Seeds of Life

Cyril Ponnamperuma

Physicists might eventually be able to come up with a grand unification theory that encompasses not just subatomic particles and the basic elements, but the code of life as well. Who knows? Life elsewhere in the universe may even be five feet tall and standing on two legs.

The shelf behind Cyril Ponnamperuma's desk is lined with colored sticks and balls — models of the molecules that gave rise to life. A can of Campbell's Soup placed in front of the molecules is relabeled to read Primordial Soup. And on the wall is a picture of Julia Child stirring one of Dr. Ponnamperuma's reeking organic concoctions. The room, needless to say, reflects the preoccupation of its occupant, for this intense and lively man has spent his career trying to answer one encompassing question: How did life begin?

"All life has a common chemical beginning," said Ponnamperuma. "If we examine the smallest microbe or the most intelligent human being, the molecules are the same. We can trace a continuum from the formation of the elements at the beginning of the universe to the appearance of replicating systems. We can draw a line from eighteen billion years ago to the time when the first man walked on Earth."

Ponnamperuma was born in Sri Lanka, then Ceylon, and received a bachelor's degree in chemistry from Birkbeck College of the University of London in 1959 and his Ph.D. from the University of California at Berkeley in 1962. The following year he joined NASA's Exobiology Division and became chief of the chemical evolution branch. Since 1971 he has been professor of chemistry and director of the Laboratory of Chemical Evolution at the University of Maryland. He is also

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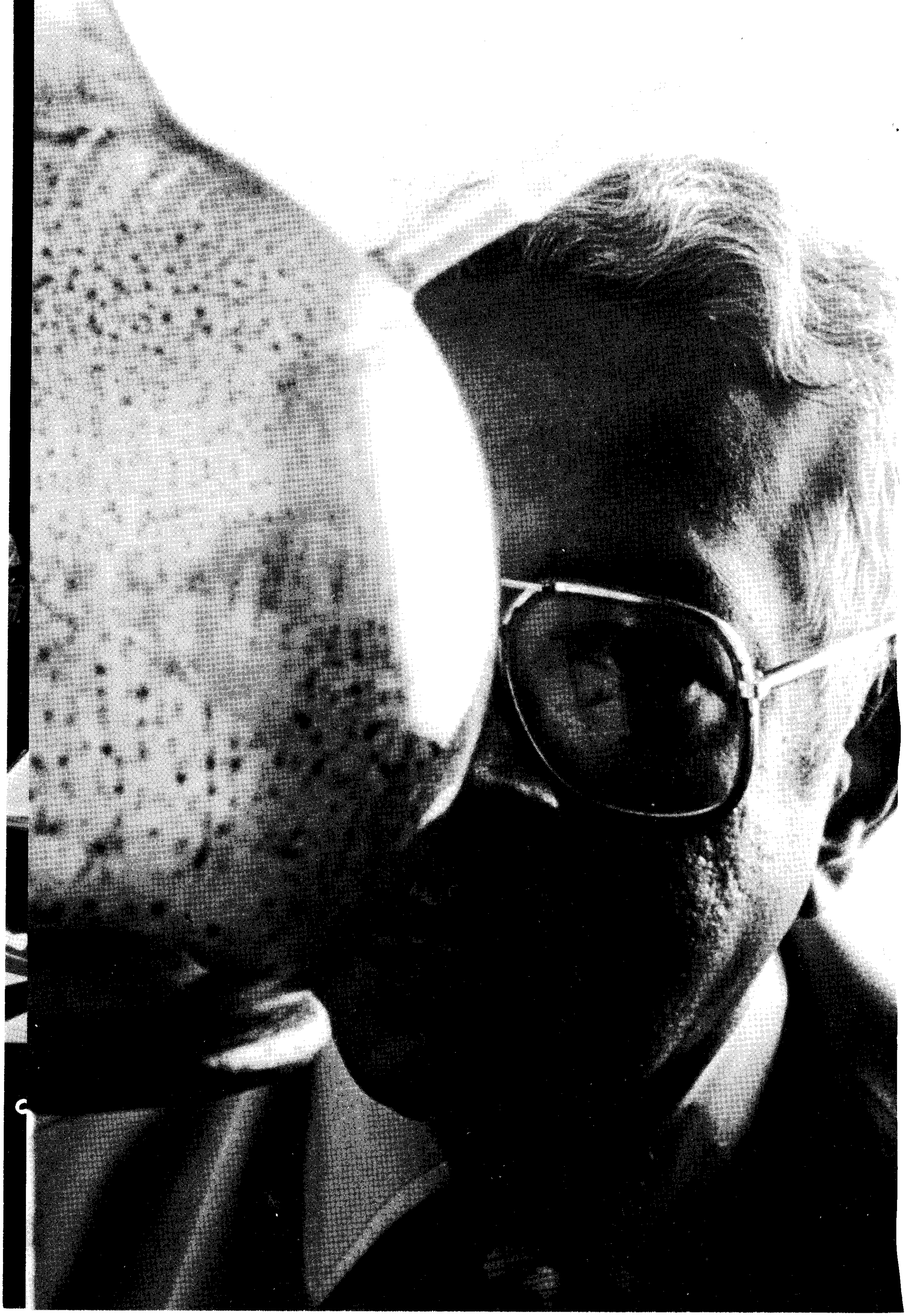

