fish growth at different numbers per volume of water. Three densities were tested – one fish per gallon, one fish per two gallons and one fish per four gallons. The one fish per gallon experiment was duplicated with filter screens of crushed oyster shells glued to sheets of fiberglass which were hung in the tanks. Densities were tested in two ways. In the first, all the fish were in one of the coupled ponds. In the second, the fish were evenly divided between the two. The two ponds

SMALL SOLAR–ALGAE POND COUPLET

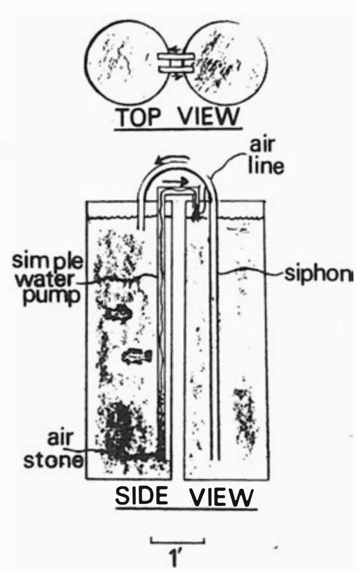


Diagram 2.

together contained a maximum of 132 gallons of water. In the first instance, 130 fish were placed in one of the ponds and, in the second, 65 were put in each of the two.

The results are preliminary and not sufficient to draw definitive conclusions without further trials in terms of density efficiency; however, some useful observations were made. With respect to growth, of all the New Alchemy experiments, the greatest mass per unit volume or surface area was produced in these small ponds. The fish used were small, weighing about 0.1 gram each. Twice daily, six days a week, they were fed 3% of their total body weight of Purina Trout Chow per pond. They grew to a maximum of 361.25 grams in one of the systems. The average ratio per couplet of wet fish to dry feed was 2.14 with a maximum of 3.59. These high efficiencies are probably due to the small diameter of the ponds, which increases the intensity of solar radiation per unit volume of water, resulting in more efficient photosynthesis and high algal production and oxygen levels. As the phytoplankton absorbs the entering light in larger systems with high algal densities, there would be a limitation of photosynthesis in the internal area of the tanks.

The design of the experiment demonstrated several phenomena about coupling the tanks. In the cases of the couplets with fish on one side, a build-up of sediment occurred in the complementary tank which fouled the water and raised levels of such toxins as ammonia. This was due to a lack of stirring of the sediments. The ponds with fish on both sides remained healthy with the exception of the trials with one fish per four gallons of water. The fish in these ponds probably were neither large nor numerous enough to stir the sediments sufficiently. Balances must be carefully worked out. If the couplets with the fish isolated on one side prove most efficient, a stirring method must be developed. Crayfish possibly could be used in the bottom of the fishless ponds to keep the bottom stirred or the sediments could be removed through periodic siphoning.

In the pond containing 130 Tilapia on one side, *Simocephalus* sp., a Cladoceran, bloom occurred. This was the first zooplankton bloom in one of these ponds. The sediment build-up was considerable at the time of the bloom which may indicate that potentially unhealthy conditions for the fish may be necessary for a good zooplankton population. Raising zooplankton as fish feed is another parameter to our Solar-Algae Pond research. This may lead to independent ponds for independent functions.

Production Experiments

Experiment 1 – Winter Trials: The two 1.5-meter outdoor Solar-Algae Ponds containing temperate species of fish were used. These included Israeli carp, Chinese Big Head carp and Chinese Silver carp. All the fish died in one of the ponds, probably because of the release of lethal copper ions from a bronze air valve which, undetected by us, fell into the pond.

Solar Pond No. 1, however, remained viable and productive. On November 28, 1975, 11 Israeli carp weighing 875 grams were introduced. On December 9, a twelfth was added at 125 grams, making a total weight of 1,000 grams. On December 1, 40 Chinese carp were added weighing 85.2 grams. On April 8, 1976, the 12 Israeli carp were removed, by then weighing 1,750 grams. The 34 surviving Chinese carp weighed 180 grams – a total increase of 844.8 grams. During the course of the experiment, the fish were fed 2,880 grams of Trout Chow and 96 grams of TetraMin, making a total of 2,946 grams of feed. The wet fish to dry feed ratio was 0.29 to 1.0. Although this was low, it demonstrated the viability of the tanks. During the course of the experiment, temperatures were quite low, during some periods just above the lower lethal limit. The trial was not a highly productive period in terms of fish mass gained, but it did demonstrate that the fish could live and grow in these ponds.

Experiment 2 – High Density Polyculture: The first warm weather experiment was intended to determine the maximum number of fish that could live in a single tank. Over the winter, 146 Tilapia were kept in a small 66-gallon solar pond in the house, totaling 2.2 Tilapia per gallon at 20°C. The number of fish put into Solar Pond No. 2 was 247 Tilapia at 3,995 grams, 13 Israeli carp at 1,950 grams and 34 Chinese carp at 180 grams, a total of 344 fish at 6,125 grams. The fish were added between April 8 and May 4, 1976. The last 54 Tilapia were added on May 4. May 7 was a dark, cloudy day resulting in oxygen levels too low to maintain the population because of insufficient solar energy to drive the photosynthetic process. As a result, on May 8, six Israeli carp at 775 grams, 45 Tilapia at 960 grams and one silver carp at 4 grams were discovered to be dead and removed. A mechanical back-up aeration system was added, but it failed on the night of May 9. The following day, 19 Chinese carp at 140 grams and one Israeli carp at 190 grams died and were removed. The water temperature rose to 30°C on May 10. The aeration was continued throughout the experiment.

Several times during the experiment, ammonia concentrations were quite high – up to six parts per million. (Less than one part per million will kill rainbow trout).* Supplemental feeding was halted

* Robinette has found that sub-lethal levels of ammonia at 0.12 – 0.13 ppm will inhibit channel catfish growth which he found to die at about 2.0 ppm. Therefore, although the fish in our experiment can withstand high levels of ammonia for a period of time, their growth could be strongly inhibited with these concentrations.

and between one-quarter and one-third of the water in the tanks was changed daily by siphoning waste water from the bottom of the tank. The water was used to irrigate parts of the garden. It was replaced with tap water. The process was continued until ammonia concentrations were reduced. Generally, it is a good practice to dilute once a week any chemical factors which could arrest fish growth or could be dangerous to the fish. During this trial, we pushed the viable limits in terms of feeding and population density.

The experiment was completed on July 15. The entire population increased in weight by 6,980 grams. During the experiment, 6,675 grams of Trout Chow, 101 grams of TetraMin and 175 grams of soy flour were fed to the fish, resulting in a wet fish to dry feed ratio of 1.0 to 1.0. This includes the dead fish which were removed. The fish were fed a supplement of *Azolla, Hydrodictyon* and *Lemma.* The tank had a rich phytoplankton bloom. These were not measured quantitatively.

Experiment 3 – Zooplankton Culture: While this experiment was in progress, Solar Pond No. 1 was inoculated with large populations of indigenous zooplankton caught from a local pond. This was done to try to grow populations of zooplankton in a solar pond as supplemental fish feed. The initial attempt was not successful. Although there was a good phytoplankton bloom in the pond, the water chemistry, nutrient balance or temperature were not suited to the small animals. Inoculations were made twice weekly from April 8 to May 14.

Experiment 4 – Tilapia Breeding: Six of the largest Tilapia were put in Solar-Algae Pond No. 1 on May 14. This was done as a breeding experiment to find whether the Tilapia would breed in this type of pond. In addition, we hoped to use their progeny to select for a fast-growing population. The fish weighed 475, 375, 350, 200 and 150 grams or a total of 1,550 grams. As of July 7, there was no evidence of reproduction, leading us to question whether all the fish were either male or female. Tilapia mating behavior requires the male to prepare a cleared spot against a dark object or surface. Because of the translucent sides of the ponds, a male backing against a surface would back into the light. This could disrupt mating behavior or limit it to night activity. In addition, the fish can see people walking past the tanks and become startled. Tilapia mothers have been known to swallow their brood if sharply disturbed. Reproduction could possibly have been arrested by a periodic striking of the side of a tank. Moriarty found that disturbing the *T. nilotica* caused inefficiency in their digestion for a time.

To help eliminate these variables and provide a breeding area, on July 7 two concrete blocks were placed in the tank and a piece of black polyethylene was wrapped around the lower half of the north side. On July 29, three weeks later, the first young Tilapia were seen, of which only three were netted out. These were the only young fish found even with further masking of the lower half of the south side on August 4. These tanks cause serious reproduction retardation if not failure. Further research is required.

The experiment ended November 9. The fish were fed a total 6,700 grams of Trout Chow Floating Pellets. The fish grew 3,550 grams with a conversion ratio of 0.53 to 1.0 wet fish to dry feed. There was a total of 20 fish – 14 young from breeding activity.

The largest fish weighed 1,100 grams (2.42 pounds). The fact that the fish grew so large demonstrated that the size of the ponds does not limit fish growth. In fact, the fish achieved a weight nearly five times larger than we feel necessary for useful production. The low ratio of food conversion is probably due to a lowering in growth efficiency with the larger fish. We abandoned selecting for a fast-growing population in Solar-Algae Ponds because it might result in the selection of aggressive characteristics. To do so would require highly controlled conditions with individual fish in individual tanks. That growth potential is a genetic variable in Tilapia has never been demonstrated. Again, work is necessary in this area.

Experiment 5 – Tilapia Monoculture: Beginning July 15, 1976, a second trial was run in Solar Pond No. 2. Two hundred and fifty Tilapia (one per three gallons) weighing a total of 40.5 grams were put into the pond. The fish came from the new population bred in the Dome. They were fed a total of 3,825.5 grams (8.41 pounds) of Trout Chow. The fish grew to 3,480.5 grams or an increase of 3.44 kilograms. The wet fish to dry commercial feed mass was 0.9 to 1.0. This figure is probably due to inability of the fry to assimilate phytoplankton during the early stages of their development, relying, therefore, chiefly on the commercial feed. In nature, *T. nilotica,* another phytoplankton feeder, have been observed by Moriarty and Moriarty (1973b) to be mainly carnivorous until they reach 3-6 cm in size. The mass of fish obtained from this pond will be discussed in regard to the other systems in the summary.

Solar-Algae Pond Summary

The Solar-Algae Ponds have demonstrated phenomenal fish productivity. The smaller ponds, used in couplets, demonstrated the highest productivity. The results, however, were inconsistent. In the two large pond productivity experiments, productivity was excellent. It is necessary to extrapolate the size of the ponds and the time span involved to that of a hectare per year in order to gain comparative figures. Fish productivity is computed in kg/hectare.

The best productivity recorded in pond aquaculture ranges between 1,000 and 15,131 kg/hectare/year, using South China herbivores in fertilized ponds with supplemental feeding (Odum, 1971). In Solar Pond No. 2, in the first trial of the summer, production was the equivalent of 142,840 kg/ha/yr, nearly ten times greater than the best natural pond culture. The second trial at 63,962 kg/ha/yr is nearly five times greater. The difference in the two is probably due to one of two reasons. It could have been because four different species of fish were cultured in the first trial and, in the second, a monoculture of Tilapia was used.

The other reason could be that immature Tilapia were used. In the second trial, the young Tilapia were mainly omnivorous during most of the experiment, subsisting chiefly on the commercial feed, whereas, in the prior experiment the fish were older herbivores capable of feeding upon the dense phytoplankton in the tank. It would, therefore, be best in the case of phytoplankton feeders to use fish of approximately six centimeters in length, when they can be mainly herbivorous. They could be bred and grown separately to this size for high production purposes.

The Solar-Algae Ponds are efficient largely because of the high amount of solar energy allowed to enter the pond. This energy drives the photosynthetic process which produces large amounts of dissolved oxygen in the water and increases the primary productivity of the pond, producing dense populations of phytoplankton for food for the Tilapia. Water temperatures and oxygen concentrations are more uniform than in a conventional pond due to the exposure of the entire column of water to light energy.

McConnell has found that the growth of *Tilapia mossambica,* which is mainly a bottom feeder, can be correlated directly to the amount of photosynthesis occurring in a pond. Using opaque tanks with open tops, he computed a linear relationship between the cube root of the mass of growth per individual and photosynthesis. His measure of photosynthesis was based on oxygen production. If this relationship can be extended to *Tilapia aurea,* the efficiency should be greater. Not only would the water chemistry affect the *T. aurea* growth, through photosynthesis, as in *T. mossambica,* it would also encourage greater phytoplankton productivity, a food source for the *T. aurea.* Therefore, due to greater photosynthetic potential, *T. aurea* should grow more efficiently using translucent solar ponds, although normal sub-surface ponds with good phytoplankton populations would also have greater efficiency with *T. aurea.* Our aquatic system demonstrates a direct link between Tilapia growth and phytoplankton photosynthesis.

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Three Experiments with Semi-enclosed Fish Culture Systems

– Ron Zweig

The Miniature Ark

The Miniature Ark consists of a small, experimental closed-loop "river" which courses through three small greenhouses. The water is circulated through the closed system by the pumping action of a sail-wing windmill and a small electric pump. The circular "river" is solar heated, receiving supplemental heat from a solar collector as well as through natural passive heating of its small greenhouse covers.

The water is pumped up from the bottom pool into the upper section where biopurification takes place. It then flows by gravity down into the covered middle pool where zooplankton are cultured as auxiliary fish feeds. These tiny aquatic animals are swept downward with the water on its return to the lowest pond in the loop. This largest and deepest pond houses dense populations of fishes.

The Miniature Ark was designed to test the effectiveness of flow or rapid nutrient exchange and biopurification in a small closed aquaculture facility. Its primary energy inputs are the sun and the wind, which provide light, heat and water flow. The Miniature Ark, as originally designed, was described by McLarney and Todd in the second *Journal of the New Alchemists.* This article chronicles attempts to improve its design as a contained food-producing ecosystem and to increase its productivity.

Redesigning the Miniature Ark's Biological Elements

The first step in the redesign of the biological elements of the Miniature Ark was to change the components of the biological filter. All the shells, plants, earth and barriers between the sub-units in the upper pool were removed completely, leaving only the cement tank. Although the filter had been very effective, there were drawbacks to it. It helped in the conversion of toxic ammonia to nitrates and in the breakdown of fish pheromones. However, because both the nitrifying bacteria and the fish in this system are aerobic, the bacteria compete with the fish for oxygen. Further competition occurs between the bacteria and phytoplankton in the system.

Most aquatic plants, including phytoplankton, compete biochemically. For instance, Murphy *et al.* reported that a species of blue-green algae *Anabaena* produces hydroxamates which chelate iron ions. By binding to the ferric ions in the system, they compete for iron, preventing other plants from utilizing it although it is a necessary nutrient in their diet. Thus, the *Anabaena* is capable of suppressing other populations of algae. This is one example of what seems to be a highly intricate chemical interaction and competition among the plants in an aquatic system. As the interaction includes bacteria, the quahog shells which provide a growth substrate were removed from the pool in the Miniature Ark. The phytoplankton serve four important functions in the system, and their populations should not be in competition with the bacteria. The functions are: (1) Oxygenation of the water through photosynthesis; (2) Food for the *Tilapia aurea* which are phytoplankton feeders; (3) Heating. By acting as microheaters, they absorb the energy of the sunlight as it strikes them, converting some of it to heat energy and warming the water; and (4) Purification. Chlorococcales such as *Chlorella* and *Scenedesmus* are capable of metabolizing ammonia directly and even preferentially to nitrates, as has been demonstrated by Syrett and others. This means they will use all ammonia present before using nitrates. This is interesting because it indicates that the phytoplankton perform at least one of the same functions as the bacteria in the filter. With *Chlorella pyrenoides,* the use of ammonia nitrogen as opposed to nitrate provides a 30% higher efficiency in the use of light energy. Therefore, some phytoplankton productivity is enhanced by the ammonia from the fish wastes. For the first time, we developed an excellent phytoplankton bloom which had a Secchi disc reading of 40 cm or less.

We are still uncertain as to all the functions of the filter bacteria such as pheromone metabolism, in terms of whether or not the pheromones also would be removed through phytoplankton metabolization. The sides and bottoms of the pools in the Mini-Ark are cement, which provides a calcium carbonate substrate for some bacteria, and this may be enough surface area to dilute the chemicals involved in fish density communication.

The removal of the shells eliminated a component thought to be useful in buffering the pH of the water. This, however, would have been a short-lived mechanism according to Spotte, as the shells rapidly become covered with an organic coating which nearly eliminates their buffering capacity. The cement walls also buffer the pH, but they, too, are quickly coated and serve chiefly as a substrate for bacteria and other sessile organisms to grow.

In terms of operation, the chief problems were with low levels of dissolved oxygen and a high population of snails. On cloudy days, the oxygen levels went as low as 0.5 parts per million and, on sunny days, as high as 12 parts per million. The cloudy days induced respiratory stress on the fish, forcing a reduction in feeding and a consequent reduction in growth. The depth of the main polyculture pool is partially responsible. An increased flow rate through splash down between pools, which would oxygenate greater volumes of water, would help. The flow rate varied between 600 and 1,200 gallons per hour, with the windmill and electric auxiliary pump moving up to 600 gallons per hour each. The windmill required good wind conditions to pump 600 gallons per hour.

A large population of snails in the Mini-Ark last summer competed with the Tilapia for both oxygen and algae growing on the walls of the tank. To combat this, we introduced our first specimens of *Cichlosoma labiatum* and *C. citrinella,* two Central American cichlids, which we received from Ken MacKaye at Yale University. They are known snail eaters, whereas the Tilapia eat snails only if they are crushed first.

The zooplankton populations in the middle pool were quite low. There was only an occasional bloom although the pool was seeded several times with indigenous species from a pond adjacent to the farm. This limited animal protein for the fish. As reported by Porter, zooplankton has been found to help in the propagation of phytoplankton. Porter indicated that *Daphnia magna* break up colonies of planktonic green algae but assimilate only part of them, allowing up to 90% of the remaining cells to grow into new colonies, thereby increasing their density. With a greater zooplankton population, a higher concentration of phytoplankton could develop, providing a food source for both the zooplankton and the Tilapia.

This summer's experimentation in the Miniature Ark involved a monoculture of *Tilapia aurea.* One thousand fish were introduced into the 34.5 cubic meter (9,000 gallons) system on 22 June 1976. They were very small (2-3 mm) having hatched in the Dome in preceding weeks. They weighed a total of 150 grams.

The chief supplemental source of food for these fish was Purina Trout Chow. This was to establish quantitative results in terms of ratio between fish mass and feed mass. The trout chow was partially supplemented with crushed snails, mosquito larvae, zooplankton, purslane, marigold flowers, comfrey, soy flour, *Azolla, Hydrodictyon* and phytoplankton (predominantly *Golenkinia*) in the system. Quantitative measurements were not taken from the latter feeds. The vegetative feeds were given to the fish in large quantities starting in late July. Before that, they were mainly carnivorous. The most significant dietary observation made, not only in this system but also in the others, was that the fish chose the highest protein source first. For instance, comfrey, *Symphytum,* was selected over all other vegetative matter. Comfrey is up to 33% protein, dry weight, and low in fiber, which makes it easily digestible. It is also high in vitamin B_{12} which it extracts from the soil and subsequently stores. Comfrey has been used for many human medicinal purposes and makes an excellent food for herbivorous fish. The Tilapia like it. It is a perennial and easy to grow in this climate. The drawback, as with most plants, is that it is 80% to 90% water and requires a good solar drying technique. (See the reference by Hills in the Bibliography.)

Azolla, a water fern, is also an excellent food for herbivorous fish as it is a symbiont with the blue-green alga *Anabaena,* which is capable of fixing atmospheric nitrogen. It, too, is high in protein content.

Live feeds, such as insects, worms and zooplankton, were also important and seemed to add to the vitality of the fish. Although midges were not used this season, they would have enhanced productivity. We are currently involved in the extensive development of live feed cultures.

A total of 27 kg (59.3 pounds at $12.00/50 pounds) of Purina Trout Chow was fed to the fish during the experiment which lasted until 26 October 1976, 126 days. The temperature profile of the main aquaculture pool for this period is illustrated on Graph 1. The experiment was extended this long to determine the potential growth of the fish. *Tilapia aurea* are believed to grow fastest in the first seventy days of their lives. The long trial was largely a social consideration because people in this culture generally prefer eating large fish. The protein content is just as high in smaller fish and the overall nutritive potential may be better, for, when fried hard, small Tilapia may be eaten whole. They are good and the small bones are not a problem. In places like Java, people are lucky to have a 2-3 cm long fish with their meals. The surplus feeding was also intended to help reduce the aggressive factor in order to select for fast growing individual Tilapia. The largest have been kept as breeders for next season. Such selection will only be possible if growth efficiency is a genetic variable in these fish.

The fish grew to 29 kg (63.8 pounds), an increase of 28.85 kg for 1,148 individuals. The wet fish to dry commercial feed conversion ratio was 1.1. In the past, the greatest productivity in the Miniature Ark was 25 kg (55 pounds) of fish. This was using polyculture techniques. This year's increase could be due to both the commercial feed input and the dense phytoplankton populations. Green algae is not nearly as easily assimilated by Tilapia as blue-green algae and bacteria because it is harder for the fish to break down the cellulose walls of the green algae through acid lysis in their stomachs. Moriarty (1973) found that *Tilapia nilotica,* also a phytoplankton feeder, was capable of assimilating 50% of the carbon from a species of *Chlorella,* another Chloroccacles, but up to 70% to 80% in *Anabaena* and *Microcystis,* blue-green algae. If a culture of the African blue-green algae *Spirulina platensis* could be grown compatibly in our system, it would be a superior food, for it is up to 68% protein and contains vitamins A, B_1, B_2, B_6, B_{12} and C. Culturing techniques are being developed in Japan (see the Nakamura reference). Some preliminary work in combination with our Tilapia research is being done at The Woods Hole Oceanographic Institution by Larry Brand. The *Spirulina* is also a good human food and is used as a flour supplement in parts of Africa. It is easily strained out of water and does not require high technologies of centrifugation for harvest. Like Tilapia, it requires a high pH and, so far as is known, a 0.1% salt solution is required, which would limit its use in terms of garden irrigation. There may be a strain, however, that would eliminate the necessity of the salt component. We do, as a rule, attempt to use indigenous species of phytoplankton which do not require sophisticated culturing techniques, but, if a simple technology could be found to allow the culturing of an alga like *Spirulina platensis* in our systems, it would be a tremendous advantage as both fish and human food.

The quality of the flavor of the fish from the Miniature Ark was the most disappointing factor. This year, for the first time, the fish from this system tasted slightly like stale fish pond algae, which is known as "off-flavor." The quality of the meat, however, was as good as ever. In trying to determine the reason for the "off-flavor", we noted two small areas on the bottom of the main fish culture pool which looked and smelled as if they had become anaerobic. Oxygen levels were lowest on the bottom, especially in the shaded southern portion. This situation did not develop in the Six Pack pool, which is a cement pond without any circulation, deeper than the Miniature Ark, having a thicker layer of sediments on the bottom. The production in the Six-Pack pond will be discussed in the following section. The "off-flavor" in one and not in the other may be explained by the species of fishes involved in the experiments. The chief difference in organisms between the Miniature Ark and the Six Pack was that, while the former contained a Tilapia monoculture, the latter housed a polyculture of both Tilapia and Israeli carp. The Mini-Ark was populated with juvenile Tilapia which did not engage in sexual behavior until late in the experiment, if at all, due to lack of sexual maturity. Unlike carp, Tilapia do not dig and stir up the bottom except during mating when, in courting behavior, the male Tilapia clears a spot on the bottom. The shallow sediment layer on the bottom of the Mini-Ark remained relatively undisturbed and, therefore, possibly became anaerobic. This could account for populations of anaerobic blue-green algae with geosmin isolated from some bacteria and blue-green algae. Geosmin has been found to be the compound causing "off-flavor" in an Actinomycetes, *Streptomyces,* by Yurkowski and Tabachek, and in a blue-green algae, *Symploca muscorum,* by Safferman *et al.* The "off-flavor" can be removed from the live fish by transferring them to fresh water for a few days. This is a common practice and has been done successfully with trout and catfish.

It would seem that the stirring of the bottom by the carp in the Six-Pack prevented a dense population of "off-tasting" organisms from becoming established. There were also adult Tilapia in the Six-Pack and their sexual behavior would increase the bottom stirring. We are considering using edible crayfish to aid further in stirring up the substrate, which would fill a niche using potential food sources from bottom detritus.

There may be another advantage to the inclusion of carp in a fish production system, as has been illustrated by Rabanal. In ponds in Alabama, where carp and goldfish were grown separately, he found lower ammonia concentrations in the carp pond. He believes that the stirring of the bottom by the carp caused more efficient absorption of ammonia by the clay colloids mixed in the water. There were higher nitrate concentrations in the carp ponds which he feels were due to the fact that the water was muddier and allowed in less light to drive the photosynthetic process which would have used up the nitrates. This resulted in less plant productivity.

These findings are important in optimizing our polyculture strategies. Our Miniature Ark research which focused on increasing productivity would have benefited from including other species, if for no other reason than to improve the taste of the fish.

The Six-Pack Pond and the Midge Pond

We conducted two studies last summer involving aquaculture in stagnant, unfiltered ponds. One pond was in the bioshelter, which was the prototype for the Ark which we call the Six-Pack, and the other was an unused pool in the midge production system. There are three basic physical differences between the ponds. The Six-Pack pond is made of cement, enclosed in a building, and square in shape measuring 4.1 meters on the sides and 1.7 meters in depth. It contains 29.25 cubic meters (7,725 gallons) of water. The midge pond has a plastic liner, is outdoors, and is a long narrow trench measuring 15.85 by 0.91 meters. It is 0.74 meters deep with a capacity of 10.7 cubic meters (2,820 gallons). The midge pond had a build-up of organic matter on the bottom and was open to invasion by many organisms from its surrounding environment. Both of these ponds received fish which had over-wintered in the house under crowded conditions. At the outset of the trials, both ponds were relatively sterile with respect to phytoplankton populations.

The Six-Pack

Fish were put in the Six-Pack pool at two different times. On 7 July 1976, 47 adult *Tilapia aurea* weighing 1,840 grams were introduced, and on 15 July, 40 more Tilapia weighing 3,820 grams were added, along with 6 mirror carp weighing 1,320 grams. The fish were fed 7.65 kg of Purina Trout Chow at about 100 grams per day plus cuttings and vegetable waste from the interior garden of the Six-Pack. The fish were harvested on 29 October 1976. At that time 60 Tilapia were found weighing 7,600 grams, an increase of 1,940 grams. Ten mirror carp were found weighing 5,350 grams, an increase of 4,030 grams. The total wet mass fish growth to mass of dry commercial feed ratio was 0.78 to 1. The relatively large growth of mirror carp in relation to that of the Tilapia is most likely due to their out-competing the Tilapia for the commercial feed. Observations during feeding confirmed the greater ability of the mirror carp to fend off the Tilapia. There was never a significant phytoplankton bloom which is a good Tilapia food source. This is due to the design of the building which allows little light to penetrate the pond. The northern half of the pool is covered by an opaque roof which eliminates some of the summer sunlight by shadowing part of the pool. The temperature profile of the pond during the experiment is described on Graph 1.

The Midge Pool

196 Tilapia weighing 5,520 grams (15.1 pounds) were put in the midge pool on 15 July 1976. Like those in the Six-Pack, these fish were at least one year old and had come from the over-wintered population. They were fed 6,840 grams of Purina Trout Chow. The pond was rich in other organisms, some edible and others not. These included frogs, tadpoles, a large painted turtle, zooplankton and a freshwater bryozoan colony. When the fish were put in, the water had a brownish hue and lacked a dense phytoplankton population. Within two weeks a dense phytoplankton population had developed. An adjacent pond without fish retained its brownish sterile appearance. Within a week the Tilapia had killed nearly all the tadpoles in the pond. Most were found floating with bite wounds on their bodies. Many of the tails had either been partially or completely bitten off.

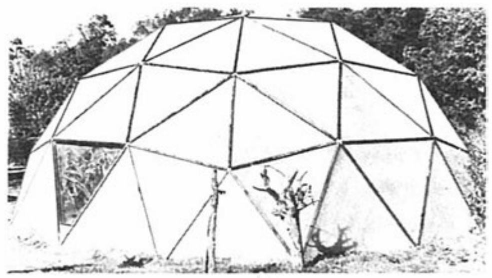
On October 6, 157 fish were harvested. They weighed 14.2 kg, which indicated a growth increase of 8.6 kg (19.1 pounds). The wet fish to dry commercial feed ratio was 1.27. In terms of the active feeding, this relatively high number was probably due to the other foods available in this pond and also to the consumption of insects which may have come to rest on its surface. The fish were extremely aggressive in their feeding behavior.

These fish were excellent in taste in spite of a rather thick sediment on the bottom. There are several probable reasons why a thick concentration of "off-flavoring" anaerobic organisms did not develop. The Tilapia were all adult and therefore active breeders involved in digging and turning over the bottom. The turtle's activity, depending on how long it was present, probably caused further stirring. The frogs also may have contributed to this. The shallowness of the pond would have provided for greater surface exchange with atmospheric oxygen both day and night in respect to volume of water. This would insure better respiration for the fish resulting in better metabolism. Dissolved oxygen levels were not measured.

The success of this simple shallow pond aquaculture is a hopeful indicator for Tilapia culture in rural areas or in any place where space is available. This kind of system is relatively easy to maintain. It could be used, for example, in crop rotation with rice in paddy culture, though the main drawback noted would be that pesticides are used to destroy rice parasites, like tadpole shrimp. Organic rice growing techniques have been undertaken at the Wehah Farm near Chico, California, by the Landsbergs. This is reported by Floyd Allen in *Organic Gardening and Farming Magazine.* They have begun using Gambusia, the mosquito fish, as a biological control for some of the parasites. Their rice harvest was only about one-half that usually produced by chemical methods. This was largely due to the condition of the soil and possibly could be remedied through such organic means as composting or the use of *Azolla**.

In the past the Chinese apparently worked out rice and fish culture strategies in conjunction with each other. The timing of planting and fish introduction have been worked on. I do not have detailed information as yet, but hopefully productive methods using organic, ecological techniques are being developed. We are beginning to look into these strategies.

* Azolla is an aquatic fern which lives in a symbiotic association with a blue-green algae (*Anabaena* sp.) capable of fixing atmospheric nitrogen which in turn is made available to rice as a nutrient source.



3 The Dome Pond

This year the aquaculture pond in the dome was used chiefly as a breeding pool for *Tilapia aurea.* Changes in the design and structure of the dome are described in the Bioshelter Section. They included the addition of a second thermal outer layer of Kalwall fiberglass, Sunlite premium grade. The internal elements remained relatively unchanged in terms of the 18.8m^3 (4,960 gal.) pool and the filters. The fish cultured were mainly *Tilapia* with a few of the Chinese big head and silver carp. The carp were new to this system.

We had considerable success with *Tilapia* breeding in the pond. Between 3000 and 4000 young fish were produced. Originally 116 adult *Tilapia* were introduced. As the young were found and netted, they were placed in a small fine-meshed cage which was suspended in the pond.

The first *Tilapia* adults were put into the pond on 23 April 1976. The first young were spotted on 4 June 1976 – six weeks later. More adult *Tilapia* were added on 8 May 1976 (36 fish), 12 June 1976 (11 fish) and 23 June 1976 (14 fish). The total weight of these fish was 4,238 gms. Previously, on 9 December 1975, we had introduced 20 Chinese big head and silver carp at 40.8 gms. Again on 15 July 1976, we added 14 additional Chinese carp at 36 gms. We had two species of Chinese carp and at the time of acquisition we were not able to discern the difference because they had arrived in a mixed lot and they were so small. The total mass of fish put into the system was 4,314.8 gms.

The main feed used in the dome was vegetative matter with some additional commercial feed. The fish were given an excess of edible plants each day. The inedible parts that were too hard for them to eat were removed to reduce the build-up of organic matter in the pond. The feed consisted of a seasonal mixture of vetch, comfrey, marigold flowers, soy flour, *Hydrodictyon,* and *Azolla* and, in addition, some zooplankton, crushed snails and Purina Trout Chow. The only quantitative measure made was of the trout chow which amounted to 10.03 kg (23.8 lbs). The pond had a rich phytoplankton population measuring 40 cm or less with a Secchi disc. Both the *Tilapia* and the Chinese carp are capable of feeding upon this phytoplankton.

The carp can live at much cooler temperatures than the *Tilapia* – 4°C as opposed to 12°C, but there are at least three drawbacks to using them. They do not breed in our system and must be induced to do so artificially. They are quite fragile fish and require careful handling. In addition, they did not grow very well, as the following data will indicate. This growth problem could be attributed to their being out-competed for food by the *Tilapia* or to their inability to assimilate well indigenous species of phytoplankton or other available feeds.

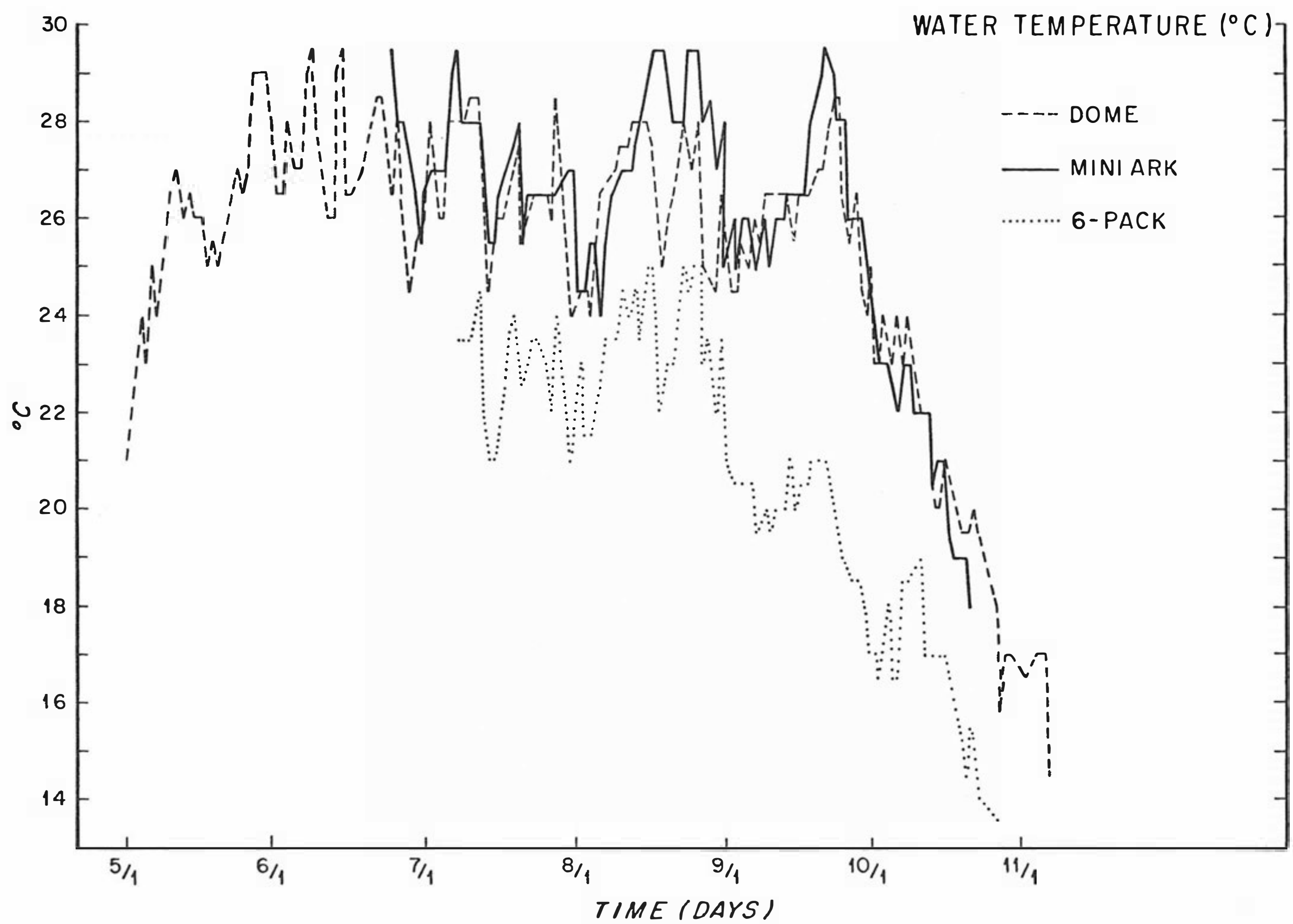
The total mass of fish removed from the dome pond

Photo by Hilde Maingay

was 27.7 kg (60.94 lbs). There were 127 large, fillet size *Tilapia* at 26 kg (57.2 lbs) or 206.3 gm per fish, 180 small *Tilapia* at 1 kg (2.2 lbs) and fifteen Chinese carp at 675 gms (1.5 lbs). The net increase in weight was 23.4 kg (51.4 lbs) which gives a wet fish to dry commercial feed ratio of 2.2. This high number is due to their primarily feeding on a large mass of unweighed vegetative matter and phytoplankton not included in the food input to production estimate.

The fish from the dome had an excellent flavor and the pond bottom was free of any questionable smell. Although this experiment was like the one conducted in the Mini Ark in that it was chiefly a mono-culture, a possible anaerobic condition did not prevail for at least two reasons. The first was that the bottom of the dome pond is covered with a couple of centimeters of easily stirred sand put there to protect the plastic liner from being punctured when the pool is drained during harvesting. Although *Tilapia* generally do not dig and stir bottom material, sexually mature fish were included initially and the males do dig holes in the bottom substrate as part of their courtship activities. *Tilapia* procreate at temperatures between 26°C and 35°C. (The daily pool temperature profile for the production period is plotted in graph 1.) They require between five to seven weeks between matings, but it is not necessarily a seasonal event and, therefore, with a sufficiently large male population, the digging behavior and stirring of the bottom is probably continuous. A second reason for the absence of smell could be that the dissolved oxygen concentrations in the dome pond were generally higher than those in the Mini Ark, so chances of an anaerobic condition developing were much reduced.

The dome aquaculture system had its highest productivity to date this season, providing an abundant new population of *Tilapia aurea.* As in our other experiments, we are working toward the elimination of the commercial feed component. A description of some of the physical and chemical parameters being tried can be found in the Bioshelter Section of this *Journal.*



GRAPH 1. MAXIMUM DAILY WATER TEMPERATURES RECORDED DURING EXPERIMENTATION IN NOTED AQUACULTURE SYSTEMS

SUMMARY OF THE WORK WITH SEMI-CLOSED AQUATIC SYSTEMS

The past year's work with semi-closed aquatic systems demonstrated a significant step toward understanding their biological complexity and production potential. The five systems tested showed how the various semi-closed system strategies compare in terms of energy requirements and their effects on fish growth. The findings provide important guidelines for future work in aquaculture research.

TABLE I.

System	1 Total Volume (m^3)	2 Surface Area (m^2)	3 Fish Production (kg)	4 Dry Feed (kg)	5 Conversion Ratio West Fish/ Dry Feed	6 Time (Days)
Miniature Ark: Re-Circulating "River" Enclosed by Three Small Greenhouses	34.5	34.1	28.85	26.95	1.08	126
Dome Pond: Biological Filtration and Re-Circulation	18.8	18.7	23.36	10.83	2.20	201
Six-Pack: Still	29.24	16.9	5.97	7.65	0.78	114
Midge Pond: Outdoors	10.7	14.5	8.65	6.84	1.27	106
Solar Pond No. 1 (Winter)	2.78	1.82	0.845	2.9	0.29	132
Solar Pond No. 1 (Summer)	2.78	1.82	3.55	6.7	0.53	179
Solar Pond No. 2 First Half Summer	2.78	1.82	6.98	6.95	1.00	98
Solar Pond No. 2 Second Half Summer	2.78	1.82	3.44	3.83	0.90	108

Aquaculture Table I lists the physical dimensions of each system and the data with respect to fish production, feed growth ratios and time required for growth. A discussion of each of these systems can be found in the preceding articles. Table II provides comparisons between the systems in terms of volume, time and surface area. The data for Solar Pond No. 2 illustrate the viability of this kind of intensive aquaculture for protein production. It should be remembered that these are the results of our first trials. Additional experiments should increase production. The results indicate the significance of light on herbivorous fish production. The increased population of phytoplankton resulting provides high oxygenation and algae production through heightened photosynthesis. The high concentrations of dissolved oxygen accelerate the metabolism of the fish, especially in warm water species, and the increased phytoplankton productivity provides more feed for mature Tilapia.

The open trench system in the midge works had significantly lower fish production than the solar ponds. It required the least energy input, however, as it was neither aerated nor used pumps for water circulation as was the case with the Six Pack Pond. The open trench was the shallowest of the sub-surface systems allowing both for the greatest gas exchange with the atmosphere and phytoplankton photosynthesis per unit volume of total water mass.

TABLE II.

System	1 Mass Production per m^2 (kg)	2 Mass (kg) Production per m^2 per 100 Days	3 Mass (kg) Production per m^2 per Year	4 Mass (kg) Production per Hectare	5 Mass (kg) Production Per Hectare per 100 Days	6 Mass (kg) Production per Hectare per Year	7 Mass Production per m^3 (kg)	8 Mass (kg) Production per m^3 per 100 Days	9 Mass (kg) Production per m^3 per Year
Miniature Ark: Re-Circulating "River" Enclosed by Three Small Greenhouses	0.85	0.67	2.45	8,460.4	6,714.6	24,508.3	0.84	0.67	2.45
Dome Pond: Biological Filtration and Re-Circulation	1.25	0.62	2.26	12,492.	6,214.9	22,684.4	1.24	0.62	2.26
Six-Pack: Still	0.35	0.31	1.13	3,532.5	3,098.7	11,310.3	0.26	0.23	0.84
Midge Pond: Outdoors	0.60	0.57	2.08	5,969.	5,631.1	20,553.5	0.81	0.76	2.77
Solar Pond No. 1 (Winter)	0.46	0.35	1.28	4,641.	3,515.9	12,833.0	1.04	0.79	2.88
Solar Pond No. 1 (Summer)	1.95	1.09	3.98	19,505.	10,896.6	39,772.6	1.27	0.71	2.59
Solar Pond No. 2 First Half Summer	3.84	3.92	14.31	38,351.6	39,134.3	142,840.2	2.50	2.55	9.31
Solar Pond No. 2 Second Half Summer	1.89	1.75	6.39	18,925.8	17,523.8	63,961.9	1.38	1.28	4.67

It was the simplest in construction and function and it produced a significant amount of fish — one and a third times greater than comparable surface areas of South China herbivore production.

A comparison of the sub-surface and Solar Algae ponds illustrates the significance of light upon the productivity of aquatic systems using herbivores as consumers. The understanding of the interrelationship and utilization of light by algae is the most important finding from the year's research. The use of solar energy to heat, oxygenate and purify pond water using phytoplankton which, in addition, serve as feed for the Tilapia is extremely useful in fish culture. The uses of light will be a strong consideration in our continuing aquatic system design strategies and maintenance procedures.

