

The World that Came in the Mail



By Carl Sagan

The world arrived in the mail. It was marked "Fragile." A picture of a cracked goblet was on the package. I unwrapped it carefully, dreading the discovery of a shard of glass or the tinkle of broken crystal. But it was intact. With both hands, I lifted it out and held it up to the sunlight. It was a transparent sphere, about half filled with water... The number 4210 was inconspicuously taped to it. World number 4210: There must be many such worlds. Cautiously, I placed it on the accompanying Lucite stand and peered in.

I could see life in there - a network of branches, some encrusted with green filamentous algae, and six or eight small animals, mostly pink, cavorting, so it seemed, among the branches. In addition, there were hundreds of other kinds of beings, as plentiful in these waters as fish in the oceans of Earth; but they were all microbes, much too small for me to see with the naked eye. Clearly the pink animals were shrimp of some suitably unpretentious variety. They caught your attention immediately because they were so busy. A few that had alighted on branches were walking on 10 legs and waving dots of other appendages. One was devoting all its attention and a considerable number of limbs, to dining on a filament of green. Among the branches, draped with algae much as trees in North Florida are covered with Spanish moss, other shrimp could be seen moving as if they had urgent appointments elsewhere. Sometimes they would change their colors as they swam from environment to environment. One would be pale, almost transparent, another orange, with an embarrassed blush of red.

In some ways, of course, they were different from us. They had their skeletons on the outside, they could breathe water, and a kind of anus was located disconcertingly near their mouths. (They were fastidious about appearance and cleanliness, though, possessing a pair of specialized claws with brushlike bristles. Occasionally, one would give itself a good scrub.)

But in other ways they were like us. It was hard to miss. They had brains, hearts, blood and eyes. That flurry of swimming appendages propelling them through the water betrayed what seemed to be an unmistakable hint of purpose. When they arrived at their destination they addressed the algal filaments with the precision, delicacy and industriousness of a dedicated gourmet. Two of them, more venturesome than the rest, prowled this world's ocean, swimming high above the algae, languidly surveying their domain.

After a while you get so you can distinguish individuals. A shrimp will molt, shedding its old skeleton to make room for a new one. Afterward, you can see the thing - transparent, shroudlike, hanging rigidly from a branch, its former occupant going about his business in a sleek new carapace. Here's one missing a leg. Had there been some furious claw-to-claw combat, perhaps over the affections of a devastating nubile beauty?

From certain angles, the top of the water is a mirror, and a shrimp sees its own reflection. Can it recognize itself?

At other angles, the thickness of the curved glass magnifies them, and then I can make out what they really look like. I notice, for example, that they have mustaches. Two of them race to the top of the water and, unable to break through the surface tension, bounce off the meniscus. Then, upright, they gently sink to the bottom. Their arms are crossed casually, it almost seems, as if the exploit were routine, nothing to write home about. They're cool.

If I can clearly see a shrimp through the curved crystal, it must be able to see me, or at least my eye - some great looming black disk, with a corona of brown and green. Indeed, sometimes as I watch one busily fingering the algae, it seems to stiffen and look back at me. We have made eye contact. I wonder what it thinks it sees.

After a day or two of preoccupation with work, I wake up, take a glance at the crystal world... and they all seem to be gone. I reproach myself. I'm not required to feed them or give them vitamins or change their water or take them to the vet. All I have to do is make sure that they're not in too much light or too long in the dark and that they're always at temperatures between 40 and 85 degrees Fahrenheit. (Above that, I guess, they make a bisque and not an ecosystem.) Through inattention, have I killed them? But then I see one poking an antenna out from behind a

branch, and I realize they're still in good health. They're only shrimp, but after a while you find yourself worrying about them, rooting for them.

If you're in charge of a little world like this, and you conscientiously concern yourself about its temperature and light levels, then - whatever you may have had in mind at the beginning - eventually you care about who's in there. If they're sick or dying, though, you can't do much to save them. In certain ways, you're much more powerful than they, but they do things - like breathing water - that you can't. You're limited, painfully limited. You even wonder if it's cruel to put them in this crystal prison.

But you reassure yourself that at least here they are safe from whales and oil slicks and cocktail sauce.

The ghostly molting shrouds and the rare dead body of an expired shrimp do not linger long. They are eaten, partly by the other shrimp, partly by invisible microorganisms that teem through this world's ocean. And so you are reminded that these creatures don't work by themselves. They need one another. They look after one another - in a way that I'm unable to do for them. The shrimp take oxygen from the water and exhale carbon dioxide. The algae (a plural word; singular: alga) take carbon dioxide from the water and exhale oxygen. They breathe each other's waste gases. Their solid wastes cycle also, among plants and animals and microorganisms. In this small Eden, the inhabitants have an extremely intimate relationship.

The shrimp's existence is much more tenuous and precarious than that of the other beings. The algae can live without the shrimp far longer than the shrimp can live without the algae. The shrimp eat the algae (and the microorganisms), but the algae mainly eat light.

Unlike an aquarium, this little world is a closed ecological system. Light gets in, but nothing else - no food, no water, no nutrients. Everything must be recycled. Just like the Earth. In our larger world, we also - plants and animals and microorganisms - live off each other, breathe and eat each other's wastes, depend on one another. Life on our world, too, is powered by light. Light from the Sun, which passes through the clear air, is harvested by plants and powers them to combine carbon dioxide and water into carbohydrates and other foodstuffs, which in turn provide the staple diet of the animals.