chairman of the board of Sri Lanka's Dambala Institute, an organization whose goal is to turn the dambala plant — otherwise known as the winged bean — into a major source of protein for the third world.

When Ponnamperuma isn't traveling around the world speaking for the institute, he spends much of the day creating organic compounds that might have been formed in the primordial sea. To validate his theory that these very molecules gave rise to life, he studies the chemistry of ancient terrestrial rock, meteorites, the neighboring planets, and interstellar space. The chemist talks about his work with all the pleasure of a poet reciting favorite lines. Clearly he sees himself as one in a long line of scientists and philosophers who have sought answers only to the biggest questions.

Today Ponnamperuma suspects that, although organic matter is common in the universe, life is not. He does believe that there is life in other star systems, however — perhaps even intelligent life.

Eileen Zalisk interviewed Dr. Ponnamperuma for Omni *in 1980. I spoke to him in 1982 and again in 1983. The three discussions form the interview that follows.*

OMNI: How do you define life?

PONNAMPERUMA: We think of something that has four legs and wags its tail as being alive. We look at a rock and say it's not living. There's a difference between these two. Yet when we get down to the no man's land of virus particles and replicating molecules, we are hard put to define what is living and what is nonliving.

We can come up with a working definition of life, which is what we did for the Viking mission to Mars. We said we could think in terms of a large molecule made up of carbon compounds that can replicate, or make copies of itself, and metabolize food and energy. So that's the thought: macromolecule, metabolism, replication.

But I think that as a result of our observations we are beginning to think of life as a property that is more and more common in the universe. In everything there is a certain measure of life.

OMNI: Has your own definition of life changed over the years?

PONNAMPERUMA: Well, I suppose I see more in it now. The definition I just gave you was only a practical definition to use in going to another planet, such as Mars. If you were to ask me about our laboratory experiments, "When do you get to the point when something is living?" I would answer, "When we see replication." If we had replication of a molecule alone in some of our vessels, I believe we would have the beginnings of life there.

OMNI: The questions you ask about how life began have been asked by philosophers and theologians and some chemists before you. Can you put the work you are doing into historical context?

PONNAMPERUMA: For centuries the idea of spontaneous generation was regarded as an explanation of the origin of life. Aristotle put his idea forward in his *Metaphysics*, where he gave us the example of fireflies rising from the morning dew. The Flemish physician and chemist Jan Baptista van Helmont gave us a very interesting recipe, titled "How to Make Mice." It instructed: "Dirty undergarments encrusted in wheat; twenty-one days is the critical period. The mice that jump out are neither weanlings nor sucklings, but fully formed."

It was the work of Louis Pasteur, who proved that living creatures did not appear in sterilized food unless they were introduced from the outside, which dealt the deathblow to the whole idea. In 1864 he told the French Academy, "Never will the idea of spontaneous generation recover from this mortal blow."

But today we are coming back to the idea of spontaneous generation. We are not talking about frogs from the primordial ooze or mice from old linen. Rather, we are looking at an orderly sequence, from atoms to small molecules to large molecules to replicating systems — to a continuum in the universe from its beginnings eighteen billion to twenty billion years ago to the time when the first man walked on Earth.

OMNI: Some of the first scientific speculations on the origins of life were made by Charles Darwin. You frequently quote the letter he wrote to his friend William Hooker, in 1871, in which he says, "If we could conceive in some warm little pond, with all sorts of ammonium and phosphoric salts, light, heat, electricity, etc., present, that a protein compound was chemically formed ready to undergo still more complex changes . . ." How does your work connect with what Darwin theorized?