Cage Culture

— William O. McLarney

New Alchemy's newest aquaculture project is the rearing of fish in floating cages. The cages were placed in Grassy Pond, which borders on the New Alchemy farm. I had hoped to be able to write a glowing "success story" about our first experience in cage culture but it didn't work out that way, for reasons understood and otherwise. Instead of a success story with how-to-do-it instructions, this is a progress report essay on the art of cage culture and a commentary on the state of fish farming in North America.

Let me hasten to state that I have not lost faith in the concept of cage culture. Growing fish in floating cages is a more or less traditional technique in Cambodia, Java and other parts of Southeast Asia. More recently, it has been applied successfully in large scale commercial fish culture in Japan and the United States. More to the point is the recent success in small scale cage culture of bluegills *(Lepomis macrochirus)* and hybrid sunfishes in the Midwest where fish farmers have been able to raise up to 100 pounds of sunfish in 3'x3'x3' cages in a single growing season. (Ligler, 1971)

I think the potential of this form of fish culture as a family or small-scale commercial food source is obvious. The implication of successful fish culture in small cages is that anyone with access to unpolluted standing water could raise fish for the table and perhaps for sale. Not everyone has such access, but a lot of people do. In Massachusetts alone, for example, there are 151,739 acres of ponds and lakes. To apply the idea to a part of the country not so favored with natural lakes and ponds, there are 75,000 artificial "farm ponds" in the state of Illinois alone, which amounts to at least 50,000 acres of potentially productive water.

I have been asked how our cage culture work relates to the Back Yard Fish Farm and similar semi-closed fish culture systems for which New Alchemy has previously been known. (McLarney and Todd, 1974) Both are intended to produce fish at low cost in a small space and in quantities appropriate for homestead use. In both methods, the fish are confined in a very small space, which simplifies feeding, inspection, and harvesting. Those without access to a natural body of water or a site suitable for building an outdoor pond will have to resort to something on the order of our Back Yard Fish Farm in order to raise fish. But for those who do own a pond, or have access to one, or can build one, there are at least two advantages to cage culture:

1. The confinement of fish in a small volume of water, as in the Back Yard Fish Farm, necessitates recirculation and filtration of the water if substantial amounts of fish are to be grown. In a large outdoor body of water, these needs are eliminated, but the particular advantages of keeping the fish in a small enclosure are lost. Cage culture combines the best of both approaches by confining the fish in a small *space,* but not a small *volume* of water. That is, the water in the cage is continually being replaced by clean water from the surrounding pond. In fact, the fish through their normal breathing and swimming movements act as a "pump" to circulate their own water.

2. In many cases, fish which already inhabit the pond can be placed in the cages for intensive culture. In this way, ponds which are overpopulated or otherwise poorly suited for food fish culture can be used as natural "hatcheries", eliminating the expense and labor of purchasing or breeding stock.

Cage culture has the further advantage of being one of the few methods of fish culture which is compatible with the other values and uses of a pond. A pond like Grassy Pond, with its extensive shallows, brush and "weeds", irregular shoreline, natural fish predators, etc., viewed solely from a food fish production standpoint, is very "inefficient." But to convert it to a conventional, "efficient" fish culture pond would seriously compromise or destroy its value in terms of sport fishing and other recreational use, wildlife habitat, and esthetic pleasure. To use it for cage culture, on the other hand, modifies only a few square feet of the pond's surface. The cages may even enhance fishing; we find that bullheads, in particular, tend to congregate under the cages, fattening on morsels of food which slip by the caged fish.

We are by no means the first ones to perceive these advantages. The editors of Farm Pond Harvest magazine, in particular, have been active in promoting the use of cage culture and other methods to restore the American farm pond to its intended role as a food-producing resource (see addresses at end of article). However, their work, like that of most others in the field, has been heavily dependent on the use of commercial fish feeds. For those of you who have not been exposed to conventional American fish culture, I should point out that it is moving rapidly in the "agribusiness" direction. One of the clearest symptoms of this is the composition of commercial fish feeds. There are numerous manufacturers of dry feeds for trout and catfish, our two principal aquaculture crops. The first ten ingredients listed on the label of one brand of trout feed are: "fish meal, meat meal, soya bean meal, wheat germ meal, fish fiber and glandular meal, animal liver meal, corn gluten meal, dehydrated alfalfa meal, dried skim milk, dried whey products..... " The list goes on and concludes with no less than 13 synthetic vitamins and 6 added minerals.

Scientifically inclined readers may be appalled at the energetics of formulating such a feed. Others will question the appropriateness of feeding fish on potentially useful human food. Still others will criticize the ethics or politics of using inexpensive fish from the coasts of South America to make expensive fish for the North American table. The least debatable drawback to such prepared feeds is the expense. Each of the ingredients costs, and these costs are rising. I know of one case where a fish farm, with the help of an economist, formulated its own low cost, high growth feed for a particular species of fish; the cost of this feed has increased by a factor of 6 in as many years. It is hard to grow fish inexpensively with an expensive food.

The prepared feeds are effective; at the present time we cannot say "Feed this and that and your fish will grow as well or better than they will on a prepared commercial feed." This is because, given the nature of American business and agriculture, virtually all the research that has been done on fish nutrition has aimed toward the development of "complete" prepared diets. It is assumed, not proven, that natural or fresh foods cannot compete economically.

I therefore conceived that it would be useful to grow fish in cages in Grassy Pond, feeding some on prepared diets at conventional rates and others on "natural" foods we could provide at very low cost and without competing with our own diets. For reasons which we do not fully understand, we failed to produce significant quantities of edible size fish on either diet. However, I think the work sheds some light on both the relative value of both types of diet and on the problems and techniques of cage culture. It is therefore reported here.

We began with only 3 cages, due to a lack of funding for the project. The mesh material for the cages was Vexar, a nylon made by DuPont specifically for use in fish cages. Fish cages have also been made of plastic coated wire, but fish farmers report this has not been as reliable as Vexar. Imagine the disappointment of the fish farmer who pulls up his year's crop — and watches it fall through the bottom of the cage. It has happened. The past winter, in Colombia, I observed some beautiful and durable cages made from strips of guadua, a type of bamboo, but I know of no indigenous North American material with similar qualities. Whatever type of cage material you choose, to maximize water circulation and minimize the need for cleaning, use the largest mesh size that will contain the fish. Ours was one quarter inch.

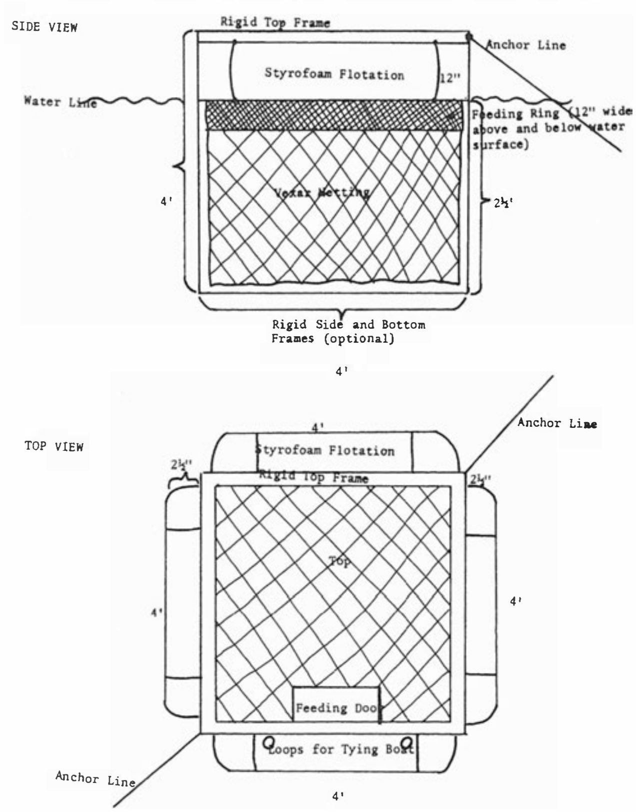
Our cages were provided with a rigid wooden frame at the surface, but were otherwise unsupported. They were constructed by sewing together sections of Vexar netting with nylon line. Commercially manufactured cages have a rigid frame on all sides, and we found out why. The unsupported cage walls tended to buckle slightly, not enough to deform seriously the cages, but enough to begin forming cracks in the Vexar. In one cage, these cracks eventually opened, forming holes large enough to permit the escape of fish.

Flotation for the cages was provided by 4 pieces of styrofoam 36" x 9" x 1", attached near the top so that 1 foot of the total cage height of 4 feet was above the surface. We felt this eliminated the necessity for tops on the cages, though if one were growing a species of fish more given to jumping than sunfish, tops would be necessary. The floats were enclosed in canvas bags so that the styrofoam, should it break, would not float away.

The cages were anchored in the pond by means of cinder blocks attached to two of the corners with nylon line. They were set in water deep enough that the bottoms of the cages were clear of the pond bottom at all times.

Figure 1 is a sketch of one of our cages, with a wooden frame added on all sides. Another feature we want to add next time is some sort of snap arrangement, so that a boat can be quickly and snugly fastened to the side of the cage.

Figure 1. Design of a 64 cubic foot floating fish cage.



For those who do not want to go to the bother of building their own cages, I have appended the addresses of a number of commercial cage manufacturers. One of them, Inqua Corporation, also offers a $1 booklet entitled "Profitable Cage Culture", (Neff & Barrett, 1975) which goes into the why and how of growing fish in floating cages in much greater detail than I can here.

Each cage was stocked with 200 "hybrid bluegills", a cross between male green sunfish, *Lepomis cyanellus* and female bluegills. The use of these fish is not essential to cage culture, which can be applied to most species which can be cultured at all. I chose the hybrid because it is supposedly a particularly fast growing fish which combines all the desirable characteristics of the bluegill with a mouth nearly as large as that of the green sunfish, so that it is easier to feed.

Each of the 3 cages was stocked on May 14 with approximately 200 young fish weighing a little over 2 grams each. The cages were designated A, B and C. For the first 15 weeks of the experiment, the fish in Cage A received only natural foods, while those in Cage B were fed daily except Sundays with 1/8 inch Silver Cup floating trout feed in an amount equivalent to 2% of the estimated total weight of fish in the cage. To form an idea as to the importance of foods which entered the cages naturally, the fish in Cage C were not fed during this time.

There were three principal components of the natural food diet:

1. Earthworms: This is of course the archetypal fish bait, and for good reason. Fish, including our sunfish, love them. Earthworms have another advantage for the fish farmer in that good methods have been developed for raising them (see Book Review – page 29) though fish farmers have not taken advantage of this. We started a small earthworm culture this year, but the bulk of our worms were gathered from compost or leaves. Worms were fed to the fish by placing them on a perforated styrofoam float. They were eaten one by one as they worked down through the holes.

2. Flying insects: These were captured with the aid of ultraviolet "bug lights." We had an old style bug light with an electric killing grid, which was donated several years ago by Gilbert Electronics of Jonesboro, Arkansas, and this was used. But this year we received the generous donation of two "Will-O'-the Wisp" bug lights from Hedlunds of Medford, Wisconsin (see list of addresses). These lights are manufactured expressly for use in fish culture. The insects are attracted to the light, sucked in by an impeller fan and blown down into the water. Due to a lack of electrical wire, we were unable to install ours over the cages, but instead had to attach a bag to collect the insects. Certainly the trap's effectiveness was reduced, but on good nights we harvested as much as a quarter pound of insects, mainly midges and moths. On bad nights the harvest was virtually nil, even during June, our peak "bug season." I imagine these lights would be more effective consistently in the Midwest or South where hot, sultry summer nights prevail, rather than on Cape Cod where windy nights are the rule. Nevertheless, the cost of providing high quality fish food in this manner was less than a nickel a day using conventional electric power. Were we to succeed in developing a U-V bug light powered by a wind-charged battery, that would be as close to a free nocturnal lunch for fish as one could get.

3. Midge larvae: Cage C was provided with a 2' x 6' burlap sheet of these larvae every other day; their culture is described in previous issues of *The Journal of the New Alchemists* (McLarney, 1974; McLarney, Levine and Sherman, 1976).

Occasional tidbits of other live or fresh foods were added, but not in significant amounts. It was more difficult to quantify accurately the natural foods than the dry feed. The amount of insects caught by the lights, in particular, was out of our control. The quantity of midges fed also varied from feeding to feeding; assuming our production rates are essentially the same as in previous years, the average feeding amounted to about 100 grams. The quantity of worms fed was more amenable to regulation, being a function of the amount of labor expended. However, since the primary goal was to develop a feeding system which would be practical for a homesteader or small farmer, the total amount of natural foods used was limited to what could be gathered in an hour. Thus, on some days, particularly later in the season, the combined dry weight of the three types of natural food fell short of the total weight of dry food fed. The approximate proportions (dry weight) of worms, flying insects and midge larvae in the natural foods diet were 75%, 20% and 5% respectively.

About every two weeks a sample of 30 fish was taken from each cage and weighed. This figure was used to estimate the total weight of fish in the cage, which was in turn used in preparing new feeding rates. Comparison with the actual weight of all the fish in a cage, on the three instances when such a comparison was made, showed that our estimates ran about 10% low.

The feeding and sampling regimes just described were followed throughout the study, with the following changes:

1. On June 29 it was determined that the fish in Cage C had ceased growing altogether, and perhaps had started to lose weight. The mean weight of the sample fish on that date was 2.2 grams; on June 14 it had been 3.3 grams. From June 30 through September 1, they received the same dry feed as the fish in Cage B, but in daily amounts equivalent to *3%* of the total weight of fish in the cage.

2. As the daily feed rations became larger, it became less certain that all the food was being consumed. On

August 4 we therefore began feeding twice a day.

3. Sometime between August 31 and September 11 a hole was formed in Cage B, permitting the escape of about 75% of the fish. When this was discovered, the remainder of the fish were removed, weighed and redistributed between Cages A and C. From then on the experiment was altered as follows: Cage C was fed with dry food at the 2% rate, Cage A received the same *plus* 100 worms (approximately 60 grams dry weight) and an average of 2.5 grams (dry weight) of flying insects daily.

4. Our first killing frost occurred on October 12; this coincided with a drastic drop in the water temperature. This was reflected in a marked reduction in feeding by the fish. It was thus decided to make the final harvest on October 19.

We had aimed at producing ¼ lb. (114 gram) fish by the end of October. Assuming 100% survival and no escape of fish, this would have given us 600 sunfish weighing a total of 150 lbs. (68,100 grams). Our actual final harvest was 367 fish weighing 14.4 lbs. (6,525 grams) or 9.6% of our goal. The mean weight of these fish was 0.04 lb. (17.8 grams) or 16% of the target weight. From a production point of view, a failure; but there is something to be learned from the experience and it has not caused me to lose faith in the potential of cage culture as a means of producing food fish on Cape Cod or elsewhere.

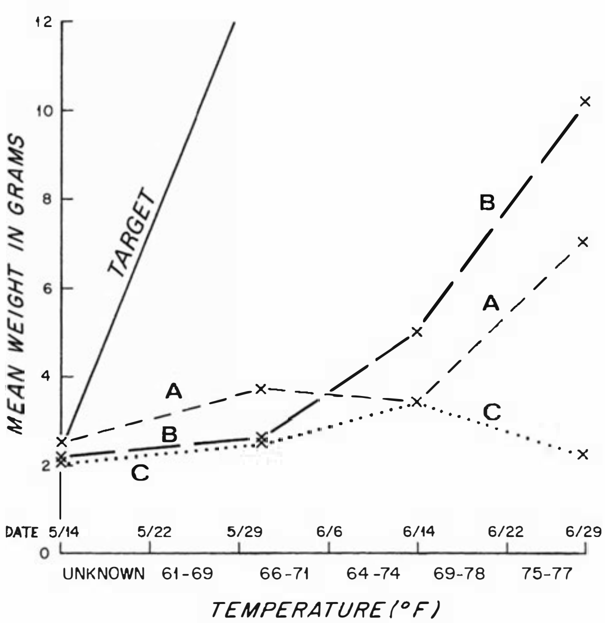


Table 1. Growth of Caged Hybrid Sunfish, May 14-June 29

Cage	Initial total wt. of fish (May 14)	Initial mean wt. of fish	Est. total wt. of fish (June 29)	Mean wt. of sample fish (June 29)	Per cent growth (based on mean wts.)
A	513 grams	2.5 grams	1420 grams	7.1 grams	184%
B	457 "	2.2 "	2040 "	10.2 "	325%
C	440 "	2.1 "	480 "	2.4 "	14%
Total	1410 "	2.3 "	3940 "	6.6 "	187%

In an attempt to analyze where we went wrong and to illustrate what we have perhaps learned, let me offer a series of graphs and tables illustrating the estimated total and mean weights of fish in Cages A, B and C, and their rate of growth during 3 portions of the study period.

Graph/Table 1 covers the period from stocking (May 14) through June 29; feeding commenced May 18. The first thing one notices from the graph is that we got off to a bad start. While in the latter part of the period (June 14 to 29) growth was satisfactory, it was certainly not so prior to that time. It may be that both the 1/8" pellets and the natural foods were too large for the fish, and that they were forced to derive a significant part of their nutrition from plankton entering the cages naturally. That this is possible is shown by the curve for Cage C, where the fish realized some growth during the period May 14 to June 14, although they were not fed.

Graph/Table 2 covers the period June 30 to September 11, during which time all three cages were being fed. Although the fish in Cage C were receiving 3% of their estimated body weight in dry food, while those in Cage B received only 2%, there is no apparent difference in growth rate except during the first two weeks of the period, which was the first time Cage C was fed at all.

The abrupt decline in mean weight of Cage B fish in the last two weeks of the period is apparently connected to the escape of 157 fish of a total of 208 during that time. Had individual fish actually lost weight at the rate indicated by the curve, it would certainly have manifested itself in poor physical condition of the fish, which was not noted during the September 11 harvest. For the sake of facilitating comparison, data from the August 31 sampling rather than the September 11 one are presented in Table 2.

Graph/Table 3 covers the final 6 weeks of the study, during which time both cages received dry feed, while Cage A also received a natural foods supplement. Growth, while very poor in both cages, was somewhat better in Cage A. The loss of weight in the last 2 weeks is associated with a sharp decline in water temperature during that time. During October most of the fish refused to accept dry feed, although natural foods were accepted whenever they were offered.

The superior growth rates of the fish which received dry feed may reflect not so much any superiority of that diet, but the difficulty of providing an adequate amount of natural food. It is virtually inconceivable that a diet composed of live earthworms and a great variety of fresh insects could be deficient in proteins or vitamins, but it may have fallen short of the fishes' carbohydrate needs. We could, of course, increase the total weight of natural foods and therefore the amount of carbohy-

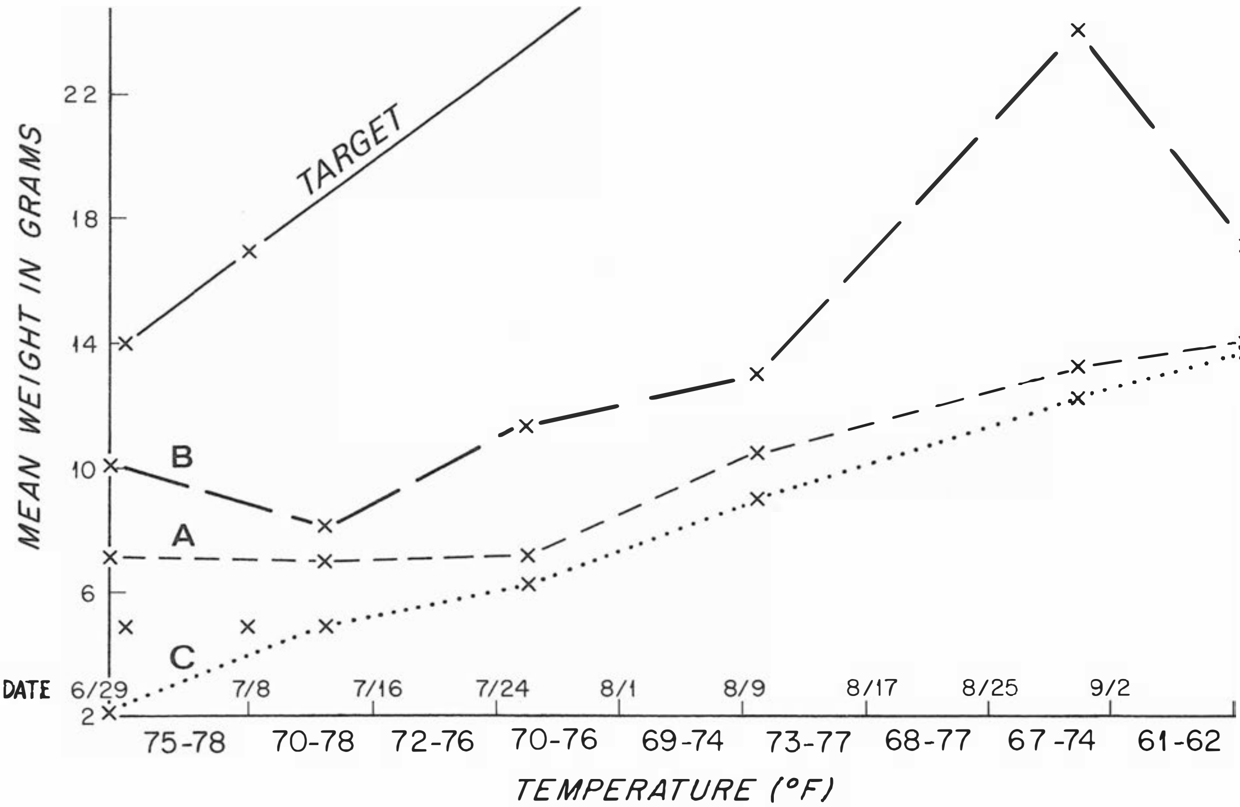


Table 2. Growth of Caged Hybrid Sunfish, June 30-August 31

Cage	Est. total wt. of fish (June 29)	Mean wt. of sample fish (June 29)	Est. total wt. of fish (Aug. 31)	Mean wt. of sample fish (Aug. 31)	Per cent growth (June 30-Aug. 31-based on mean wts.)	Per cent growth (May 14-Aug. 31 - based on mean wts.)
A	1420 grams	7.1 grams	2640 grams	13.2 grams	86%	428%
B	2040 "	10.2 "	4820 "	24.1 "	136%	995%
C	440 "	2.4 "	2460 "	12.3 "	413%	957%
Total	3940 "	6.6 "	9920 "	16.5 "	151%	617%

drates reaching the fish by improving the efficiency of our worm culture or by adding additional types of food. But we should also consider a compromise feeding strategy. Carbohydrate is relatively easy and inexpensive to supply in dry form; the cost of prepared fish feeds is largely due to the protein components. On the other hand, protein and vitamins are present in high proportions in most natural foods. It may be that the "ideal" fish diet would be a dry feed made of cheap grains, plus a smaller quantity of live or fresh food of animal origin.

Comparison of the different diets aside, the harvests from the cages were uniformly disappointing. One factor which may have contributed to this has already been mentioned — use of food particles too large for the small fish in the first month of the study.

There may also have been some problems with water quality. Periodic testing of dis-

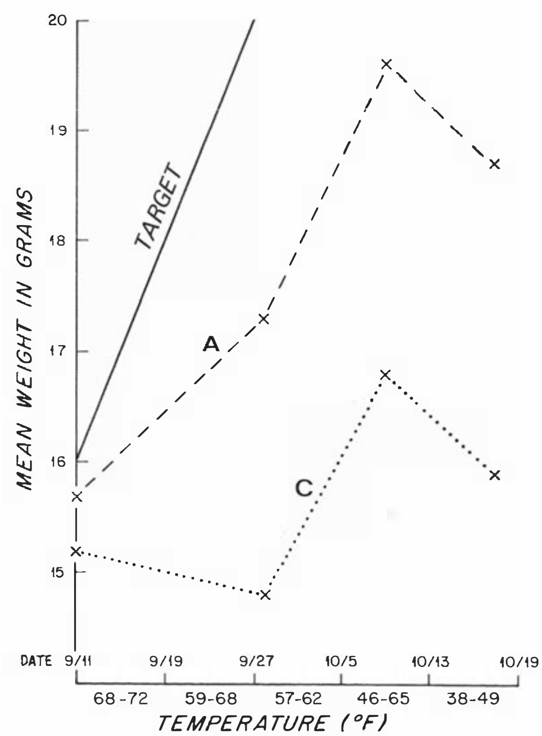


Table 3. Growth of Caged Hybrid Sunfish, September 12-October 19

Cage	Est. total wt. of fish (Sept. 12)	Mean wt. of sample fish (Sept. 12)	Total wt. of fish (Oct. 19)	Mean wt. of fish, (Oct. 19)	Per cent growth Sept. 12-(Oct.19 - based on mean wts.)	Per cent growth May 14-(Oct.19 - based on mean wts.)
A	3535 grams	15.7 grams	4020 grams	18.7 grams	19%	——
C	3430 "	15.2 "	2505 "	15.9 "	5%	——
Total	6965 "	15.3 "	6525 "	17.8 "	16%	674

solved oxygen concentration and pH in the cages and in the open pond always revealed near-optimum levels. No differences were observed between the two environments. But there may have been other problems we were unequipped to detect. Due to unusual hydrological conditions which prevailed in 1976, the volume of water in Grassy Pond was well below normal and the channel which ordinarily connects it with a larger pond dried up. This combination of circumstances may have contributed to a build-up of sulfur compounds or other harmful substances which would normally have been flushed out or diluted. (The presence of sulfur was obvious to anyone wading in the pond.)

Time of feeding may have been more important than we at first surmised. Initially the fish were fed only in the morning; later a late afternoon feeding was added to the schedule. Feeding during the full heat of the day was avoided, but a strict schedule was not kept. At first, the fish fed enthusiastically whenever food was offered; but, as the season progressed, they became more reluctant to accept the dry feed. Late in the season a few feedings were done very near dawn or dusk, and the fish appeared much more enthusiastic. It seems as though better food utilization might have occurred if we maintained a strict dawn/dusk feeding routine.

Of course, the total weight of fish obtained in the final harvest was reduced by the loss of some individuals. I have mentioned the loss of the majority of the fish from Cage B. At various times during the year, 15 fish were lost due to diseases or accidents. At the final harvest, 16 other fish were missing from Cage A and 68 from Cage C. It seems unlikely that these fish could have escaped, but neither is there any other apparent explanation for their disappearance.

There is another possible reason for the low production of our cages which should be considered. I may have chosen the wrong fish. Hybrid sunfish are a new idea in aquaculture, and a good one; but in my excitement over them I neglected to consider carefully the character of the environment I chose to work in. At least 12 species of fish inhabit Grassy Pond. Among them are two sunfishes, the bluegill, one of the parent species of our hybrids and the pumpkinseed *(Lepomis gibbosus)*. Neither grows rapidly nor attains large size frequently in Grassy Pond, although both species do well in nearby ponds. The brown bullhead *(Ictalurus nebulosus)*, on the other hand, does better in Grassy Pond than in most ponds in our vicinity. The brown bullhead is a fine food fish with omnivorous feeding habits and generally hardy; it should do well in cage culture. In 1977, funds permitting, we shall test both sunfish and bullheads with a variety of diets incorporating both prepared dry feeds and fresh natural foods.

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Neff, G. N., and P. C. Barrett. 1976. *Profitable Cage Culture.* Inqua Corporation, P. O. Box 1325, Homestead, Florida 33030. 30 pp. $1.00.

ADDRESSES OF SUPPLIERS OF EQUIPMENT AND INFORMATION CITED:

Farm Pond Harvest. Professional Sportsman's Publishing Company, Box AA, Dept. C , Momence, Illinois 60954.

Manufacturers of cages and materials for making cages:

Astra Pharmaceutical Products, Inc., Framingham, Massachusetts 01701. (Cages)

E. I. DuPont de Nemours and Co., Inc., Film Department, Wilmington, Delaware 19898. (Vexar netting)

Inqua Corporation, P. O. Box 1325, Homestead, Florida 33030. (Cages)

Panduit Corporation, 17303 South Ridgeland Avenue, Tinley Park, Illinois 60477. (Ties for fastening netting to cage frames)

C. E. Shepherd Company, P. O. Box 9445, Houston, Texas 77011. (Cages and coated wire for making cages)

Manufacturers of "bug lights"

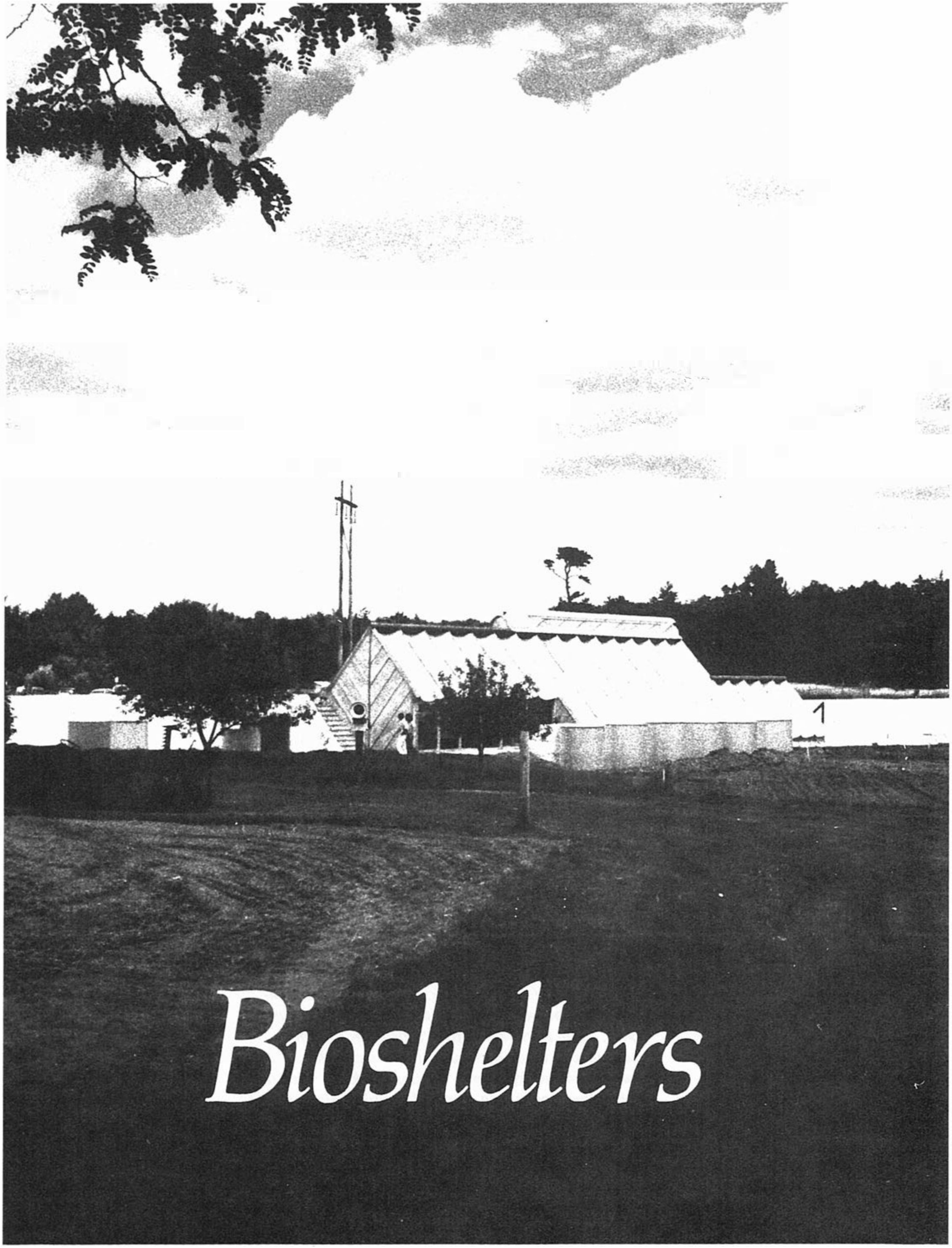
Environmental Systems, Inc., RFD 1, Peterborough, New Hampshire 03458.

Gilbert Electronics, Inc., 3113 East Nettleton Avenue, Jonesboro, Arkansas 72401.

Hedlunds of Medford, Inc., P. O. Box 305, Medford, Wisconsin 54451.

Ken's Channel Catfish - Hybrid Bream Hatchery and Fish Farm. Route 1, Alapaha, Georgia 31622.

Bioshelters



If, like some cultures, we were given to characterizing our years in some less prosaic manner than chronological numbers, as in the Year of the Tiger or the Year of the Dragon, or, as the time we first knew Bill McLarney has come to be called the Summer of the New Potato, then this past year for us would have to have been the Year of the Arks. We have somehow survived their construction, completion, openings and first winter. And the results up to now seem to more than justify the effort expended. They work. The word must be fairly well around by now that the bioshelters on both Cape Cod and Prince Edward Island weathered the past winter, the fiercest in years, in fine fettle, having only infrequent recourse to wood and coal back-up systems.

Because of this and because we think that, having launched the idea, it is ripe for as many adaptations and applications as people choose to make of it, we are initiating with this issue a separate section of the Journal for their discussion. From now on, the application is the thing. To date, we are aware of two. In Massachusetts, John Ames is undertaking the manufacture and sale of a small solar greenhouse based on the design of our Six-Pack described in Laura Engstrom's article. And in Nova Scotia, Ole Hammarlund and David Bergmark of Solsearch have designed a bioshelter annex which has been added to the back of an old farmhouse. Barbara Jack and Dick Hinners, who did much of the construction themselves, have built it for Dick's mother, Mrs. Ann Hinners, a long time New Alchemy Associate. It is called the Granny Ark and will unquestionably qualify as the first antique-furnished bioshelter.

The other articles in this section I like to think of as a trilogy. They are partially included in the Book of the New Alchemists. The first, by John Todd, advocates a fundamental shift in the paradigm of design, using the P. E. I. Ark as the model of the tangible results of such an approach. In "Bioshelters as Organisms", Ron Zweig elaborates on this type of thinking, using the analogy of the dome and a cell as a working illustration of what we mean by the Biological Metaphor. Earle Barnhart in the "Bioshelter Primer", describes in theory and actuality the creation of a semi-closed ecosystem in the Cape Ark. As with the solar algae ponds, the secret of the bioshelters seems to lie in a greatly increased receptivity to light.

TOMORROW IS OUR PERMANENT ADDRESS

— *John Todd*

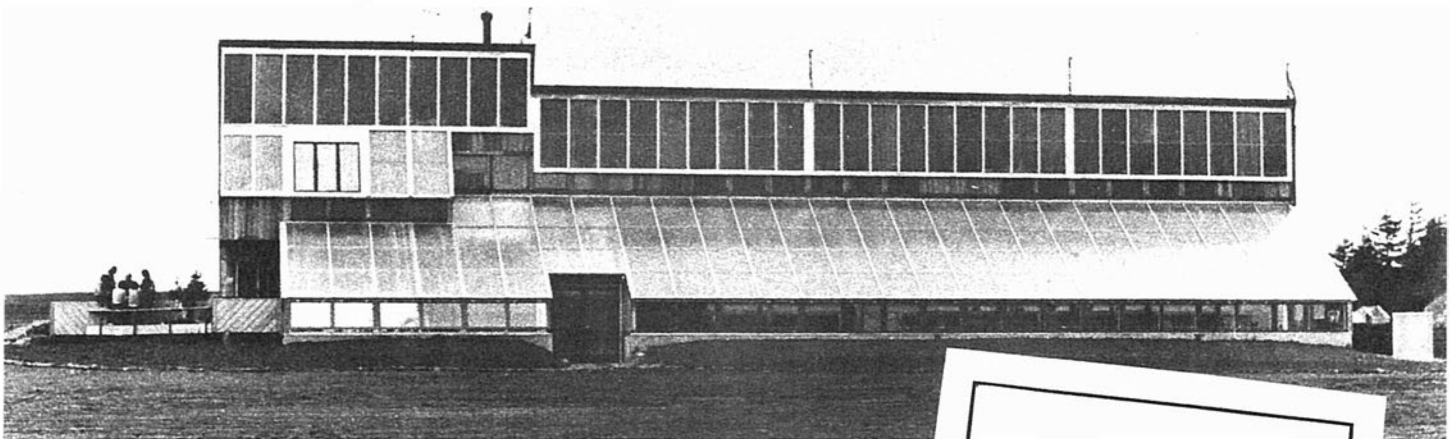
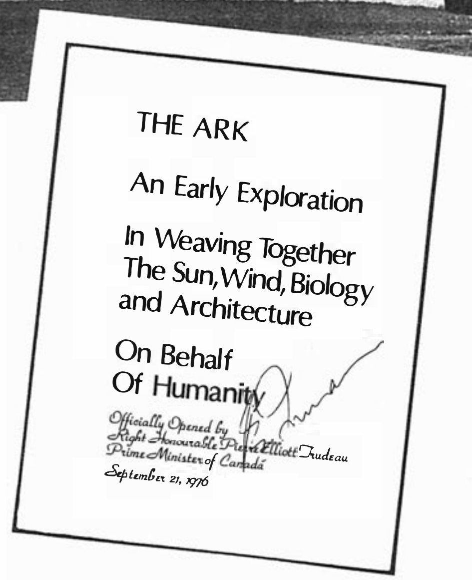


Photo by Hilde Maingay



Dedicated with love to my children
Rebecca, Jonathan and Susannah

PART 1 — A THEORY OF DESIGN

It is no longer a question of moral exhortation or religious revivalism; it is a question of having faith in a few simple ideas, for only such simple ideas can transform the world.
— Herbert Read

It is the possible that we need to identify.
— Lancelot Law Whyte

I believe that humanity is on the verge of a scientific and intellectual revolution that will alter our sense of ourselves and our relationship to nature and to the planet. Such a change will transform our understanding of how human communities should be sustained. Subelements of knowledge and science which are are now fragmented will become linked. Through this process, we shall achieve a more profound understanding of the human experience, our biological past and our place within the natural order. Fields as disparate as anthropology, psychology, the origins of consciousness and myth, physics, biology including agriculture, medicine and the study of natural systems, climatology, material and structural sciences, electronics, aerodynamics, light and optics, architecture, landscape architecture and modes of transport and communication will be seen increasingly as elemental entities in a larger organic whole.

Contemporary science separates knowledge. Today's scientific worldview, limited in expertise to narrow fields, has shattered unities inherent in pre-industrial cultures. In the absence of a powerful and moral religious tradition, a vacuum has been created within which bits and pieces of knowledge fly about us. Some are comprehensible, many are not. It will be the remolding of the bits and pieces, ancient and new, that will bring a rebirth of a more wholistic vision.

Few people are unaware of the dangers created by modern science and technology, yet few seem to comprehend the fundamental way in which science, through not being part of a larger unity, has become morally bankrupt and dangerous. Specialists often base their arguments for the use of nuclear power on *relative* safety, claiming that nuclear power plants have a small *probability* of failure. But they are creating a world in which probabilities do not matter. The new technology must be infallible in order to be tolerable. But the engineers and scientists building an infallible world are fallible human beings. They are attempting to create a perfect energy converter; but imperfect creatures cannot create perfect energy sources. It has therefore been necessary to fabricate technical and scientific controls to protect us from this fundamental failure of thought. Experts have assumed that they can find the means of storing deadly nuclear wastes with half-lives up to 25,000 years; that perfect containers can be made; and that in 100 or 10,000 years people will be able to deal with their ruptures and leaks. They have further assumed that terrorists cannot break through defenses and that control systems, materials and designs are close to perfect. Because of such assumptions, a totally intolerant technology has been developed. It is a demonic bargain and never in our history have we tried to create machines or organisms that are either perfect or perfectly containable.

This intolerance of human frailty also exists in contemporary research on the naked gene. To protect humanity from the likelihood of a scientifically-conceived super pathogen arising in some laboratory, procedures for containing pseudo-organisms created in the name of pure biology or cancer research must be developed. Standard or even ultra-rigid laboratory procedures cannot contain the uncontainable forever.

Lancelot Law Whyte[1], in an article dedicated to the memory of Herbert Read, said that Read's passionate conviction was distinguished from the ideas of earlier thinkers by several features. These were his stress on the individual, his emphasis on the visual sense in arts, his organic outlook based on an awareness of the crucial role of the organic realm and of biology, and his sense of urgency that the achievements or failures of the rest of this century might determine the fate of humanity for a long time to come. Plato speaks for eternity, Read for our unhappy time.

Herbert Read felt the present human situation could not be viewed against eternity; that it is a matter of this century. He felt that there might be an organic tendency towards coordination, dominant in all species, which since 1914 has been operating at an unconscious level in millions of people. It has been preparing for a radical transformation of the human psyche from the outdated, parochial condition of the past to a universal and organic way of thinking and living. He thought that unless this preparation has been carried far enough, we are doomed.

I feel that the preparation has been carried far enough. I hope, in this essay, to delineate the earliest forms of a new synthesis. I am convinced that a large number of creative possibilities for the future are close at hand. Using the paradigm of New Alchemy's work on the Ark, I shall attempt in Part II to look at the larger question of design and emerging possibilities.

How can we reintegrate modern knowledge and the deepest insights and wisdom from the human experiment into a comprehending and satisfying worldview? For example, can we synthesize what we know in such a way that people can trap and utilize energy wisely? Can they grow sufficient food to maintain health yet neither despoil nor threaten the planet? Can integrated structures be designed for living, manufacturing and carrying out such functions as government and education? Can transport and communications be tied to human and ecological dictates and can energy, food, shelter and culture function together enabling individuals to feel integral yet unique?

Modern society is highly interconnected. These interconnections provide diverse, deceptively stable support elements for human activities. But the connections will prove incomplete and vulnerable as the structure and fabric of modern societies fail to be adaptive. The energy, fuel and fertilizer crises have revealed the frail nature of the links connecting the vital support elements of the industrial world. Wilson Clark has said that global networks carry interdependencies too far. For example, modern agriculture is predicated on access to phosphates, most of which come from Morocco, and on a rapidly waning supply of natural gas, which is the primary energy source in the production of nitrogen fertilizers. Without these, and many other substances, our industrial agriculture could not function. Our farms are connected to the politics of North Africa, the Middle East and other regions of the world. This kind of dependency leads to a global tension that fosters violence and ultimately disintegration rather than cooperation and mutual understanding.

Each sub-unit in such an interlinked global system, whether it is an agricultural or manufacturing unit or a transport system, is incomplete. It cannot function alone. This is a fundamental difference between the structure of society and that of the living world. In the living world each subcomponent, while being interdependent, is at the same time a complete unit, whole and autonomous. In this way, opposite tendencies are fused by nature. For example, a cell is capable of carrying out all the functions normally attributed to life and, as such, is a mirror image or reflection of higher levels of organization. It predicts the organism of which it is a component. The accompanying article, "Bioshelters as Organisms" by R. Zweig, expands this point. And while the organism of which it is a part is dependent upon nutrients, energy and support from other organisms, it is at the same time capable of functioning as a complete entity. In nature a continuity exists in which the smallest living element is an image of each level of organization. A unicellular organism is structured and operates in much the same way as a complex organism such as a tree or a higher animal which, in turn, has much in common with the ecosystems that sustain organisms. The same kinds of ganelle to the biosphere.