Our big world is very like this little one, and we are very like the shrimp. But there is at least one major difference: Unlike the shrimp, we are able to change our environment. We can do to ourselves what a careless owner of such a crystal sphere can do to the shrimp. If we are not careful, we can heat our planet through the atmospheric greenhouse effect or cool and darken it in the aftermath of a nuclear war. With acid rain, ozone depletion, chemical pollution, radioactivity, the razing of tropical forests and a dozen other assaults on the environment, we are pushing and pulling our little world in poorly understood directions. Our purportedly advanced civilization may be changing the delicate ecological balance that has tortuously evolved over the 4-billion-year period of life on Earth.

Crustacea, such as shrimp, are much older than people or primates or even mammals. Algae go back 3 billion years or more. They've been working together - plants, animals, microbes - for a very long time. The arrangement of organisms in my crystal sphere is ancient, vastly older than any cultural institution we know. The inclination to cooperate has been painfully extracted through the evolutionary process. Those organisms that did not cooperate, that did not work with one another, died. It never occurs to the shrimp to, let's say, pave over an algal garden and make a parking lot. Cooperation is encoded in their genes. It's their nature to cooperate.

But we humans are newcomers, arising only a few million years ago. Our present technical civilization is just a few hundred years old. We have not had much recent experience in interspecies (or even intraspecies) cooperation. We are very devoted to the short-term and hardly ever think about the long-term. There is no guarantee that we will be wise enough to understand our planetwide closed ecological system, or to modify our behavior in accord with that understanding.

Our planet is indivisible. In North America we breathe oxygen generated in the Brazilian rain forest. Acid rain from polluting industries in the American Midwest destroys Canadian forests. Radioactivity from a Soviet nuclear accident compromises the economy and culture of Lapland. The burning of coal in China warms Argentina. Diseases rapidly spread to the farthest reaches of the planet and require a global medical effort to be eradicated.

And, of course, nuclear war imperils everyone. Like it or not, we humans are bound up with our fellows and with the other plants and animals all over the world. Our lives are intertwined.

If we are not graced with an instinctive knowledge of how to make our technologized world a safe and balanced ecosystem, we must figure out how to do it. We need more scientific research and more technological restraint. It is probably too much to hope that some Great Ecosystem Keeper in the sky will reach down and put right our environmental abuses. It is up to us.

It should not be impossibly difficult. Birds - whose intelligence we tend to malign - know not to foul the nest. Shrimps with brains the size of lint know it. Algae know it. One-celled microorganisms know it. It is time for us to know it too.

When the Apollo Astronauts set out for the Moon - during that brief period of manned exploration between 1968 and 1972 - they carried all their food with them. One way, it was a short three-day journey. Now there is increasing interest in missions of men and women to the planet Mars and even the eventual settlement of other planets. But a trip to Mars typically takes some nine months or more. If you carry all your food and oxygen and water with you, you must carry a great deal of additional mass, which makes the trip much more difficult and expensive, and therefore much less likely.

The solution is to recycle our wastes, generate our own oxygen and grow our own food. So an interplanetary spacecraft carrying a human crew must become something like a closed ecological system. It must hold non-human life, especially plants. If we humans venture far from Earth, we must make our spaceships into gardens.

Serious study of such systems is under way. For example, the commercially available EcoSphere described in the accompanying article was developed by Joe Hanson of NASA's Jet Propulsion Laboratory.

However, the most elaborate attempts to devise closed ecological systems involving humans, at least so far, have been made by the Soviets. In a Siberian research institute at Krasnoyarsk is a facility called Bios. In it, subjects live out their daily lives long enough for a trip to Mars. The longest continuous stays have been for five months, but one researcher has, in multiple experiments, spent an total of 13 months inside. Reportedly, occupants are issued only a fifth of the food they will need, and there is no re-supply of water and air, no flushing away of waste products. In fact, nothing enters or leaves except electricity and radio waves. Hydroponic tanks are everywhere, and Bios is filled with plants - dill, kohlrabi, wheat, peas and many other vegetables - grown in soilless nutrient media. The "travelers" bake bread. The vegetation generates oxygen. Wastes are recycled.

They are still learning. They have a furnace in which everything inedible, such as plant roots and straw, is burned. But the catalysts were not working well at first, and slowly the cabin began to fill with poisonous oxides of nitrogen from the furnace. The growth of wheat slowed considerably, the potato leaves began to curl. The plants had noticed a problem before the humans did. When the catalysts to remove noxious gases were replaced, the air freshened and the plants revived.

Such systems are being perfected and will play a key role in future human exploration of the solar system. There is nothing that ties such closed ecological systems to spaceships. After the astronauts and cosmonauts set down on Mars, their food, air and water can still be supplied largely by the plants that accompanied them on their long journey. Sunlight and other energy sources will be available, and Mars itself can be made to yield up oxygen and water.

Perhaps some future Johnny Appleseed will dot Mars with self-contained ecosystems, oases that will be the inns and way stations for the explorers of the 21st century.

Dr. Carl Sagan, director of the Laboratory for Planetary Studies at Cornell University, was a recipient in New York of the United Nations Environment Program Medal and in Tokyo of the Honda Prize for "contributions toward... a new era of human civilization."