PONNAMPERUMA: Well, Darwin's warm little pond has in it the germ of the entire concept of chemical evolution. What we try to do in the laboratory is to re-create Darwin's warm little pond.

When Darwin wrote to Hooker, he was trying to extend his own ideas. There's no doubt that if we accept Darwinian, or biological, evolution, we must postulate a form of evolution before it, and that would be chemical evolution. Chemical evolution is the process that started with the beginning of the universe and that led to the appearance of life on Earth. Darwin's ideas along those lines were rather ignored for a long time.

Then, in 1924, the Russian biochemist Alexander Ivanovich Oparin argued that there was no fundamental difference between living organisms and lifeless matter, and that life must have arisen in the process of the evolution of matter. In 1926 the British scientist J. B. S. Haldane wrote a paper suggesting the formation of primordial broth by the action of ultraviolet light on the earth's primitive atmosphere. Haldane gave us the idea of the primordial soup.

OMNI: Those who study chemical evolution have been creating their *own* primordial soup in the lab for decades. Can you explain the whys and wherefores of those efforts?

PONNAMPERUMA: Chemical evolution is based on the idea that the building blocks of life were made before life began. Start by examining the history of the earth — the earth is about 4.5 billion years old, and we believe the oldest life on Earth appeared before 3.8 billion years ago. We have reached that conclusion because of the fossils of living molecules found in 3.8-million-year-old sedimentary rocks at Isua, in Greenland, which are among the oldest known rocks on Earth. So, our goal in the lab is to learn what happened between 4.5 and 3.8 million years ago. The idea is that during this early period there was a primordial soup that underwent chemical reactions, giving rise to life.

Our early efforts were aimed primarily at proving this scenario. The first one to try was Melvin Calvin, with whom I studied at Berkeley in the early sixties. Calvin believed that the atmosphere of the early earth was primarily carbon dioxide, so he filled a flask with carbon dioxide. Then, to simulate radiation on the primitive earth, he used alpha particles, synthesizing some simple compounds, such as formaldehyde and formic acid. The next people to try their luck were Harold Urey and Stanley Miller. Miller and Urey calculated that the early atmosphere was rich in hydrogen, so they mixed hydrogen with methane and ammonia in a flask, simulating the early atmosphere and oceans. Then they applied lightning — the electric spark — and when they examined the water, they found basic organic chemicals, including amino acids, the building blocks of protein. The suggestion was that this flask contained the primordial soup of organic molecules from which we evolved.

OMNI: How does that classic experiment hold up today?

PONNAMPERUMA: As it turns out, today we believe that the hydrogen in the primordial atmosphere was lost very rapidly. In fact, the early atmosphere was mostly carbon dioxide, much as Calvin envisioned. Calvin simply forgot to add nitrogen to his flask. If he had, he would have gotten amino acids. And we would be talking about the Calvin experiment, not the Urey-Miller experiment.

OMNI: You've done Calvin's experiment, but *with* the nitrogen, I take it.

PONNAMPERUMA: Our experiments go through all the stages of the changing primordial atmosphere. But we're no longer striving to show what Calvin, Miller, and Urey tried to show — that a primordial soup stocked with organic molecules must have existed on the ancient earth. That's been proven. We're trying to show that these basic organic molecules — the primordial molecules — combined to form larger, replicating molecules made of protein and nucleic acids [the building blocks of genes]. If we can create such molecules, we will, in effect, have created the genetic code. [The genetic code is the specific pattern of DNA molecules that instructs our bodies to produce the proteins of which we're made.] If we can create the genetic code, we will have created life itself.

OMNI: In other words, you're trying to create life in the lab out of inanimate matter. Do you really believe you'll succeed?

PONNAMPERUMA: Once we understand the chemistry more fully, yes. We have to find out why these very basic molecules of protein and nucleic acid interact. Using various physical and chemical techniques, we'll find out how they fit together. At the moment, for instance, we're using a technology called nuclear magnetic resonance to analyze the way protons move as some of these molecules come together. If we understand the forces that drive these molecules, we can combine them. Though we've just begun our studies, we've already come to realize that the genetic code is not a random formula: there is a fundamental relationship between all the molecules of which life is composed.

OMNI: Is the relationship so fundamental that these same molecules might come together and form the same code, and the same type of life, throughout the universe?