In the living world evolutionary design is for some unexplained reason continuous and highly adaptive. Inherent in its adaptability may lie some of the clues essential to attempting a synthesis of modern knowledge. Such continuous adaptability is very important. It is at once architecture and structure; it is also a dynamic process, developing unity where chaos would otherwise ensue. The First Law of thermodynamics says that energy is neither created nor destroyed. The Second Law of thermodynamics says that energy can only be degraded or dispersed. This is entropy or a measure of disorder. Because no transformation is 100 per cent efficient, there is a continuous degradation of the quality of energy. But in the universe and in living forms rather than degradation into chaos, through the process of entropy, we have the creation of spacial forms and morphic order. This may well be energy's last hurrah. Physics vs. biology; energy vs. life.

Such must be the basis not only for a reintegration of modern knowledge, but for the maps or models we devise for restructuring the ways in which human communities are sustained. Should we uncover the morphic form of the earth and of life within it so that we understand its organization and self-tending abilities, the keys to design will be attainable. The term "morphic" is borrowed from Lancelot Law Whyte who used it to describe all processes that generate spacial form. He used "morphic", a word derived from Greek, as a modern name for the spacial expression of the tendency towards unity, order and intelligibility. This tendency in nature has been recognized as long ago as Plato, but there has been no theory fully explaining it. After 150 years of intensive biological study, however, there are the rudimentary beginnings of a satisfying explanation of how the world works. Some grasp of the adaptive strategies that enable nature to accomplish so much with so little becomes possible. In the term nature I mean to include its ecology, successional changes and pathways and in a larger time frame, its evolutionary course.

Organismic and wholistic biology is perhaps one of the least appreciated and least taught areas in science. Yet, within this century, an enormous increase has taken place in our understanding of the fluxes, movement of energy and the physical dynamics of living systems. It is beginning to be understood how living systems reorganize themselves, becoming higher expressions of the possibilities inherent in life. By "higher" I mean simply that which is attainable by the interaction of life forms. Ecosystems change with time. These changes are limited by a variety of factors, including climate, the availability of nutrients and the nature of neighboring ecosystems. Ecosystems shift from entities which, for example, have initially linear food

simultaneously. They tend to accumulate organic matter and increasingly reuse and recycle resources. They tend to become more diverse yet more equitable in the sense that individual elements dominate less. On Cape Cod as a sand dune gradually becomes a pitch-pine and oak forest, the stratification and spacial structure of the area changes from being rather loosely to more highly organized. The nature of resident organisms changes with succession and the cycling within becomes increasingly close, having been fairly open in earlier stages. The exchange rates between various organisms and their environment become slower, more subtly pulsing and wastes or organic matter are increasingly used within the system itself. As an ecosystem evolves toward a higher state, there is an initial selection for rapid growth, a pioneering phase. The ecologist's term is r-selection. As the ecosystem matures, more feedback control is introduced and more elements integrated into the larger whole. This is termed K-selection. In terms of productivity there is a shift from an emphasis on quantity in earlier successional stages toward one of quality. In the living world homeostasis increases over time. Symbiosis, the conservation of resources and, in some cases, the ability to resist perturbations from outside increase. Further information accumulates. Information might be considered to represent the transformation of energy to its most useable state – the last hurrah of which I spoke.

In this general overview, I have tried to describe the process by which nature changes over time. Such occurrences as fires and flood or changes in climate can reverse this process. It is not linear. But nature is constantly organizing, even under stress. Life has adopted a variety of approaches to accomplish given ends. One of the ironies of human history is that most civilizations from the ancient hydraulic ones of the great river valleys through colonial cultures to modern industrial societies have based their support on practices antithetic to the course of nature. All of them have violated principles which, although not yet fully understood, have proven extraordinarily successful for all other forms of life. We have not yet considered devising a culture which emulates the processes of nature. I should like to propose that culture can be transformed through such an emulation.

We are learning that the structure of a system, and not its coefficients, determines its ultimate behavior.[2-6] This discovery, if true, will have an enormous impact on all levels of design. It implies that the behavior and fate of a system is determined by its organization and structure and not by its rate of expression or its coefficients.

The structure of modern industrial Western civilizations and, to a large degree, that of all societies has been fundamentally and radically transformed since the industrial revolution. The present structure was predicated on the fragmenting of function. Manufacturing, commerce and agriculture became separated in both space and time, and there is a division of the city from the countryside. Superimposed on this was a global support network of resources, like minerals, fibers and, in more recent times, food. In a period of a few centuries, the Western world passed from a condition of somewhat autonomous subunits that were relatively integrated and internally self-regulating to partial units operating in a global context. Originally, this was based on imperialism and colonialism, more recently upon multi-national economic units. A dramatic change in the energy infused into these systems caused a radical transformation. Energy in one form or another was conceived of as being cheap and limitless, either as the coolie or the slave in the colony or as massive quantities of coal. The dependence on petroleum and its derivatives in the last hundred years is an even more dramatic example.

The structure of the contemporary world assumes a foundation of limitless supplies of cheap petroleum. This assumption underlies fossil fuel fired generating plants attached to central power networks and industrial agriculture which uses between 5 and 20 calories of petroleum-derived energy to put one calorie of food on the American table. Architecture is comparable in its practices, with massive use of glass, air conditioning and heating. Transport networks and manufacturing, sustained by fuel demanding engines, are highly energy inefficient. Commerce pays little attention to energetics, as the World Trade Center in New York attests. Even medicine is not immune. Industrial civilizations were based upon substances thought to be limitless and inexpensive which are now known to be finite and increasingly costly.

Photo by Nancy Jack Todd

Structure determines fate. Coefficients vary rates and relative dominances within a system. The physicist Amory Lovins [5] has suggested that, if structure and not system coefficients determines behavior, as he believes, our present civilization is fated and will prove unsustainable.

Unfortunately, at the same time that structure is beginning to be seen as pivotal, science and technology are addressing themslves almost exclusively to coefficients. For example, in the transport sector, automobile engines are being designed for greater efficiency. The goal is to double gas mileage over that of a few years ago. This is a coefficient-related activity on the part of technologists. At no point is the transport structure itself including the highway system and the fuel base being seriously questioned. Because we have built a society to which this structure is essential and because, as we know it, it will collapse without the automobile, the larger question of transport remains taboo for scientists and designers. The same holds true in architecture. Although architects are devising ways of conserving energy, little attention is being paid to the function of buildings in society. We use separate buildings for teaching, commerce, manufacturing and living. Food is grown in separate greenhouse structures. The functions of buildings have been separated into distinct units which are incomplete from an energy and social perspective.

Architecture addresses itself to coefficients; structure is left intact. Combining the various functions through integrative design, which could lead to a vision of buildings as "ecologies", is not being considered. This is true in agriculture and in many other key areas of human endeavor. By focusing on the coefficients, science and technology are buying time for society. The ability of contemporary science to improve technology but not alter the fundamental structure of society helps explain the drive to develop nuclear power so that there will be enough power within this century to sustain the existing industrial base. A blind attempt is being made to sustain a system that is unsustainable with its highly centralized interconnected energy grids and its massive use of energy. Genuine alternatives are not readily conceivable. An alternative, which would require a radical restructuring, could lead to more humanly based techniques and environmentally restorative methods of providing for the needs of people. At the present we are trapped in an intellectual cage, created by our own science. The future is either apocalyptic or materialistically euphoric, à la Herman Kahn.

If it is assumed that coefficients are only buying time, the vital support elements of our society must be totally redesigned. For a transition to take place, the new processes being created must be allowed to co-exist within the present structure. A beginning can be made by asking simple, fundamental questions. Only by asking such questions can a societal structure that is truly adaptive be foreseen.

It is perhaps the first time in history that people are being asked to create, on a multiplicity of levels, the landscape of the future. There will be little time for the slow adaptation of techniques that has characterized change in human experience until now. The central task now is to find an adaptive structure in which individual lives are optimized. In the first place, it should be a structure in which a majority of people participate in the processes that sustain them; in which part of their time is involved in the production of energy and food and in tending their shelters and the landscapes that nourish them. New kinds of structure imply unprecedented levels of synthesis, for part of the necessary reintegration of the human experience must include a heightened awareness of the natural order upon which we depend. People and process must become one.

The second aspect in the design of an adaptive human support system is that scale or size be reduced. Present technological societies operate through technocratic elites. Because of such elites most people are removed not only from the activities that support them but also from control of political and economic processes. If people lived in smaller systems, their experience would be more direct and political judgment on the part of the majority would become more sensitive. It should be possible to redirect science along participatory lines in terms of both the physical aspects of life and in terms of the body politic.

A third basis for an adaptive society is that human needs be fused with the needs of the biosphere. The biosphere is the vehicle which provides us with the gases we breathe, our foods and the purification of our wastes. From it come all the materials upon which we depend. Ecosystems far larger, far more complex than ourselves or our societies, are essential to us. This needs to be acknowledged in the new synthesis. The highest priority is that these ecosystems be enhanced, that their fabric be strengthened by our presence. Only through working with the biosphere can we help ourselves. This is not impossible if it is a basic premise of design.

The fourth essential part is that inexhaustible energy sources — the sun, the wind and biofuels — should be the primary inputs within an adaptive framework. Natural systems are predicated on these forces. Human ones ought to be. Each region should develop a structure based on the energy fluxes impinging upon it. If this becomes the basis for design, more autonomous subunits would evolve. They would be more highly integrated into the larger environment and less vulnerable to disruptions or scarcities. Remaining petroleum would not be burned carelessly but could be used for long-lived materials, special medicines and the like. If the natural energy falling on a region were made the basis for life support, more subtle, less violent technologies would ensue, which would allow for a degree of human involvement now impossible because of the nature of most of our machines. This is the case with New Alchemy's Ark on Prince Edward Island which is powered by the sun and the wind. Wholistic design within an ecological model gives birth to what are now dimly conceived possibilities.

What is an adaptive structure? It would have to include the above characteristics, but to be successful it must go one step further. We must ask: are there in the living world equivalent processes which, when subtly adapted to structural and electronic components, can sustain societies, performing the jobs presently done by capital intensive, energy-consuming and polluting processes? Can organic, living equivalents to the mechanical and energy demanding support components be found in nature? At New Alchemy we have been exploring this question for several years and we are finding such living equivalents. Agriculture and energy can be structured on the models of living systems. To do so, it is necessary to integrate biotic elements with structural, electronic and appropriate technological components, employing the strategies of nature. There may be an adaptive design unity inherent in nature which can be used for human ends.

Photo by John Todd

In the adaptive model of nature lie design ideas that will enable humans to create societies and cultures as beautiful and as significant as any that have been. Several explorations will be described in Part II. In the simplest terms we must ask such questions as: "Can a plant do for us what a gasoline-powered machine now does?" This does not mean we must turn our backs on contemporary science. Rather it needs redefining and redirecting. It will take many technologies and techniques to explore the living world, in particular modern materials and electronics. Energy and climate research will focus on the sun, the wind and biofuels; food research will emulate the strategies of ecosystems. By the term "ecosystems", I mean interconnected, interdependent assemblages of plants, animals and microbes living together and interacting with non-living components of which they are a part. Examples are a forest, a field or a pond. In terms of design, shelter, housing and building would integrate energy and food findings with architecture.

The wonder of a plant lies in the fact that it is. From the point of view of design, a plant is noteworthy because of the way it fits into its larger ecology and has, through its morphology and physiology, devised methods of trapping and transforming energy, using nutrients, creating foods and providing structure and shelter for itself so that it can withstand perturbation and change. It symbolizes a triumph in design. It is no coincidence that, as primary producers, plants do a great deal with very little, yet sustain many other forms of life. The biological metaphor or analogue may be the most important guide available. Should we create a culture in the image of the biosphere, it would bring about a revolutionary change in the way in which people live on the earth. It would have an impact as great as the introduction of agriculture some ten thousand years ago. Inherent in an adherence to the lessons of the plant or the forest is a way of seeing and of connecting knowledge. Biological consciousness would fundamentally alter our sense of what human communities might be. It would be no less profound than the changes in the sixteenth century that led to the foundation of the modern scientific worldview. Human consciousness and our place on the planet are being questioned. Research on the atom, the naked gene and other heedless practices we permit are creating in their shadow a new sense of identity and destiny. The Ark on Prince Edward Island is an early attempt by the New Alchemists to explore the landscape of the new synthesis. It is still firmly rooted in the contemporary tradition of which we are a part, but it affirms an almost infinite number of possibilities. Henry Drummond's* Law of Laws frames the meaning of the theory of design:

"That if Nature be a harmony, there must exist a unity and continuity extending through all realms which for me is the physical, organic, aesthetic and mental."

*Quoted in Reference 1.

PART II – AN ARK FOR PRINCE EDWARD ISLAND

The biologically sophisticated Ark project makes manifest our interdependence with the natural world, reintegrating us into it and enhancing our sense of wholeness: a special strength of combined innovation in energy and agricultural systems.
– Amory B. Lovins[5]

It is a fact perhaps not fully appreciated that northern societies or those in harsh climates have greater energy needs and dependencies than those with milder climates. More energy is required to accomplish given societal tasks and to maintain a particular standard of living. In order to achieve present day standards of living, modern industrial civilizations depend upon global networks requiring disproportionately large amounts of fuels, foods and shelter. Canada and the United States use more energy per capita than any other nation.[7] A good share of Canada's petroleum is burned in heating buildings.[8]

About 55 per cent of the Canadian energy use is in heat, nearly all of it at a relatively low temperature, below 140^{o} Centigrade. Space heat (less than 100^{o} Centigrade) accounts for over 58 per cent of the total heat budget with the domestic sector using the great bulk of it. Electricity, the subject of so much debate and the scene for so much capital investment, plays a far less significant role in Canada's energy budget. In 1969 more than half of the total energy was consumed as heat and only 14 per cent as electricity (op. cit.).

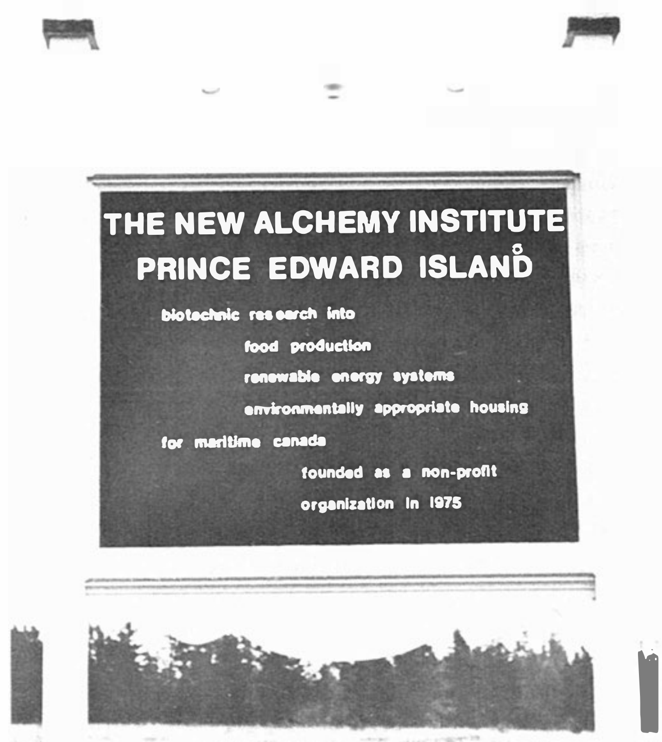


Photo by John Todd

Photo 1 – Entrance to the Ark, Spry Point, Prince Edward Island, Canada

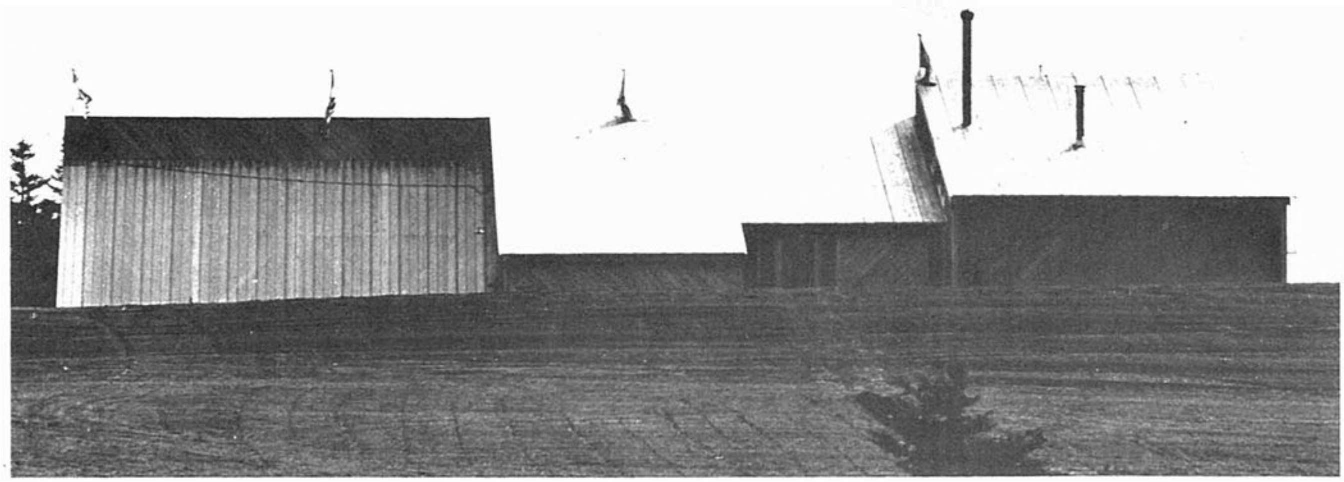


Photo 2 — North Side of the Ark, with Berm in Foreground

Photo by Robert Todd

As electricity, fuel, fertilizer, food, storage and transport costs rise and their petroleum bases dwindle, nations requiring substantial energy will have to reduce their standards of living, which is precisely what is happening at the present, or they have the possibility of taking a bolder step and redesigning themselves to accomplish much more with less. The Ark attempts to do this. It combines into one solar and wind powered structure: a household, resident greenhouse, a microfarm, including production aquaculture, a vegetable greenhouse and tree nursery components, a small barn–shop, a waste purifying system and a research laboratory. It is a first attempt to create symbiotic associations out of support functions normally separated in space and time. Unprecedented levels of integration between energy, food and shelter systems have been attempted. As such, the Ark is a first effort at a new synthesis.

With the Ark on Prince Edward Island, we redefined how people live and sustain themselves by focusing on redesign and restructuring at the smallest functional unit of society — the household. Since housing affects the majority of the population and is the major fuel consumer for space heating, human habitations represent a logical starting point in a critique of society. The Ark project began as a question. It asked if it might be possible to devise a human habitation as a bioshelter. A bioshelter is a structure inspired by biological systems, capable of providing its own energy and climate, treating its own wastes and growing food for the residents.[9-11] We were interested in carrying the concept one step further and designing a human habitation as a bioshelter with the capacity of a small economic unit, which could pay its way through the sale of its surplus power and produce.

In collaboration with Solsearch Architects, the New Alchemy Institute has built two Arks, one on Cape Cod and one in Maritime Canada. The Ark on Prince Edward Island to be described here differs from the Ark on Cape Cod in that it is a human habitation as well as a microfarm. It has, as well, its own power-generating and waste treatment facilities. In the Prince Edward Island Ark, bioshelter design combines the various support elements into a single structure. The Ark on Cape Cod is exclusively an agricultural bioshelter. The Prince Edward Island structure is much more complex. It has to function in an extreme climate on the eastern end of the Province of Prince Edward Island in the Gulf of St. Lawrence. Its location on Spry Point is surrounded by pack ice during the winter and early spring months. The Cape Cod climate is benign by New England standards. Additional heating, trapping and storing components were required in the Canadian Ark. To function as a human habitation, its climatic control needs were greater and internal waste purification and sewage treatment were required. From a design point of view, the Ark on Prince Edward Island

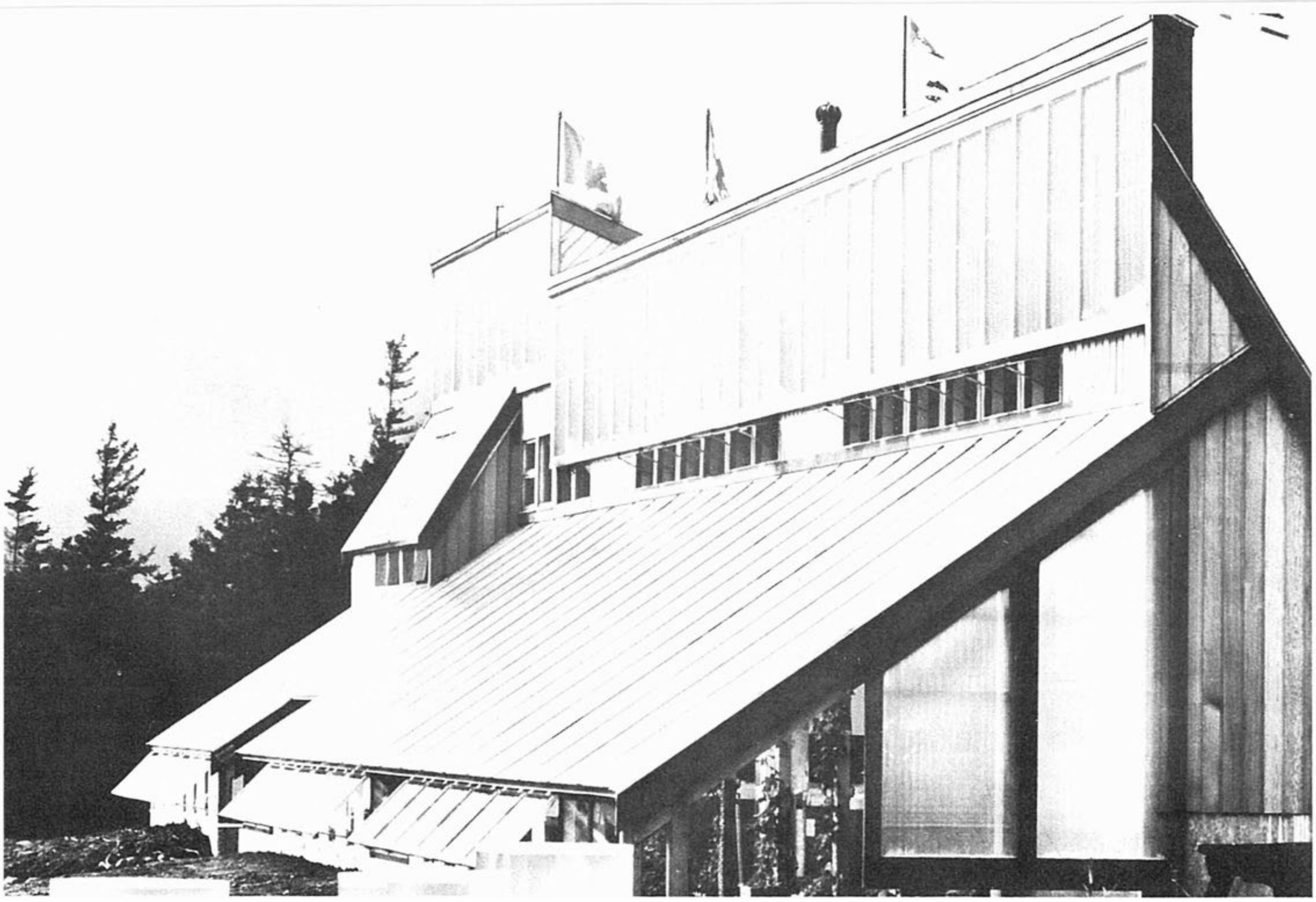


Photo by John Todd

Photo 3 — Southern Aspect of the Ark. The Vertical Panels are Solar Collectors. The Translucent Roof Covers the Biotic Zones.

is an extension of the concepts developed in the Cape Cod Ark. But because it is more complex in a bio-social sense, there is within it a higher degree of integration. It is technologically as well as biologically more sophisticated than the smaller, less costly Cape Cod Ark.*

A bioshelter that is a human habitation is not just a house although superficially it may look quite similar. From the north side, the Ark on Prince Edward Island resembles an architecturally conservative house which is made more modest by the presence of the earthen berm which partially hides its bulk (Photograph 2). But the differences between the Ark and an orthodox house are many and fundamental; the Ark is a microcosm designed to serve a range of human needs not now provided by housing. It is modeled on an ecosystem. Its architecture is solar (Photograph 3). Together they are able to perform a wide array of tasks. In many respects the Ark is the antithesis of the contemporary house. Instead of continuously and wastefully consuming finite substances such as petroleum and other fuels, it attains its climate from renewable energy sources, namely the wind and the sun. A comparison of the Ark with orthodox housing is made in Table I. From a design point of view the differences are radical. The table lists 20 categories or attributes of design. Economics and costs are considered as well as the social and the environmental impact of the two approaches to design. Table I attempts to put the design theory, outlined in Part I, into concrete form. The existing structure of housing and housing networks, with sewage systems which dump human wastes into lakes and rivers and inefficient heating with finite substances like natural gas which require extensive distribution networks, can be compared with a bioshelter which is a whole semi-autonomous entity. Several important differences between houses and the Ark should be touched on; the contemporary house is wasteful of the heat it consumes, while the Ark stores heat, including summer heat, at various

*** Note: Accompanying article by E. Barnhart describes the Cape Cod Ark.**

A COMPARISON OF THE ARK WITH ORTHODOX HOUSING

CATEGORY	ARK	ORTHODOX HOUSING
UTILIZES THE SUN	Source of Heating, Climate, Purification, Food Production and Much Interior Light.	Some Interior Light – Often Negative Role Necessitating Air Conditioning
UTILIZES THE WIND	A Source of Electrical Energy from Windmill Wind-Driven Circulation through Composting Toilet.	Only Negatively, Increasing Fuel Demands through Infiltration.
STORES ENERGY	YES – in Three Systems and Growing Areas.	NO.
MICRO-CLIMATOLOGICAL SITING	Integral to Design.	Rare.
WASTE PURIFICATION	YES – Except for Grey Water which is Piped into Leaching Bed.	Wastes Untreated and Discharged to Pollute.
WASTE UTILIZATION	Purified Wastes are Nutrient Sources in Interior Biological Cycles.	NO.
FUEL USE	Wood, a Renewable Source, as Supplemental Heat.	Heavy Use of Gas, Oil or Inefficient Electricity.
ENERGY CONSERVING	YES – Also Uses Energy to Serve Simultaneous Functions.	NO, or Rarely.
ELECTRICITY CONSUMPTION	About same as Orthodox House but Electricity Used for Many Productive and Economic Functions.	Fairly Heavy Consumer.
FOODS	Diverse Foods Cultured Year-Round	Not Within – Often Summer Gardens.
AGRICULTURAL CROPS	Vegetables, Flowers and Young Trees	NO.
AQUACULTURAL PRODUCE	Fish for Market.	NO.
ECONOMIC UNIT	YES – Viability to be Determined.	NO – Financial Burden.
OPERATIONAL COST	LOW – Ultimately Exporter or Power.	HIGH – Particularly in Fuels and Electricity.
INITIAL COST	HIGH – Due to Energy and Biological Components – Uses Larger Amounts of Quality Materials.	Moderate.
VULNERABILITY TO INFLATION AND SHORTAGES	SLIGHT.	SEVERE.
IMPROVES CLIMATE AND LOCAL ENVIRONMENT	YES – Locally by Windbreak and More Broadly through Reforestation.	RARELY – Most Intensify Weather.
TEACHES ABOUT THE LARGER WORKINGS OF NATURE	YES.	NO.
INCREASES SELF-SUFFICIENCY	YES.	Rarely.
STIMULATES LOCAL AND REGIONAL SOLUTIONS	Possible.	Unlikely.

TABLE I

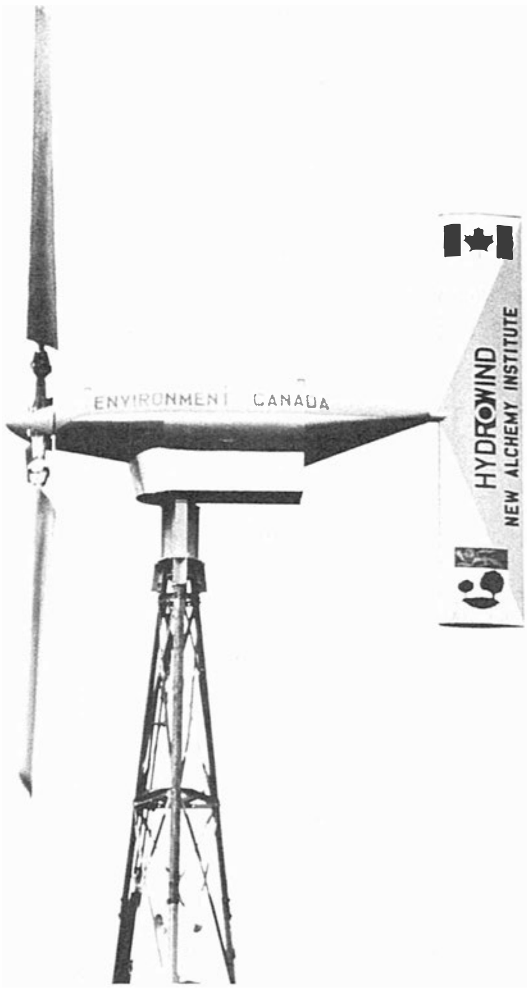


Photo by John Todd

Photo 4 — HYDROWIND
— The New Alchemy Wind-Driven Power Plant

temperatures and in different ways for use in several climatic and biological roles. Instead of drawing continuously on external electrical and other energy sources, the Ark will ultimately become an exporter of power by generating more electricity than it needs. A wind-driven power station adapted simultaneously to the needs of the Ark and the requirements of the local utility network has been developed so that power can be produced both for the Province and for the Ark. The Ark accepts power from the Island utility when the wind is not blowing and returns it to the network when it is blowing hard (Photograph 4). The New Alchemy experimental windmill, known as Hydrowind, is hydraulic.

Because most houses pollute not only through the burning of fossil fuels but also through the discharge of sewage, the bioshelter wastes are treated internally in a dry toilet-composting system. After being purified wastes are used as nutrient sources in living cycles within. Since the bulk of the heating is solar, emissions from burning are reduced and confined to wood gases from an auxiliary combination fireplace-stove.

Household dwellers normally consume foods that have been stored for long periods, elaborately packaged, highly processed and transported over long distances, particularly in winter. The Ark produces fresh foods on a year-round basis. While food autonomy is not a design goal for the Ark, a wide array of fresh produce is cultured within, including fish, vegetables and greens for the residents. Photograph 5 shows part of the residential food growing area adjacent to the kitchen. There is an economic dimension to the Ark unknown in contemporary single-family houses or condominiums, which represent major economic burdens. The Ark is designed to produce significant amounts of food, flowers and young trees. Much of the Ark research has been and will continue to be directed toward devising internal food-producing ecosystems that will provide a viable economic base for bioshelter dwellers. Photograph 6 is an outside view of the Ark's east end. The barn and food processing area is on the right and the commercial food growing area is on the left. Although an Ark is more expensive to build than a conventional house, the fact that it is a combined residence and microfarm with its own internal economy helps it to pay for itself. The processing and sale of crops could underwrite construction, finance and maintenance costs. This is a design objective, however. It will take a number of years of research to reach it.

There is an urgent need, especially in northern nations, for a dramatic shift in attitudes toward human habitations. In many ways the suburban house represents a failure of design. The designers Day Chah-

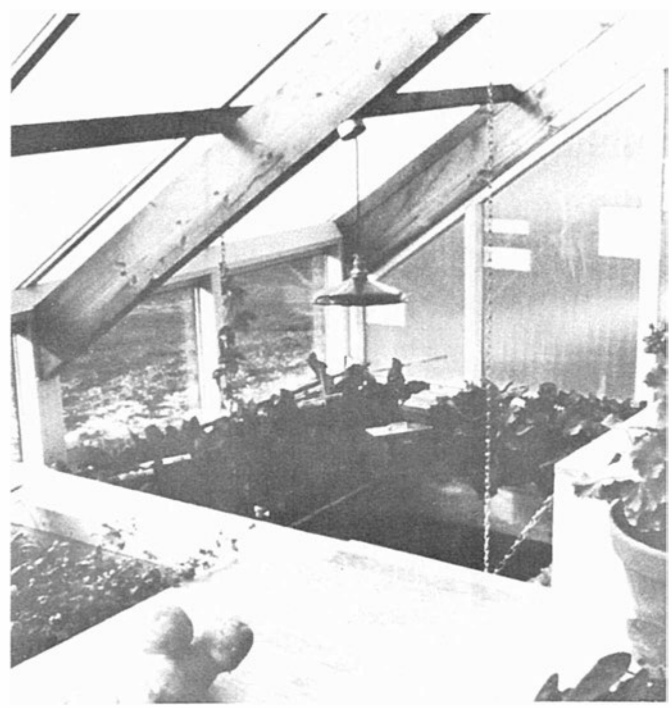


Photo by Albert Doolitt

Photo 5 — Kitchen Area Adjacent to the Residential Food Garden

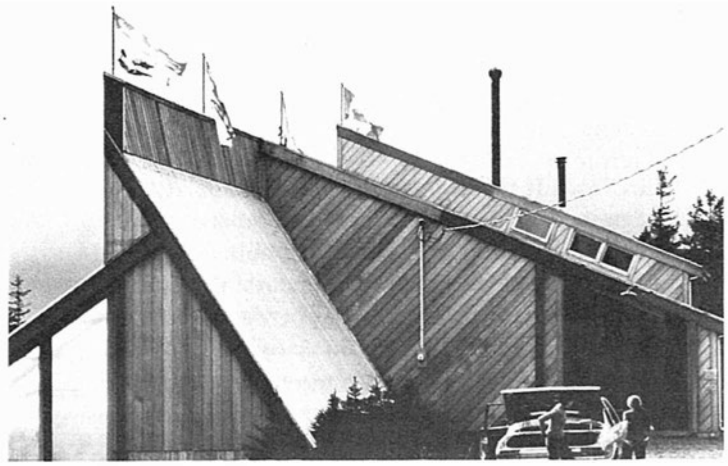


Photo by John Todd

Photo 6 — Eastern End: Greenhouse Area on Left and Barn - Food Processing Section on the Left

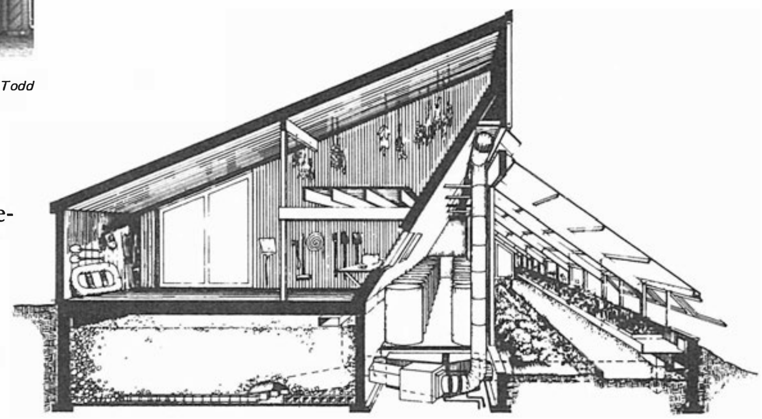
roudi and Sean Wellesley-Miller have summarized the design failure.

"Historically, the various utility systems and services that go to make up a home have been developed in a piecemeal manner in isolation from each other. Consequently, while some components or sub-systems may be near optimum, the total system is seriously sub-optimal. This state of affairs was relatively unimportant, at least in the short term, during the historical period when the ability of the natural environment to process wastes and supply cheap energy and water was well in excess of the short term demands placed upon it. Now that we are approaching foreseeable limits, this is no longer the case and something more than a piecemeal approach is called for."[9]

DISCOVERIES THROUGH ECOLOGICAL DESIGN

Efforts to apply ecological strategies in the design of the Ark have led to a number of bio-technical breakthroughs. An example of the benefits of a structural shift to a new design paradigm is that the Ark is not only a house. It is among other things a fish farm. The fish culture system is not only for rearing thousands of fish for market but also provides some of the Ark's climatic needs.

The aquaculture facility was designed as both a low temperature (30-35° Centigrade) solar powered heat collector and a fish culture complex. Illustration No. 1 depicts two rows of 40 solar-algae ponds within the Ark in the center of the drawing. Light enters the building through the translucent south roof and wall exposing the ponds to solar radiation. Photograph 7 shows the algae-filled ponds and the commercial food growing area of the Ark. The aquaculture ponds have highly translucent walls and contain dense blooms of light-energy absorbing algae. The algae not only provide feed-stock for the fish but act as efficient solar collector surfaces. The water-filled ponds perform as heat storage units. Unprecedented levels of biological productivity have been reached in the solar algae ponds.[12,13] Fish production per unit volume of water is the highest recorded for a standing water body. This is not the sole function of the aquaculture facility. When temperatures drop in the large greenhouse area and in adjacent rooms including the laboratory, heat is radiated from the ponds and the building is warmed. In a three-day blackout during a violent, late November storm, the solar-algae pond complex was the only



Ill. 1 — Ark Section through Barn, Rock Storage and Greenhouse Areas. Solar-Algae Aquaculture Ponds are in Two Rows Down the Middle.

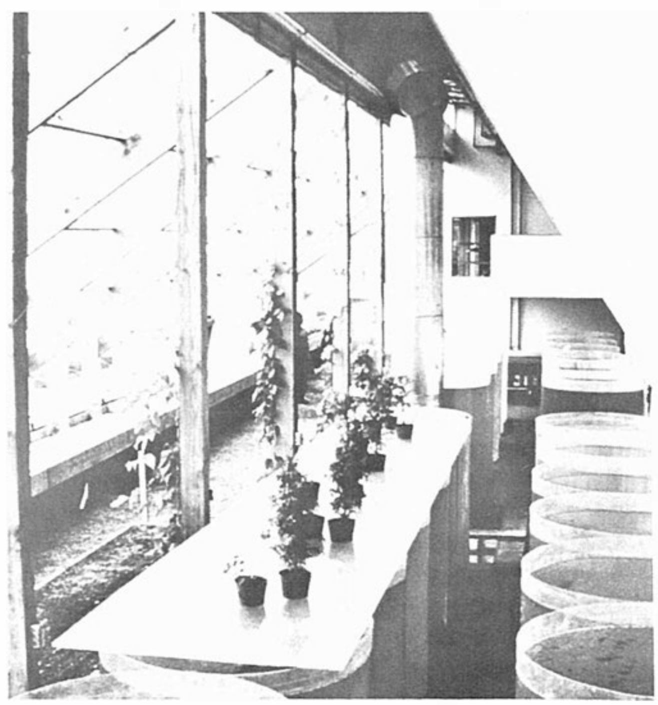


Photo by Albert Doolittle

Photo 7 - Part of Commercial - Experimental Food Growing Area. Solar-Algae Ponds on the Right.

operational heating system. Temperatures outside dropped below -5° Centrigrade and winds were in excess of 50 km/hr, yet the crops within survived.

The design of the solar-heated aquaculture facility was the result of our deliberate search for processes in nature which, when combined with appropriate technologies, would substitute for fuel-consuming, capital-intensive hardware. In this case, living organisms and a renewable form of energy were asked to replace some of the functions of machines. For example, light was substituted for a range of energy-consuming and expensive equipment normally used for biological regeneration and circulation in the aquaculture ponds. The ponds are made with walls that allow over 90 per cent* of the light to enter through the sides. Their placement in the structure where they can best receive solar energy, and the introduction of microscopic algae which absorb the incoming energy, purify the water of fish toxins and provide feedstocks for fish result in a new and ecological approach to fish culture and climate regulation. The bulk of machinery, energy demands and external fish feeds are eliminated. Light, algae, herbivorous fish, translucent building materials and a cylindrical and modular design allowed such a substitution. The integration of heating and food production freed us from dependence on technologically complex solar heating which involves collectors containing expensive copper, selective black absorber surfaces, pumps, piping and heat exchangers. Fossil fuel-burning furnaces are not used in the facility.

Symbiotic relationships at various levels of design are sought actively. Again, the example of the aquaculture facility in the Ark is fitting. In addition to nurturing a commercial fish crop and heating a greenhouse, it is a source of irrigation and fertilization for the vegetable, fruit and tree seedlings within. Metabolic by-products and organic matter from the ponds can increase shallow rooted leafy crop yields up to 120 per cent.[14] The process of creating new linkages between ecological and engineered elements is ongoing and may be increasingly mediated by sensors and electronics devised for this purpose. In one experiment we are coupling fish raising with leafy crop hydroponics on the pond surfaces. In this experiment the rigid insulating pond tops are replaced with a floating "raft" of styrofoam beads which provide insulation and support for leafy crops such as lettuce. Lettuce is a moisture-loving crop. Its roots must be in an oxygen-rich milieu for rapid growth.[15] In the experimental system the lettuce roots will penetrate between the floating beads and enter the warmed water. Warmed water that maintains a fairly stable temperature should increase lettuce growth considerably. The plants will derive most of their nutritional needs and carbon dioxide directly from by-products of aquaculture. The oxygen critical for the roots will also come from the pond having been generated photosynthetically by the algae in a daily rhythm which may match the oscillating requirements of the lettuce.

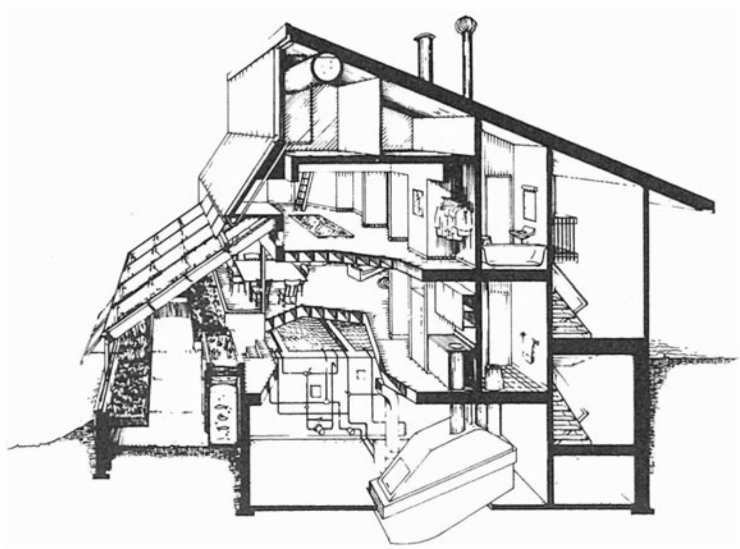
In Table II the biological/structural approach to design in the Ark's fish facility is compared with the most advanced engineered/technological closed-system aquacultures. The fundamental shift in design toward a new structure can be visualized through this comparison. In the Ark an ecosystem powered by light effectively replaces a mechanical approach for raising fish in small spaces. It is more comprehensive in that it provides climate and resources for terrestrial agriculture within. Biological strategies become a genuine alternative in food, energy and shelter design. Although Table II is confined to aquatic systems, it conveys the scope of the new synthesis as well.