PONNAMPERUMA: We're gradually reaching that conclusion. If you look at the specific amino acids and proteins that make up life on Earth, you'll find they're ideally suited to their function. I think we'll eventually prove that the genetic code is universal.

OMNI: Are we perhaps being too narrow in our definition of life? Is it possible that in other places there is life based on something other than the DNA–RNA–amino acid apparatus we've been talking about?

PONNAMPERUMA: It's certainly a valid question. It is possible, but most unlikely. And the reasons are simple.

The periodic table of elements that exist here on Earth is the same elsewhere. The elements are the same. The chemistry of the compounds is the same. The movement of electrons around the nucleus of the atom will be the same, whether it is here or on Alpha Centauri. And as far as life is concerned, carbon is the center of everything. The nearest chemical to it from a structural point of view is silicon. But I think the similarity is merely superficial.

Take the difference between carbon dioxide and silicon dioxide. One is a gas; the other is quartz. In spite of four and a half billion years of evolution and the abundance of silicon available, you don't see silicon in functional, living molecules, only in nonliving molecules.

I would conclude that it is highly unlikely that the chemistry anywhere in the universe will be any different. It will be a nucleic acid–protein life. As a matter of fact, physicists might eventually be able to come up with a grand unification theory that encompasses not just subatomic particles and the basic elements, but the code of life as well. Who knows? Life elsewhere in the universe may even be five feet tall and standing on two legs.

OMNI: Then you think that Darwinian evolution — including mutation and natural selection — controls the form of life on other planets, too?

PONNAMPERUMA: The process of natural selection, of course, has to come in to improve the original form and create biological variety. But evolution at the molecular level is not precisely Darwinian. Instead, we're talking about a process of change. It's much more of a straightforward process.

OMNI: You mean a chemical reaction?

PONNAMPERUMA: A chemical reaction. Which things react better with what.

OMNI: You say that the genetic code is essentially the same throughout the universe. But what evidence is there besides the laboratory simulations?

PONNAMPERUMA: We also study meteorites. Meteorites are small pieces of rock from the asteroid belt that get trapped in the earth's gravitational field and fall to the ground. They are believed to have been formed, like the planets, from the solar nebula some four billion six hundred million years ago. Among the meteorites are some that are classified as carbonaceous chondrites, which contain organic matter. These meteorites give us an unusual opportunity to study organic compounds of extraterrestrial origin.

Under the glass there is the Murchison meteorite, which fell in Australia on September 24, 1974. That is the meteorite in which, for the first time, we were able to establish very clearly the presence of extraterrestrial amino acids.

Since that time we have looked at other meteorites — the Mighei, which fell in the Soviet Union in 1966, and the Murray, which fell in Kentucky in 1952. In each case we were able to establish the indigenous nature of the amino acids.

Incidentally, we had a tremendous bonanza of meteorites in 1980. An expedition to Antarctica during December and January of that year brought back three thousand new fragments of meteorites. Twenty-eight are carbonaceous chondrites. These meteorites are a great resource, since they appear to be uncontaminated by terrestrial organic material. They give us evidence of amino acid formation that may have been occurring even before the planets were born. So, short of going to the asteroid belt and bringing back a meteorite, we have some of the cleanest evidence available.

OMNI: Any other evidence?

PONNAMPERUMA: Since about 1968, radioastronomers have been directing their telescopes at the interstellar medium. At first they didn't expect to find anything except hydrogen and maybe some silicates. But they were astounded to discover hydrogen cyanide, formaldehyde, and fifty-three other organic molecules — the very stuff from which proteins and nucleic acids can be made. As a matter of fact, even ethyl alcohol has been observed. A colleague here at

Maryland, who discovered ethyl alcohol, called me up soon after that and said, "Cyril, I made a calculation on the back of my envelope, and I've learned that in the constellation of Orion there are 10^{19} fifths of alcohol." Orion is laden with alcohol; the universe is reeking with organic matter. You could say that the universe is in the business of making life — or that God is an organic chemist. It was a staggering discovery.

OMNI: You have also looked for life or prelife on both the lunar surface and on Mars. What were the results?

PONNAMPERUMA: Well, we examined fractions of every lunar sample that was brought back from *Apollo 11* through *Apollo 17*. We made an extensive search for traces of organic material that might be indicative of chemical evolution. We found about two hundred parts per million of organic matter, but no evidence of amino acids, no evidence of any molecules of organic significance. This showed us that if there was any organic matter on the surface of the moon that dated from the very early stages of the solar nebula, it has been destroyed.

When we went to Mars, it was a different story. Our task on Mars was to play the part of the devil's advocate. What happened on the surface of Mars was that the mass spectrometer told us there was less than ten parts per billion of organic matter. It was surprising — less than on the moon. So, in the absence of organic matter, the chances of any life seem to be very small. Hardly likely, in fact.

OMNI: What are the implications of the fact that you are able to create these biological molecules in the laboratory and to find them in the meteorites, yet when you actually look at other worlds, you're not able to find any indication of them?

PONNAMPERUMA: That's a very good question. All that we know about the surfaces is that this organic material has disappeared. We don't expect to find any on Venus. The temperatures there are too high. Mars is too oxidized. However, when you move away from the sun and look at Jupiter and Saturn, especially Jupiter, the whole planet is just laden with organic material. It's a boiling cauldron of organic molecules. So the synthesis of organic molecules under the right conditions is certainly no problem.

But once having formed, they disappear if the conditions change. So there are certain narrow limits within which these molecules, once formed, will survive — at least to the point where life would originate.

OMNI: If life didn't originate elsewhere in our own solar system, what is the likelihood that it originated somewhere else in the universe?

PONNAMPERUMA: Well, as I told you earlier, I do think it is likely. There are 10^{23} stars in the universe. If that is the case, there are 10^{23} possibilities for life. But not all stars have conditions around them that are suitable for life. Optimistic calculations, such as those of Al Cameron, at Harvard, say that 50 percent of all stars may have around them conditions suitable for life. More conservative estimates say 5 percent. Whether 5 percent or 50 percent — or even 1 percent — of 10^{23}, it is still a very big number.

Put this together with what I've said about our laboratory studies of chemical evolution in the universe, and the chances for life seem very great.

OMNI: What about the possibilities of intelligent life that can communicate with us?

PONNAMPERUMA: Once again, if we push our arguments to their logical conclusion, we can say there must be intelligent life elsewhere.

In the one example where we know it has happened, here on Earth, one draws the conclusion that biological evolution is an inevitable result of chemical evolution. And intelligence may be an inevitable concomitant of biological evolution.

OMNI: There seems to be another point of view emerging. In terms of intelligent life, perhaps we are alone in the universe.

PONNAMPERUMA: I beg to differ. I think we've barely begun to scratch the surface. Give us time. Right now only a few searches are being made.

OMNI: What searches are going on?

PONNAMPERUMA: Well, the newest effort, conducted under NASA sponsorship, is directed at continuously monitoring deep space with large radio telescopes for unusual signals, presumably from an extraterrestrial civilization. There's not much money being poured into the effort, but when something unusual is found, other, more powerful radio telescopes could concentrate on the spot from which the signal came. The current effort is at most a screening.

OMNI: How does this search differ from past searches?

PONNAMPERUMA: We're listening in on many more radio channels now, and, as I said, we're listening constantly. We've never done that before.

OMNI: Is the current effort likely to detect an extraterrestrial communication?

PONNAMPERUMA: No, this alone won't do it, but it's a beginning. In order to detect a signal, you probably have to look for at least thirty years. You need a process of detection and, just as important, a method of interpretation.

OMNI: But how can you be so sure there are messages out there for us to intercept?

PONNAMPERUMA: If there are civilizations as advanced as we are, there must be messages, even if they weren't left for us. *We've* sent a message, giving an account of what our life here is like. There must be others. There must be books, even libraries, out there to read.

OMNI: Even if messages do exist, though, why are you so sure they've been sent in the form of radio waves? Couldn't they have been coded in an infinite number of ways?

PONNAMPERUMA: Well, electromagnetic radiation — including light rays, x rays, and radio waves — is the fundamental energy of the universe. Any civilization would use electromagnetic radiation to communicate — it's the natural thing. Now, why radio waves? Well, there's a particular radio wave length — twenty-one centimeters, to be exact — where background radio noise is least. If you wanted to get a clear signal out, you might send it at that frequency. And there's another twist to this. Twenty-one centimeters turns out to be the length of waves emitted by hydrogen, the most common element in the universe. And even more fortunate, the other radio wave length subject to little interference is eighteen centimeters. That turns out to be the wavelength of the hydroxyl molecule, made up of one oxygen atom and one hydrogen atom. Hydroxyl [OH] combined with hydrogen [H] yields water, or H_2O. It makes most sense to send signals at any point at or between those two frequencies. As chemists, we are delighted to greet our extraterrestrial neighbors at this cosmic waterhole, which is at once convenient and symbolic.