The biological metaphor inherent in the shape, heating or food raising aspects of the Ark is valid. The end points of the design process meet basic human needs. In this context structure is redefined and moved towards culturally adaptive ends.

We have dealt with the new bio-architectural design ideas at the point of interaction of aquaculture and energy within the Ark. Many other aspects of its design are ecologically inspired. Some of the characteristics the Ark shares with ecosystems are:

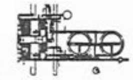
i. *Integration*

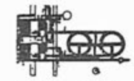
Energy, nutrient, structural and biotic components interact through a range of pathways to create a unique environment. An attempt has been made to achieve relative stability, sharing of limited resources and high efficiencies within each sub-element. Illustration No. 2



Ill. 2 — Section through Residential Greenhouse, Hot Water Heat Storage, Composting Toilet and Living Areas.

*Kalwall Corporation, Manchester, New Hampshire, published figures and not readings made within the ponds.

	New Alchemy Solar-Algae Multispecies Fish Culture 	Salmonid Culture in Recycling Silo System 
CATEGORY	**BIOLOGICAL/STRUCTURAL**	**ENGINEERED/TECHNOLOGICAL**
ENERGY SOURCE	THE SUN	ELECTRICITY
ENERGY USE	Minimal – Radiant. Solar energy, plus supplemental compressed air.	Heavy electrical demand for recirculating, heating, cooling, purifying, etc.
DESIGN EMPHASIS	a. Passive – few moving parts; b. Internal, self-regulating and purifying ecosystems powered by a renewable energy source – THE SUN; c. Internal photosynthetically based	a. Hardware based; b. Energy-intensive with rapid flow-through; c. External foods d. Emphasis on technological regulation; e. Elimination of plants, animals other than cultured species; f. Sterilization.
MATERIALS	a. Light transmitting .060-in. thick fiberglass cylinders; b. Placement in light-reflecting courtyards or walls; c. Auxiliary compressed air equipment.	a. Metal tanks, pumps, filters, water exchangers, heating-cooling units, sterilizers, automatic feeders, cleaners, back-flushing plumbing, columnar gas exchangers, etc.
STRUCTURE	SIMPLE – based on maximization of light absorption.	COMPLEX – technologically.
BIOTIC ENVIRONMENTS	Relatively complex – photosynthetically based ecosystems.	Simple – Elimination of most organisms except for micro-organisms in bacterial filters used in water treatment.
CONTROL	Primarily ecological and internal through interactions of micro-organisms, phytoplankton, zooplankton, detritus, also through use of several fish species occupying individual niches – occasional water change and sediment siphoning.	Electrical, chemical and mechanical controls superimposed unto the water body in which fishes are housed.
LIKELIHOOD OF CONTAMINATING FISH FLESH WITH POISONS	Slight – Fish feed predominantly low on food chain particularly algae in a protected environment. Dangerous chemicals NOT USED for disease control and environmental management → Less dependent upon contaminated commercial feeds. Solar-Algae ponds do, however, require thorough initial leaching.	Highly likely – Fish fed exclusively upon commercial feed, contaminated with agricultural poisons; also these feeds include fish meal from marine species which might contain poisons – Toxic contamination from disease and sterilizing chemicals, including algicides, and from stabilizers, etc., in pumps, plastics, piping, etc.
RECIRCULATION	Occasional – Low-flow, air lift pumps used to exchange water between two Solar-Algae ponds.	Continuous and rapid – Up to 1500 litres per minute (23,760 gallons per hour in a 4,888-gallon facility).
THERMAL REGULATION	a. Ponds are efficient year-round solar heaters – Algae absorb solar energy thereby heating water – Summer venting and partial shading with plants prevents overheating. b. Heat-tolerant species.	a. Refrigeration and heavy energy requirement for heating to maintain narrow thermal range throughout year. b. Heat-sensitive species.
OXYGEN FOR LIFE SUPPORT	Generated internally by algae during photosynthesis supplemented at night with compressed air.	Continuously supplied from industrial oxygen cylinders.
FISH SPECIES	Phytoplankton feeding – tilapia and and Chinese carps Detritus and zooplankton feeding – crayfish, bullheads and Israeli carps All excellent tasting fish.	Carnivores – trout and salmon – could also be used for raising channel catfish.
PRIMARY FEEDS	Internally grown feeds – particularly attached and planktonic algae, also zooplankton. Bulk of feeds grown with fishes in the Solar-Algae ponds.	Processed commercial feeds – prepared from fish meal, soy and grain meals, vitamins, minerals, stabilizers, etc. Most potential feeds also for direct human consumption.
SUPPLEMENTAL FEEDS	Flowers, weeds, vetch, midges, earth worms. Commercial fish feeds are used in moderate amounts to optimize growth.	Often animal by-products prepared from slaughter-house offal

	New Alchemy Solar-Algae Multispecies Fish Culture 	Salmonid Culture in Recycling Silo System 
CATEGORY	**BIOLOGICAL/STRUCTURAL**	**ENGINEERED/TECHNOLOGICAL**
DISEASE CONTROL	Control through emphasis upon disease resistant species, such as tilapia and bullheads. Mass mortalities from disease rare.	Salmonids sensitive to diseases. Control through H_2O sterilization, chemical and antibiotic treatments and quarantine procedures. Mass mortalities from disease common.
BIOPURIFICATION	Toxins purified internally, as algae and other organisms rapidly utilize them as nutrient sources.	Toxins purified through technological steps and tertiary water treatment, including bacterial filtration.
a. Clarification	None – particulates important component of internal ecosystem.	Screening and steam cleaning to remove particulates.
b. Sulfide Toxicity	Not yet experienced.	Occurs when filters clog – requires back-flushing to eliminate anaerobic layers in filters.
c. Nitrite Toxicity	Not yet observed – algae photosynthesis prevents nitrite build-up.	Occurs on occasion – water change most effective treatment.
d. Ammonia Toxicity	Ammonia utilized by ecosystem. Green algae take up ammonium directly during photosynthesis. Nitrification takes place naturally in shallow sediments. If ammonia should ever build up, tilapia carps and bullheads can withstand ammonia levels up to 10 times greater than those lethal to salmonids.	Ammonia toxicity major threat to system. Nitrification through chemical, physical and biological methods. Plastic media trickle filters and/or submerged aerobic bio-nitrification filters are used. Filter bacteria often pre-activated on synthetic growing media.
e. Nitrate Toxicity	Toxic levels not yet observed, as most nitrogen incorporated by algae prior to nitrate stage in nitrification process.	Columnar denitrification requiring introduction of outside chemical sources of organic carbon, such as glucose and methanol – column filled with polypropylene flexi-rings.
HOLDING CAPACITY	Densities of 3 fish/gallon have been held for up to six months – fish ranged from fingerling size to 250 grams.	Salmon smolt densities of 8–10 fish/gallon with continuous dilution of fresh well water at 5–10% rate.
PRODUCTIVITY	Projected fish production of 30–40 kg/m^3 per year. First trials yielded 2.55 kg/m^3 in 100 days (9.31 kg/m^3 per year). Equivalent to approximately 143,000 kg/hectare per year.	Projected fish production of 54 kg/m^3 per year, or 1000 kilograms of 0.5 kilogram salmon in an 18,500-liter system with flow rates up to 1500 litres per minute. Average flow – 620 litres/minute.
LIFE SPAN	Pond material life span – 20-30 years.	Not known. Continual replacement of filters, pumps, sub-units, etc.
MANAGEMENT	Amenable to amateurs familiar with aquarium techniques. Novices start with low densities.	Requiring engineering, therapeutic and and handling skills of high order.
TOLERANT OF MISTAKES	Tolerant, except for too heavy supplemental feeding.	INTOLERANT
ENVIRONMENTAL IMPACT	Beneficial – Pond water and by-products used to irrigate and fertilize gardens and orchards.	Varying from little impact to potentially harmful with discharge of treatment chemicals and back-flushed filter materials.
COST	Capital cost of 25-35 cents/gallon to build depending on light reflecting courtyard for pond, and aeration system. Facilities with additional ponds will cost proportionately less.	Capital cost of scaled-up 2nd and 3rd generation facilities, each with an estimated capacity of 500,000 pounds of fish per year is expected to be 1 million dollars.** Estimated to be equivalent to 80 cents/gallon capacity. Smaller systems much more costly per gallon.
RUNNING COSTS	LOW	HIGH

* Description of "Technology of Closed System Culture of Salmonids," based on 1974 report of Thomas L. Meade, College of Resource Development, University of Rhode Island.
** Personal communication with design engineer, 1977.

TABLE II

shows how closely the various components are tied together in an architectural context. The residential food garden is on the left. The hot water storage which contains 20,000 U. S. gallons in three adjacent chambers, the solar heating controls and the composting chamber of the composting-dry toilet are in the basement. Immediately above the hot water storage chambers are the living-dining areas. The living room is shown in Photograph 8 and the dining area and porch overlooking the sea to the southwest in Photograph 9. The bedroom areas are directly above.

The integration between structural, heating and biotic elements is depicted further in Illustration No. 1. Below the barn-food preservation area is the 118 cubic yard rock-hot air storage chamber for the 2000 square foot (185.8 m^2) greenhouse section. Immediately in front is the 20,000 U. S. gallon aquaculture facility. Under the translucent 2500 square foot (232.3m^2) south roof are areas used for vegetable and flower crops. The bench against the south wall is for the rooting and propagating of young trees using mist irrigation. Photograph 10 shows part of this area.

Table III gives the square footages for the subelements within the structure.

ii. *Redundancy and Diversity*

The Ark's climate is achieved through nine diverse, complementary techniques. It relies upon two active solar hot water systems, including a 700 square foot (≃65 m^2) collector for space heating and a passive warm water aquaculture facility for the bulk of its heating. An active warm air and hot rock storage system in which a fan circulates the air in and out of storage utilizes solar heat trapped by the building beneath its translucent south face. A heat exchanger transfers energy from the hot water to the hot air system, providing a relatively sophisticated degree of redundancy and control. A wood-fired furnace, yet to be used, has been installed as an emergency back-up system.

Energy needs have been minimized through a number of conservation techniques. These include few north side windows, tight construction methods and elaborate insulation of up to 12 inches of fiberglass on

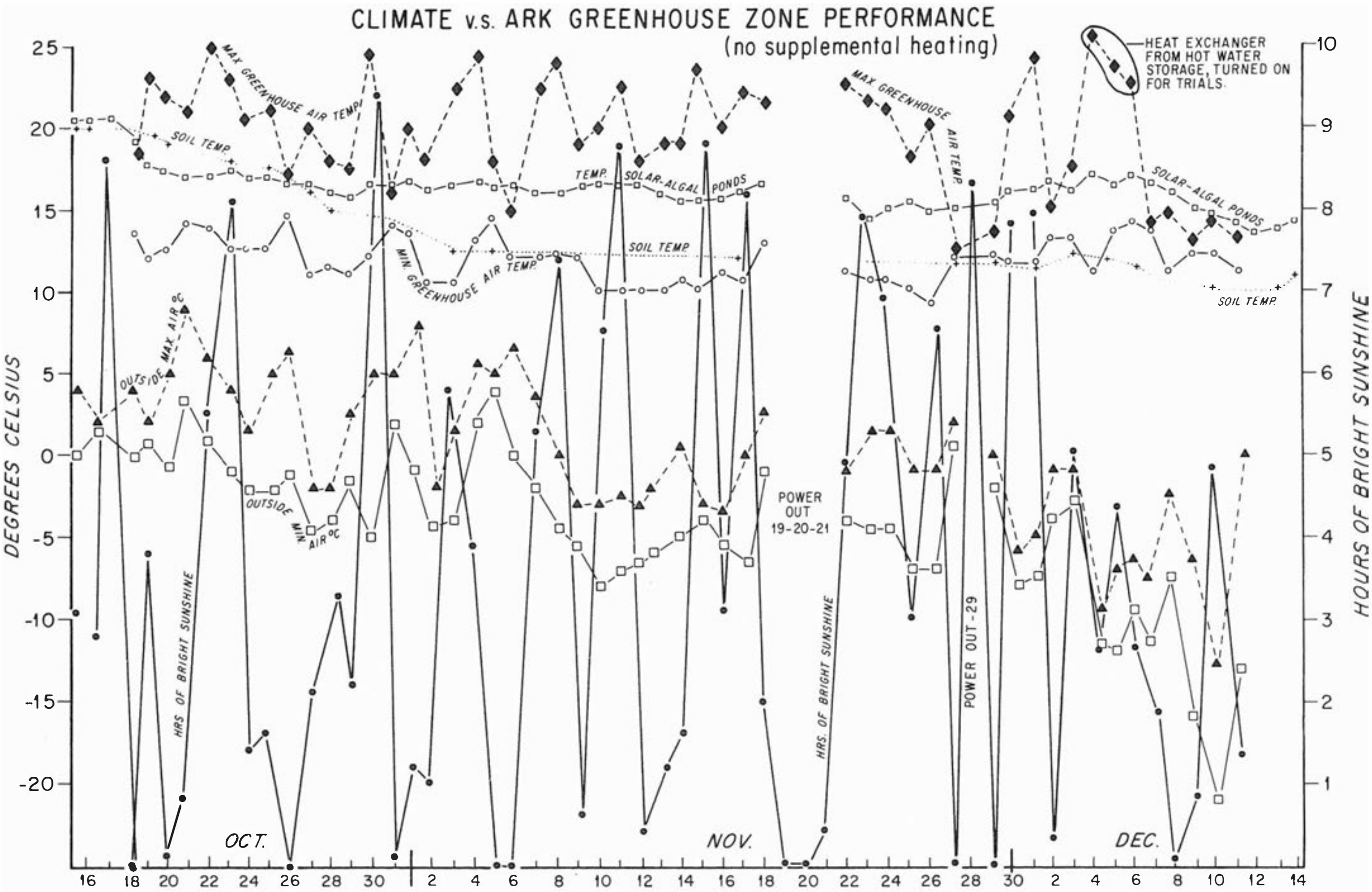


FIGURE I

the ceiling. The overall energy budget is further reduced through attention to micro-climatological possibilities. Windbreaks help protect the Ark on all sides but the north. Here an earthen berm was constructed to deflect north winds over the building.

The whole system approach to climate control has already proven its worth. During the same November storm mentioned earlier, the Ark's windmill was shut down and Island Utility electrical power was off for three days. The building was without either its hot air or its fan-coil hot water heating and the standby wood furnace was not used because the resident was in the hospital. The solar-algae ponds provided most of the heat, releasing an estimated million B.T.U.'s to maintain a safe internal climate in the food growing area despite sub-zero conditions outdoors. Figure 1 shows the building's performance during that period.

iii. *Renewable Energy Sources*

The Ark emulates nature by depending upon the effective utilization of solar energy and its derivatives. The dominant input is the sun. Winds provide some of the electrical power. Wood is used for supplemental heat. Biotic components provide gas exchange, humidity regulation, air purification and waste treatment, absorb solar energy and produce foods in commercial quantities. The diversity of renewable energy networks enables it to function as a semi-autonomous bioshelter.

iv. *Photosynthetically Based Food Chains*

As in a pond, field or forest, photosynthesis in the Ark provides the basis for its food chains. In the aquaculture facility, several species of green algae proliferate, providing feedstocks for fish and regulating the metabolism of the fish culture ponds. (See Table II for details.) The growing of food and tree crops is a direct photosynthetic process.

v. *Microbial Pathways for Self Regulation*

Waste is decomposed using microbial means. Human sewage, kitchen and garden wastes are composted and sterilized biologically.

The Swedish composting dry toilet reduces water use by approximately ten thousand gallons per person per year. Since wastes, apart from grey water, are treated internally, no sewage is dumped into the sea, nor does the Ark require a central sewage treatment plant. Such a structure situated in a densely populated urban area would save society an estimated $40,000.[16]

The dry toilet-compost system eliminates sewage sludge which is a major environmental pollutant and human pathogens.[17] The Ark will produce an estimated 550 to 600 pounds of high quality fertilizer per year containing approximately 46 pounds (20.9 kilograms) of nitrogen, 14½ pounds (6.6 kilograms) of potassium and 6¼ pounds (2.8 kilograms) of phosphorus from human wastes and kitchen garbage. In addition to the fertilizer from household wastes, greenhouse refuse including weeds, roots and outer leaves of the crops, seaweed, fish offal and miscellaneous organic matter will be generated. After one year, waste material is reduced some 95 per cent by volume and is completely composted and safe for use as a fertilizer.

The dry toilet is a Swedish Clivus Multrum. It is technologically simple but, in order to function, it contains a biologically complex ecosystem that is based on chemosynthetic autotrophs. These organisms do not require light to reduce carbon dioxide and to synthesize nutritive substances. A few simple instructions are all that is required to operate dry toilets despite their biological complexity.[18]

within the Ark. The metabolic waste products of the fish are treated in the sediment layers of the solar-algae ponds. They are eventually siphoned into the deep garden beds where they are used as fertilizer. Diverse microbial communities have been introduced into the greenhouse soils to help check plant diseases and pests and to increase carbon dioxide production. Low levels of carbon dioxide would otherwise limit greenhouse crop production.

vi. *Overall Homeostasis*

Homeostasis is accomplished by different routes. Several of these have been described. Our design objective has been to achieve a high degree of homeostasis or control within the Ark with a minimum of energy and cost. Much has yet to be learned as this is an area in architecture that has been little explored. We have made an effort to create biologically, architecturally and electronically a number of internal symbiotic elements. Symbiosis characterizes stable

ARK SQUARE FOOTAGES

	Square Feet	Square Feet
MECHANICAL SPACES		
Equipment Room (Net Floor Area)	253	
Rock Storage Duct Work Space	66.5	
Tanks (Gross Including Walls)	441	
Tanks (Net Capacity):		
Tank A	49	
Tank B	113	
Tank C	201	
Total Tanks		363 square feet=2540 cf.
Rock Storage Area:		
Gross	480	
Net Usable	400	
Well Room:		
Gross	70	
Net	50	
GROSS AREA DEVOTED TO HEAT STORAGE		921
NET AREA OF TANKS AND ROCKS		763
NET FLOOR AREA DEVOTED TO MECHANICAL		≈370
COMMERCIAL GREENHOUSE		
Gross Area		1910
Net Usable:		
Fish Tanks	680	
Growing Beds	480	
Suspended Planters*	272	
Circulation	408	
FAMILY GREENHOUSE		
Gross Area		234
Net:		
Suspended Planters and Herb Planter	128	
Fish Tank Area	19	
Circulation	80.5	
ATTIC SPACES		400
WORKSHOP		293
BARN/GARAGE		
Net Interior:		
Floor Level	430	
Loft	200	
Total		630
RESIDENTIAL CIRCULATION		
Net Interior Rooms:		
Entry	80	
First Floor Hall (including Closet)	55	
Hall to Livingroom and Lavatory	32	
Upper Hall	40	
Stairs and Landings	146	
Total		353

	Square Feet	Square Feet
SERVICE SPACES		
Net Interior:		
Lavatory	27.5	
Bath (including Linen Closet)	47.5	
Laundry	17.5	
Kitchen (Plus Broom Closet)	145.0	(54 square feet counter top)
Total		237.5
LIVING SPACES		
Net Interior:		
Laboratory (Plus Balcony and Closet)	235	
Livingroom/Dining Room	505	
Small Bedroom (including Closet and Shelf)	170	
Large Bedroom (including Shelf, Closet and Loft)	286	
Master Bedroom (including Closet)	207	
Total		1403
OUTDOOR SPACES		
Lower Deck	225	
Upper Deck	72	
Total		297
GROSS RESIDENTIAL		
(Less Family Greenhouse)		1812
GROSS FAMILY GREENHOUSE		234
Residence Total		2046
GROSS COMMERCIAL GREENHOUSE AND WORKSHOP AREA		22210
GROSS ANCILLARY SPACES		
Laboratory and Balcony	242	
Entry and Hall	140	
Barn and Loft	572	
Basement	350	
Total		1304
TOTAL GROSS BUILT AREA TO BE OCCUPIED		
(Doesn't Include Attics, Tanks and Rock Storage)		5560
GRAND ENCLOSED TOTAL		
(Includes Attics, Tanks and Rock Storage)		6881

FIGURE III

Photo by Albert Doolittle

Photo 8 — Living Room. Solar Heat Storage Beneath in Three Tanks Totalling 20,000 U. S. Gallons.

and energy efficient living systems. By coupling food production to internal purification cycles, nutrients are conserved and continuously recycled. We chose to assemble deep and diverse soil ecosystems for the Ark. We wanted soils that would be productive for commercial crops, fertile and intrinsically capable of regulating disease and pest organisms. Our "homeostatic" approach to terrestrial greenhouse gardening is not common. It differs from commercial greenhouse practices in that the latter incorporate sterile growing mixtures in shallow benches or growing beds as a substrate for crop culture and are heavily fertilized and frequently sprayed, fumigated and sterilized.

In the Ark, we sought to create soils that were semi-permanent and would continue to increase in fertility over time.

A greenhouse glazing (Rohaglass SDP16 — a new acrylic double-glazing) was used that permits ultraviolet wavelengths to penetrate and strike soil and plant surfaces, helping to regulate bacterial and fungal populations and possibly reduce the probability of plant diseases. There were a number of reasons for opting for a deep soil ecosystem instead of sterilized, chemically managed shallow growing beds. In the first place, the former does not require biocides which threaten fish life. Secondly, sterilization is an energy intensive process requiring heat or toxic fumigants such as methyl bromide or chloropicrin, whereas viable soils are ecosystems capable of utilizing available energy and are highly efficient in energy use. Thirdly, a rich soil environment can generate the high levels of carbon dioxide necessary for optimal plant production. These high levels are often supplied industrially in many commercial greenhouses which are otherwise incapable of supplying their own CO_2 needs. Fourthly, weeds and crop by-products, if not sprayed, can be fed to the fishes. Over the next few years, it is our intention to compare the biological approach employed in the Ark's contained environments with standard greenhouse practices. During Fall-Winter 1976-1977, lettuce, kale, spinach, chard, broccoli, parsley, bean, herb and flower crops have grown well, being free of disease and relatively unaffected by pests.

The Ark's climatic stability or resistance to external perturbations seems to be remarkably high for a northern climate solar facility that is situated in a region of sporadic sunlight. With its large solar facade, the structure oscillates thermally more than a thermostatically regulated building heated with fossil fuels but, as Figure 1 shows, the environment within remains stable with outside temperatures as much as 34.5^{o} Centigrade colder than inside the greenhouse area. After November 5, the minimum interior air temperature varied only 5^{o} Centigrade, the pond temperatures 3.5^{o} Centigrade and soil temperatures 2.5^{o} Centigrade. After a year of collecting solar heat, full storage capacity will be attained. At that point, oscillations should dampen and the Ark's thermal stability will be further enhanced.

In common with natural ecosystems, the Ark has high levels of internal information and low entropy. It is a miniature world. Its information tends to be organized, internal and complete rather than spread loosely among interconnected elements as occurs in highly stressed environments or in relatively wasteful industrial societies. The comparatively low levels of entropy within the bioshelter enable it to make a more positive contribution than an ordinary household to the exterior environments or to society. We are attempting to study homeostasis, information and energetics within the Ark. Photograph 11 shows the laboratory where thirty-three climatological, biological and performance characteristics are monitored. It is hoped that through measurement, analysis and computer modeling using "real time" information, the broader question of design can be extended.

vii. *Interphasing with Adjacent Ecosystems*

Designers tend to neglect creative interphasing with adjacent ecosystems. It should be possible for a household or a building to contribute to its surrounding environment.[19] Most reduce neighboring ecological integrity and pollute. Ecosystems tend to interact with each other in more subtle and beneficial ways which include ameliorating and stabilizing climates and exchanging nutrients and organisms. The Ark minimizes the release of toxic materials from a human habitation. It contains a tree-propagating facility which is intended to help reforest the surrounding region. Mist propagators assist in germinating seedlings and in propagating rooting cuttings of thousands of valuable trees. Most will be fruit, nut and fodder trees destined for orchards, windbreaks and ecologically derived agricultural forests. The tree facility epitomizes the ideal that bioshelters not be retreats from the larger world but building blocks for a society rooted in concepts of stewardship.

ACCEPTANCE OF AN ARK-TYPE LIFESTYLE

The following comments are subjective impressions condensed from those of the designers, architects, builders and tenders.

Living in the Ark can be an extraordinary experience. Living and working in a structure where the sun, the wind, architecture and ecosystems are operating in concert has affected most of us. It seems to foretell what the future could bring. Each of us involved in the project would like to live one day in an Ark-inspired bioshelter. Its psychological impact is not easily articulated. The Ark, as a humanly-derived microcosm, creates a sense of wholeness and integrity engendered by a high degree of self sufficiency. The growing areas function as half-way stations between the residential interior and the external environment. There are no barriers, only

Photo by Albert Doolittle

Photo 9 — Dining Room, Overlooking Sea to the Southwest. Resident Greenhouse on Left.

external "membranes" separating inner living and laboratory spaces from the biological working areas and the out-of-doors. There is a natural progression from one sub-environment to another. Because of this, the world outside is less alien and even an ally as the source of one's fuel and power needs.

Working with vegetable crops, flowers or trees or tending the fish while a howling blizzard rages is exciting. Watching the sensors in the laboratory read out the Ark's various functions and monitor its health while the cold wind rages connects one consciously to the forces sustaining all life. One feels immediately useful knowing that tree seedlings will help in reforesting and that the crops will help to feed the community. Knowing it is a center for gathering knowledge leads to a sense that untold possibilities exist and that the dialogue has begun. It is our feeling that bioshelters can extend the human experience in northern climates.

ADOPTION OF BIOLOGICAL DESIGN MODELS

Material and fuel scarcities and increased pollution will necessitate that society shift to more semi-closed systems for performing crucial tasks. But the shift could take place within the old paradigm rather than through a new synthesis. It is not given that design approaches borrowed from nature will be adopted. It will probably not be understood that there is a need to rely upon organisms organized into ecosystems in order to continue vital functions of society. A totally engineered approach overlooks the necessity of a partnership with nature. It assumes erroneously that strictly physical and chemical technologies can cope without massive and cheap fuel subsidies. Yet only living systems can do this. The recent debate over U. S. plans for the colonization of space has exposed the fallacy of relying on completely engineered life-support systems for long periods of time.[20,21] Nor is an all technological solution elegant. It has a tendency to be bulky and to use too many materials. It is neither reproductive nor self-maintaining and, if all its structure, functions and controls are comprised of metallic hardware engineering, it will be poor at energy utilization.[22] A greater potential lies in the ecological design and engineering of complex ecosystems. These have the advantages of self-maintenance, respiration and controls partly in the form of multiple species of organisms which allow for natural combinations of circuits and "bio-hardware" selected probably at thermodynamic limits for power and miniaturization for millions of years.

The Ark is one of the first synthetically framed explorations of a new direction for human habitations. With its use of diverse biotic elements, energy sources impinging upon or generated at the site and internal

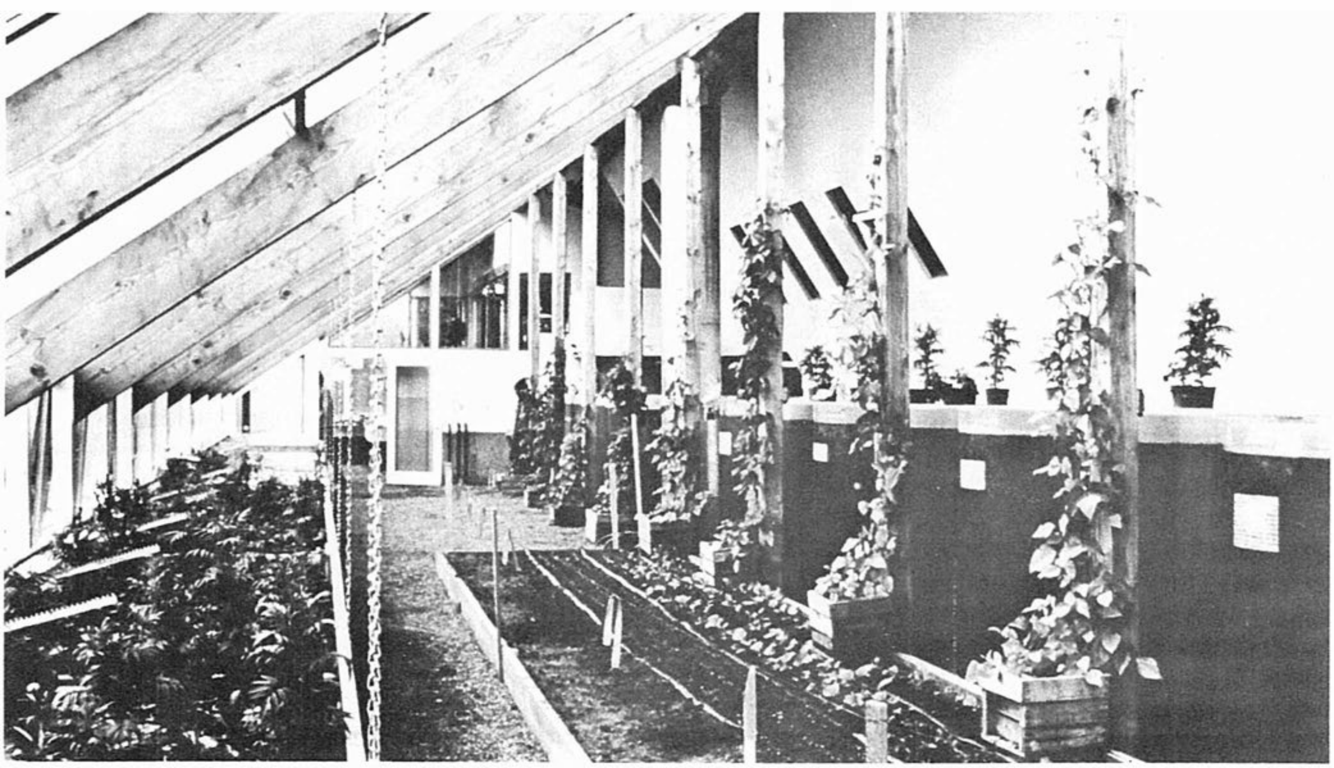


Photo by Albert Doolittle

Photo 10 – Production Greenhouse Area i. Mist Propagating Bench on Left. ii. Vegetable Culture in Middle. iii. Aquaculture on Right.

integration of human support components normally exterior to households, it begins to redefine how people might live. The Ark is not an end point, but an early investigation of a viable new direction. As such it gives concrete form to conserver society concepts.

EXTRAPOLATION OF ARK CONCEPTS TO OTHER DESIGNS AND REGIONS

The Ark has over thirty sensors which continuously monitor the performance of energy, climatological and biological processes and phenomena. These are printed out, at present, in analog form onto recorders. This year we will install a computer-based system for modelling and simulations.

Computer models using the experience of the Ark will rapidly improve the design of bioshelters. The Ark is unusual in the sense that it can be monitored as a "complete" system containing biotic and engineered elements. It can also be divided into subcomponents to elucidate couplings and dependencies. The monitoring already has defined the Ark as a dynamic system of interacting components. This growing body of information can be used to develop computer models of the Ark's dynamic systems. The models can be verified accurately by comparing their predictions to the subsequent behavior of the Ark. Once the model is proven realistic and accurate, it can be extended to model hypothetical bioshelters of differing design in environments unlike that of Prince Edward Island.

Such uses of simulation are well known in industry. While they have been attempted for environmental studies and ecosystems, it is rare that the systems under study can be carefully monitored or manipulated. The Ark provides us with a powerful tool for approaching larger theoretical questions of design. The computer techniques applied to design aircraft or chemical plants can be applied within the Ark to exploring wholistic design theories from an ecological point of view. Ecologists have used systems analysis before but not in the conceptual and useful way as will be possible with the Ark.[23] A mini-computer installed in the structure can be used for much of the initial modelling as well as for monitoring and regulating the behavior of the systems. Thus simulation and observation can be done together in "real time."

THE APPLICATION OF ARKS THROUGHOUT SOCIETY

The widespread usefulness of bioshelters and bioshelter concepts will be questioned and opposed on a number of social, legal, agricultural and economic levels. One senior agriculturalist has criticized the concept on the grounds that Canadians are demanding increasingly that their food be pre-packaged, pre-digested, pre-prepared and ready to heat and serve. Bioshelters producing fresh food run counter to current trends. Yet, despite rising food costs, fresh produce from Florida, California and Mexico is extensively imported and Canada still sustains an approximately $15,000,000 a year greenhouse food crop in the face of rising fuel costs and inefficiently designed structures.

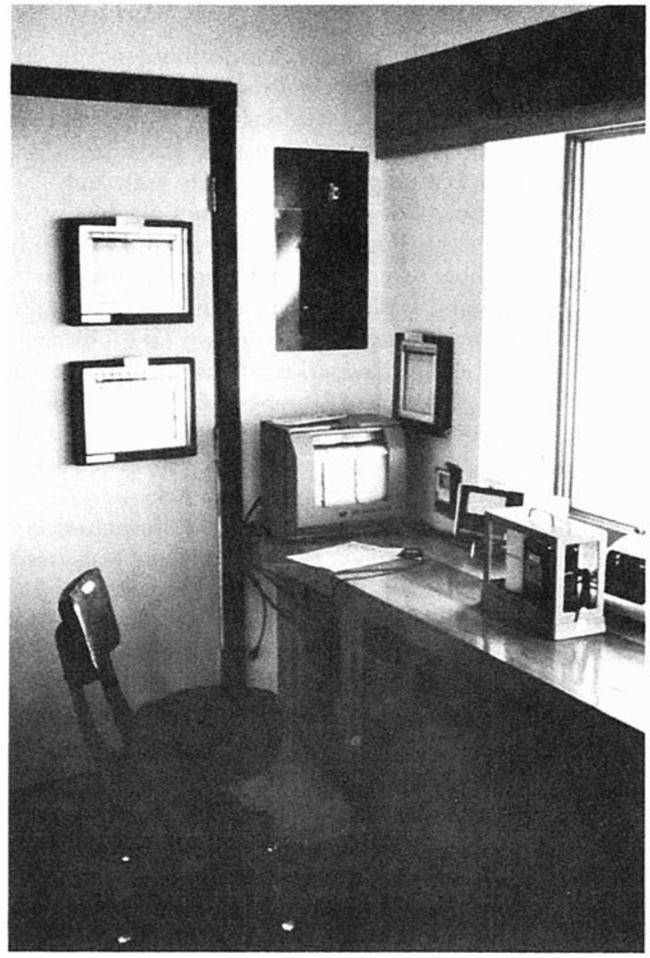


Photo by Albert Doolittle

Photo 11 – Research Laboratory

At the same time, there is a small but growing number of people wanting high quality foods. Another sector, one which often overlaps with the prior group, wants to know the source of their foods and to be assured that they are grown in relatively biocide-free environments. They will pay a premium for such foods. On Prince Edward Island, where food tastes are not generally sophisticated, the demand for produce from the Ark has outstripped our supplies. Even if the Ark were altered from an experimental to a production facility, we could not meet the demand in the rural area where the Institute is situated. A large number of bioshelters producing year-round foods would have ready access to local outlets as such a market is not easily saturated. When projected against increases in food, transport, processing and storage costs, bioshelter produce might become competitive in the near future.

The full value of bioshelters for northern societies will not be realized until power and fuel costs increase further and shortages and disruptions of fuel supplies take place, as has been the case with natural gas in many parts in the U. S. Compared with poorly built and poorly insulated oil or gas heated houses, the higher initial capital costs of bioshelters may limit their adoption for a number of years. This period should allow for the design and testing of second and third generation structures with increasing emphasis on sophistication of design and minimization of costs. We are beginning to foresee a potent new direction for bioshelter development where passive heating-architectural components and ecological entities play an even greater role than in the present New Alchemy Arks.

Possibly the most serious criticism of bioshelters is that they are too complex. Being engineered ecosystems containing high levels of information, they are esoteric, beyond the average person to operate and maintain. While it is true that the Ark is the product of a synthesis created by biological designers, materials experts, agriculturalists, a soil specialist, an integrated pest control scientist, algologists, fishery experts and fish culturalists, architects, solar energy scientists, electronic and computer designers, a systems ecologist, a philosopher and aeronautical and hydraulic engineers, it is also true that the overall design objective was to fabricate a system with its accompanying controls that can be taught to and even improved upon by non-specialists. There has been a conscious effort to design the Ark for lay people.

New Alchemist Ron Zweig[12] describes part of this process in chronicling a small food growing bioshelter built over four years ago. Just prior to the quote he has described the sensor-monitoring instruments he has devised.

"Through the use of information gained with this instrumentation, it will be possible to describe how such a micro-environment could be maintained optimally with much simpler recording devices. Also we shall be able eventually to compile a list of parameters which can be monitored chiefly through human observation. This could be done in terms of humidity, temperature, sight, smell, etc. If, for instance, a pond began to smell oddly, one would know that possibly a portion of the water should be changed with fresh or that the flow through the filtering system should be increased. A color change, from green to brownish hue, for example, would evoke a similar reaction. High temperatures or humidity could require venting the inside atmosphere with the outside cooler, drier one. An overcast day would indicate a decrease in the amount of feed for the fish during the cloudy period to allow for the low oxygen or toxic waste metabolism; i. e., ammonia, by the phytoplankton. There are many factors that have been well documented, and others that we are discovering which we shall have to incorporate in a simple guide to managing these systems. This addition of instrumentation to our work allows us to redefine our bioshelter research and optimize productivity through integrating basic biological principles and the information gained in our observations of their interactions."

Through sophisticated and sensitive intrumentation we are searching for sign posts and keys to enable future tenders of bioshelters to do without expensive mechanical and electrical controls.

A complementary approach is being followed by Albert Doolittle, monitoring-computer specialist for the Ark. He is devising tiny micro-computers to match precisely the needs of the Ark's subsystems. Their capacity and programming will be simplified and the cost of their fabrication will ultimately be much less than most micro-processors available today. His work will interphase human, biological and electronic controls so that a relatively inexperienced bioshelter resident could be trained by the systems themselves without having to worry that his or her inexperience might lead to failure in any major subcomponent. For example, on an overcast day, the micro-processor, basing its decision on accumulated information and incoming sensory inputs, might print out or display instructions telling the resident to cutback 50 per cent on supplementary feeding to the fish. It would further explain that the low light had reduced the ability of the algae to produce enough oxygen to cope with the biological oxygen demand that would be created by normal levels of supplemental feeding. Under other circumstances, it might request reduced feeding because of an unexplainable build-up of ammonia. Based on "real time" information, it could go on to suggest diagnostic procedures.

In our specialist society we tend to underrate the capabilities of a majority of people. There is a deep human tendency to seek a dialogue with non-human organisms. While it often appears in an atrophied form in pet owners, for example, the tendency is almost universal. Plant-filled windows of high-rise apartments attest to this. Although feeding a dog from a can or watering a plant is hardly tending a complex ecosystem, there are people who maintain vegetable gardens or tropical fish aquaria and in so doing are, in a simplified form, caring for ecosystems. The step from the garden or the aquarium to a bioshelter is one of degree, not kind. In 1976 over half of the householders in North America had some kind of food garden. There are many million tropical fish hobbyists. Both these facts suggest that people are willing to work with ecologies based on the same principles as exist within the Ark. These people represent a broad cross-section of society.

There is yet another way of looking at our contention that the prerequisites for bioshelter living exist widely in our culture. A few generations ago, the majority of North Americans lived directly off the land. Although sound stewardship was not a characteristic common to these rural agriculturists, most of them had enough biological savvy to operate highly diversified family farms and homesteads and to build the culture we have inherited. Most people knew how to sustain themselves. If the need or desire were broadly felt, in a few years enough modern ecological, engineering, electronic and agricultural knowledge to manage a bioshelter could be taught. The Ark for Prince Edward Island is a first test of these assumptions.