OMNI: What do you think will happen to us when we finally make contact?

PONNAMPERUMA: We'll see a whole shift in consciousness. Such a discovery would have the same kind of impact as the Copernican revolution or Darwin's theory of evolution.

OMNI: For one thing, it might make us feel less important.

PONNAMPERUMA: Well, we're not unique. But I don't think our importance would be diminished. On the contrary, we'd feel less freakish, part of a magnificent cosmic plan.

OMNI: Speaking of magnificent plans, what do you think of Francis Crick's theory of panspermia — the idea that life was sent to Earth eons ago by an intelligent, extraterrestrial civilization?

PONNAMPERUMA: There's no way of disproving Crick's idea, but I feel uncomfortable with it. Panspermia, actually, is an old idea first put forward by Lord Kelvin, who suggested that life came to earth on the back of a meteorite. This was revived by Arrhenius at the turn of the century, and now we get it in a different form from Crick. Crick postulates the existence of a civilization somewhere watching the earth. According to his theory, that civilization knew *exactly* when the primordial soup was ripe for injection with a germ that could live and develop. He puts forward this idea because he feels that the chance of life evolving through a natural sequence of events is rather slim. So what does he go and do? Suggest an even more improbable thing: that an alien civilization has seeded the earth at precisely the right instant of geologic time. Sometimes I wonder whether he really believes what he wrote. I reviewed *Life Itself*, Crick's book on the theory, and I quoted his wife, who said the whole idea was science fiction.

OMNI: What do you think of the astronomer Fred Hoyle's theory that diseases come from space?

PONNAMPERUMA: The suggestion is bizarre. Hoyle contends that each time you have a cold, it's because a virus has fallen down from a comet in heaven. So when Halley's Comet comes around in 1985, the human race might get wiped out. I'm willing to buy the idea that organic molecules are there in comets; maybe even under special conditions you might get to the point where cometary life evolves. But to get a virus, specific to a human, evolved completely away from the earth is very, very hard to accept. You've got to throw away all of modern biology. The other difficulty I have with Hoyle is his theory that interstellar molecules are really bacteria. As a matter of fact, we had a meeting here on comets and the origin of life, and Hoyle's collaborator showed a slide that said, "Interstellar Grains = Bacteria." One of his arguments was that the infrared spectrum of the interstellar grains resembled the infrared spectrum of cellulose. If there's cellulose in space, he said, there must be a bug that produces it. They've recently concluded that if you take bacteria and crush them, you get the same kind of spectrum. So they argue that in 3 degrees Kelvin, in the deep cold of space, these bacteria are alive. And that, to me, is very hard to accept. First of all, how did the bacteria ever evolve to that point? Second, how do they survive? And third, I can produce a hundred different things that will yield the same kind of spectral pattern.

OMNI: Hoyle and Crick are brilliant scientists. Why have they come up with such flaky theories?

PONNAMPERUMA: Everybody has his blind spot or his Achilles heel, and scientists are no exception. Many of them believe they are impartial in their thinking and uninfluenced by their surroundings. Some are very egoistic, and put forward ideas they feel the whole human race has got to bow down and accept. Others might be excellent in one area of science — astronomy, for instance — yet believe they have insight into all fields, without an awareness of the pitfalls. Scientists are human — they're as biased as any other group. But they do have one great advantage in that science is a self-correcting process.

OMNI: A collective venture.

PONNAMPERUMA: That's right. If Hoyle's recommendations had been followed, for instance, we would never have landed on the moon, because he told us it was all covered with dust, and that everything would just sink right in. If we had believed Carl Sagan, we would have found the surface of the moon covered with organic matter. People like Hoyle are bold thinkers. But you've got to be bold and, at the same time, have a solid foundation in science.

OMNI: Is it possible that life might be starting up on earth again, right now?

PONNAMPERUMA: Up until recently, we believed that was impossible. As a matter of fact, the whole basis of our work was the idea that the conditions that gave rise to life disappeared, so we had to re-create them in the laboratory. But recently we've been considering the concept of *neoabiogenesis*, the theory that terrestrial life is arising again. The idea gains support primarily because of the information we've got from the Galápagos vents, the hydrothermal vents deep under the sea. These vents are actually regions where the earth's crustal plates are pulling apart, spewing sulfur and volcanic heat. Here you have conditions that seem ideally suited for life to begin — you have gases coming out of the crust of the earth, you have the right kind of soil, you have the energy. It's an incredible thought, but what happened four billion years ago might be happening again right now. How can one test this hypothesis? Only by going down to the vents themselves.

OMNI: Are you planning a trip?

PONNAMPERUMA: We were talking about it at a meeting here not too long ago. We invited a geophysicist, some microbiologists, and so on, and they all said it seemed like a reasonable scientific undertaking — if we could get the money. It would cost about $5 million to take a submarine down there, bring some material back up, and test the hypothesis. So, scientifically, it is not an unreasonable suggestion. But our difficulty would be to separate very primitive, recently evolved microbial life from microbial life that has been part of the ocean for eons.

OMNI: How would you do that?

PONNAMPERUMA: The evolution of any species can be studied at the molecular level. Species that are related on the evolutionary tree will always have gene sequences in common. A bacterium newly evolved at the vents would be vastly different, in the genetic sense, from one that had ancestors in the original primordial ooze. But I must emphasize: even if the sequence of genes differs, we expect the genetic code itself — the individual molecules making up the genes — to be the same as ours.

OMNI: If you did go down there and find newly evolving life based on the same genetic code we have up here, wouldn't that be evidence for your hypothesis that the genetic code is universal?

PONNAMPERUMA: Yes, it would be just as dramatic as finding our genetic code on Venus or Mars.

OMNI: Could neoabiogenesis be occurring on land in our realm as well?

PONNAMPERUMA: Probably not. You need sterile conditions for the genesis of life. Up here, microbes would gobble up the prebiotic molecules as soon as they were formed. If one managed to escape a microbe, it would be oxidized by oxygen.

OMNI: How did you happen to get interested in the field of chemical evolution?

PONNAMPERUMA: I had a very strange odyssey. Both my parents were academically oriented. My father was the principal of a school. I had an uncle who was a chemist, and my earliest memories are of him doing all kinds of experimental work in the kitchen. So there was a scientific interest, but at that time I didn't think it would come to anything. Then I had the fortune to meet a remarkable man named J. D. Bernal. He taught us physics, and once, instead of giving us a lecture on electricity and magnetism, he spoke about the origins of life. And that's the first time I learned that one could do experimental work on the origins of life. After that I had the experience of going from one excitement to another, from one university to another, from meeting people to getting involved in the NASA space program at just the right time. I stayed there until 1971, then I came here to the University of Maryland.

OMNI: Despite your immersion in chemical evolution, I take it you've also kept up with the issues of the third world.

PONNAMPERUMA: My whole family is very internationally oriented. One brother is at the International Rice Research Institute in Manila, the other was head of a UNESCO program for Asia. I've become an American citizen, but I feel more a citizen of the world with an American passport. And this naturally draws you into activities that can help others on the international scene.

OMNI: What are you involved in now?

PONNAMPERUMA: For one thing, I'm involved in the Dambala Institute. Dambala, otherwise called the winged bean, is an underutilized plant we hope will become a major source of protein for the third world.

OMNI: Why dambala?

PONNAMPERUMA: It's a remarkable plant. You can eat the leaf, like spinach; you can eat the bean, like the green bean; you can eat the tuber. When it's dried, it is like soya. It has a large amino acid content. But no one had taken much interest in it.

OMNI: Why is that?

PONNAMPERUMA: It's an enigma, really. It's hard to believe that this plant grew in my backyard when I was a kid.

OMNI: Did you eat it?

PONNAMPERUMA: Oh yes, it was the poor man's vegetable. We ate it as a vegetable, but never thought of it as a source of protein. It became of potential value to scientists when the U.S. National Academy did a study of underutilized plants. They highlighted the winged bean as one example of something that could be studied. As a result of these recommendations, *Time* magazine had a little paragraph about dambala in an article. Soon after that, I was having lunch with the president of Sri Lanka, and he pulled out a folder and showed me this clipping and asked me, "Do you know this plant?" And I said, "Of course I do," and then he said, "I'd like to make Sri Lanka the dambala capital of the world. Help me do something about it." So this is how I got involved. I arranged a meeting in Sri Lanka of the people I knew were interested in the dambala; this led to an international meeting one year later, at which we had about 150 people from around the world. There's a lot of interest in dambala in Indonesia, in Thailand, in Nigeria. The scientists at the meeting made a spontaneous motion to go ahead with an institute. Right now I'm chairman of the board of directors, but we're looking for someone else to raise money, to get programs going.