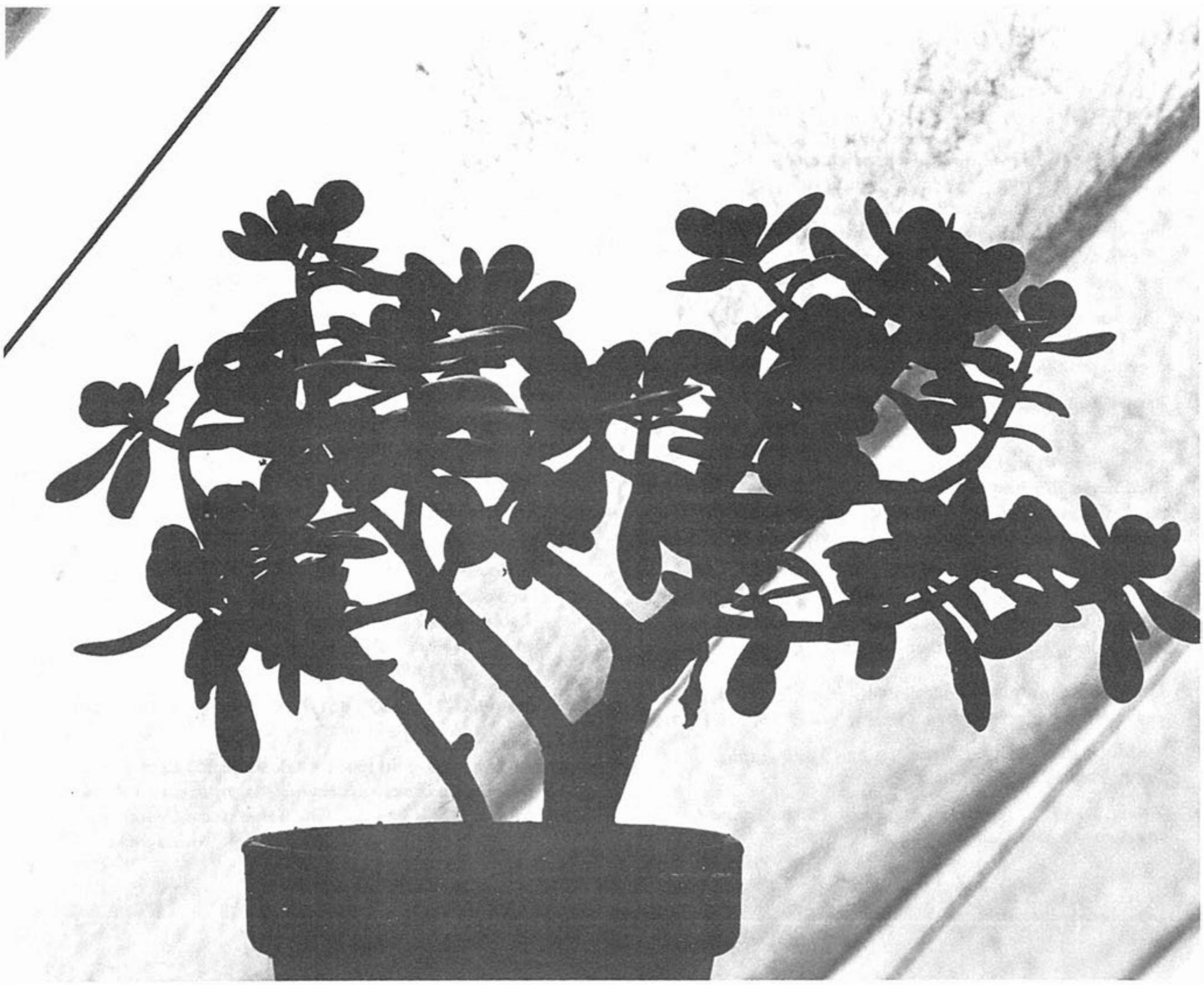


Photo by John Todd

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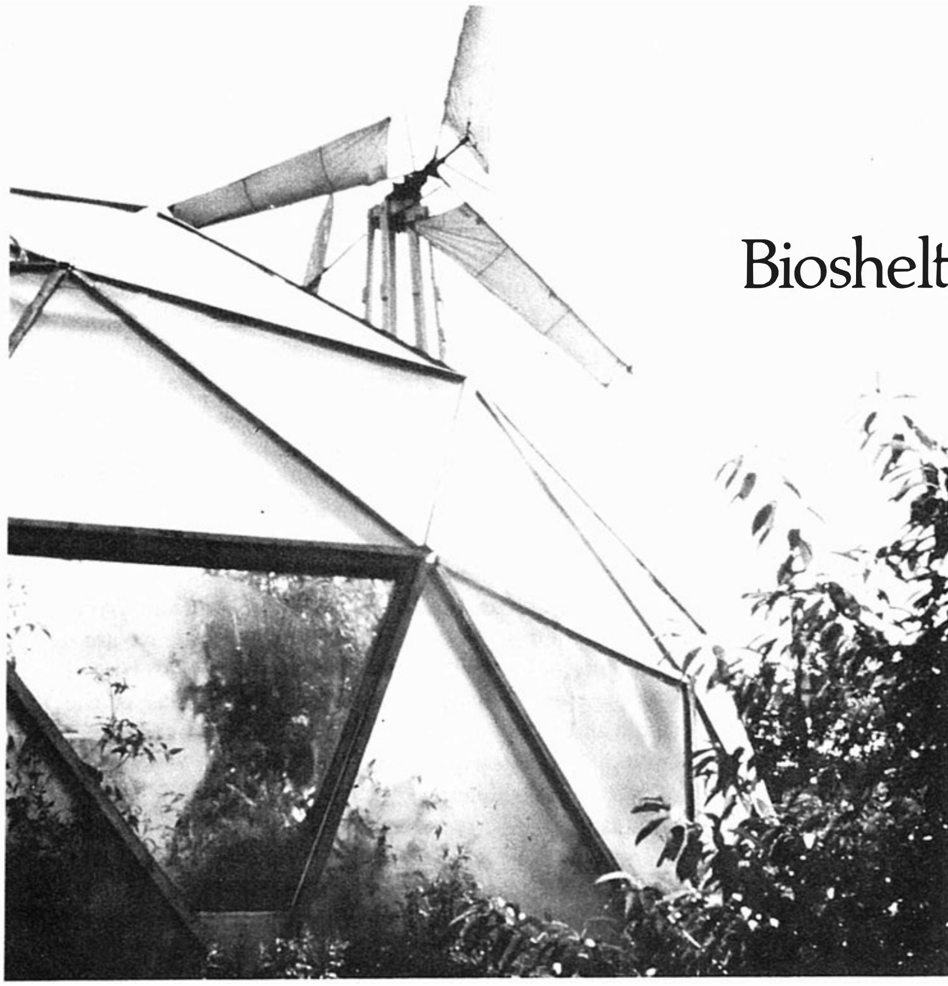


Photo by John Todd

Bioshelters as Organisms

– *Ron Zweig*

Our work with the design and operation of bioshelters is perhaps the most complex aspect of the research at New Alchemy. Initially, translucent structures such as the dome, the miniature Ark and our bioshelter prototype, a small solar-heated greenhouse, were built to extend the growing season for both tropical and temperate organisms to be used for human food. This was done through the collection and storage of solar energy in aquatic systems using the pools in these systems to raise fish, store heat and irrigate both inside and outside crops. From these initial experimental studies, the biological complexities and interrelationships within such systems became more apparent. The structures themselves were found to function as "living" organisms using the microenvironment defined by their external membranes as the basis of their "life." Subsequently, two large structures, the Cape Cod and the Prince Edward Island Arks, have been designed and constructed based on both the information gathered from our own work and on other sources that were discovered in biological and greenhouse literature. The Prince Edward Island Ark includes living quarters for a family.

Our approach to the selection of the components for these structures came first from looking to the natural environment and choosing the biological phenomenon that would be necessary for them to function as living structures and to be productive and healthy. We focused on biological solutions as opposed to technological ones, choosing the former whenever possible.

These bioshelters or semi-closed ecosystems can be seen to be analogous to life as it is found on this planet. In looking at the Earth, it becomes evident that it, too, is a semi-closed ecosystem, receiving much of its energy from an outside source, the sun. Sunlight strikes the atmosphere or outer translucent membrane enveloping the planet. Its outer ozone layer creates a semi-permeability which filters out much of the lethal ultraviolet rays, allowing most of the other wavelengths to pass through unaffected. Life, thereby protected, exists on the Earth's surface within its own evolved, ecological balance, changing through evolution or through major physical disruptions such as earthquakes, floods, droughts, etc. This is an idealized state working solely within ecological parameters without human interference.

In looking from the macrocosm of the Earth to the microcosm of the individual cell and from these to bioshelters, many similarities can be found. Like the Earth, the single cell is also a semi-closed ecosystem. It requires nutrients from outside to allow it to function and replicate. The complexity within is enormous and the balance of its interaction allows the cell to live. An analogy surprisingly close to the eucaryote[1] cell can be made with our dome or backyard fish farm, the early bioshelter, as described in the second *Journal of the New Alchemists.* This will be the focus of this essay.

The outer structure of the dome is covered with two layers of translucent fiberglass ¾ inch apart, which form a thermal pane and function as a protective membrane for the system. There is a 2 inch-thick vertical layer of styrofoam 4 feet deep beneath the dome's circumference. This membrane, much like that of the earth's atmosphere and of the single cell, allows sunlight to enter and to be absorbed and converted into heat energy. The thermal pane traps this heat energy and retards its loss, a function of semi-permeability.

The microenvironment within the dome can be compared to the protoplasm of the eucaryotic cell. There are many organelles[2] within the cytoplasm and many components including organisms within the air and water encompassed by the dome. Several loose analogies can be made between these systems. The chloroplasts of a living plant cell produce oxygen through photosynthesis which, in terms of the dome system, can be compared to the activities of both the aquatic and terrestrial plants living within it. These include the vegetables and herbs growing around the periphery of the ponds and the phytoplankton and other photosynthesizing organisms in the pool and in the biological filter. Each component of the biological filter and the polyculture pool can be related to the vacuoles[3] of a single cell. Their function is the purification of toxic compounds that could kill the animal components. The relationship between the use of the fish waste in the pond water as a fertile nutrient source for aquatic and terrestrial plants can be seen to be similar to that of some bio-chemical pathways within the cell, in the action of the nitrifying bacteria in both the soil and on the quahog shells in the filter. The use of these procaryotic[4] bacteria is clearly an example of eucaryotic mechanisms in terms of incorporating them as a subcomponent in the dome system. By converting the ammonia within the system to a nitrate form, a plant food is created. The plants which feed on these nitrates are then fed to the herbivorous fish, such as the *Tilapia.* This completes the cycle, for it was originally the fish that released the wastes into the system because of their inability to use more than about 10% of what they ingest. The rest is waste. The cycle is continuous. On a macroscale, the filtration system can be compared to that of a circular river.

The electric pump used to circulate the water through the filtering beds can be compared to a ribosome at the cell level. A ribosome, so far as is known, is the center for the coordination of protein synthesis in a cell. It is, however, autonomous from its final protein product in a chemical sense as the pump, at the same time, is autonomous from the pond water.

The energy for the electric pump could come from a wind generator. At the present in the dome we are still using public utilities. If a windmill were to be used, it could be considered the mitochondria[5] of the dome and other water pumping systems. In this analogy this electrical energy would be the replacement of the chemical energy of the cell. The windmill, though, would be an external component. Excess electrical energy could be stored in batteries as in the cell it is stored in sugars and starches.

The chief information center for the cell is known to be the nucleus and its genetic material — DNA. In this regard, much of the control and monitoring of the dome system and the other bioshelters is left to the human element. We are now considering the use of small computers to aid in this. They could be used not only to record information but also to regulate the environment within the ecosystems. For instance, if the dome's environment were to become too warm, the mini-computer could trigger the opening of vents. This kind of system would be an extension of human involvement through programming the device for what we understand to be optimal conditions.

The nucleus within the cell is not the only center of information. The mitochondria and chloroplasts have their own genetic material which governs their replication and behavior. This, theoretically, is carried over from their initial procaryote existence before their evolution within eucaryote cells. Other genetic factors have been known to lie elsewhere in the cytoplasm regarding heredity. In the dome, in addition to the larger physical components themselves, there are interactions between them which can be observed and in many cases predicted. There is a situation similar to the semi-independence of

1. Eucaryote: applied to organisms having membrane-bound nuclei, Golgi apparatus and mitochondria. Includes the cells of most organisms except blue-green algae and bacteria.
2. Organelle: an entity with specific functions within a cell similar to the organs in our body.
3. Vacuole: a membrane-bound fluid or crystal-filled space within a cell.
4. Procaryotic: lacking a membrane-bound nucleus, plastids, Golgi apparatus and mitochondria, as in bacteria and blue-green algae.
5. Mitochondria: the centers for the production of bio-chemical energy.

...phases, in terms of the plants, fish and other animals within the structure. They are controlled, to a large extent, by their physical and chemical environment. There are many interactions, both biological and chemical, in the dome system that as yet we have neither defined nor understood. This is especially true of the many micro-environments within the confines of the dome.

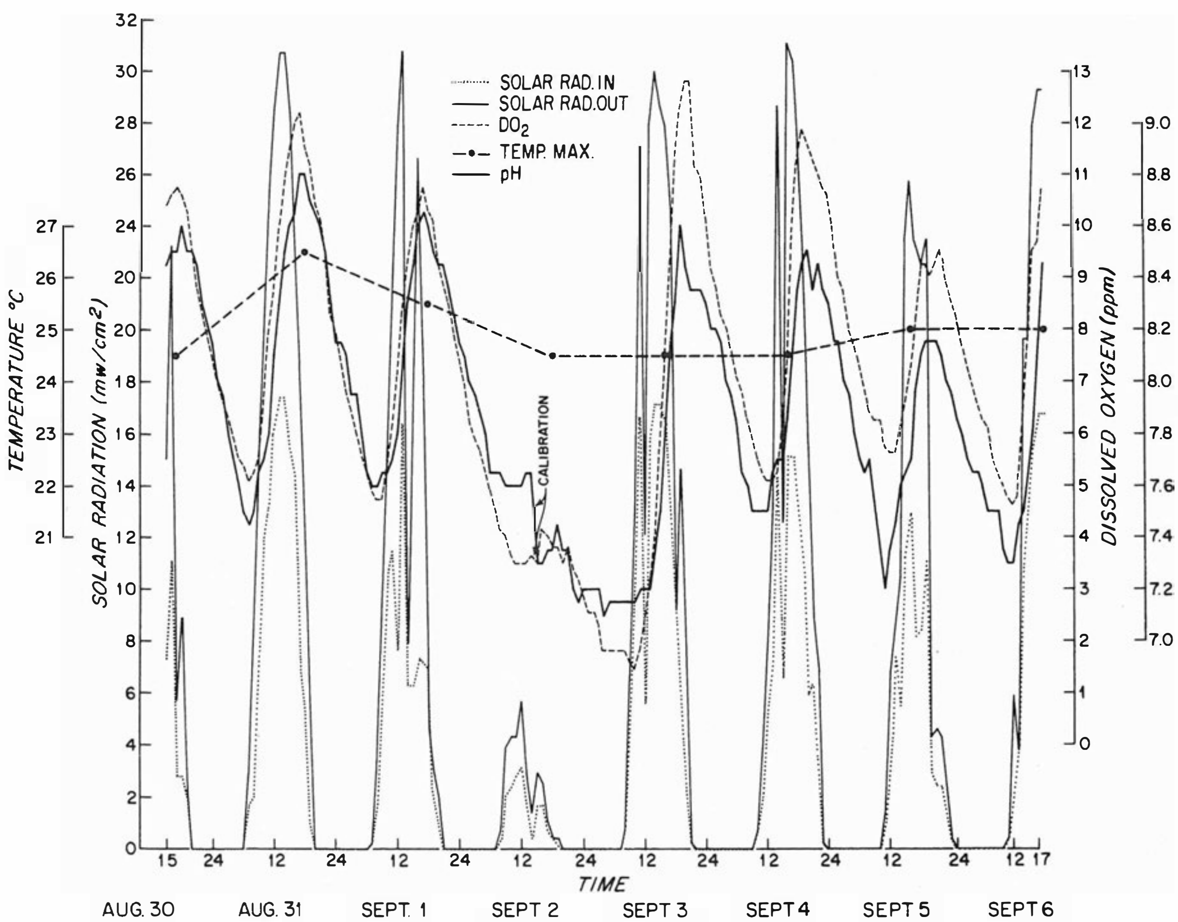
The dome system was designed to raise food, a definitive biological activity, but the design of many structures could advantageously incorporate existing natural phenomena. Among the most obvious are proper orientation for the use of solar energy, the collection of rain water or even a composting toilet. Small greenhouses could be included as has been demonstrated by the Prince Edward Island Ark.

Throughout this analogy, the dome has demonstrated the possibility of looking at physical structures as living systems. This is done through an initial consideration of the biological components to be established in a system and by building to allow for the necessary parameters. The interrelationships between the organisms inside must be taken into consideration to achieve a balanced healthy system. We have included in the dome, as mentioned previously, a polyculture pond, a filtering system and an agricultural area on the ponds' periphery. All of these interrelate. We have begun measuring certain physical and chemical parameters within the structure including air and water temperatures, relative humidity, pH of the water and dissolved oxygen in the water. Solar radiation striking the outside membrane as well as that penetrating the fiberglass membrane and reaching the pond surface is monitored. In addition, we shall be measuring ammonia concentrations in the polyculture ponds, carbon dioxide concentrations in both the pond and air, and moisture levels in the soil. These measurements will be used not only to understand how these systems behave and how they respond to environmental changes as they are set up, but they also will be used to optimize food

Photo by Hilde Maingay

production through modeling. With such physical and chemical data, we can interrelate our previously recorded information on fish and vegetable production, such as the numbers of each species in relation to the make-up of the total population for the most successful polyculture strategies. Most of the following data focus on the aquaculture in the dome.

The following graph illustrates how five different parameters interrelate: they are temperature, dissolved oxygen and pH of the pond water, solar radiation striking the outside of the dome and that penetrating through the double fiberglass membrane to the inside. All the measurements were recorded continuously on an Esterline-Angus twenty-four channel Multipoint chart recorder – Model E 1124E – except for the pond temperature which was measured once daily at the points indicated. The previous graph was transcribed from its millivolt equivalents to the ranges as described. The chart recorder was set to run at eight inches per hour. It did not, however, have an internal clock. This explains the discrepancy between solar time in terms of mid-day and the scale at the bottom. It is on



PARAMETERS OF PRODUCTIVITY IN THE DOME POND

This graph represents one week of monitoring the main aquaculture pool in the dome system. Dissolved oxygen is measured in parts per million and solar radiation in milliwatts/cm^2 (mw/cm^2). SOLAR RAD OUT is the ambient outside measurement and SOLAR RAD IN is the intensity striking the pond surface. The pond temperature was measured once daily while the others were measured continuously. The chart recorder ran slightly faster than its setting creating the discrepancy between the time of day indicated and the intensity of the sunlight expected.

Eastern Daylight Savings Time. The lines of the graph were established by connecting the points between hourly readings taken from the chart paper. This reduced over one hundred and twenty feet of chart paper to the above size. The dissolved oxygen was measured with a Chemtrix Oxygen meter Type 30 and the pH with a Chemtrix pH meter Type 40E. The solar radiation was measured in millivolts per square centimeter with an Agromet-Lintronic Dome Solarimeter.

The kind of information that can be obtained from such a graph can help determine the health of our "organism." For instance, should the dissolved oxygen fall below a certain level, it could result in stress or suffocation for both the fish and algae in the pool depending upon the tolerance of the species. It is essential that dissolved oxygen be monitored to insure a proper balance between numbers of fish and potential oxygen production through photosynthesis.

The sunlight that penetrates the dome to the surface of the pond is absorbed by the phytoplankton in the water, triggering photosynthesis. The predominant phytoplankton species has been identified as *Golenkenia* sp. with some *Scenedesmus* sp. and a few other trace species. The diurnal pattern of solar radiation for both inside and outside the dome structure is clearly illustrated. During the week of the recordings, measurements were as high as 31.1 mv/cm^2 outside ambient with all readings going to zero each night. Some days had periods of scattered clouds. On September 2 the sky was overcast for the entire day as illustrated by the low radiation readings. Some days, such as September 3, had periods of scattered clouds illustrated by the variations that day as compared with August 31 which was free of clouds. On September 3 the outside radiation was higher than on September 4, but the inside levels were inverted – that is, it registered higher inside on September 4. More water condensation between the fiberglass layers on September 3 could be the reason for this.

To determine the rates of photosynthesis, fluctuation of concentration of dissolved oxygen in the water was recorded. The oxygen tended to follow the intensity of the solar energy received. The oxygen level went up during the day and down at night. There was a delay after light readings were recorded before the oxygen level would level off and begin to increase. For instance, on August 31, 8.9 mv/cm^2 were required and, on September 1, 7.6 mv/cm^2 were required. This indicates there is a required threshold level of solar energy coming into the system before oxygen is produced in excess of that necessary to maintain the respiration of both the animal and plant life in the pool. Other sources of oxygen coming into the water can be a result of atmospheric exchange at the surface or from splash from the water flowing down the different levels in the filter.* These, however, are relatively stable and the pumping rate is also constant.

The pH or acidity of the pond water followed the oxygen concentration very closely in terms of activity. When the dissolved oxygen concentration increases or decreases the pH follows, as indicated by the graph. This is largely because of the photosynthetic activity within the pond. During a sunny day, the photosynthetic process utilizes carbon dioxide and releases oxygen as one of its by-products. The higher the carbon dioxide concentration, the greater the acidity; and, therefore, the lower the pH or vice versa. Alkalinity was not measured. Since we did not possess a carbon dioxide electrode at the time of these recordings, an accurate CO_2 concentration was impossible to calculate. However, it is inversely related to pH. As the pH increases, the carbon dioxide concentration decreases.

From the data collected, it is possible to determine roughly the amount of carbon fixed each day in the primary production of the photosynthetic process in the dome pond. From the graph, primary productivity seems to be limited by the amount of carbon dioxide in the water. On August 31, a clear, cloud-free day, the solar radiation striking the pond reached 17.4 milliwatts per square centimeter and the dissolved oxygen level climbed to 12.2 parts per million at its peak, from a low of 5.1 parts per million the night before – a change of 7.1 parts per million. In comparing this information with that of September 4, we see how primary productivity is limited. This statement is based on the basic photosynthetic equation – $CO_2 + H_2O \xrightarrow{light} (CH_2O) + O_2$. This is the basic summation of the chemical reaction; however, there are several steps involved, as described by Calvin and Bassham, showing overall that the oxygen produced is in balance with the carbon dioxide consumed. During August 31, a clear day, the solar radiation striking the dome pond reached 17.4 mw/cm^2 and the dissolved oxygen level climbed to 12.2 parts per million at its peak, from a low of 5.1 parts per million the night before – a change of 7.1 parts per million. On September 3, with some morning cloud interference, the solar energy striking the pond climbed to 17.1 mw/cm^2 while the oxygen level reached a peak of 12.8 parts per million from a low of 1.45 parts per million the night before, an increase of 11.35 parts per million. The difference in temperature of 2^oC for the two days can account for only a 0.26 parts per million DO_2 in terms of saturation at 26.5^oC and 24.5^oC – saturation is approximately 7.92 parts per million and 8.18 respectively (Lind). This would indicate that with the dark, cloudy day of September 3, there was a build-up of CO_2 in the system due to a lack of conversion to oxygen as a result of low levels of solar energy available to drive the photosynthetic reaction. Even with the higher energy striking the pond on August 31, the oxygen level did not get as high as that of September 3. The minimum pH on August 31 was as low as 7.45, whereas on September 3 it was down to pH 7.1, indicating a higher CO_2 concentration than on September 4. Therefore, CO_2 would seem to be the limiting factor for photosynthesis in the pond on at least these two bright days. Everything else, so far as we can find, was constant for both days in terms of inputs into the pond. This information will be computed in terms of primary productivity later in this paper.

As already mentioned, this kind of information can indicate the health and productivity of such a

*Diffusion in and out of the water was not measured and probably accounts for a small percentage of deviation.

system. The oxygen level is a good measure of the stress on the fish and organisms, at least in terms of respiration. *Tilapia* remain in good condition with dissolved oxygen levels as low as 4 parts per million. As illustrated by the graph, the pool dropped to 1.5 parts per million DO_2 within the upper 25 cm of water (measurements were made within this range of depth). It was probably a bit lower below that depth, in which case the whole pond was well below 4 parts per million DO_2. The *Tilapia* were under stress and their metabolic activity was detrimentally altered. The aquatic system of the dome became unhealthy to the fish due to this deficiency. *Tilapia,* being physostomes, which are fish with an opening to their swim bladder, are capable of using this organ to exchange gases and to some extent use the atmosphere above the pond as an oxygen source through "gulping" at the surface. It is common on cloudy days in many of our systems to see this behavior. If the pond had been highly overstocked, this situation could have become critical with a possible anaerobic condition occurring, which would cause the death of both fish and phytoplankton.

Such monitoring can allow us to compare different populations in a variety of polyculture strategies. The effect of many chemical changes is still unknown to us. For instance, we found that during this one-week period the pH of the system was as high as 8.8 and as low as 7.1. Just what effects this pH fluctuation has on the microorganisms like bacteria, phytoplankton, zooplankton and protozoans are unknown to us, but possibly whole populations of bacteria could be replaced by others with such diurnal changes. These are areas we have yet to investigate in order to increase our understanding of these systems as wholes. Each aspect in itself is simple, but the totality of the interactions can be quite complex. Within a limited range, living systems have the capability to achieve their own balance. The components to be included and the way in which they are established will determine production.

It is possible to compute primary productivity through the use of recorded levels of dissolved oxygen. On all days described besides September 2, the concentration of DO_2 surpassed normal saturation. For example, on September 3 a supersaturation of 12.8 parts per million DO_2 at 24.5^{o}C was recorded. At 24.5^{o} C the normal saturation is approximately 8.18 parts per million; therefore, in the late afternoon of September 4, 150% saturation was achieved due to the high photosynthetic activity. The equation for computing primary productivity in regard to DO_2 levels is found in *Standard Methods for The Examination of Water and Waste Water,* 1975, 14th Ed. Its carbon fixed mg/1 is equal to mg O_2 released per liter times 12/32 times 10^3 times the volume in cubic meters. To determine the volume of water in which photosynthesis was occurring, a Secchi disc was used which determines light penetration to 5% or minimum photosynthetic depths. The reading was 40 cm. The volume of water concerned in the dome pool was 6.74 cubic meters of the 18.78 cubic meters of the total pond, or 36% of the total volume. By taking the increase in dissolved oxygen levels daily, we can determine the amount of carbon dioxide photosynthesized each day. This was recorded at 18 grams of carbon fixed on August 31, 15.2 grams on September 1, 1.52 grams on September 2, 28.7 grams on September 3, 17.1 grams on September 4 and 10.4 grams on September 5. This shows that the limiting factors in this system are the amount of carbon dioxide available and the amount of solar energy with the wavelengths of light necessary for photosynthesis entering the pond. According to Cook (1949) the total amount of solar energy that could be used under optimal conditions by a culture of *Chlorella* (a species of Chlorococcales) was 2.5%. On a sunny day, as illustrated by the graph, this 2.5% would be in excess in terms of the amount of carbon dioxide available; there, CO_2 is the limiting factor on bright days.

Through the use of information gained from this instrumentation, it will be possible to describe how such a microenvironment could be maintained optimally with much simpler recording devices. We shall be able eventually to compile a list of parameters which can be monitored mainly through human observation. This could be done with humidity, temperature, sight, smell, etc. If, for instance, a pond began to have an odd smell, one would know that a portion of the water should possibly be changed for fresh or that the flow through the filtering system should be increased. A color change, from green to a brownish hue would evoke a similar reaction. High temperatures or humidity could require venting the inside atmosphere to outside, cooler, drier air. An overcast day would indicate a decrease in the amount to be fed to the fish to allow for low oxygen production or toxic waste metabolism, such as ammonia, by the phytoplankton.

Many biological factors in the area of our work have been well documented. We are discovering others that we shall have to incorporate in a simple guide to managing these systems. The addition of instrumentation to our work allows us to refine our bioshelter research and to optimize productivity through integrating basic biological principles and the information gained in our observations of their interaction.

I should like to thank Al Doolittle and Bill von Arx for their assistance in this work.

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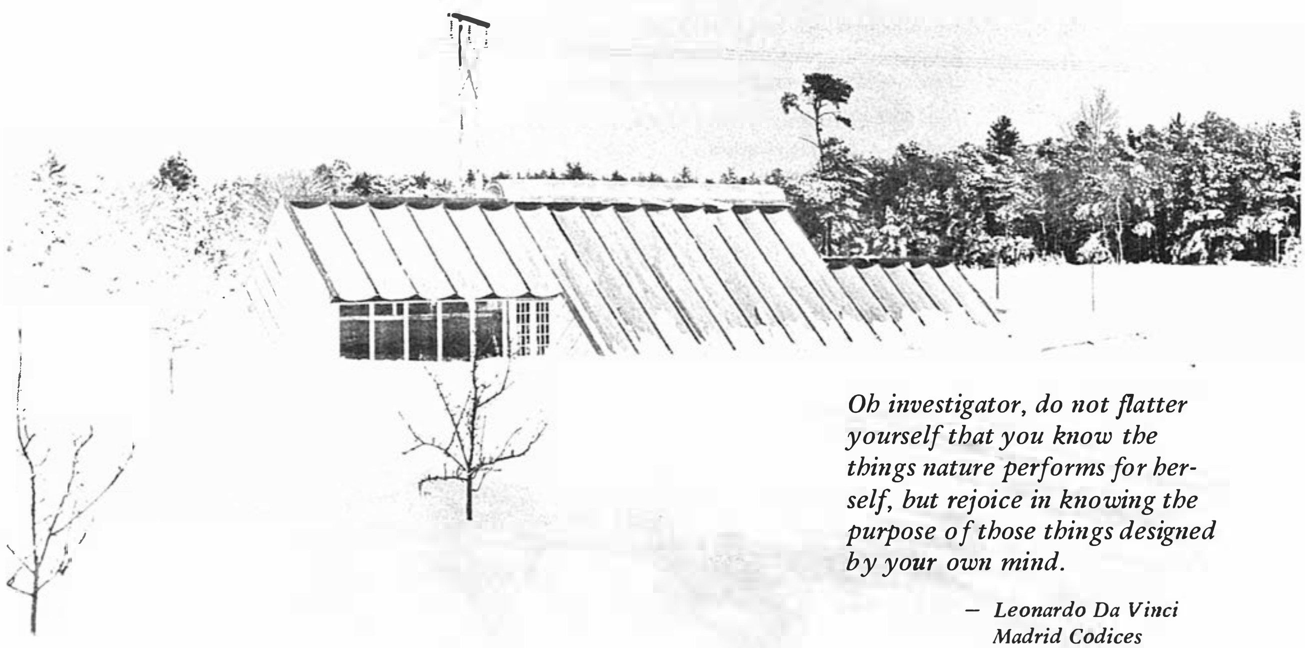
Photo by Hilde Maingay

Bioshelter Primer

– Earle Barnhart



Oh investigator, do not flatter yourself that you know the things nature performs for herself, but rejoice in knowing the purpose of those things designed by your own mind.

– Leonardo Da Vinci
Madrid Codices

Photo by Hilde Maingay

THE INTENTIONAL DESIGN OF MICROCOSMS

I. INTRODUCTION

The process of creating a microcosm of life, protected and nurtured by an architecture that is responsive to its environment, is at once exhilarating and sobering. The realization of the human role within the mystery and complexity of biological systems comes slowly. As designers and maintainers of bioshelters, we are attempting to unravel the complex relationships which exist between living organisms and their substrates, between biological organizations and their environment, and between human actions and their consequences. In bioshelters we have a unique opportunity for investigating some of these relationships on a human scale, simultaneously providing ourselves with year-round food supplies.

All of the plants, animals, and micro-organisms used in agriculture have developed, over time, in a matrix of physical and biological conditions that influence their present suitability for human manipulation and use. Where human communities are mindful of their physical dependence on the health of their landscape, symbiotic partnerships develop. When human communities ignore or forget basic ecological dynamics, the biological environment that protects and nurtures them deteriorates, often resulting in deserts or floods, droughts or famine. The rate at which large-scale degradation can occur is frightening. In Costa Rica recently, large regions have evolved from tropical forest to desert in less than a decade. If humanity is to survive, we must learn to recognize and respect successful ecological patterns, whether in the wilderness, a garden, or a bioshelter. Sensitivity to the dynamics of the whole is crucial. The investigation of biological microcosms is one path to the kind of sensitivity required to comprehend wholes. It is hoped that the subsequent knowledge will enable us to act more wisely in the world.

The reality of a winter food garden in northern climates has become possible for significant numbers of people only in this century. Enclosed plant communities range from sterile commercial monocrop factory-greenhouses to exquisite and exotic zoological gardens. New Alchemy's development of bioshelters is part of a long-range program for year-round fresh food production. We are trying a number of methods of extending the annual growing season. We are working with cold frames, solar-based cloches, and several kinds of greenhouses for vegetable and aquaculture gardening. For mid-winter conditions, research is now centered on medium-sized, solar-heated structures which enclose an internal garden ecosystem of plant, animal, and soil communities. The aim is to develop an interesting, productive microcosm of vegetables, vines, insects, trees, and aquaculture ponds for winter food production.

The Cape Cod and Prince Edward Island Bioshelters, which we call Arks, are comparable in size to small, family-operated, commercial greenhouses. Each was designed in response to its particular climate and is intended to require no fossil fuels for maintaining its internal climate. The Cape Cod Ark is limited to vegetable and fish production and has appropriate climate control facilities to sustain it. The Prince Edward Island Ark includes not only agriculture and aquaculture, but also a residential area for a family, which takes advantage of the heating and climate control of the rest of the structure. Similar architectural and ecological strategies are employed in both Arks, many of which will be discussed.

II. ARCHITECTURAL STRATEGIES

The general appearance of the Cape Cod Ark is shown by accompanying architectural drawings and photographs. The major features are calculated to stabilize the effects of external weather oscillations and to form diverse internal microclimates of temperature, light and moisture conditions. The ecologist, Eugene Odum, suggests that, in nature, the great diversity and organic structure of a mature ecosystem have survival value in the resulting ability to achieve some measure of stability or homeostasis, but that, in a fluctuating physical environment, this is at the cost of a decrease in net productivity. We are testing the idea of using the physical structure of the Ark to supply the desired environmental stability of a mature ecosystem, while maintaining the productivity of a "young" one. By sustaining a more stable internal climate comprised of many diverse microclimates, we are able to grow a large variety of food plants in the winter season. This results in a more diverse biotic community in the Ark and in an interesting winter diet for us. Architectural elements such as terraces, aquaculture ponds, stone walls, and vertical trellises all contribute to the structural complexity of the interior.

The major components of the building include:

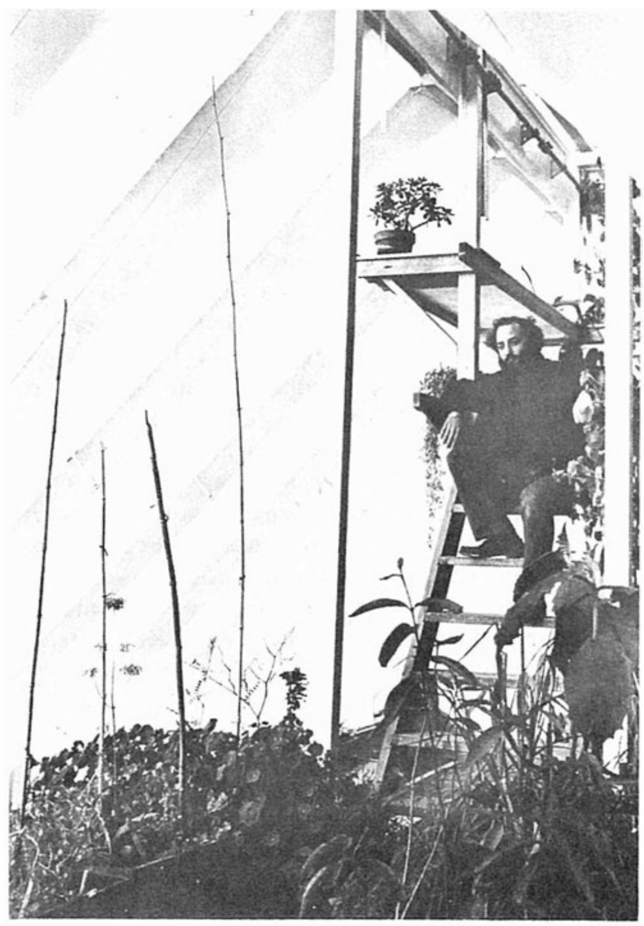
Solar Membranes. The south-facing roof and parts of the east and west walls are formed of double-glazed fiberglass which allows light to enter the structure but retains warm air. The fiberglass tends to diffuse incoming light, spreading it evenly to all corners of the growing area. This characteristic avoids "burning" of delicate greenhouse plants in seasons of intense radiation. The fiberglass also admits some of the natural ultraviolet light, important in the control of fungus. Curved into transparent cylinders, the same material is used in solar aquaculture ponds, because it allows for maximum photosynthesis and dense algae growth.

Passive Thermal Mass. Only a fraction of the light entering the Bioshelter is used directly by the plants for photosynthesis. Much of it turns to heat and is used in the evaporation of water. Some is absorbed as heat by soil and plants. The absorbed heat is valuable in warming the plants' microclimate at night. We have tried to maximize the mid-day passive heat absorption process to use for later night warming in the following ways:

(1) The retaining walls of the vegetable terraces are made of field stone.

(2) The high north foundation wall and the walls of the rock storage bin are of solid concrete and are insulated from the outside soil to reduce conductive losses. These walls absorb heat from both direct sunlight and warm daytime air.

(3) The solar aquaculture ponds used in the Ark are important units of heat storage. Previous experience



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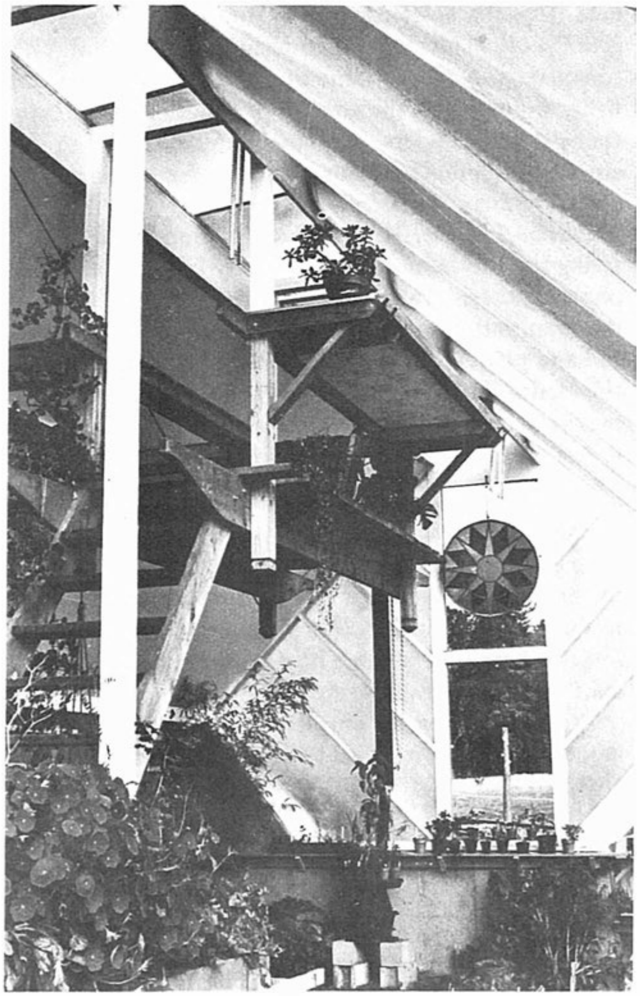


Photo by John Todd

with these ponds in greenhouses where the ponds are the major thermal mass has shown that a body of water is remarkably effective at moderating the diurnal temperature cycle. We are now discovering that above-ground transparent ponds containing an algae culture are even more effective than in-ground ponds. The solar ponds have a better absorbing surface in low-angle winter sunlight. Light entering at all levels allows thermal mixing instead of thermal stratification as in in-ground ponds. At night, more heat enters the air by convection because less is lost into the ground by conduction. By careful placement of solar ponds, one can create special temperature zones for tender plants, and the rate of heat release at night can be regulated by double-glazing the pond or using a lid.

(4) The open concrete pond absorbs light and heat, and the warmed water is used for irrigation.

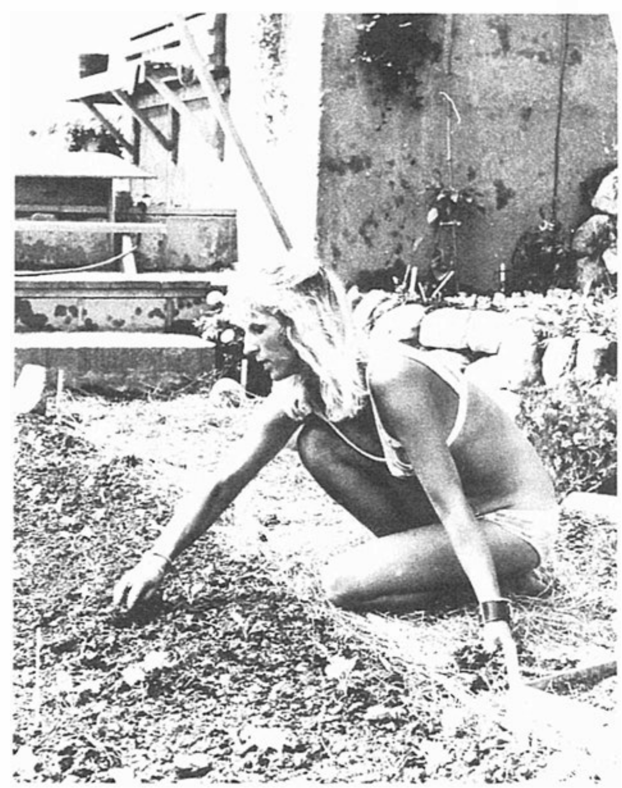
Active Diurnal Heat Cycling. Even with large amounts of thermal mass in the structure, on bright sunny days there is often a surplus of heat that accumulates in warm air near the ceiling. The warm air is drawn by a fan into an air duct in the north wall and is blown into a large concrete bin filled with fist-sized stones. As the warm air passes through the matrix of stones, it loses some of its heat to the stones before being exhausted back into the building again. During the warm portion of the day, excess heat is stored in the stones, keeping the plants from overheating. Halfway through the next night, when the passive thermal masses have already cooled, the fan comes on and circulates air through the warm stones, then into the greenhouse in the pre-morning hours when it is most needed.

Light Reflecting Ceiling. The sloping inner surface of the insulated north roof is painted white to reflect light downward onto the plant canopy. In some northern greenhouse tests of this design, light intensities at the plant canopy were greatly increased due to the reflection.

Convective Venting. In the summer months when no heat storage is required and excess heat must be removed, ventilation panels at the peak of the roof are left open and hot air rises from the building by convection and is replaced by air entering through the open doors. If necessary, the fan can actively exhaust hot air to the exterior.

III. BIOTECHNICS

Within the confines of the climate-modifying structure just described, we have begun to assemble an ecosystem of plant, animal, and soil communities which will be productive, healthy, and beautiful. Many of the basic principles of ecosystem structure and function have been formulated by diligent scientific research,

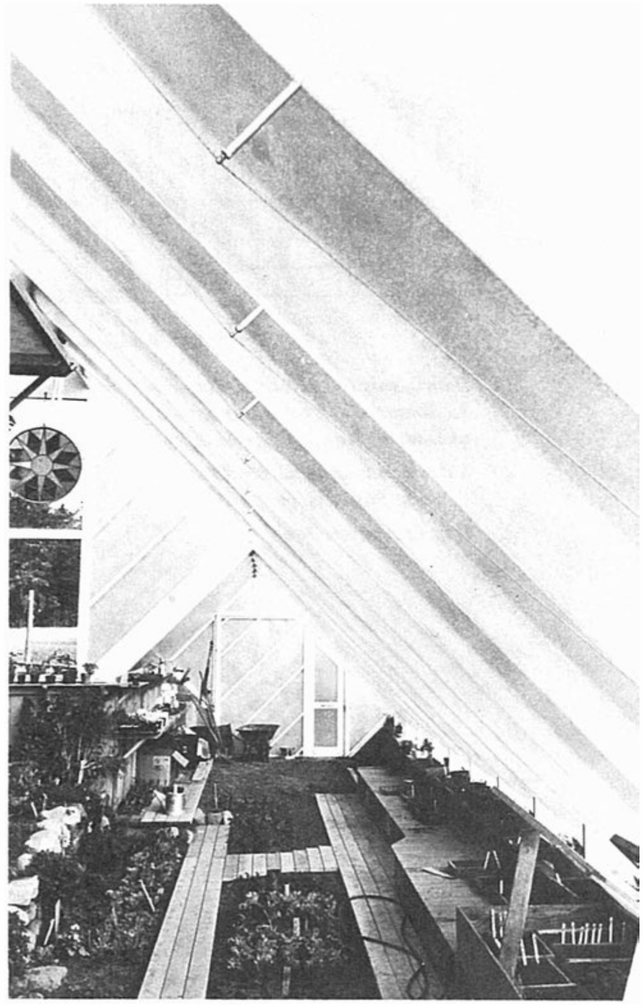


but no comprehensive design theory relating humans, agriculture, and nature has been proposed that is directly applicable to our task. We are engaged, then, in a subtle challenge, to understand the apparent workings of the natural world deeply enough to live and to co-exist permanently and creatively within it. Speculating on the possibility of such a symbiosis between the earth and humankind, René Dubos is optimistic:

> "Symbiotic relationships mean creative partnerships. The earth is to be seen neither as an ecosystem to be preserved unchanged nor as a quarry to be exploited for selfish and short-range economic reasons, but as a garden to be cultivated for the development of its own potentialities of the human adventure. The goal of this relationship is not the maintenance of the new status quo, but the emergence of new phenomenon and new values. Millennia of experience show that by entering into a symbiotic relationship with nature, humankind can invent and generate futures not predictable from the deterministic order of things, and thus can engage in a continuous process of creation."