OMNI: Do you think plants like dambala will solve world food shortages?

PONNAMPERUMA: Such plants offer a temporary, short-range solution. In the long run, they constitute only one of many ways of dealing with the problem. The other solution I'm interested in working on is related to what I've been doing in the laboratory — making amino acids, making carbohydrates, and making protein. Today I'm making protein in order to show how life originated. But suppose you could make carbohydrates and protein in the lab, directly from the atmosphere, without plants or animals as intermediaries . . .

OMNI: The way we make polyester?

PONNAMPERUMA: That's right, we could take carbon, nitrogen, and hydrogen from the atmosphere and convert them directly into food. I'm not suggesting we give up plants and animals altogether, but the potential is there. I'll give you an example: I'm working with

NASA to develop food for astronauts from carbon dioxide in the atmosphere of the space vehicle.

OMNI: How long do you think it will be before we use such a system to make food for the world at large?

PONNAMPERUMA: I think if an attempt is made, it may not be long. We could make as much as 20 percent of our food that way. Right now the limiting factor is the energy: we would currently have to power such a system with electrical energy or ionizing radiation, and that would be too costly. But suppose we came up with a way of using light from the sun? That would make the system economically feasible. And food made this way would be available completely independent of climate.

OMNI: How do you have time to participate in such a variety of projects all around the world?

PONNAMPERUMA: I have to work twice as hard. The day never ends. I try to do all my reading at night. And then, I have some very good people working for me — I can't do every experiment myself. I spend a lot of time discussing the research with them. What I miss most is the time for writing. I often have three or four papers that should have gone out to the press, but they keep getting delayed. That's the situation now. I was in India recently for a series of lectures, and during that time I thought, As soon as I come back, I'll get those papers written. Now it's time for me to go again, and I haven't gotten to them. But they'll get done somehow.

OMNI: Dr. Ponnamperuma, you've spent most of your life tracing our evolutionary path back to that original primordial soup. But do you have any thoughts about humankind's future?

PONNAMPERUMA: The Laws of natural selection and survival of fittest normally dictate the direction of evolution. But humans can now break that pattern because they *understand* what's happening. The moment you evolve a human level of intelligence, you can control the process. And that's what's going on now — I call it *directed* evolution. I don't believe we'll ever evolve wheels on our feet, though some people feel that's an alternative to automobiles. I do believe, however, that we'll use technologies such as genetic engineering to improve our capacities and eradicate disease. We'll see better muscular regulation, as well as cures for cancer, viral infections, and all kinds of enzyme deficiencies. Once we better understand what's going on at the molecular level, we'll be able to do in tens or hundreds of years what would take nature billions. Right now human genes come together when people get married — it is a chance mixing of the gene pool. But once we've grasped the whole genetic process, we'll be able to arrange our lives so that we know what children we'll give birth to. Of course, some people say how terrible, to take all the surprise and fun out of it. But on the other hand, we might get to the point where we begin to understand the value of such knowledge. If you know that certain genes coming together are going to result in mental illness, for example, you might want to prevent that from happening. Or you might want to control human breeding so that you get to the point where people are more intelligent. It's obvious to me that intelligence is a genetic thing, and whatever one may say, genes for brilliance seem to run through certain families. Look at the Huxleys. We don't want to have everybody looking the same way, but on the other hand, I think if there is a measured discreet use of this knowledge, life could improve.

OMNI: Aren't you afraid of creating a *Brave New World* sort of situation?

PONNAMPERUMA: That danger exists. Take the situation we're in today with atomic energy. Understanding the atom is a tremendous boon, but we've also used our knowledge for destruction. So that danger is always there, but it shouldn't prevent us from the pursuit of the knowledge or its application.

OMNI: How would you institute the genetic control you're talking about?

PONNAMPERUMA: Someday, I hope, we'll have a library of genes to help us.

OMNI: Once we've completed our own evolutionary journey, do you think we'll send terrestrial life to other worlds, engaging in directed panspermia of our own?

PONNAMPERUMA: Who knows? We'll certainly have the potential. There are always people who want to explore, who want to go and look at things, whether it's the North Pole or Antarctica. So from that point of view, we'll always have terrestrial life leaving the solar system and inhabiting other worlds. That would be a natural consequence of progress.