The reciprocal transformation required to evolve such a symbiosis implies that humans must learn and learn well their responsibilities to the whole of which they are part.

Some general patterns in the workings of nature can guide us. The accepted indicator of health in natural ecosystems is diversity, diversity of species, niches, food



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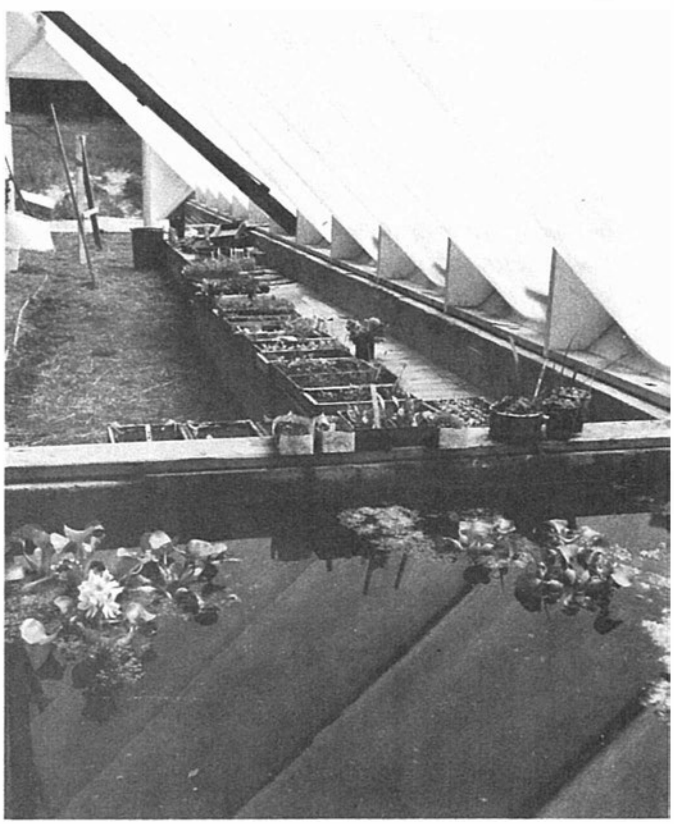
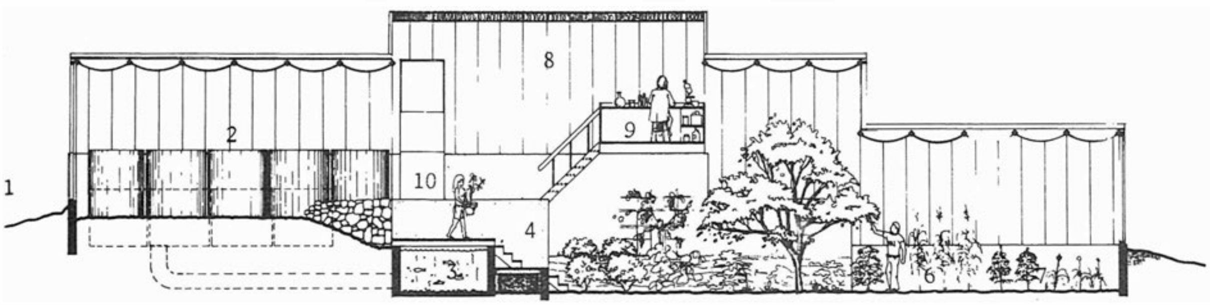


Photo by Robert Cole

chains, and so on. Most present agricultural ecosystems are purposely *not* diverse, since high net productivity of food demands a simplified food web with humans occupying many of the top positions.

The immediate aim of agriculture, then, is to act upon an ecosystem to promote a net productivity of food and materials in excess of that required within the ecosystem by its members. The wider task is to accept that humans are *in* the ecosystem (as large omnivores), and to discover which patterns of behavior within the ecosystem offer the chance of a permanent ongoing co-existence between themselves and the earth, sustaining both human culture and all other species. Possible models for such continuing co-existence would be those human cultures which have remained in one region for centuries without causing the progressive degradation of their supporting ecosystem. Absolute failures are easy to observe and well documented. Successes are difficult to ascertain, but potential candidates exist at two interesting extremes. One is the slash and burn agriculture of the Maring people in the New Guinea rain forests, in which the forest ecosystem is allowed to remain complex doing

CROSS SECTIONS OF THE CAPE COD ARK



1 - Courtyards (Not Shown) Housing 33 Solar-Algae Ponds Connected to Interior Aquaculture Facility

2 - Solar Pond Aquaculture Elements — Warm Water Heat Storage

3 - Demonstration Pool

4 - Rock Hot Air Heat Storage

5 - Experimental Economic Plant Culture Zone

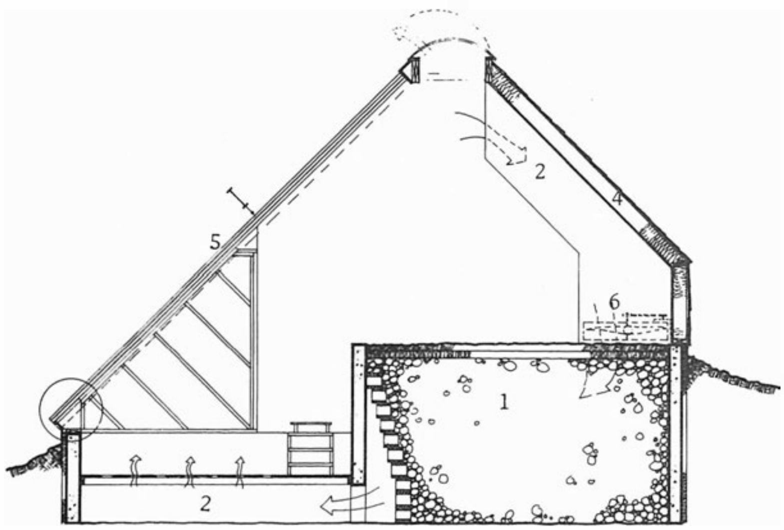
6 - Production Zone

7 - Food Crop

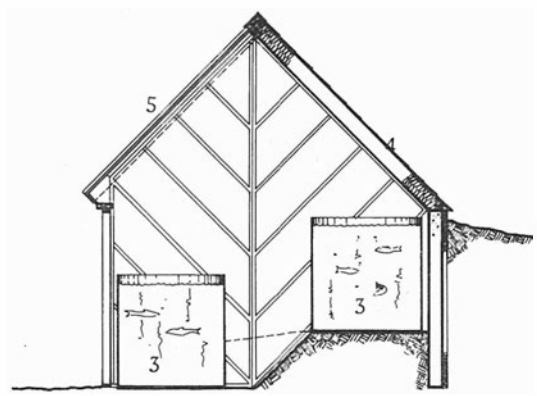
8 - Insulated North Reflective Interior Surface

9 - Research Laboratory Pedestal

10 - Fan for Removing Hot Air to Rock Storage



SECTION A.A



SECTION B.B

1 - Rock Storage

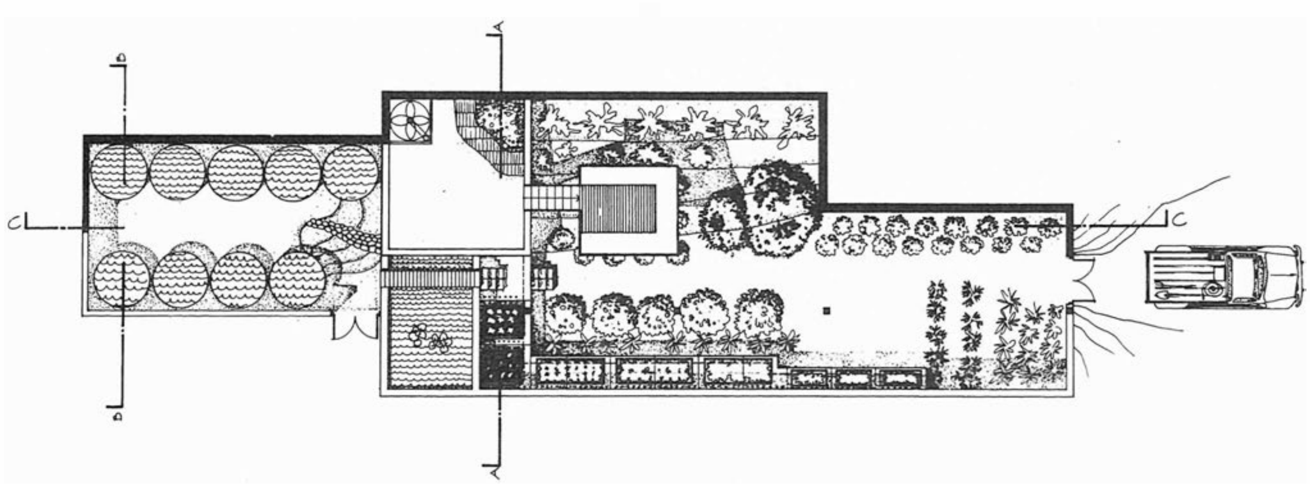
2 - Air Flow

3 - Translucent Solar-Algae Pond for Intensive Fish Culture

4 - Insulated North Wall

5 - Fiberglass (Double Layer) Southern Exposure

6 - Fan



the regeneration and recycling work essential to maintain fertility. The other extreme is labor-intensive garden agriculture in Southeast Asia in which people regenerate domesticated species and recycle nutrients manually within the ecosystem. Conceptually, the bioshelter tends to resemble the latter, insofar as intense care and management of carefully selected food plants maintain a stable "young" ecosystem, completely domesticated yet highly productive. In such an agriculture, each species is selected for its value to humans and is continuously sustained by them.

A. MICROCLIMATES

In constructing the bioshelter ecosystem, we have chosen valued traditional food plants as major species and have tried to calculate the optimum microclimate and required auxiliary species for each one. For instance, some fruiting vegetables need pollinating insects while others require predators for aphids. The entire garden ecosystem of food plants, insects, soil organisms, etc., by virtue of its historical domestication is simplified yet productive. By providing and encouraging essential regulating species and discouraging competitive or non-adapting ones, a new community can be formed which is adapted to the bioshelter conditions.

Each garden organism is somewhat specialized in such habitat requirements as root depth, soil temperature, light/shade preferences and moisture. Therefore the initial design criterion for the Ark was that it provide a moderate over-all climate with numerous microclimates, so that a wide range of food plants could be grown. Examples of these microclimates include:

Terraces. In the smaller prototype of the Ark we observed that a general temperature gradient existed; cold air from windows and cracks settled on the floor, while warm air rose to the ceiling. The few degrees difference in soil and air temperature was sufficient in the same light conditions to produce green peppers on a raised bed but not on the floor. In the Cape Cod Ark there are several terrace levels. On ground level, we are growing the most hardy vegetables, such as lettuce, chard, kale, and parsley. On middle levels, we grow head lettuce, snow peas, green beans, and herbs. On the high terrace during spring and fall months are tomatoes, peppers, cucumbers, and bamboo.

Terrace Walls. The retaining walls of the terraces are of field stone, each containing numerous pockets of soil for plants. Because the stones are warmed by the sun daily, the plants there have a slightly drier, warm zone. Some of the clinging or hanging plants used are New Zealand spinach, strawberries, nasturtiums, thyme, parsley, and other herbs. Another retaining wall, this one below the main aquaculture ponds, is of concrete blocks set with their holes running horizontally. This area is dry and shady; plants growing in these soil pockets are herbs, ivy, comfrey, vetch, purslane, and other fish foods.

North Wall Trellises. The high concrete north wall creates a vertical warm zone for climbing and espaliered plants. The wall remains warm in the evening, where tomatoes, malabar spinach, figs, grapes, and cucumbers grow.

Heat Storage Bin. A unique area for subtropical species is on top of the heat storage bin, which is at a generally warm elevation and is warmed from below by stored heat. On this surface are many tropical and subtropical species, planted permanently or temporarily overwintering. Several plants from New Alchemy's Costa Rican Center are there, including perennial sweet peppers, lemon grass, papayas, naranjila, and hibiscus. In addition, there are dwarf citrus, dwarf cherry, a large rosemary, and various palms and ornamentals.

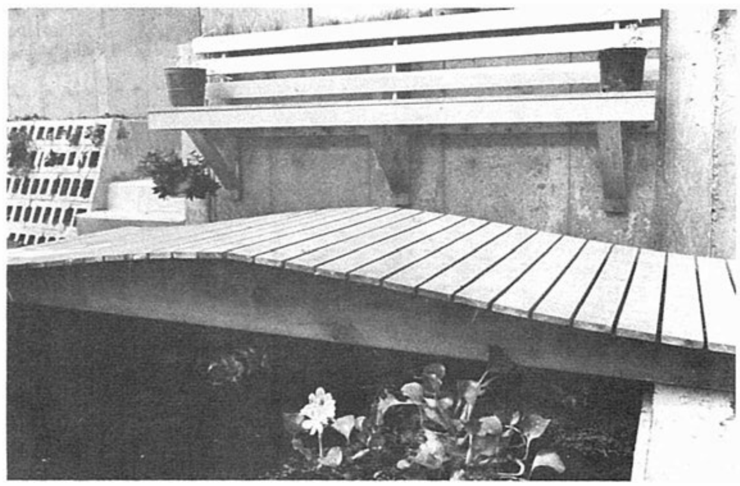


Photo by Robert Cole

Seedling Bench. Circulating air from the heat storage bin is distributed to the Ark through a long low air chamber along the southern wall. The surface of this chamber is ideal for the propagation of vegetable seedlings, tree cuttings, and tree seedlings, as it receives bottom warmth from the air passing beneath. On this surface we grow seedlings for periodic winter replacements, and large numbers of seedlings for spring use. This bench also serves as a potting area.

Compost. Any weeds and vegetable waste not fed to fish are composted in one corner of the ground level. This is a somewhat controversial practice in terms of greenhouse sanitation, so until we have further evidence, we shall compost wastes indoors but use the compost outside. It remains a slow, constant source of CO_2 and heat as it decomposes, and provides a home for crickets, spiders, beetles, sowbugs, and other insects.

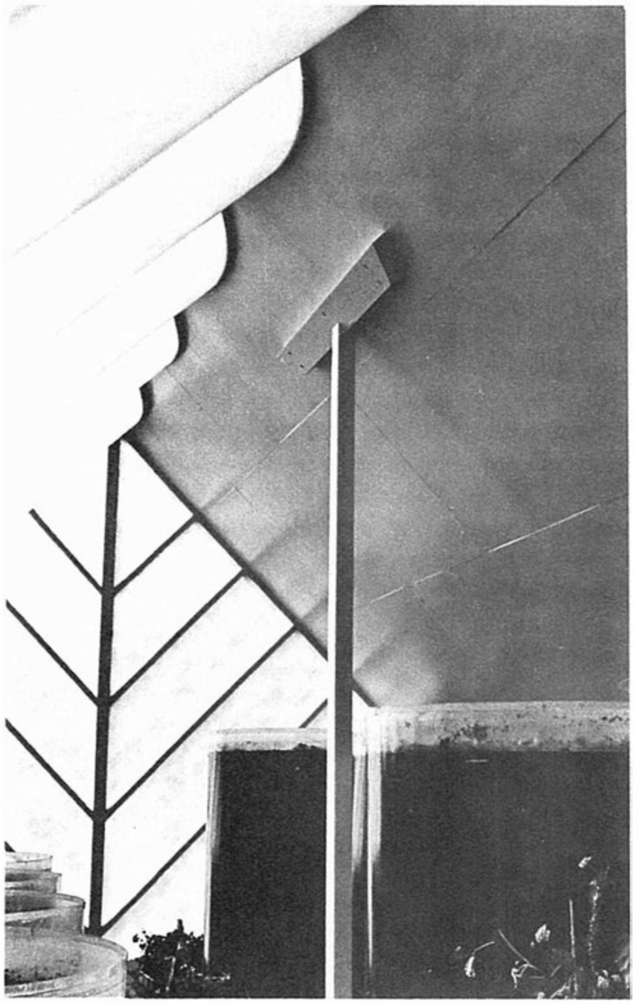


Photo by John Todd

Herb Area. One portion of the growing area has been reserved as a permanent habitat and food source for predatory and pollinating insects. It contains many flowering herbs, wild flowers, and garden-edge plants to provide continuous shelter, nectar, and pollen. Within this area there is also a tiny pond for use by insects, toads, and other residents.

Open Pond. The garden area is irrigated with water from the concrete pond. The water is partially warmed through the wall that divides it from the heat storage bin and is a biotic reservoir of aquatic species for aquaculture purposes. In it are a variety of plants and animals, including several species of fish, *Azolla,* water hyacinths, turtles, a frog, freshwater mussels, and crayfish.

Solar Aquaculture Ponds. At various locations in the garden area we have placed solar aquaculture ponds to provide a localized microclimate for plants that might benefit from warmth radiated from the ponds at night. By careful positioning of one or more ponds near a wall, specialized zones for sensitive plants can be created.

B. BIOTA SELECTION

In the selection of organisms for a bioshelter, some knowledge of the dynamics of an outdoor garden is helpful. We have tried to establish a polyculture of garden vegetables, herbs, flowers, and several small trees and vines together with obvious associated pests and predators in a rich, biologically-active soil. While all of the interactions of combined organisms cannot be predicted, patterns that appear in successful gardens can be approximated.

Soil. The soil in the growing area and terraces is comprised of a twenty-four inch deep mixture of field topsoil, leaf mold, and rotted manure, with small inoculations of garden, meadow, lakeside, and forest soil organisms. The health of soil life is more difficult to observe than that of larger organisms, but the soil's function of nutrient processing and recycling is vital to the long-term performance of the ecosystem. The soil community may also be crucial to the maintenance of the gaseous equilibrium of the internal atmosphere. Earthworms were added to the soil to aid in mixing and decomposing the initial rough organic matter and to distribute soil microorganisms. Earthworm density may eventually be used as an indicator of the soil condition.

Plants. The majority of plants tested over the past two winters has been food plants – garden fruits and vegetables. Other categories have been herbs, tropical tree seedlings, ornamentals, houseplant cuttings, and vegetable seedlings. A list of all plants tested appears in Appendix II. Varieties which thrive and produce well are being tested for optimum microclimate and growth periods; varieties which sicken or are overwhelmed by pests are removed. Outstanding successes in Cape Cod conditions are noted in Appendix II. Another group of plants, those that spontaneously appear from weed seeds, are not listed, but include hairy vetch, purslane, clover, and buckwheat.

Animals. Animals include humans, soil organisms, insect pests and predators, toads, birds, bees, wasps, spiders, and many others that are obvious members of garden fauna. Some were intentionally introduced, but most entered on plants, in soil, or as colonists during the fall. Several intriguing immigrants are: a tree frog which provides jungle sound effects, paper wasps which perform most pollination duties, and visiting birds who drop in occasionally for a bite to eat. An annotated list of introductions and observed immigrants appears in Appendix III.

An interesting analogy on the population dynamics of the Ark ecosystem is that of the species on an island located near a mainland. Population ecologists now theorize that newly formed islands absorb colonizing species rapidly until an equilibrium is reached between immigration and random extinction of species on the island. Mathematical models of this theory have been verified in several instances and may be appropriate in understanding a bioshelter.

Pseudo-Organisms. In a sense, a solar aquaculture pond could be compared to a new type of organism, exhibiting mixed characteristics of a cell, an organism, and an ecosystem. It admits light, has an internal photosynthesis/respiration process and a "body" temperature and metabolism, and is linked to the gaseous equilibrium of the bioshelter atmosphere. Distinctions between levels of biological organization become hazy when analyzing such a community.

IV. INVESTIGATION: PURSUING THE STATE OF THE ARK

Presently we are engaged in several directions of research: (1) Testing food plants for adaptivity and productivity; (2) Monitoring succession and development of new food web relationships; and (3) Investigating climate control patterns and their effect on ecosystem productivity. These activities are closely interrelated and the methodology is evolving with the structure. The main concepts of each investigation will be touched on briefly.

Testing Food Plants. The food production aspect of the bioshelter is considered part of a larger agricultural process including summer gardens, food forests, and animal husbandry. The function of the present bioshelter in that scheme is to produce a source of winter vegetables, a year-round supply of fish protein, vegetable seedlings for summer gardens, and valuable fruit and nut seedlings. Of particular interest to us is whether such an integrated agriculture can sustain a family or small group by supplying their food needs with enough surplus to market to their community.

We are concentrating on vegetables which are enjoyed fresh or which cannot be easily stored from the summer. By monitoring growth rates and production periods, we hope to develop a seasonal planting sequence to supply constant fresh food and seedlings as needed. Certain crops grown commercially in northern greenhouses are being analyzed to discover whether bioshelter production could be competitive with greenhouses using fossil fuels.

Monitoring Succession. Soon after the construction of a microclimate and the introduction of desired species, a natural phenomenon occurs of which all gardeners are painfully aware – pests and unexpected weeds appear. Since we do not completely understand the functions of minor organisms, and indeed are often not even aware of their existence, it is wise to respect their presence until it becomes apparent that they cause a difficulty. We have allowed most species to remain observed but unmolested as we determine their roles. Weeds in the soil are allowed to grow until it appears that either the root system or leaf canopy is interfering with a food plant. The weed is then either removed or dug into the soil at that spot. Undoubtedly the presence of the weed in the soil stimulates some segment of soil microorganisms, and such diversity of process may be valuable. Yearly applications of outdoor garden compost and seasonal migrations of insects guarantee a continuous influx of species over time, and careful observation should reveal new relationships as they arise.

Climate Control: Fine Tuning. One type of climate control is the establishment of temperature microclimates. This is done through permanent architectural elements and through variable control of active heat storage and air circulation. A further possibility is an auxiliary wood stove for cold, cloudy periods. The mechanical and fuel energy required for these controls, and the resulting benefit in productivity, is of great importance in determining the ultimate effectiveness and viability of bioshelters.

Other fundamental questions yet to be answered include: the overall effect of great or small tempera-

Photo by John Todd

ture fluctuations on the productivity of the ecosystem; the importance of air movement to productivity; the addition and optimum utilization of auxiliary heat. We are developing instrumentation to help us begin to answer these questions.

V. EXPLORATIONS

A great many facets of bioshelters remain to be explored. Fields of research which New Alchemy is initiating are:

Sheltering Bioshelters. Biological climate modification of architectural structures using winter windbreaks and summer shading with vines and trees.

Plant Selection. Developing plants genetically adapted to bioshelter existence.

Computer Modeling. Use of instruments and mathematics to test predictive models of improved bioshelters.

Wind and Solar Power Sources. Development of windmill compressed air for mechanical tasks and solar cells for electrical controls.

Human Bioshelters. New hybrids between human housing and bioshelters, in which each benefits from the sharing of solar energy and climate moderation.

The Cape Cod Ark is an early stage in the development of the bioshelter concept. We are just beginning to sense its potential as a catalyst in humankind's understanding of nature. The most captivating vision is one which includes people in the system, as is being tried in the Prince Edward Island Ark in Canada. To assume the conscious responsibility of the ecosystem that sustains one is a fundamental change in awareness that has been sadly lacking in the industrialized west. Perhaps by this route, by first contemplating and internalizing the microcosm, larger changes can follow.

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APPENDIX I

The Ark — Bioshelter 1 — Cape Cod Microfarm

STRUCTURE

Length	90'	(27.43 m)
Maximum Width	28'	(8.53 m)
Floor Area	1950 sq. ft.	(181.16 m^2)
Adjacent Aquaculture Courtyard (Not Shown in Illustration)	1200 sq. ft.	(111.5 m^2)
45° Angle South Facing Roof	2000 sq. ft.	(185.89 m^2)
Vertical South Facing Roof	160 sq. ft.	(14.86 m^2)
Translucent Ends	320 sq. ft.	(29.91 m^2)
Laboratory Pedestal	72 sq. ft.	(6.7 m^2)

AQUACULTURE

Pool	2,872 gallons	(10,870 liters)
9 Interconnected Solar Ponds In Interior	6,610 gallons	(25,020 liters)
21 Interconnected Solar Ponds In Exterior Courtyard	15,422 gallons	(58,380 liters)
Total Solar Pond Aquaculture Facility	22,032 gallons	(83,400 liters)

CLIMATE

Air Circulation — 3' Diameter 1 hp Fan
Hot Air Collection-Subsoil Duct Return

Venting 200 sq. ft. (18.58 m^2) On The Peak
Plus Doors and Vents Along South Side

Hot Air Storage (Rocks) 43 cu. yds. (181.16 m^3)

Translucent Sloping Roof
Suspended 5' Wide (1.52 m)
Fiberglass in Catenary Curve. Double Walled
Separated by 1" (2.54 cm) Air Space

Material: Kalwall Corporation Sun-Lite Premium 0.040" Thickness (0.10 cm)

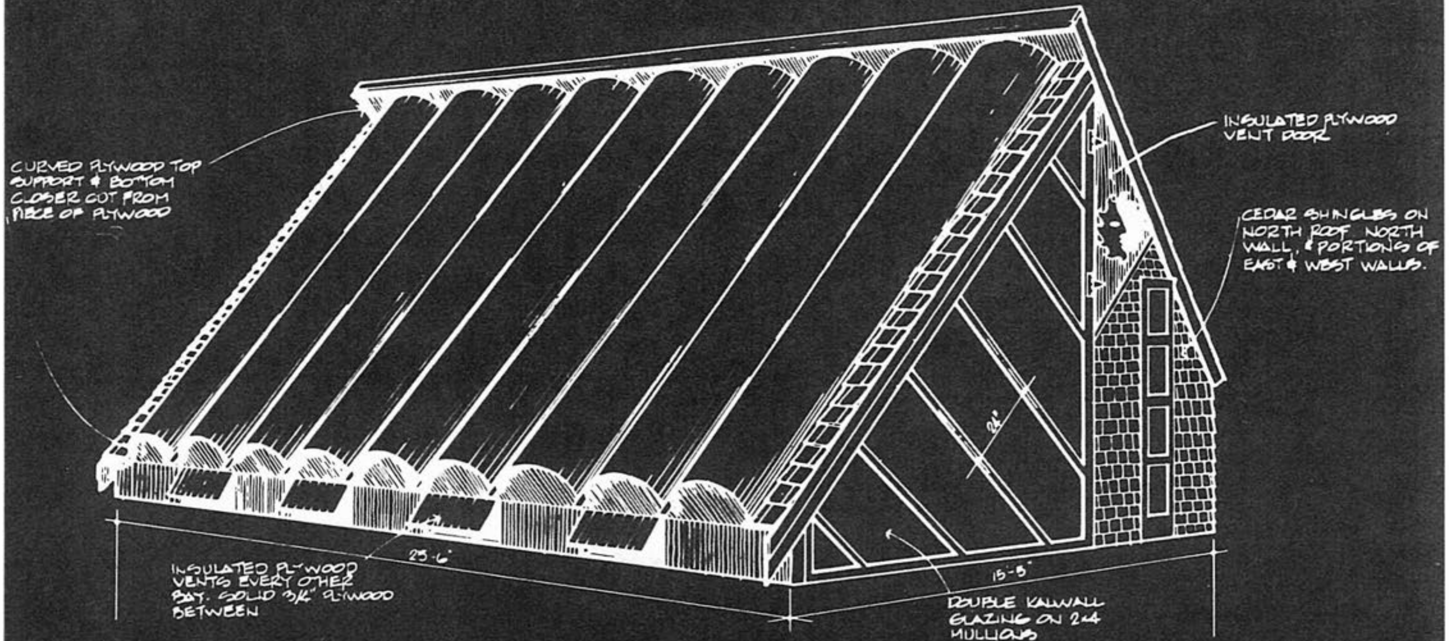
Single Layer Ultra-Violet Transmission 5% @ .33 microns
85% @ .38 microns

Visible Light Transmission 90+% (.38 - .76 microns)

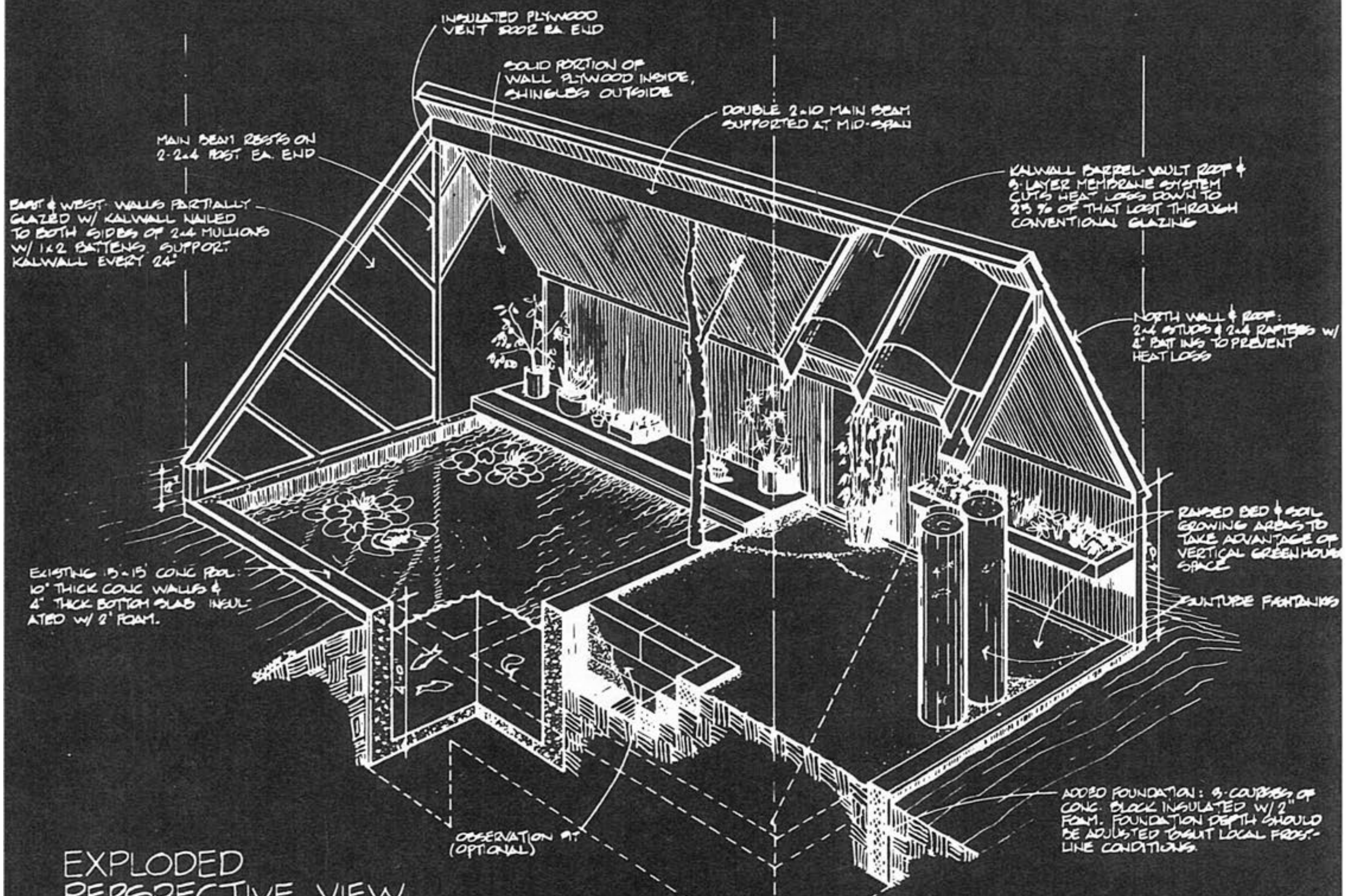
Short Wave Infra-Red: Most Transmitted (.76 - 2.2 microns)
Long Wave Infra-Red: Most Blocked and Retained in Interior (2.2 - 50 microns)

North Walls and Roof
½" Plywood on each Side 6" (15.24 cm) Fiberglass Insulation
Shingled

Foundation Insulation: 2" (5.08 cm) Polyurethane



The Six-Pack:



EXPLODED PERSPECTIVE VIEW

APPENDIX II – PLANT LIST

The following plants have been grown and observed in the Bioshelter.

Ajuga - W	Broccoli	Fern, Boston	Luffa - V	Passion Vine - V	Shallots, French - C, H
Aloe vera - S, H	Brussels Sprouts	Fig - V, T	Marigold	Paw Paw - T	Spearmint - H
Alyssum - W	Cabbage - C	Fig, Weeping - T	Marigold, Mexican	Peas	Spider Plant
Artichoke, Globe	Chamomile, German - H	Garlic - C, H	Marjoram	Pennyroyal - H	Spinach, Bloomsdale
Avocado - T	Chard, Swiss - C	Geranium	Mulberry	Peppermint - W, H	Spinach, New Zealand - W,
Azolla	Cherry, Catalina	Grape - V	Nasturtiums - V, W	Peppers, Sweet	Spinach, Malabar - V
Bamboo - T	Chinese Cabbage - C	Hollyhock	Naranjilla	Peppers, Costa Rican	Strawberries - W
Basil, Sweet - H	Chives, Garlic - C	Impatiens	Okra	Petunias	Sunflowers
Basil, Purple	Coleus	Ivy, Swedish	Onions, Yellow - C	Philodendron - S	Sweet Peas - V
Beans, Green	Comfrey - H	Ivy, English	Onions, Bunching - C	Potatoes, Sweet	Tansy - H
Beans, Purple Pod	Crown of Thorns	Kale - C	Oregano - H	Purslane - W	Thyme, Creeping - W, H
Beans, Scarlet Runner	Cucumber	Kohlrabi - C	Otaheite Orange	Pyrethrum	Thyme, Lemon
Beans, Broad Windsor	Date	Lemon, Dwarf	Palm	Radishes - C	Tomatoes - V
Beet	Dill - H	Lemon Grass	Papaya - T	Rosemary - H	Turnips
Begonia, Strawberry	Eggplant	Lime, Dwarf	Parsley - C, H.	Rue - H	Vetch - W
Borage - W, H	Endive - C	Lettuce – C	Parsnips	Sage - H	Wandering Jew - W, S

W - Well suited to growing on vertical wall spaces
S - Shade tolerant
V - Tall plants to be trained vertically
C - Cool season food plant
H - Herb
T - Tree-sized plant

Many other plants have been started from seeds or cuttings in the Ark, to be used in other areas. Hardwood cuttings of food trees are a special type of plant propagation which is being carried out in preparation of tree stock.

APPENDIX III - ANIMAL LIST

Terrestrial - This is a partial list, including only intentionally introduced animals and most obvious observed animals.

Ants, Black	Observed
Bees, Honey	Observed
Cabbage Worms	Observed
Carolina Lizard	Introduced
Centipedes	Observed
Crickets	Introduced
Earthworms	Introduced
Earwigs	Observed
Frogs	Introduced
Praying Mantis	Introduced
Slugs	Observed
Sowbugs	Introduced
Spiders	Introduced
Spider Mites	Observed
Toad, Garden	Introduced
Toad, Tree	Introduced
Warbler, Palm	Observed
Wasp, Paper	Observed
Wasp, *Trichogamma prediosum*	Introduced
Whitefly	Observed

Aquatic

Bluegill	Dragonfly
Carp, Israeli	Gourami
Carp, Grass	Mussels, Freshwater
Catfish, Bullhead	Snails
Crayfish	*Tilapia*
Damselfly	Water Boatmen
Daphnia	Water Striders

APPENDIX IV - SUGGESTED WORKING BIBLIOGRAPHY

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A Backyard Solar Greenhouse

– Laura Engstrom

The "Six Pack" was built to test principles and materials to be used in the P. E. I. Ark. The ground plan was adapted to an existing concrete pool. The "Six Pack" is also an example of a small, inexpensive aqua-agriculture structure suitable for supplying food supplement to a family.

CONSTRUCTION NOTES:

3-layer plastic membrane system – Suntek material was used at New Alchemy. Tedlar Membrane is also acceptable. For economy, a 4 mil ultraviolet-resistant polyethylene film film may be used, although it tends to be less transparent and shorter lived than Suntek or Tedlar. Care must be taken to avoid air leaks in installing the membranes.

Sealants – All unpainted joints are sealed with clear, exterior grade silicone rubber sealant. All painted joints are caulked with latex caulking compound before painting.

Paint – All interior surfaces get a minimum of 2 coats of gloss white exterior grade, fungus resistant oil - or alkyd - based enamel. Do not use latex paint.

Wood Treatment – All wood used in locations where moisture could be trapped, i. e., sills, joists between membranes, the plate at the south eave, etc., should be pressure-treated lumber or site-treated for rot using Cuprinol or a similar rot-preventive. It is very important to treat the end grain of wood before it is nailed in place. "Hydrozo" water repellant is a good end grain sealant for unpainted locations.

Vapor-Barriers – 2 mil polyethylene film is recommended. If foil-backed insulation is used it should always be installed with the foil to the inside of the wall. Always make lap-joints in the vapor barrier at a stud or joist.

For improved heat storage we recommend adding a system which would transfer the heat built up at the top of the greenhouse into the pool water or into an insulated bed of rocks for use at night or on sunless days.

This fall we resumed the biological work started last year on a new experimental bioshelter informally called the Six Pack. It is a small structure whose design by Solsearch was an outgrowth of a northern climate greenhouse developed at the Brace Research Institute at McGill University. The "Six Pack" was built to evaluate light transmitting materials being considered for the larger human habitation Ark built on Prince Edward Island. It is a prototype solar greenhouse intended for year round use by households to supplement their diets with fresh vegetables and fish.

Design Overview:

It shares with the Brace greenhouse the following characteristics:

The greenhouse is oriented on an east-west axis, the south-facing roof being transparent and the inclined north-facing wall being insulated with a reflective cover on the interior face. The angle of the transparent roof and the rear, inclined wall are each designed to permit respectively optimum transmittance of solar radiation and maximum reflection of the radiation on to the plant canopy.

This type of greenhouse is designed to avoid the significant amount of heat lost by radiation from the interior of a conventional greenhouse through the large transparent north-facing wall. Since the light enters mainly from the south side, very little is sacrificed in insulating the north wall. The reflective coating serves to redirect light reflecting from the interior back on to the growing area.

The New Alchemy bioshelter is innovative in a number of ways including its aesthetics, use of vaulted fiberglass panels on its south face, and the mounting underneath the fiberglass three layers of a transparent insulation known as Solar Membrane. The membrane is produced by Suntek Corporation and was tested for the first time under growing conditions in this bioshelter. Another unique aspect of its design is the incorporation of a fish pond within the structure for solar heat storage and aquatic food production. The pond water, rich in nutrients, is used to irrigate and fertilize the crops within.

The accompanying diagrams of the solar backyard greenhouse give its dimensions and type of building materials.

It is our hope that small bioshelters like the Six Pack will prove a worthwhile venture for a family or group of families interested in growing their own greens throughout the winter, even in colder sections of the country. Since it uses no additional source of heat or light other than the sun, it is inexpensive to maintain. However, as temperatures fluctuate sometimes as much as 40°F in a twenty-four period, and in the coldest months will approach freezing, the number of crops that will grow well during the winter is fairly limited. We are still involved in testing various food crops to determine those most suitable to the solar greenhouse environment.

Care and Management in the Six Pack :

We found that a very mild soap and water solution sprayed on the leaves of plants once a week effectively controlled the aphid population. Wood ash sprinkled around the base of plants served to discourage slugs although applications must be repeated after each thorough watering which may increase the alkalinity of the soil and affect the plant growth – a subject for possible future experimentation. Whiteflies and fungus remain a problem.

Bees and wasps entered the structure and were among the beneficial insects which pollinated various plants. *Trichogamma prediosum,* a tiny wasp which is known to parasitize eggs of butterflies and moths, was introduced as larvae and allowed to hatch within the greenhouse. Because of their microscopic size, we have not yet been able to determine if they are still present.

In early August last year, we began to prepare the ground in the building, raking out undecomposed leaves and adding lime, rock phosphate and green sand. We also filled several large wooden boxes and three cement containers with soil and compost and brought those in. Ground and containers were then planted both with seedlings and with plants brought in from the gardens. A good sampling of warm and cool season food plants, house plants and a few miscellaneous were included. (See Appendix) Generally, they were allowed to grow with a minimum of care and attention to determine their basic suitability to the greenhouse environment. With the onset of winter, most of the warm season crops began to mold and were removed, but some of the hardier plants continued to grow and provide food.

The crops chosen were those which had been most successful in last year's experiment plus a few new candidates. (See Appendix) Malabar and New Zealand spinach, chard, kale, Chinese cabbage and several herbs were brought in from outside to extend their growing season. Chard, kale and parsley were also started as new seedlings in the fall, along with purple pod beans, kohlrabi, lettuce and endive. These plants now constitute our most successful crops and will definitely be included in plantings in subsequent years.

We also planted onions and garlic which were still healthy and growing in early December. Hopefully, they will reach full maturity. A small number of beets were planted, some of which have reached acceptable size. Others are still quite small. Further plantings are in order to determine their value as a greenhouse crop. Several other plants need further testing as well. Beefsteak and Tiny Tim tomatoes were severely damaged by fungus. Almost all members of the cabbage family were affected by aphids and slugs.

Small cucumber plants were transplanted indoors in mid-September and did not grow well at all. Green pepper plants from flats grew very slowly and did not produce. In mid-October, as temperatures decreased, chard, kale, Chinese cabbage and Malabar and New Zealand spinach continued to thrive and grow. The perennial herbs grew very well, but the sweet basil was attacked by mold.

A second crop of lettuce and endive was planted on October 20. The growth rate was significantly slower than that of the late summer planting (see graph). Fullheart endive appears to be growing more rapidly than most types of lettuce.

It is expected that some of the cool season crops will survive the winter, providing us with salad greens throughout January and February. Warm season crops, with the exception of Malabar spinach, have had an extended growing season.

It is difficult for us at this point to know the ultimate production potential of the Six-Pack. Methods and procedures for providing optimum growing conditions within the greenhouse are still being worked out. A more detailed knowledge of its climatology is essential. For example, on October 20, it was discovered that every type of lettuce and endive with the exception of Salad Bowl lettuce and other more recently planted seedlings had turned bitter, although only a few plants had bolted and many were just reaching their peak of production. This situation may have been brought about by unfavorably high temperatures and could have been avoided by better regulation of venting throughout the day.

Ventilation, watering of crops, spacing of plants, coordination of plant types to micro-climates, type and degree of mulching, proper soil composition, seeding sequences – these are some of the factors which must be evaluated in order to optimize the growing environment within solar greenhouses. The challenge is more difficult with Cape Cod's erratic weather conditions.

It should perhaps be mentioned that the small solar greenhouse need not function solely as a means of food production, although this is certainly the primary concern. It is a psychological boon to those who actively become part of its ecosystem. Hanging pots of nasturtiums, impatiens and other colorful house plants help to balance the functional with the aesthetic. And to all of us summer gardeners, it is a joy to step, trowel in hand, into a balmy greenhouse smelling of earth and herbs and marigolds, even in the coldest months of the winter.

APPENDIX

Animal Diversity Within the Six-Pack Ecosystem

Fall 1975 - Winter 1976

Introduced:	*Observed:*
carp	ants
dragonflies	aphids
gourami	bees
lizards	black flies
praying mantis	cabbage worms
snails, snail eggs	caterpillars
spiders	centipedes
tilapia	cutworms
toad	earwigs
tree frog	frogs
Trichogamma prediosum	praying mantis
	rats
	slugs
	snails
	sow bugs
	spiders
	wasps
	water striders
	white flies

Plants Tested in the Six-Pack

Fall 1975 - Winter 1976

Fruit	*Warm Season (tender) Vegetables*	
avocado	beans -	green
dates		purple pod
papaya	cucumbers	
passion vine	eggplant	
strawberries	peppers -	hot
		sweet
	spinach -	Malabar
	tomatoes -	Beefsteak
		Tiny Tim

Cool Season (hardy) Vegetables

beets		lettuce-	Bronze Leaf
broccoli			Early Prizehead
cabbage -	Matsushima		Grand Rapids
	Red Mammoth		Great Lakes
endive -	Fullheart		Johnny's Resistant
	Green curled		Oak Leaf
garlic			Parris Island
kale			Ruby
kohlrabi			Salad Bowl
lettuce -	head	onions	
	Bibb	parsnips	
	Buttercrunch	spinach -	New Zealand
	Dark Green Boston		Winter Bloomsdale
	Iceberg	Swiss chard	
	loose head		turnips
	Black Seeded Simpson		

Herbs

annual		*perennial*
basil -	ornamental	chives
	sweet	lemon thyme
borage		oregano
marjoram		peppermint
parsley		sage
		spearmint
		thyme

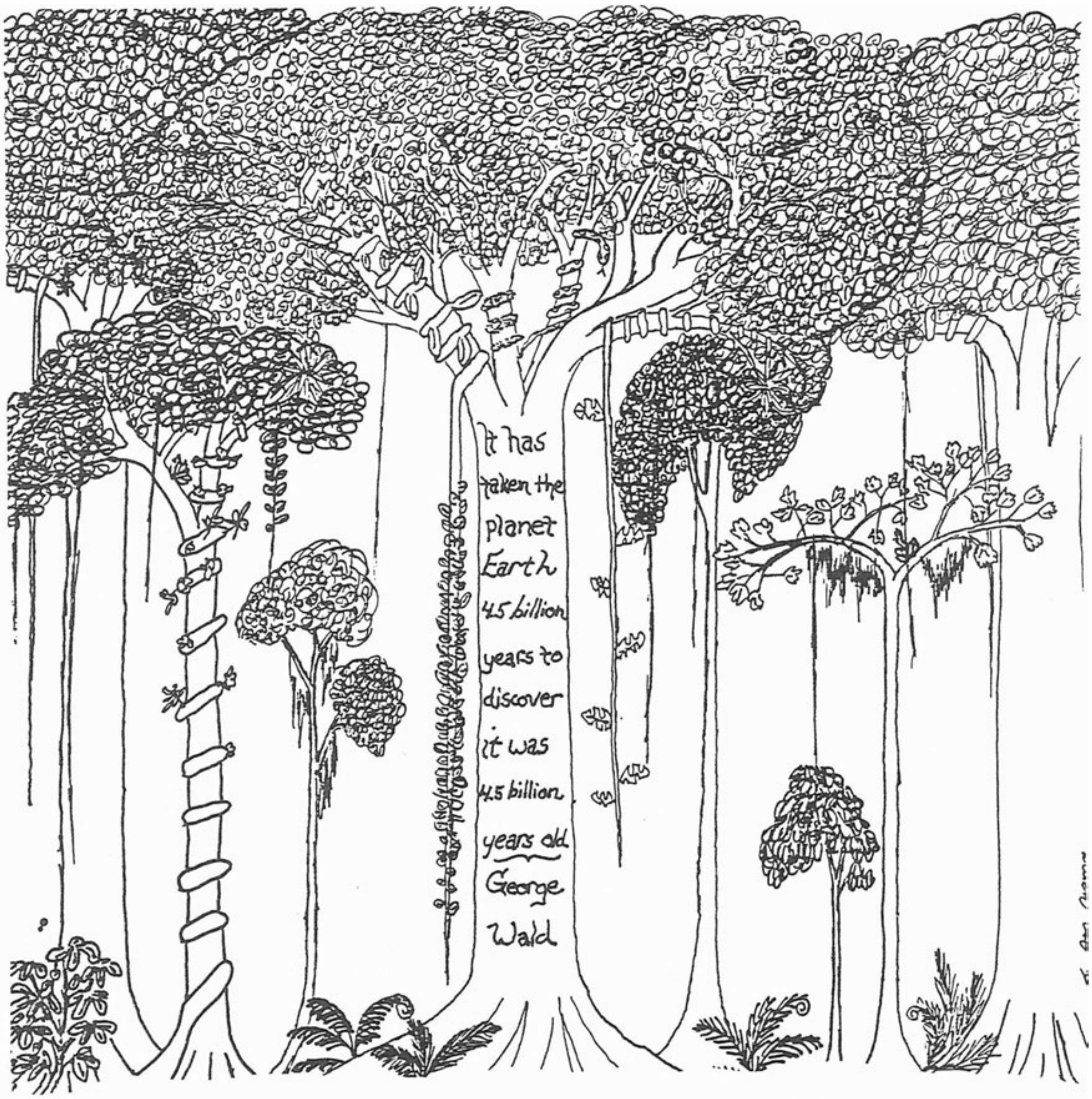
Ornamentals and Non-food Plants

aloe vera		marigolds
azolla		nasturtiums
Canterbury bells		North Carolina black bamboo
Christmas cactus		petunia
cockscomb		rose marrow
coleus		spider plant
geranium		strawberry begonia
hyacinths		succulents
impatiens		trumpet vine (cutting)
ivy -	English	umbrella plant
	Swedish	wandering jew
lotus		wisteria
luffa		wisteria (cutting)

REFERENCE

Lawand, T. A., R. Alward, B. Saulnier, E. Brunet. *The Development and Testing of an Environmentally Designed Greenhouse for Colder Regions.* Brace Research Institute, Macdonald College of McGill University, Quebec, Canada. 1974.

Construction Plans for the Touchstone Greenhouse, which is based on the Six-Pack, are available to Associate Members of the New Alchemy Institute for $25.00. Membership is a prerequisite for obtaining plans, in order to assist N. A. I. with further bioshelter development.


It has
taken the
planet
Earth
4.5 billion
years to
discover
it was
4.5 billion
years old
George
Wald

Explorations

The two articles in this section reflect a continually expanding network of which we feel New Alchemy to be a part. A major factor in the extension of this network is our friendship with the Lindisfarne community. It has been through it that we met both Richard Falk and Evelyn Ames who wrote the papers included here. Dick Falk is Milbank Professor of International Law at Princeton and a Senior Fellow of the Institute for World Order. His article traces and binds together many of the disparate threads that form the main body of the resistance to what seems the dominant direction of this culture. His discussion of a politics of conscience points out the underlying political nature of actions not always construed as such, and the fundamental agreement of those acting directly on behalf of people who are suffering and those whose efforts are directed toward apparently ecological concerns.

Author and poet Evelyn Ames' article on "A Return to the Feminine Principle" brought a mythological dimension to my own thinking. Since the publication of "Women and Ecology", I have seen many articles querying along comparable themes. The oppression of women, the alienation of men and resultant unhappiness of all of us in a culture of unsettlingly rapid flux is a recurring theme these days. Like a chronic itch, it's always there. Understanding for all of us comes slowly, and contributions, large and small, are very much needed. A major one has been Elise Boulding's book, "The Underside of History", which brings new insight on long-ignored feminine participation in history. Jean Baker Miller's book, "Toward a New Psychology of Women", is a new and popular book which reaffirms the value of the affiliative and communicating aspects of the feminine experience. Like both of these books, Evelyn Ames' article sheds light on little comprehended and often thickly veiled aspects of the human experience.

Return to the Feminist Principle*

— *Evelyn Ames*

Perhaps the greatest paradox of our time is what might be called the failure of success achieved in the modern industrialized world. As, one after another, the excesses of that success bring crises and dire warnings, there are deepening misgivings that the driving masculine principle is on the rampage and that, if its dominance continues unchecked, we shan't survive. The very existence of such misgivings is cause for at least some hope; and, although it is is too early to see anything that might be called a trend, there are signs that that dominance of the masculine may have peaked out and a new age begun in which the feminine principle will again be re-honored, though in a new way.

It might be helpful to begin with the meaning of the terms feminine and masculine principle and to say at once that they apply to both men and women and that the whole subject is much bigger than any single woman, any man. It isn't even women, or Woman, that is meant by the feminine principle but a part of the psyche shared by both sexes, only more intrinsic to women, and the opposite pole of the principle intrinsic to men. This is well illustrated by the ancient Chinese philosophical symbol of Yin and Yang, those two interwoven forms of black and white in which each element at its fullest contains the seed or spark of its own opposite; night and day, yielding and firm, water and fire, feminine and masculine — all the complementary opposites are represented by it. Because the feminine is associated with night and the moon, Yin, the dark half of the circle, represents the feminine and Yang the bright and masculine half.

In Pathan, one of the ancient capitals of Nepal, there is a stone figure of the Lingam — the symbolic phallus — standing upright in the Yuni, a horizontal circle with a channeled opening — symbol of the womb. To the Hindu these forms represent Creativity and Fertility, or else Power and Nature: in combination, the Creative Energy of the Universe. For both principles, it should be noted, are energies. There is a danger of confusing the feminine principle with stereotypes of supposedly feminine qualities such as being passive, the weaker sex, coy and seductive and so forth, rather than the nourishing, loving and protecting element of the feminine — which, in action, it hardly needs saying, exacts great energy, work and imagination.

In the cave temple of Elephanta, near Bombay, dedicated to the god Shiva, there are two especially outstanding sculptures. One, the hermaphroditic Shiva, is divided, not like Greek and Roman versions of Hermaphroditus but vertically through the entire body; it represents very movingly the two principles in harmony, in one being. The other, the famous triple-headed Shiva, has on one side the face of the god's masculine energy — here shown in its furious destructive aspect; on the opposite side, the face of feminine creative energy (as one is told) and, in the middle, the transcendent union of both. If that phrase "creative energy" following "feminine" is startling, it is because the whole concept of the feminine principle has become weakened, for reasons I hope to make clear.

In an attempt to discover what I could about the feminine principle at first hand, I experimented by presenting to myself in a period of free meditation the question "what is the feminine principle?" After a time a series of mental images appeared, one after another or becoming the other, as clearly as if I were looking at a slide show. There is nothing definitive or particularly clever about this: what is interesting

**Adapted from a lecture given at Wainwright House Center for Development of Human Resources* is that these images rose out of the unconscious, that they were right there and I hadn't known it.

I saw first a large earthenware jar — one of the recognized symbols of the "Great Mother", more specifically the symbol both of emptiness and of containment; of receptivity. Next came a fountain: givingness, overflowingness; quickly followed by the image of someone playing a harp — muting the strings with outstretched hands and laying an ear against them: the listener to resonances. Suddenly, then, I was in a primitive country and saw a woman carrying water in a jar balanced on her head: the water-carrier, a sustainer of life. The jar being very full, some water spilled on the ground and a strange thing happened: she set down the jar, kneeled on the earth and rubbed mud from the spilled water onto her face. Aside from the obvious connotations of her being in touch with the earth, this puzzled me. Then I read in an account of the recent coronation of King Birenda of Nepal that one part of the ceremony consisted in smearing him with mud to symbolize his awareness of the land and closeness to his people. My water carrier also laid her ear to the ground — she tuned into the earth — and dissolved into the last image of a girl holding a giant conch shell to her ear and listening to the sea — symbol, of course, of the unconscious. Receiving, giving, listening, supplying, getting into touch with the earth and the unconscious: though only some of the attributes of the Feminine Principle still they all belong to it.

Weeks later, under very different circumstances, a free meditation on the masculine principle produced the following, also extremely vivid images: first, a javelin-thrower in the act of hurling the javelin in a contest which, I'm sorry to say, turned into a figure holding a rock over his head with both hands and about to smash it down on a victim. Then to my intense interest, came a building superintendent at the Pyramids, ordering lines of slaves and assigning them work; and a ruler? judge? (I wasn't sure which) anyway, a thoughtful figure seated in a raised place as if weighing evidence. The next scene was inside a submerged submarine where a man sat reading instruments and adjusting dials. The submarine became damaged; it surfaced; men leaped overboard and were marvelously rescued by helicopter. Last I saw swarms of workers around a cathedral. Quickly summarized, what have we got but a competitor in skills; a killer; an organizer; a leader; an engineer and explorer of ocean depths (interesting that it was that and not outer space); heroic rescuers; builders.

There they are: two very different kinds of energy — two forces which, combined, are the creative force of the universe as are all opposites when they are held in balance or in creative tension. It is illuminating to consider how the balance between these two energies, these principles, has shifted through history and then to examine the shift occurring right now, but before doing so, there is one more footnote, as it were, which seems worth mentioning. That is the origin of the words lord and lady. *Hlaf* is the Old English for loaf, and lady, or *hlafdige*, is the loaf-kneader — she who kneads and makes the bread. Lord is the *hlafweard* or loaf-warden — he who guards the bread which in primitive societies was probably a lot more important than guarding the gold at Fort Knox. There is a suggestion in these words, and their origins, of the feminine and masculine in cooperation which seems to me beautiful.

Readers with any knowledge of Jung will know that the masculine is identified with ego and with consciousness, the feminine with the unconscious, and that each of us carries in the unconscious the archetype — or physic pattern — of the other. What Jung called the "anima" represents to the man the eternal feminine in him, his Yin; what Jung called the "animus" is the woman's Yang or the masculine principle within herself. Finally, each of us repeats in his or her own development the entire experience of the species — those shifts of balance we are about to consider — which means that a girl must dissolve her natural unconscious wholeness in order to become a complete person: she must relate to the masculine in herself; and a boy must detach himself from the mother, not just his actual mother but the relationship to the Great Mother, in order to become himself. He then tends to relate from the distance of the conscious world — as Jung's follower Neumann put it; in fact masculine self-discovery depends on the separation of the conscious and unconscious systems. Which is exactly what happened in the early period of humanity.

Early societies were matriarchal — not necessarily structurally but, more importantly, psychically; matriarchal consciousness, in harmony with the earth and the unconscious, dependent on favorable moon-periods for planting and harvesting — a patient, waiting kind of awareness — was predominant. The basic formula was this: woman = body = vessel = world. The Great Mother was worshipped and women were priestesses (in some cultures they ruled, as well) but the significant thing is that humanity went through a phase in which the feminine principle and the unconscious dominated the masculine principle and consciousness. In the eastern Mediterranean one sees remnants of this in the Minoan civilization of Crete which then merged — became married, as it were — to the Mycenean. Greek mythology resulted from this collision of matriarchal pre-Greece with the aggressive, patriarchally minded Acheans who invaded Greece from the North.

Humanity, or the part of it with which we are most familiar, moved out of the unconscious just as the individual boy detaches himself from the mother to become whole — and moved into consciousness which then became patriarchal; these were successive psychological phases. Gods replaced goddesses, except for Athena, whose citadel of Athens held out against the patriarchal tide; men ruled; society evolved the hero, rescuing the maiden from impossible dangers, and reduced the earth goddess – the Great Mother – to a wife in the home. And with that reduction, the concept of female creative energy gradually diminished. (Incidentally, patriarchal marriage is about as old as our historical knowledge – for the very good reason that writing and record-keeping are achievements of the evolution of consciousness.)

We know all too well the next stage, our Judaeo-Christian heritage in which the body, nature, sexuality and women became of the devil, the feminine principle was seen as pure evil and witches were burned at the stake. Nor was there any feminine Godhead left, except for the Virgin Mary, whose presence in the Catholic Church is therefore of far more than theological importance. With the Reformation, even she disappeared from Protestant societies; the feminine principle was totally gone from the church; there were no women in heaven. And of course this process of relegation to the devil, this making a witch or monster out of someone or some idea, is exactly what we do as individuals or societies when we are trying to break away from or out of a situation and move into the new. (It should be added, too, that the negative, shadow-aspects of the Great Mother and of the Feminine Principle are indeed monstrous: devouring, engulfing, bringing death as well as life, like the Hindu goddess Kali with her apron of skulls.)

Coming to this country and nearer our time, there was one particular period in the development of our frontiers when women were partners of their men and the two principles co-existed in remarkable balance and harmony. There is a beautiful book about this called "Westward the Women" by Nancy Wilson Ross, celebrating those exceptional women (there must have been many of them) who shared their men's dangers and hardships while still cherishing and nourishing the feminine and cultural values. One marvels how they did it. Perhaps it was because a part of their psyches found itself returned to the familiar matriarchal consciousness which lives in accord with seed-time, the earth, the moon. In wild and foreign territory their spirits were at home.

With the arrival of the Industrial Revolution, what Bronowski calls the Drive for Power, we recognize where we are: the masculine principle in full and omnipotent control; goals barely formulated before they are achieved; the earth – and that includes some of its evils, its diseases – conquered, as we say; every imaginable, and unimaginable product produced, the solar system beginning to be explored. We must never forget that the masculine principle and patriarchal consciousness have, quite literally, produced and developed Western civilization, and that consciousness is an extraordinary "organ of adaptation and accomplishment" as Neumann calls it: it gets results, it by-passes nature's slow workings and telescopes time by transferring information. When one tries to grasp what has been achieved it boggles the mind. Today, particularly in our own country where the symbolic javelin was hurled the farthest, we are suffering from the excessive success of the masculine principle while everything in us that is tender, thoughtful, caring, is crying out in anguish and despair. The feminine principle has been shut away, devalued, and if not exactly thrown a bone, then its equivalent: placated with another electric gadget.

The English author, J. B. Priestley, writing from Texas in the mid-fifties in the book called "Journey Down a Rainbow", said it was easy to see why America is described as a matriarchy: women have much of the money, there is all this fuss about Mother, and their adornment is the basis of a stupendous industry; also they are often very aggressive, and demanding and dictatorial. But this misses the point, he claims: America is dominated by the masculine, not the feminine principle; the values of our society are masculine, not feminine. If women have become aggressive it is because they are struggling to find satisfaction in a world that is not theirs: they are like the inhabitants of an occupied country, compelled to accept values and standards alien to their deepest nature.

"Woman wishes to take root (he writes); this society is uprooted. She is deeply conservative; this society is nothing if not progressive. She wants slow but certain growth; this society is restless and for ever changing. She desires an erotic personal relationship... what she gets is a muddle of hasty sex, social partnership and a tangle of legalities... She wants a securely rooted family tree; there are fewer and fewer of them. She believes, in the ancient wisdom of her heart, that nothing matters except the quality of personal experience, what real men, women and children are feeling about life; but this society attends to everything except that..... Her essential nature cries out for a devoted lover, healthy children, a home filled with easy intimate talk, laughter, absurd or charming ceremonies, and nothing whatever out of cybernetics and science fiction, buildings two thousand feet high, travel at five hundred miles an hour and dinners arriving in capsules.... So she takes her revenge.... bringing to the conflict her willpower and hysterical energy. She will be hard on men because it is they – or the principle they represent – who are responsible for her feelings of deep unease, frustration, insecurity... she will often be unfair..."

That is a pretty dreadful picture but, speaking for myself I can only say that in recent years everything feminine-principled in me has been revolted by the wasteful, mechanized aspects of our society and its cost to our deeper humanity. Consider that one phrase it has produced: "built-in obsolescence". Could any concept go more deeply against the grain of the creature who for hundreds of thousands of years has cared for the cooking-pots and water-jars and garments which were so painstakingly made? Even more, whose anatomy, physiology and psyche have all evolved to nurture and protect the built-in life *expectancy* of the species? How she is outraged by billions being allotted to 'better' wars, and not just for weapons superseding a hurled rock or bullet but total species and planet destroyers! Woman = body = vessel = world. Something way beyond the personal is threatened. The masculine "drive for power" principle having fulfilled itself to the brink of suicide, the feminine life-and-earth principle is in all-out revolt. As the poet Robert Bly puts it, the Great Mother is moving again in the psyche.

The feminist movement and "fem lib" revolution are inevitable, almost predictable, results, though what is happening there makes for a confusing picture and one must be extremely careful in judging it. The understandable criticism is made that in this movement woman (so far) has chiefly emancipated herself from her own femininity; the fear is that if women, in their rush to achieve certain human rights become too much like men — are too animus-propelled — the balance is upset, the Yin-Yang polarity lost. Certainly the expressions "militant feminists" and "radical fem-libbers" are contradictions in terms, for warlike and combative is what the feminine principle is not. Yet I have to recognize that in my own life it was when the feminine in me was — for whatever reason — blocked, or I felt it threatened, that I have become combative. As Florida Scott Maxwell puts it, when a woman feels beleaguered and beset, what does she do but "yell down the castle walls and call up every handyman in the place to help" — and this, of course, is the man in herself. So I think we must realize two things here: that the feminist movement is one, very necessary part of a much bigger phenomenon, that of the return to the feminine principle — and, secondly, that in establishing the human rights of women in society, the women who have led and are leading the movement have perhaps had to sacrifice the feminine in themselves for the sake of the rest of us. It is thanks to them that women are at last beginning to have a right to their own bodies and what happens to them; that they are able to pursue their own careers if they want to — although there is still much, very much to be done, for it remains extremely difficult for women to carry both home and career without help, financial and otherwise. But we are beginning to have women cabinet ministers, governors, even prime-ministers and women can and do achieve great things while still acting under the inspiration of the feminine principle. You know such women and so do I and if there has been, so far, more of an emancipation from the feminine than toward it, the movement is still very young. Françoise Giroud, new State Secretary for the Condition of Women in the French Cabinet, says that the present evolution of women and the way it will turn out is — to her mind — the most profound revolution that highly developed societies will have to contend with.

Nor is it without reason that this present wave of the revolution came at the same time as the general awakening to the environmental situation and our new understanding of the planet after seeing it from the moon. The two phenomena are intimately related. For the sense of surroundings, of interior space — of home, if you will — is deeply embedded in the feminine psyche and "home" is now becoming enlarged to include the whole earth. The basic formula of woman = body = vessel = world which obtained in the early period of the species has taken on new dimensions, new meaning; it is returning, but on a different, *conscious* level. In fact, matriarchal consciousness has never disappeared: it still exists in those layers of the psyche that belong to the early periods of history, and it continually plays a part in men's lives as well as women's — in their inspiration, intuitions, hunches.

Other fascinating forces seem to be at work. In the collective unconscious of our time, there has been a growing awareness of a man's relationship to his own unconscious, feminine side and of a woman's relationship to her animus — or Yang. Surely the very fact that such minds as Jung's, Neumann's, Freud's and Erickson's, all the many pioneers and explorers of inner space, emerged in this particular epoch, is highly significant. It has also been pointed out that the hidden tendency of the life-process itself seems to be toward creating a more complex feminine psychology; some mutation in consciousness is taking place. Could this be because of women's long experience in relating to the dominant masculine principle? Has there been a subtle cross-pollination?

Meanwhile there are innumerable outer signs of these inner developments. Perhaps the most conspicuous one is the new feeling about the planet and the speed with which this planetary awareness is growing — paradoxically helped along by the masculine principle's great triumph in reaching the moon, and the sudden energy crisis and shortages resulting from the masculine principle's great excesses. The rate of growth of an ecological conscience — in itself related to the feminine — is almost breathtaking. One fascinating example was recently reported in the press in Brazil where a hundred and seventy million acres of forest have been eliminated, and from near Sao Paulo, the fastest-growing modern city in the world. In an outlying town, three people climbed into a single tree they didn't want cut down and stayed there till the police put them in jail. Yet that isn't the end of the story; the whole town rose in revolt, there were riots and demonstrations. All over one tree, after billions of destroyed trees! At some point, people do take a stand.

New-old life-styles begun by protesting young people in the violent sixties are also on the increase: less eating of meat (less killing); more articles being made by hand; more individuals and families growing and preserving their own food than have done so since before agriculture became big business; in fact, one hears that home gardening equipment and seeds have now become big business. A striking change is in young people's appearance — their perceptibly gentler presence — and the sharing of work in the home: fathers caring for children, husbands helping wives with housework and the whole phenomenon of role-shedding and blending of roles formerly associated with one sex only. This movement seems to be much bigger than giving women greater freedom, big as that is; it is really an honoring of feminine values in both men and women, thereby enriching their joint lives, putting them in touch again with life's roots and secret processes. Also, and even in spite of ourselves, shortages and rising costs are driving us into a new-old attitude toward more moderate consumption and care for what we have. One evidence of this is the outstanding new trend in architecture toward what is called adaptive use and multiple use of buildings. Instead of automatically tearing old buildings down, running the bulldozers in and building enormous new structures, good old buildings — like the Wainwright Building in St. Louis, the old City Hall and Chickering Piano factory in Boston — are preserved and restored to new usefulness as apartments, shops, community centers. Practicality seems to be returning along with the old fashioned virtue of *thrift,* that fine old word which is no less than the substantive, noun form of the word *thrive.*

Another movement which has accelerated amazingly is the interest in Eastern systems of thought and meditation and the growth of Yoga, Tai-chi, Sufism and other esoteric disciplines — now even advertised on boardings along our pavements — all a great turning toward the spirit, and the unconscious, toward body disciplines and greater balance between the masculine and feminine principles.

Finally, and combining each of the above-mentioned changes, is the phenomenon of the intentional communities springing up and growing here and there in many parts of the world, experiments in an alternative, small community way of life. These are not the communes of the sixties, although communes may well have been their first, wilder seeds. What we are considering here are highly disciplined, carefully planned and organized communities for all ages, founded on principles of sound ecology, hard work and, in most cases, around the central core of a religious or spiritual practice. Where they differ from past Utopian communities is that they are not isolated from the world around them and, in those with which I am familiar, a very realistic view of world-wide trends has made their leaders and members choose a way of living more in keeping with the way things *are* and where they seem to be going. In fact, one might well say that the rest of us, going our merry or not-so-merry way of dependence on an increasingly complex civilization are the Utopians — still continuing to assume that this tremendous and fantastically ingenious structure is going to survive and improve — technology will take care of that — we will learn how to "harness the atom" (what a phrase!), we may even be able to engineer an improved human species and so forth.

I am on the board of one such new age community — Lindisfarne, founded by William I. Thompson who wrote "At the Edge of History" and "Passages About Earth", and I have visited and worked at another, longer established one — Findhorn, in northern Scotland, which has attained some notoriety through its portrait in "The Secret Life of Plants". Not only the extraordinary vegetables and flowers they grow there, but everything I saw and experienced, related to the feminine principle — to the earth, and to reverence for life in all its forms; to caring — for the people you are with, the vegetables you are raising, the kitchen equipment with which you prepare them. To paraphrase Blake, the motivation seems to be "everything that *is* is holy". There is no luxury, but there is comfort, order and beauty; there are studios for different fine crafts — not as hobbies or occupational therapy, but articles made for the community to use or to sell. Though the location is in a wild and rather desolate region of northern Scotland, one feels anything but isolated: visitors come from all five continents and Community members make use of the finest audio-visual equipment to produce cassettes and slide shows for their own educational and entertainment facilities and to broadcast to the world what they themselves are doing. To be there even for a few days is to feel yourself in a planetary village.

In the director's office at Findhorn there is a huge map of the world, probably six by nine feet across, bristling all over with different colored pins. It looks like those war-maps on which facts about ally and enemy are all marked out, but these pins either represent other new-age communities or individuals of outstanding practical or spiritual insight who are already living in the new age. It is not a map of peace as opposed to war, but a map of faith — in an emerging new principle. To give that principle a single name such as planetary is too simplistic, though it does indeed recognize the planet in the old way as our Great Mother and in a new way as the source of energies we have still to learn about. And it isn't fossil fuels or atomic power that are in question, but the existing natural ones, including those little known electro-magnetic forces which surround the world and of which we and consciousness are a part.

In thinking and speculating about the new age we are entering, several things stand out. The life-styles I've mentioned are a new-old way of living; the interest in esoteric spiritual disciplines is a new return to very old practices; the Findhorn and Lindisfarne kind of community is a return to the extended family or tribe of early cultures, the new thing about it being that it is voluntary, planned, chosen – and there lies all the difference. This is a conscious choice, not an unconscious inevitability, just as all these manifestations are new forms of very old situations. They are quite literally re-turns – not in the sense of arriving back somewhere, which, in our usual masculine, goal-oriented way we usually associate with that word return, but of going once more in a given direction, around a center. As much as it is possible to think of the evolution of humanity and of consciousness, one can visualize it as a spiral (like that shell held to the girl's ear) and guess that we are perhaps at a point on a curve swinging in a familiar direction but at another level. This is inevitably different because, in spite of the claim that human nature doesn't change, hasn't improved and so forth (all of which may well be true) certainly our situation is vastly affected by our greater numbers and our enormously greater knowledge. The environment in which we are now living, says William I. Thompson, is *information.* The patriarchal consciousness which has dominated for anywhere from four to six thousand years has evolved to the point that it is making the intuitive fairy-tales of early peoples come true; see and hear at a distance, we get to the moon and planets and order technological jinn to bring us information about them; the unconscious dreams and experiences of early times are now being consciously carried out. But – says Neumann – "when patriarchy has fulfilled itself or gone to absurd lengths, losing its connections with Mother Earth" a reversal occurs: patriarchal consciousness re-unites with the earlier more fundamental phase.

It is enticing to speculate and to extrapolate. And it seems possible, even probable, that humanity is due, not for a going back to matriarchal consciousness since nothing in life does go back – but for a conscious turning again to the natural wisdom of matriarchal consciousness and the feminine principle. Unlike the pre-Greek marriage of two kinds of consciousness which produced Greek myths, (perhaps even the glory of Greece), the long predominant masculine principle may now combine consciously and by choice with a long dormant feminine principle. The Sleeping Beauty fairy-tale carried out? Perhaps – for it seems as though we now long for a balanced consciousness as well as desperately needing it.

Really there is no other choice: the present path is suicidal as we all know. That "extraordinary organ of adaptation and accomplishment" has adapted to conditions it shouldn't adapt to. But this return will take doing, and it will take above all trust and mercy. What man must do is not fear being submerged again in the Great Mother; man has been there, done that, but he pulled himself out with such long effort that he still fears it and even tries to make his wife more rational, more like himself. As Professor Higgins sang in "My Fair Lady", "Why can't a woman be more like a man?" But this is precisely what she must not do. We women must, in fact, beware of our Yang, our own masculine principle, taking us over; we need to become *more,* not less inspired by the feminine values. And we mustn forget that symbolically, the seat of matriarchal, of mother consciousness, is the heart, not the head. The ego of the masculine principle, that familiar head-ego, often knows nothing of what's going on in the deeper center, in the heart, and we must make it our business to listen to the heart. "The modern woman" wrote Jung, "stands before a great cultural task which means, perhaps, the beginning of a new Era."

What would Jung observe if he were alive today? He was deeply excited by the significance of the Marian Year, celebrated in the Catholic world in 1954 – and so much has happened since! One can feel changes ever in the last two or three years and those with an ear to the ground of the Women's Movement may now hear not only the loud media-noise of those who are acting out all women's ancient hurt and anger, but the subtle appearance and growth of a new, affirming process. In many parts of the country, in consciousness-raising groups and support groups of various kinds as well as in women's clubs and intimate talk between friends, what might be called a leit-motif is being given voice. The old anger may still be part of it but what is newly heard is a deep sense of the importance of the feminine to the world as a whole. Women are waking up to their particular gifts and powers and there is a note of excitement in the discovery equally if not more compelling even than the demands for equality. They are beginning to feel – not just to see – how the feminine's emphasis on being rather than doing, and the unconditional quality of its givingness, are needed for its protection of the planet and its protection of men from their own destructive drive. What one hopes and prays for is that the resentments, sometimes the fury, of the devalued feminine will become transformed into the fuel for the kind of deep commitment necessary to work out a new balance between mother consciousness and the masculine drive for power. This cannot happen too soon to save us from ourselves.

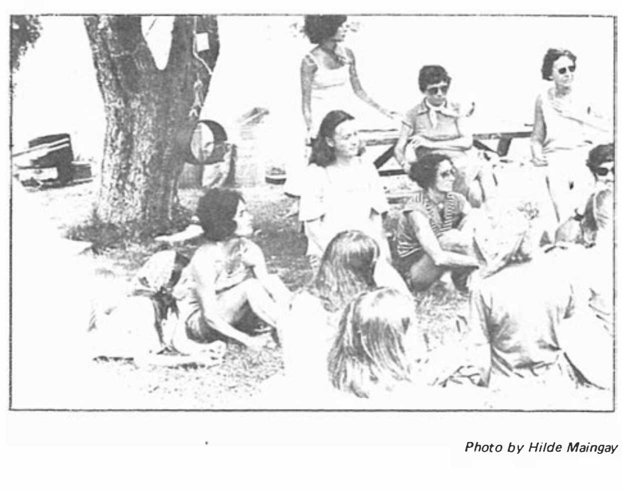


Photo by Hilde Maingay

Morningsong

a wooden room:
to be beside you in a simple bed
to wake in simple light
and to drink from simple cups
subtle water

simple wood and light
simple cup and bed
simple warmth and calm
difficult

the simple word difficult

simply open the door:
the pines and cabbages drink the light
the animals follow us with their eyes,
patiently wait to be fed.

after the dark milk of our dreams
we have the bright breast of this day

plain table   subtle fire
our two plates round as moons

bless the pan. bless the spoon. bless the morning.

– Dawnine Martinez

Political Prospects, Cultural Choices, Anthropological Horizons

— Richard Falk

If you see the sword coming.... blow the trumpet and warn the people, then if those hearing the trumpet do not take warning, their blood will be on their own hands.

— Ezekiel, 33:3-4

..... The future which we know throws its shadow long before it enters.

— Anna Akhmatova,
"Amadeo Modigliano",
N. Y. Review of Books, July 17, 1975

It doesn't require biblical prophecy to discern the seriousness of the present human predicament. Disregarding apocalyptic possibilities, present realities associated with collective violence, mass poverty, ecological decay and widespread repression establish a firm foundation for discontent with the present political order at every level of organization. Symptoms of malfunction inter-link on a planetary scale, making our era the first of universal history. Such symptoms are emerging at the same time as the expectancy for social justice on the part of many people throughout the world is calling into question the prevailing order of privilege and tradition in national societies as well as connections between national poverty and weakness and the structure of international society.

Perhaps the link between "national security" and "nuclear catastrophe" remains the most powerful metaphor of a wider condition of pathological politics. The wisdom of our leaders and the resources and safety of our people depend on the proposition that our security can be safeguarded by mutual threats of genocide, threats upon the lives and well-being of hundreds of millions of people with no voice to protest against such awesome danger and uncertainty. A nuclear arms race goes on with expensive, technetronic innovations that improve accuracy, reliability, and destructive force of nuclear warheads, and bring into being new weapons systems (so-called vertical proliferation) that perpetuate the arms race with no longer even the pretense of adding to security. Simultaneously, the means to enter the nuclear club is spreading to many additional governments and may soon be available to splinter political groups as well (so-called horizontal proliferation). In a world system beset by inequality and premised upon a conviction that "might makes right", there is little hope of restraint by those who hold deep grievances. The rational prospect of self-destruction has never deterred those who are desperate or are deeply convinced of the justice of their cause. So we have a situation of mounting danger with no political will evident in any official institution to transform the situation. A virtual sense of resignation and inevitability prevails. During the 1976 Presidential election campaign neither Gerald Ford nor Jimmy Carter queried either the decency or vulnerability of a security system permanently based on nuclear deterrence and arms competition. It should be noticed, however, that Jimmy Carter did assert in his Inaugural Address an intention to "move this year a step toward our ultimate goal — the elimination of all nuclear weapons from this earth." We must await with watchful skepticism, to see if these encouraging words are translated into appropriate policies; we must as well watch what our Soviet superpower rival does to encourage or inhibit impulses toward denuclearization. At present, however, there is no basis for hope that nuclear weapons can be eliminated so long as "security" is entrusted to national military establishments upholding the competitive position of the main sovereign states that together make up the world system.

Despite objective circumstances that make it reasonable to regard our basic political arrangements as obsolete, it seems necessary to recognize that they are also durable. The array of forces favoring the status quo makes it implausible to anticipate global reform that could overcome the inadequacies associated with a world of roughly 170 sovereign states of greatly unequal size, wealth and capability, each pursuing its state interests with scant regard for either each other's or the general well-being of the planet.

This double awareness that change in the political realm is, at once, necessary and impossible underlies the pessimism about the future that prevails in the West. Knowing that pessimism as a posture is often self-fulfilling and tends to immobilize, how do we resist immobilization and begin to consider the nature of the change required of our political structures and the choices available to our culture? I wish to address these issues in the context of planetary politics, seeking, above all, to encourage political activity that rejects a posture of hopelessness and is committed to the establishment of a just world polity as the framework within which national societies and small communities are governed.

The change that is needed is so fundamental that its achievement must be measured over decades, possibly centuries, not years. Therefore, we launch, as it were, upon a voyage; we must depart with a firm sense of present actualities and move toward a destination that is provisional and remote. But, though the destination may be remote, the goals for undertaking the journey must be defined in a realistic spirit. Belief that the journey is possible must undergird the risks. Both the departure and a course wisely set can bring hope to those who join. An early launch is critical as each passing year makes the rites of passage more hazardous. The aspiration that accompanies such a voyage calls to mind a response of Abdul Qadir, a holy person of Sufi tradition alive in the XIIth century. On being asked by an inquirer for guidance — "Can you give us power to improve the earth?" — he is reported to have replied:

> I will do better: I will give this power to your descendants, because as yet there is no hope of such improvement being made on a large enough scale. The devices do not yet exist. You shall be rewarded; and they shall have the reward of their efforts and of your aspiration.
>
> (Idries Shah, *Tales of the Dervishes*)

We need to begin. In beginning we find the ground of our action and the hope needed to sustain risk.

Politics partakes of continuous evolution, offering the challenge of continuous self-transcendence. A "solution" of political issues in some kind of utopian polity is contrary to the evolutionary context of human existence, standing outside the flow of time. No ideal end of history can be happily envisioned; the stoppage of the flow of time would itself have a sterilizing impact upon human consciousness and so would be inconsistent with the judgment that some ideal polity had been attained. By contrast, the contingent politics we endorse is built on an ethos of revolutionary patience: contingent because subject to further evolution and dependent on fallible visions and actions of people; revolutionary because fundamental; patience because the revolution may not possess the capacity to transform existing power structures for many decades.

I. Manifesting Political Conscience

A commitment to possibility is required of those who undertake the voyage. Contingent politics is rooted in such commitment and encourages individuals and groups to manifest political conscience in the face of overwhelming resistance. Some problems may be too difficult for humans to solve. The problem of separating the security of large groups from the technological capacity — cool and abstract — to inflict massive death and destruction may be one such problem, but we do not yet know this. We have not yet

tried. We must start by asking the same sorts of questions as Liz McAlister, one of those brave, unsung persons among us who, as a peace activist, bears witness with body and soul to the reality and gratuitousness of the nuclear menace:

> What has our use of, possession of, proliferation of the bomb done to our spirit as a people? What would it mean if we use these bombs again? What would it mean if others used them against us? What does it mean to destroy the world?... Why the pervasive moral numbness, the crippled public intelligence and imagination? Why the despairing suspicion that nuclear lunacy has gone too far, is too big to fight, too well financed, scenarioed, socially entrenched?... Why will the American left look upon the nuclear arms race as merely one of a myriad of pressing public issues? Who gives any of us the irrational luxury of that conclusion?

What makes these questions vivid for Liz McAlister is that she, in communion with others at Jonah House in Baltimore, is building her life around their seriousness. As I write she is in jail as a consequence of acts of civil disobedience. On December 28, 1976, she joined others in chaining shut the doors of the Pentagon and pouring blood on its columns. With these acts she dramatized for others the seriousness of nuclear policies and challenged the dominant sense of their abstract, irrelevant bearing on our lives as well as the facile view that such issues can be left to the government and are, in any event, beyond the competence or reach of the citizenry.

More is required than manifesting a seriousness of concern; we have heard enough of mere opinions. Liz McAlister and her comrades offer us a view of action that defies a calculus of probabilities without claiming success in the face of formidable odds. Here is Liz McAlister's formulation:

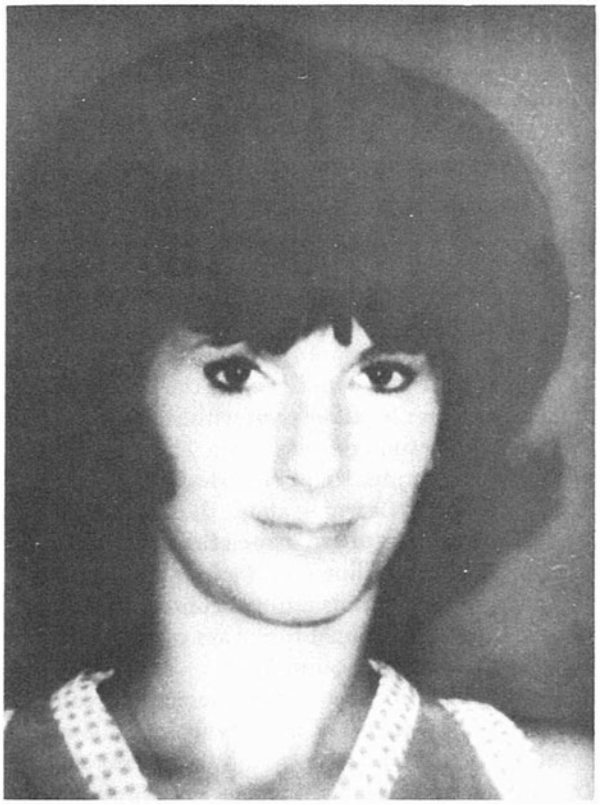
> Can a handful of folk — you and me — awaken conscience and concern? Can we bring life out of this present picture of death? Life is precarious and unpredictable, and the only way to live it is to make every effort to save it as long as there is a possibility of doing so.
>
> (quotations from Liz McAlister taken from *Year One, Vol. II, No. 6*, December 1976)

The Vietnamese people and their revolutionary leaders could not have persisted in their war of almost 30 years against the French and the Americans if they had based their struggle on a calculation of probabilities. Only by concentrating upon the possibility of victory could they ignore the overwhelming probability of failure. Lacking the motivation and inspiration of the Vietnamese, the American Peace Movement, faced with tiny risks by comparison, was repeatedly disillusioned and intimidated because its activities did not produce quick and dramatic results. Such disillusionment arises from an insufficient feeling for struggle as a process that persists despite frustrations and failures. To move toward a just world polity presupposes an assurance that the means and ends are necessary and requires an acceptance of risk, struggle, uncertainty, at every stage, including the capacity to persevere in the face of apparent failure.

Manifesting conscience in concrete deeds by exemplary individuals is critically significant for raising political consciousness about planetary politics. At this stage, the abstractions about planetary danger are so generally accepted that they verge on being platitudes that numb more than arouse. Indeed, political leaders in control of the present outmoded, dangerous, and unjust system themselves bemoan human destiny and acknowledge the seriousness of such realities as nuclear threats, famine, poverty, terror and pollution. However, these same leaders accompany their words with policies that aggravate the very conditions they deplore. By acknowledging the dangers, the managers of power seek to enhance their capacity to govern by building public confidence; by ignoring such dangers in their policies they avoid challenging entrenched vested interests with a heavy stake in high technology, militarism, big business and overseas investment. Considering these realities, it is hardly surprising that official rhetoric points toward the need for transformation and official policies toward the opposite need to sustain the status quo.

The art of ruling an obsolete political order depends on obscuring the gravity of a situation from the citizenry. Otherwise legitimacy would erode and radical movements gain a foothold. If unrest or adverse developments (war, famine, economic or ecological catastrophe) were to make this tension between words and deeds more apparent, as began to happen for many younger Americans in the late 1960's, then we would expect the political leadership to opt for repression rather than benign adaptation. And, indeed, the repressive policies initiated in the Johnson and Nixon presidencies confirm this assessment. On a more intellectual level, the viability of democratic accountability and participation is challenged. Interestingly, the Trilateral Commission, that organization of the super-elite dreamed up by David Rockefeller to coordinate the interests of dominant classes in North America, Western Europe and Japan, sponsored, as well as Jimmy Carter's bid for the presidency, a study arguing that the West was being endangered by an excess of democracy and that the future of these countries might depend on the willingness of their governments to establish greater control over their citizenry even if this meant curbing democratic rights (see published book *The Crisis of Democracy*). Perceptions of this sort reveal a deteriorating situation better than the formal reassurances given by our leaders, but the corrective responses proposed are so menacing that it is as critical to expose their design as to grasp the reality of positive possibilities.

It is juxtaposed against this background that the heroic exploits of individuals challenging these negative trends attain their significance. To the actions of Liz McAlister can be added those of Karen Silkwood, Jim and Shelley Douglass, Dan and Phil Berrigan and countless others whose concerns in a variety of policy contexts inspire their deeds of conscience. We mention these particular individuals to give substance to our argument. Karen Silkwood died a violent death under highly suspicious circumstances while seeking to expose the dangers of nuclear contamination to herself, to her co-workers, and indirectly to all of us, from the Kerr-McGee nuclear fuel plant in Oklahoma. Jim Douglass fasted for weeks against nuclear weaponry and, with the support of the Pacific Life Center, led a campaign of civil disobedience against a proposed base for Trident submarines at Bangor, Washington. With 70 others, Jim Douglass entered the base on August 8, 1976, by cutting a section out of the wire fence protecting the Naval facility. Proclaiming the Trident as an incipient "crime against humanity", the group chose to demonstrate on a Sunday that was between the anniversary of the Hiroshima and Nagasaki bombing. Jim Douglass has been convicted of "mali-

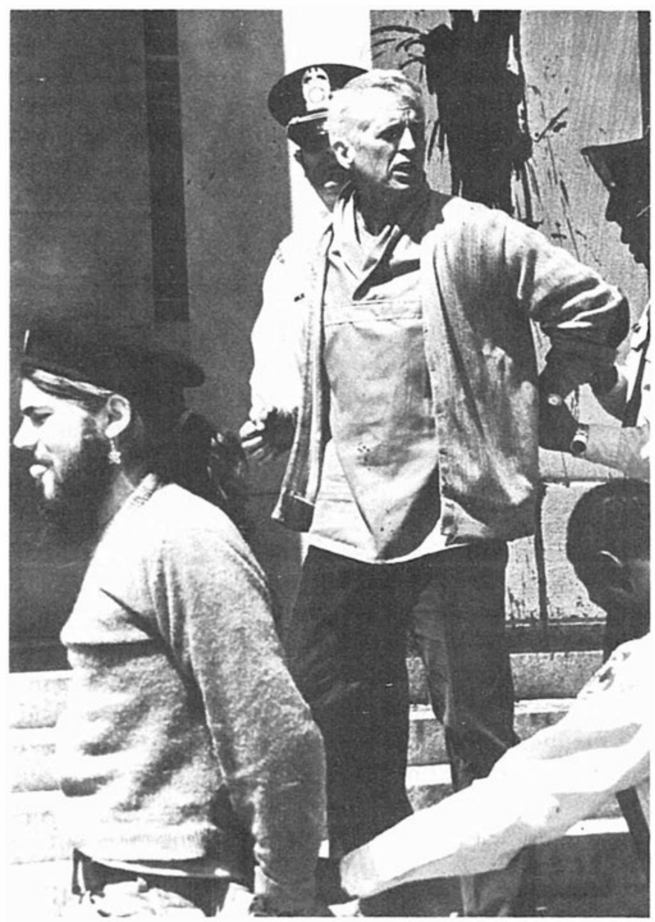


U. S. Agency for International Development has recently admitted to shipping abroad pesticides declared too dangerous for use in the United States; South Vietnam and Indonesia evidently were sent sixty-four metric tons of leptophos for use on cotton crops, despite evidence linking this pesticide to serious nerve disorders and paralysis. Nor can such official insensitivity be linked exclusively to a single ideology. The bureaucratic socialist states within the Soviet orbit have to varying degrees subjected their own people to repressive and cruel policies and have shown, in general, less concern for public well-being than have the capitalist democracies. For instance, Soviet failure to protect its population from the hazards of nuclear energy is notorious and appears far more serious than the lamentable record of protection achieved by American regulatory institutions (Atomic Energy Commission; Nuclear Regulatory Commission). Manifesting conscience through defiant confrontation with the arrayed power of the state is a lonely, frustrating experience that demands profound moral and political dedication. The media characteristically fail to interpret such activity in a clarifying way, confining attention to the punishment imposed by the state and ignoring matters of motivation and concern. Consequently individuals engaged in such activity often feel

cious trespassing" and sent to jail for 90 days; his wife Shelley, also a leader in the struggle, was sentenced to a term of 60 days. Similarly, Dan and Phil Berrigan's frequent recent acts of non-violent but militant witness against the war system are treated as "crimes" by the system. To manifest conscience in ways that expose the violence of the dominant war system, especially if disrespect for property or official symbols of power is displayed, is regarded as "criminal."

The message of such actions is clear: do not trust official institutions or public reassurances on matters of vital significance to the health and safety of the society. It is naive to assume that governments are committed to the well-being of even their own people despite the nationalist mythology associated with the sovereign state. Notably, the most flagrant abuses of human rights are at home, directed toward those who supposedly are beneficiaries of the protective custody of the wrongdoing government. Governmental behavior toward foreign societies, global interests and the future is even less conscientious. Protests against the irresponsibility of foreign governments is common enough, as when Liberia registers as seaworthy unsafe oil tankers (e. g. Argo Merchant) or China explodes a nuclear device that showers radio-activity over the northern hemisphere.

No state is immune from the tendency to endorse the pursuit of power, wealth and prestige, regardless of the harm done to others. A humiliating example can be drawn from recent American behavior. The



isolated and misunderstood. There is not as yet a supportive movement of the sort that existed during the Vietnam period that stands behind those who actively seek a radical restructuring of the world political system.

The message of the deed is not the only effective way to address these issues at this time in American society. Another way to manifest conscience is to embody positive values in concrete life circumstances of personal existence, including joining in the effort to build communities that are as independent as possible of high technology, of the state bureaucracy, and of the money economy. In this regard experimental communities prefiguring a future that is minimally dependent on the state and the market for self-realization are inspiring examples; they demonstrate that alternative futures of a positive sort can exist, at least on a small scale, and be made to work; that we are not yet irreversibly entrapped in an experience of cultural disintegration. Cultural explorations of this kind often are laden with hopeful political content; the New Alchemy Institute, the Philadelphia and Pacific Life Centers, the Lindesfarne Association and the Zen Center (San Francisco) are some positive examples with which I am familiar. In each context, the emergent reality radically repudiates the mainstream polity and culture, particularly its pursuit of a styrofoam prosperity that is rooted in a "national security mentality" and disjoined from the pursuit of life, liberty and happiness for each individual.

A third way of manifesting conscience with regard to planetary prospects is to depict as credibly as possible the contours of a just world polity. To avoid sterile utopography such positive visions need to be accompanied by transition strategies that weigh issues of attainability as seriously as those of desirability. These images of the future, drawn upon a large canvas of ideas and ideology, can foreshadow a positive destiny for human society that complements deeds of conscience by activists and cultural innovations by communities of conscience. As a civilization and as a species, we need images of "the big picture" because, in a period accurately called the age of interdependence, there is no space that is insulated from danger; "the little picture" of private actions and communal life will not flourish if the pressure on governance structures intensifies. If pressure increases, the state is certain to close off experimental space because of its threatening potential. Even now, most people in most societies have no present opportunity to manifest conscience in their lives without inviting death or brutalization. Therefore, a response to the current condition that has any prospect of success must include some program for mobilizing mass support around the possibilities of a new political order of planetary scope based on peace and justice. The World Order Models Project of the Institute for World Order has been seeking to work out such images of "the big picture." In a series of books, intellectuals from the main regions of the world have projected distinct images of how to achieve a world political system based on peace, economic equity, human rights and ecological balance (e. g. Mendlovitz, ed., *On the Creation of a Just World Order*; Kothari, *Footsteps into the Future*; Mazrui, *A World Federation of Cultures*; Falk, *A Study of Future Worlds*). These images, though crude, initiate a global process of envisioning alternative orders of power and wealth that could exist at the *center* of societal arrangements rather than within experimental space along the peripheries of power. These images (not blueprints) emphasize public education as an immediate priority. Learning about the dangers and failings of the present order, associating these dangers and failings with prevailing values and institutional forms, and building a transnational consensus around new values and institutional forms are essential to shaping a different political order.

A just world polity embodying these values can take a variety of forms. The underlying institutional hypothesis is that the state system cannot provide sufficient "central guidance" to deal with problems of planetary scope such as fallout, ozone depletion, endangered species, nuclear peace, disaster relief, tanker spills. Separate state interests are too diverse and antagonistic either to achieve necessary levels of cooperation or to elicit appropriate concern for the well-being of the whole planet and of future generations. Both a global ethics of space and a futurist ethics of time must emerge as real components of political consciousness if we are to deal with major symptoms of societal distress.

A subsidiary conviction is that to conceive of central guidance on top of the state system, in the manner of "world federalism", would merely create a super-bureaucracy, exacerbating disastrous tendencies toward "bureaucratic centralism" that are already crippling spiritual possibilities on the national level. Therefore, our political imagination needs to be stimulated beyond the facile view that the existing failures of governance at the state level to provide adequate security and well-being can be remedied by expanding the scope of governance to a planetary scale. Technology is not the only realm where small is, or can be, beautiful; politics is paramountly such a realm as well. We need to envision how a perspective of smallness translates into social, economic and political forms of organization. How can we achieve world order values, in other words, within a political framework of minimum governance?

Such speculations spring from an understanding of the modern state, its role, strengths and limits. To dismiss the state as "obsolete" overlooks the degree to which peoples of the Third World regard the building of strong states at this stage of their development as a progressive step enabling higher degrees of political, economic and cultural independence; i. e., the state as instrument of anti-imperialism may be regarded in a positive light. Such a positive function of the state does not eliminate criticism of statism as it operates within and among the northern tier of advanced industrial countries, but it does complicate the issue of the state.

Given the outline of priorities for a just global order, certain policies follow. Political and economic decentralization accompanied by a strengthening of cultural vitality must precede and predominate in the process of transformation. Political and economic decentralization at the state level, especially for the rich and powerful, is quite consistent with centralization of the interdependent aspects of international life (e. g., oceans, environment, reserves, human rights). This view of institutional change is dialectical – small is beautiful to achieve human-scale communities, large is necessary to cope with the destructive effects of unregulated and highly interactive human activity. The premises of a social movement to evolve a just world polity derive strongly from the ideological traditions associated with libertarian socialism, philosophical anarchism, humanism, and militant non-violence. Bakunin, Kropotkin, Whitehead, Gandhi and Martin Luther King are among the intellectual forbears of such a movement for change.

The political situation during a time of fundamental change is characterized both by exceptional vulnerability and by a release of creative energies among those that know the old game is almost up. On the one side, we hear intimations of impending doom (Richard Nixon confided to visitors during the last days of his presidency, "I could pick up that phone right now and in twenty-five minutes seventy million people would be dead", as reported by Sen. Alan Cranston, *Rolling Stone,* February 26, 1976, page 35). On the other, we see growing evidence of a spiritual reawakening that includes the rediscovery that national destiny as well as human survival depend on our capacity as a species to participate reciprocally in nature and on our willingness to grasp both distant and near in their totality, as parts of the whole. Of course, such rediscoveries to take hold presuppose a cultural mutation, a veritable leap beyond where we find ourselves that cannot be anticipated by any projection of past trends or any incremental process of continuous adjustment. The options are polar: breakdown or breakthrough. In this sense, hope depends on a radical turn of mind. As Doris Lessing has written ".... there are lungs attached to men that lie as dormant as those of a babe in the womb, and they are waiting for the solar wind to fill them like sails." *(Briefing for a Descent into Hell).* In contrast, despair (or its double – fatuous optimism à la Herman Kahn) reflects a prosaic turn of mind – deploy rational faculties to continue doing what we have, making those small adjustments that seem possible given constraints on change, given the inertia of large organizations, and given the entrenchment of powerful elites and interest groups. Intellectually, as well as politically, no tools for adjustment available to those now running things can provide us with any prospect of a positive human destiny.

Future possibilities are also embodied in past social arrangements. Grasping the life style and world vision of American Indian tribes, for instance, vividly expresses a spiritual conception of human reality, including such values as simplicity, communal solidarity, and connectedness to nature, as expressed in *Black Elk Speaks.* Without romanticizing such past social orders, it is important to realize that satisfying modes of social existence preceded and were displaced by our highly rational civilization with its linear insistence on measurable progress and its insensitivity to cycles and spirals of evolution as assessed by normative achievements like peacefulness, happiness, beauty, spirituality, playfulness. Realizing values appropriate to our situation implies drawing upon the heritage of the past as well as upon innovation. Appreciation of a heritage is not a matter of nostalgia for that which is beyond recall, but of building upon the usable past while working toward a desirable future.

II. Some Comments on the Political Realm

The argument of this essay is that the political prospect of our time must be interpreted primarily in light of the possibilities of cultural renewal along specified lines of value change. What I wish to consider here are both the limits of our present political structures and the possibilities for cultural transformation of consciousness that will influence the configurations of a global policy. By "political" I mean the governing process, that is, the institutional arrangements of power and authority relating to security and welfare within specified boundaries. The territory can be as small as the family, as R. D. Liang points out in *The Politics of the Family,* or as large as the planet or larger. The central political focus in our time is the sovereign state, partly because of its accumulation of incredible firepower to sustain order at home and abroad. Science fiction writers like Ursula LeGuin in *The Dispossessed* extend our political imagination beyond the planet, disclosing the possibility of interplanetary, even intergalactic, politics. As expected, scientists are beginning to make these fictional boundaries of the imagination part of our potential social reality, as Gerald O'Neill's projected "space colonies" indicate.

Politics is closely associated with "economics", the defense or extension of arrangements for the production and distribution of income and wealth. Of particular importance in the present world situation is the extent to which the state upholds rights to own, accumulate and transmit "private property." The ownership of the means of production, which is the issue that most sharply distinguishes socialism and capitalism, the motivation underlying work, and the location of decisional power with respect to production priorities, such as planning versus profits or worker control, are critical economic issues. Other economic issues with political content include the transmission of inequalities from generation to generation, as in "inheritance" or class structure, and the economic inequalities between social classes that leave the "lower"classes below the poverty line. Equality of economic opportunity, independent of sex, race and age, also raises important issues these days for the political process. Class consciousness, the sense of injustice by the deprived, often determines whether the governing process rests on consent, education and persuasion or on force and intimidation. One sign of the deteriorating world situation is the declining presence of consensual government at the state level or, put differently, the disappearing legitimacy of government. The image of the "illegitimate" state arises from a composite of its inability to rule by consent and its related inability to satisfy fundamental human needs for security and welfare.

Politics also is inevitably bound to the pattern of beliefs, values, myths and goals embodied in a culture that identifies and unifies a particular societal grouping. The legitimacy of the state depends also on whether the pacifying myths of the state that arouse loyalty and obedience are commonly accepted by most of the people. "The king can do no wrong" was one such myth that was supportive of the prerogatives claimed by kings and queens. In the contemporary bureaucratic socialist state the reigning monarch has been replaced by "the party" that claims absolute wisdom to rule because it relies upon an infallible body of ideological dogma. Many sovereign states are multicultural; they encompass several religions, languages, heritages, group identities within given territorial boundaries. The political task then at the state level is to propagate unifying myths of shared experience that engender loyalty from each cultural element. If the apparatus of the state is dominated by one cultural entity, a wide-based loyalty is difficult to promote. Indeed, much political conflict in the present period arises from struggles of transnational and subnational groups to achieve greater measures of political autonomy within fixed state boundaries. Most of the separatist movements active in Quebec, Scotland, Iraq, Ethiopia, the Soviet Union, Spain and Belgium are operating in states where the apparatus of governing has been captured by an antagonistic ethnic, regional, religious or language group.

Cultural identity exists on a civilizational level as well as on the state level; the beliefs, values and goals of a civilizational identity transcend the boundaries drawn on world maps or even the boundaries created by separate languages, races and religions. Sensate materialism, for instance, is buttressed by the conviction that "progress" in human affairs is possible only so long as science-based technology is continuously applied to increase the productivity of agriculture and industry. Both socialist and capitalist political ideologies share this underlying commitment to economic growth, measured by increases in GNP. An image of indefinite expansion of world product ignores "the limits to growth" arising from the constraints of finite acres of agricultural land, deposits of mineral resources and environmental capacity to absorb pollution. Despite a flurry of interest in 1972 in *The Limits to Growth* published under the auspices of The Club of Rome, the governing elites of the world have unanimously reaffirmed that, at least in the short run, only growth can deal with the economic issues that matter – jobs, inflation, not to mention profits. Although useful in posing questions, the Club of Rome perspective – elitist, technocratic – took for granted the desirability of maximum material growth, confining its analysis to matters of sustainability.

Only very recently has questioning of the cultural underpinnings of industrial civilization been taken seriously; hence, we have the gradual emergence of "a counter-culture" in Western, open societies. These gropings toward cultural renewal converge around the view that spiritual realities are the essence of every benevolent pattern of human development, that a technology geared to abstract and aggregate societal goals such as GNP increases and returns on capital is not socially beneficial, even if it were ecologically sustainable, and that economic over-development tends to occasion cultural regression. In a time of cultural regression, life seems meaningless and many pathological patterns of behavior emerge; there is a loss of personal and communal centeredness, a deepening alienation from neighbors, from nature, from spiritual possibilities. The inability of American citizens to walk safely in their cities, despite the extraordinary levels of societal affluence attained, is indicative of a failing culture. Neighbors who watch a woman being assaulted and raped from the safety of their apartment windows without bothering to telephone the police exemplify this loss of human connection. Such loss disposes the dissatisfied toward violence and the satisfied toward repression. Terrorism of many descriptions results on both sides. It is no wonder a police chief in the Bronx, when interviewed about his role, described it as heading "an army of occupation."

Attitudes toward "nature" are reflected in a cultural identity. The mainstream culture of the modern West upholds the human capacity to transcend, to dominate and to pacify nature. This attitude has precipitated a global ecological crisis that is destroying our habitat and diminishing the life prospects of future generations, simultaneously producing mass alienation. Individuals entrapped in this dying culture start from their own reality of "alienation" to explore a wide variety of strategies for "reunion" with nature. Not all of the explorations are desirable. At one extreme hard drugs impose intolerable costs on body and spirit as the price of a bogus, if exhilarating, reunion. At another, "quick fix" business propositions like EST help their customers tune out of the alienating circumstance of the culture, at least for a while, by various psychological devices of reinforcement, assuring individuals of the normalcy of their feelings and actions, as well as affirming egocentric views of social experience (get what you can, don't feel guilt, don't judge others).

Alienation from nature produces a mind set that compartmentalizes rather than interconnects and unifies. Thus, those who live in a faltering culture tend to examine its politics and economics but not necessarily its underlying values and beliefs. We accept that the governing process seeks to sustain economics that serve the dominant culture. Those who are deeply dissatisfied with economic performance because it is wasteful or unfair or destructive are characteristically at odds with prevailing politics, but do not necessarily draw the dominant culture into question. For instance, most of the ideological/political struggles associated with socialism, fascism and liberalism that have produced much of the high-technology in our country are carried on within an accepted cultural framework of secular materialism. Only recently is the political question beginning to be posed in cultural as well as economic terms. The Chinese emphasis on "cultural revolution" and the emergence of "counter-cultural" forms in the West are two directions of radical politics that express an appreciation of the fundamental role of culture in structuring societal forms, as well as human consciousness. Such a cultural emphasis tends to convert political outlooks from a concern with "events" (the revolution) to a focus on "process" ("permanent evolution"). Cultural preoccupations also lengthen time horizons as the processes of change connected with underlying beliefs, values, myths and goals are slow and continuous.

Whether attempts at cultural renewal can endure in a hostile global climate is questionable. Even China's experiment, while a profound example of cultural renewal, is not without deep difficulties. Mao Tse-tung's imposition of a rigid common conception that was intolerant of any dissent makes Chinese culture vulnerable, especially with Mao's absence, to the appeals of the technetronic age and the bureaucratic centralizing tendencies of the modern state. Cultural innovations in Western democracies are equally vulnerable. In some sense they are dependent on the beneficence of liberalism in the culture whose values they abhor. Such dependence can be corrupting, but, even when it is not, the state will be disposed to crack down on innovation when pressures, resulting from the failures of liberalism, mount against its own claims of legitimacy.

To seek or to create possibilities for cultural renewal is a radical expression, in the sense of going to the root of things. Due to its nature, such expression is rejected by almost all those who dominate present political and economic arrangements. In my view, to expect political renewal to emanate from the official institutions of the state located in Washington is as foolish, though not quite as obviously foolish, as to expect cultural renewal to come from the TV networks or Hollywood movies. Indeed, the nihilistic quality of recent big budget Hollywood movies reflects a cultural condition of severe anomie — all viewpoints are corrupt; self-seeking is drenched with violence; technological gadgetry infatuates the characters; the backdrop is often an antiseptic surrounding of urban modernity, and a figure that critic Richard Eder identifies as the "anti-hero" dominates the script. "King Kong", "Marathon Man", "The Next Man", "The Killer Elite", "Network" and "Three Days of the Condor" are productions in this vein. A growing awareness of this cultural situation is more likely than is an awareness of the political situation. An underlying illusion of competence in the political arena persists, despite a temporary loss of public confidence in the integrity of the governing process created by Vietnam/Watergate. However, political and cultural consciousness are becoming reconnected here in the United States, and this holds promise.

Many of those who were disillusioned politically in the 1960's have been working seriously to rebuild the culture. Properly interpreted, their disillusionment does not entail renouncing goals like peace and justice, but it may represent a realization that these goals cannot now be directly, narrowly or exclusively pursued. What has been difficult for political radicals in America to learn is that the climate for change does not yet exist and that there is no quick fix for the polity once it is understood that the priorities for change are integrally linked with shifting values, as well as shifting power elites. But such an understanding is essential, for without a culture-based politics of renewal every prescription for either reform or revolution is certain to fail when put to the test. In addition, in the United States there is no basis as yet for mobilizing support for radical change. Revolutionary initiatives, being premature, prompt counter-revolutionary tactics by the state. Indeed, modern experience with political revolutions increasingly is being interpreted by those Western radicals seeking fundamental structural changes in social, political and economic realms, as discrediting politics per se. More accurately, this experience should be understood as discrediting autonomous politics. Such an understanding could move us beyond despair for the future, because the therapy, although slow, is attuned to the pathology as well as to the relation of forces and can be immediately vindicated in concrete situations of individual and group behavior.

When a country is materially impoverished, as is the case throughout Asia, Africa and Latin America, the process of alienation can be deferred if the societal energies are mobilized around the elimination of poverty, the attainment of equity and a vision of societal purpose. Cuba, after decades of corruption and slumber, has illustrated this dynamism during the Castro years. But if it is correct that spiritual identity is integral to human fulfillment, then alienation is bound to emerge if Cuban society is constrained for an indefinite period by a materialist ethos of work and service. Even though "work and service" under revolutionary conditions can partake of some spirituality, especially when they are inspired by a charismatic leader with a vision of the future, cultural creativity eventually presupposes a level of individual freedom to transcend earlier societal norms or a traditional core of shared beliefs that provides a spiritual center available to all. Without either freedom or tradition, cultural decline is bound to result and a condition of cultural underdevelopment emerge. We know from Western experience that materialist satisfactions, even in circumstances of individual freedom, will not prevent cultural underdevelopment if spiritual values are totally divorced from the daily realities of work and living.

Poor countries have stressed the priority of economic development in recent years. Only lately has it become clear that, if the strategy of economic development is dominated by the goals of a privileged elite or is carried out without concern for human effects, the results are likely to be adverse. Political or economic changes that are separated from a preservation of human rights are necessarily reduced to a conventional political attempt to seize power on behalf of a repressed elite. Even if a one-dimensional change should succeed and live up to the promises of those seeking power, it is unlikely to provide the kind of restructuring of behavior and institutions capable of integrating political, economic and cultural perspectives. For this reason, a new stress on human rights is being made around the world by those who hold progressive ideals associated with peace, empathy and love of nature. The elementary realization of human rights is a precondition for cultural renewal.

This emphasis on human rights is also a response to the repressive exercise of state power in a situation of deepening crisis, especially throughout the Third World. These tendencies can be summarized as a drift toward several varieties of authoritarian rule in the Third World. The authoritarian solution, combining extreme centralization of power and brutal practices of repression that include torture on a systematic basis, is a direct consequence of reliance upon capitalist or market-oriented development strategies in contexts of massive poverty and extensive inequality, where an acute sense of injustice on the part of victims exists. That is, development strategies, exemplified by such societies as Brazil or South Korea, generally put the governing elite in the service of a somewhat larger societal grouping, about ten to twenty-five per cent of the total, composed of traditional land-owning and industrial elites, skilled laborers, merchants and the civil servants, including the military. A recent affirmation of faith in this development model was inadvertently made by Pablo Baraona, Director of the Central Bank in Chile and a close economic advisor of the Pinochet regime, when he asserted that the fact "that more than 90 per cent of the people are against our policies is proof that the model is working " (quoted in *N. Y. Times,* December 8, 1976, page A18).

The organic interplay of politics, economics and culture provides the basis for reconstructing the future in beneficial ways. Such a view starts with a critique of those forms of "development" that rest on mere "growth", without emphasis on "justice" or "the quality of life." It moves from critique to activity, either by way of political struggle or cultural innovation. Because societal circumstances vary dramatically, what makes sense in the United States may be impossible to undertake in the Soviet Union and inappropriate in Zaire or Bolivia. There is, however, a common motif: humane development. That kind of development will encourage political, economic and cultural forms that move toward goals that can be professed under all circumstances: non-violence, economic well-being, human rights and ecological balance.

Concrete expression of these shared goals will be determined by the particularity of individuals and groups as they decide how best to act given their own talents, desires, circumstances of time and place. In general, however, we require a solution of planetary scope as well as one of human scale. We require myths of solidarity and destiny that generate the political will to evolve planetary procedures of central guidance. As soon as possible, we need minimum institutions of planning, regulation and assessment that are both responsive to the realities of interdependence and reflective of a new positive consensus to create planetary community. Our need is urgent, but the nature of the task is such that it cannot be rushed without being ruined. Decades, at least, will be required.

Finally, cultural politics on the levels of human interaction and planetary politics on the level of global interdependence will depend mainly on grassroots political possibilities. The official elites in most governance structures are incapable of a radical re-structuring of their attitudes and behavior. Instead, the citizenry must be mobilized to challenge the assumption of official institutions; leadership responsive to a new populist ideology must emerge. Whether this can happen, and where, is problematical. Do we look to Governor Jerry Brown as a political forerunner, a bearer of some of the values of cultural renewal but also as one compelled to operate, for political effectiveness, within a web of vested interests and stereotyped beliefs?

We do not know whether we can or will succeed. But we do know, I think, that we will be lost — spiritually, and quite possibly, biologically — if we fail to try. The case for trying seems overwhelming.

III. An Anthropological Postscript

Science fiction writers have always been acutely aware that the universe may include several planets capable of sustaining human-type societies and that the fundamental history and organization of each may be dramatically different. It is often unclear whether a particular author believes that the foundation of this difference is a matter of cultural evolution or reflects the presence in the universe of an array of species with differing social traits. In the latter instance, the interpretation of the difference is largely an anthropological matter, and its careful study could help illuminate both limits and potentialities bearing on human development.

Ursula LeGuin touches on these issues toward the end of *The Dispossessed* when the physicist-hero Shevek is voyaging back to the anarchist planet of Annares after an extended visit to Urras, a planet that seems close to what our earth civilization might become in a couple of centuries if we prove lucky enough to escape an apocalyptic transfiguration. Shevek engages in conversation with Keng, the ambassador from Terra, about different human societies, those "...billions of people in the nine Known Worlds?" Shevek explains to Keng that his creative breakthrough ("Transilience, space travel, you see, without traversal of space or lapse of time") would make possible a mutually beneficial, new planetary order among these nine worlds, but that A-Io, a country in Urras, sought possession of the new understanding of ultimate reality for imperialist purposes, "to get power over others, to get richer or to win more wars." Shevek, in the end, chooses to repress knowledge under these circumstances: "I will not serve *any* master."

Keng concludes that the anarchistic community of Anarres sounds too good to be true: "I wept listening to you, but I really didn't believe you. Men always speak so of their homes, of the absent land.... But you are *not* like other men. There is a difference in you." Since Anarres was originally created by countercultural struggle on Urras, the difference discerned seems mainly unconnected with species traits, but is an expression of cultural potentiality.

But Keng herself sounds like one who comes from neither world. To her "Urras is the kindliest, most various, most beautiful of all the inhabited worlds. It is the world that comes as close as any could to Paradise." And she notes that for Shevek, in contrast, Urras is Hell. What, then must Terra be like? Keng describes Terra:

> My world, my Earth, is a ruin. A planet spoiled by the human species.. We controlled neither appetite nor violence; we did not adapt.... there are not forests left on my Earth. The earth is grey, the sky is grey, it is always hot... there are nearly a half billion of us now. Once there were nine billion.... We failed as a species, as a social species.

The destiny that befell Terra is now threatening us. In a sense, Urras is our positive destiny, Terra our negative destiny. Both are dysutopias. Annares is depicted by Ursula LeGuin as "an ambiguous utopia", problematic, but better than anything the rational mind can calculate, an anarchistic polity that embodies a radically different set of societal arrangements. Is it out beyond the reach of the human species and, hence, utopian, in the sense of being imaginable but unattainable? Or is it one of the possible lines of potential human development encoded into our genotype as a species? After listening to Shevek tell about his own belief in human potentiality,Keng exclaims "I thought I knew what 'realism'was," and Shevek replies, "How can you, if you don't know what hope is."

Hope, to be credible, has to be founded on radical expectations. Muddling through cannot expect to achieve more than the world of Urras and is more likely to invite the fate of Terra, a degraded human existence, but not total extinction. Jean Paul Sartre, interviewed on his seventieth birthday, described his greatest failing as not being radical enough, not going far enough in following through on his beliefs. How to find the insight and wisdom and strength to be radical enough is probably the most important issue facing individuals who are both realistic and hopeful about the future. I was recently impressed by Anais Nin's self-appraisal at the end of her sixth volume of diaries: "I feel I have accomplished what I hope to accomplish: to reveal how personal errors influence the whole of history and that our real objective is to create a human being who will not go to war." This outlook is what I mean by an anthropological perspective.

Such a perspective concerns *limits* as well as *horizons*. Earlier in this essay I ventured the view that we may be dealing with some problems that are too difficult for human beings to solve. If that is correct, the expenditure of effort for their solution merely deepens frustration. I feel that such reasoning applies in recent decades to many dimensions of technology. We have already allowed our curiosity and greed to open too many Pandora's Boxes to survive very well as a species. Our sense of historical absolutism is such that *any* step needed to achieve immediate security or prosperity seems justifiable at the time. The nuclear bomb is a prime instance of anthropological arrogance. We are the wrong species to handle this kind of technology in any acceptable way. Our political forms are too unstable to assure restraint over time. Our personality structures are too variable to ennoble much confidence that psychopathic behavior will not intervene at some stage to unleash a gratuitous nuclear holocaust. Furthermore, the biosphere is subject to such a variety of natural disasters that it is impossible to assure physical stability for long time periods. This questioning of human capacity seems well-founded given recent experience as diverse as Auschwitz, Hiroshima, Gulag Archipelago.

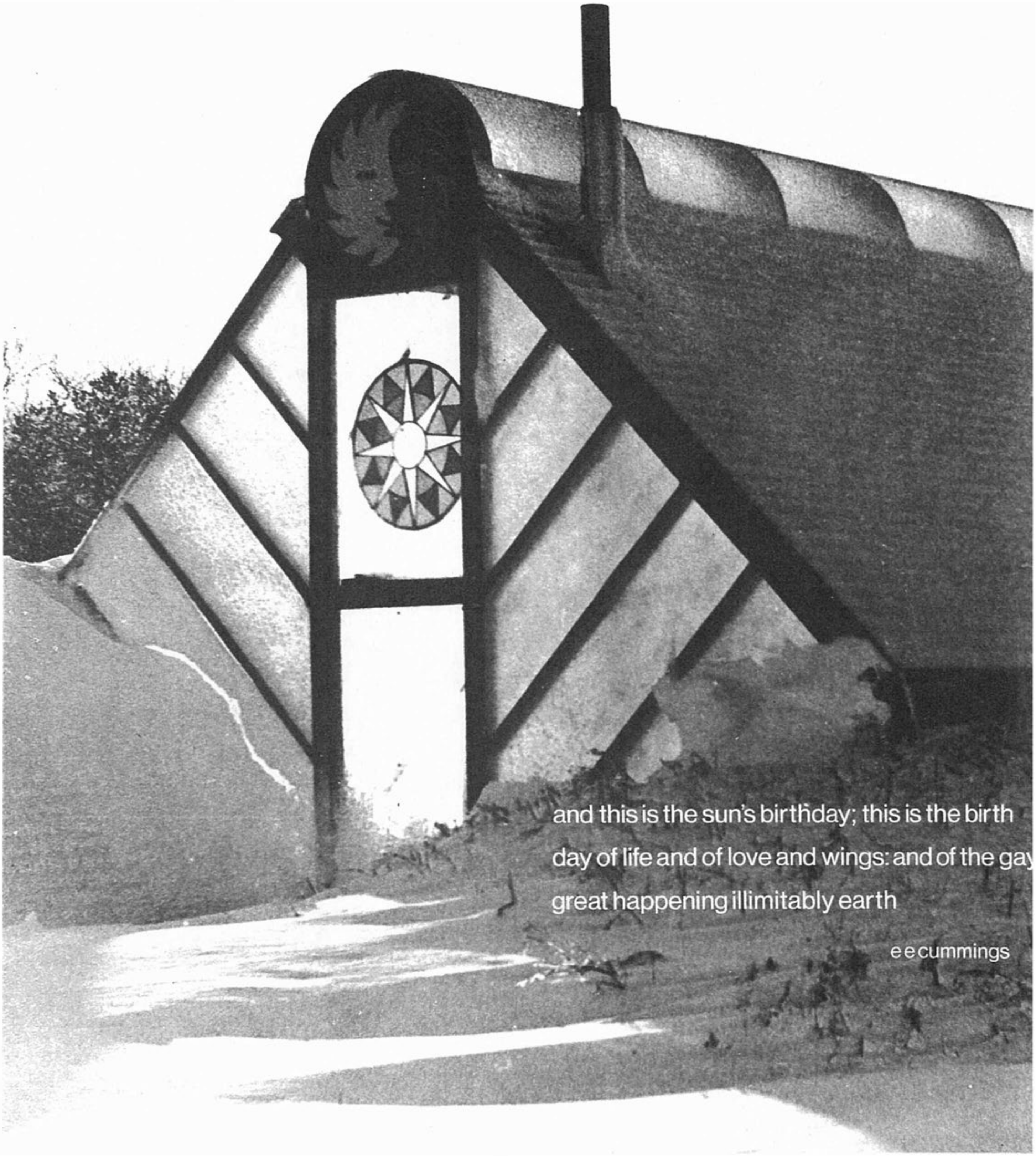
The experience with nuclear technology is worth examining. The bomb was originally developed at a furious pace ("The Manhattan Project") because of a fear during World War II that Germany might acquire it first. But once we had acquired it, we used and developed it along quite different lines. The use of the bomb against the Japanese lacks a credible national survival justification, despite the rationalization that it saved lives of the society that used the bomb. Even this limited claim of "military necessity" is controversial; some historians feel that Japan was prepared in any event to surrender, or would have, had a demonstration explosion been made. After the bomb was used, the United States made only a short-lived, half-hearted and controversial attempt to achieve nuclear disarmament. When the attempt failed in 1946, a process of continuous evolution of nuclear weaponry and its gradual dissemination began. Furthermore, the governments of nuclear states have insisted on independent discretion to use these weapons as they see fit in international conflict situations.

And now thirty years later energy concerns are leading governments around the world to make heavy investments in nuclear power industries not only as sources of electricity but also for assured access to nuclear weaponry at little additional cost or effort. Like the bombs, nuclear reactors create hazards that require the kinds of perfect control that human society is ill-equipped to provide. Too much stability and technological ingenuity is required over too long periods. To aspire after such stability is itself undesirable and dangerous, creating pretexts for further interventions by the state in our lives. The presence of numerous nuclear reactors in societies that include many disturbed and tormented individuals, as well as social and political discontent, points up the need for extensive police surveillance and a permanently militarized polity. Any enlightened citizenry would demand to live in a police state as the lesser of two evils in the event nuclear power takes hold in a major way.

Like Icarus we are trying to fly close to the sun with waxen wings. Perhaps this impulse to do more than we can has been part of our temperament as a species from the beginning; perhaps, it played a positive role in earlier periods, helping our ancestors to find their way out of the cave and enabling human beings to accomplish marvelous and mysterious things. But with the advent of nuclear technology, biogenetics and weather control, we have exceeded our limits as a species. The wax that holds our wings is melting. Is there time to descend? Do we have the wisdom and will to do so?

Anthropologists of the future will be fascinated by whether we pose and respond to such questions. For now, those who care about the future will do well, I think, to mobilize their energies to oppose the powerful forces that insist upon the inevitability of technetronic momentum.

Photo by Hilde Maingay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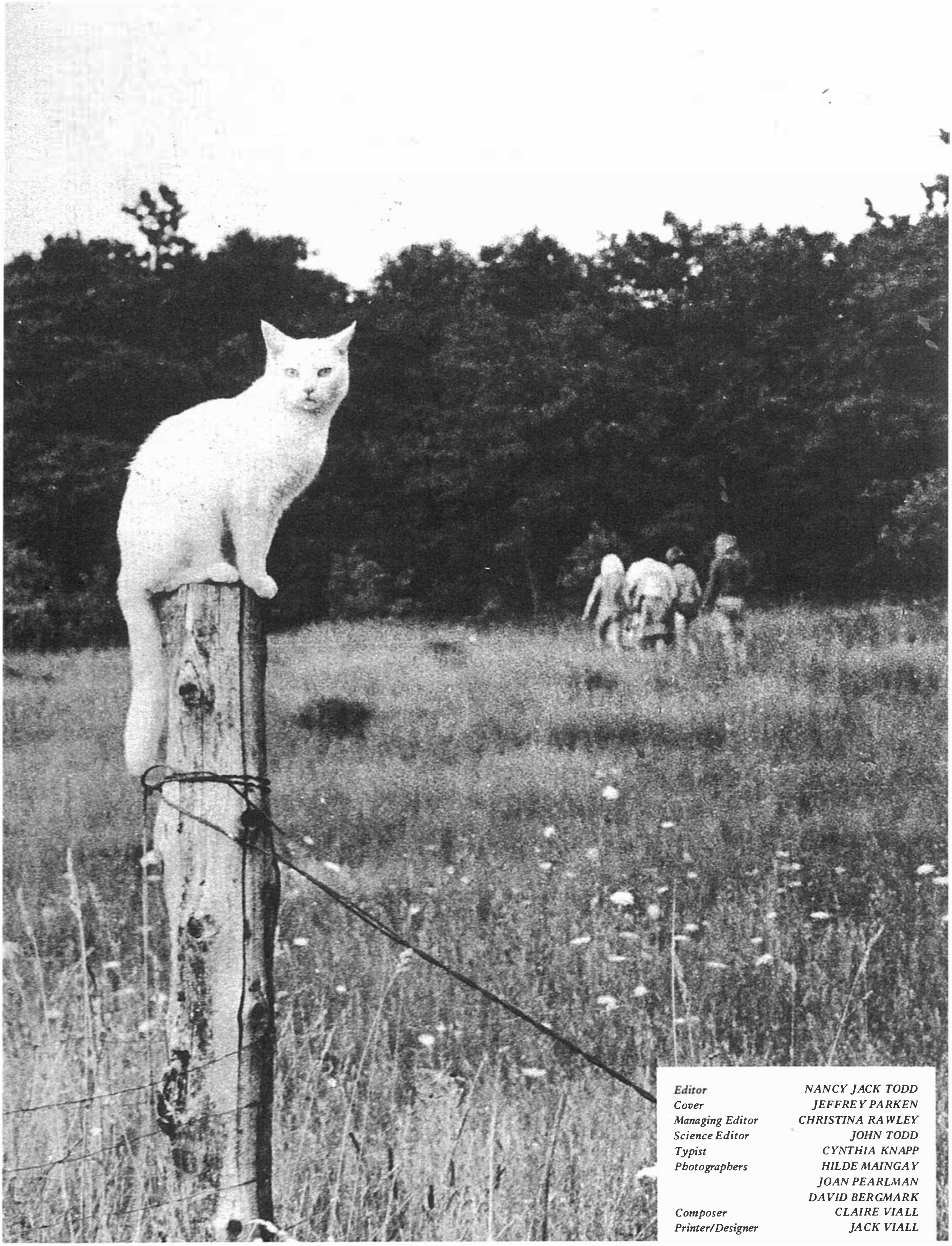

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