# PART IV

## LIFE IN THE GALAXY

Wednesday 1 June, 2200 - 2230

After-dinner lecture by G.S. Shostak

Chairman: H. van der Laan

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# LIFE IN THE GALAXY?

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## 1. INTRODUCTION

It is a decided honor to have the opportunity to address as distinguished a group as is present this evening, and I am particularly grateful for the very complimentary introductory remarks of Harry van der Laan. To paraphrase Einstein's comment on a dissimilar occasion, such a lovely preamble entails a risk that the packaging may prove better than the meat.

As you know, this year has seen the establishment of a special I.A.U. Commission (No. 51) to deal with the subject of exobiology and the Search for Extra Terrestrial Intelligence (SETI). It is, therefore, all the more appropriate that we give at least some attention to the question of biological activity in the Galaxy.

However, in keeping with the present setting and post-prandial atmosphere, my utterances will be more diverting than comprehensive, and this discourse should perhaps be likened to that most civilized of after dinner drinks, the digestive: capable of dissipating the effects of overindulgence and distinguished by its bad taste.

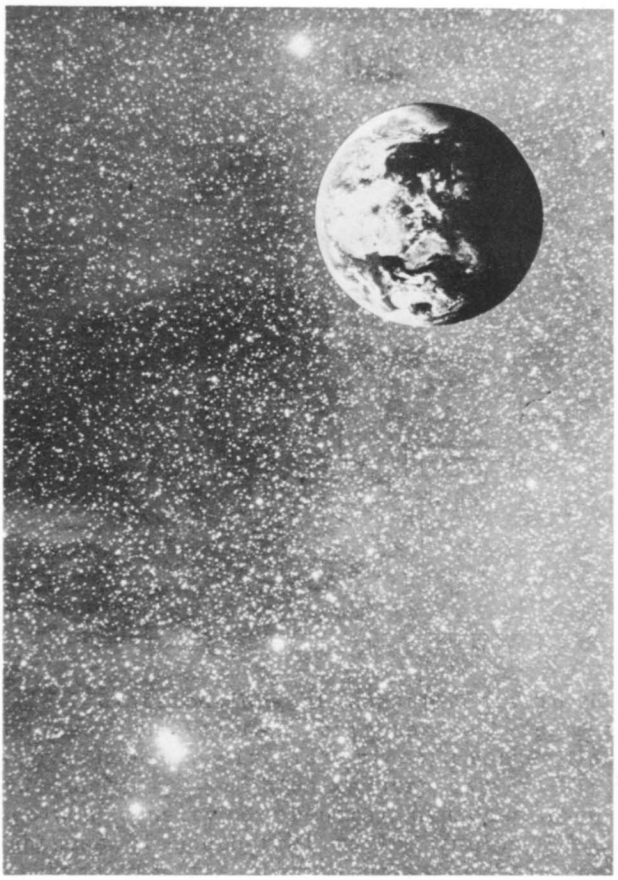
## 2. PURPOSE OF THE TALK

Our subject, then, is extraterrestrial life in the Galaxy. We believe in its existence, or don't, largely as a philosophical matter, since tenable arguments can be made both ways. As with many scientific questions, there is an unconscious tendency to array evidence on the basis of what we feel must be the correct answer.

One of the most compelling arguments for alien life, largely because of its generality, is being uncomfortable with uniqueness. It seems that every time man has thought that he was in the centre of things -- be he Ptolemy or Kapteyn -- the facts have proven otherwise. There are hundreds of millions of stars which are cousin to our Sun in



*H. van Woerden et al. (eds.), The Milky Way Galaxy, 623–632.*



the Milky Way. If they all have inhabited planets, then it is a virtual certainty that at this moment (whatever that may mean) a symposium on the Milky Way Galaxy is in session on a distant world. Thus, even this conference is not unique. (I remark, however, that we must extend our horizons to more distant galaxies to ensure a reasonable chance of finding a talk similar to my own taking place now.)

Indeed, for most of recorded history, it has been assumed that the Universe was teeming with life. The last century produced several schemes to signal potential neighbours, including a plan to set Siberia ablaze or, less environmentally destructive, to use large mirrors to brand our initials onto the tender surface of Mars. The aliens are a constant subject of science fiction, alternately interested in teaching us how to avoid nuclear war, and obsessed with the necessity to flatten Tokyo.

But the subject of life in space has heated up substantially since the Second World War, largely because there is now the chance that philosophizing and speculation may finally yield to experimental proof.

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It's one thing to sit in a parlour discussing the possible sphericity of the Earth, and quite another to borrow three small ships from Spain and sail the Atlantic.

Tonight's discussion, then, is predicated on the fact that meaningful experiment is possible, and the first part of the talk will deal with that subject. Later, having pondered the most propitious techniques for uncovering the aliens, we will consider whether one should bother. (In deference to those who believe the aliens have already landed, a facility is provided on stage for any extraterrestrials who may wish to phone home [the speaker indicates a nearby telephone, provisioned with an upward-leading cable]. In light of the currently distressed economic situation in the Netherlands, I must ask that he call collect.)

## 3. FINDING THE EXTRATERRESTRIALS

In ferreting out the aliens, one might consider searches of both an active and a passive nature. Of the active quests, just looking around is the most patently obvious technique.

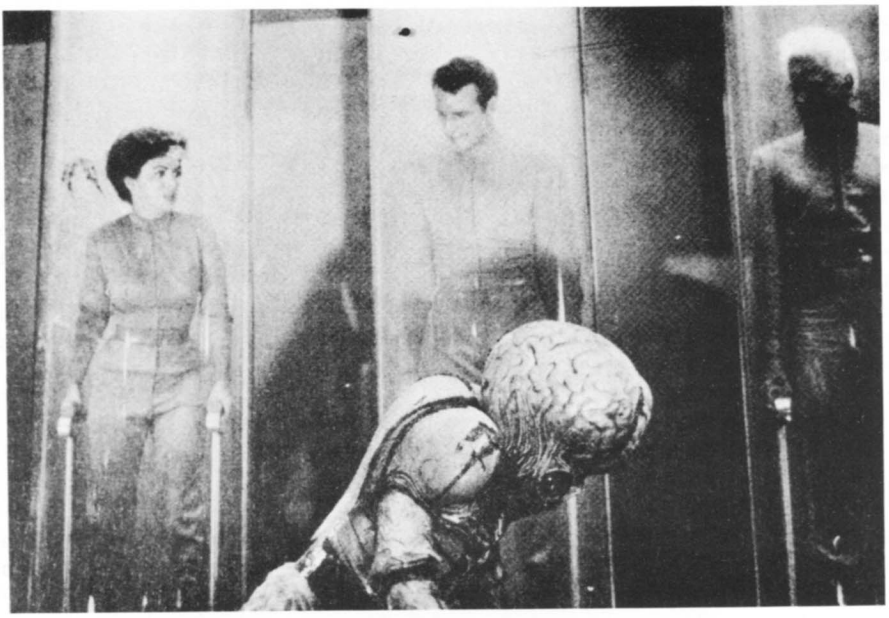
I will begin with "where they're not". One place they're not is the Earth. In fact, these stunning photos of our planet taken from but a few hundred miles away show how difficult it is to recognize that we're here.

The Moon is also a biological wasteland: geologically, organically, and, I might note, culturally dead.

Venus is Earth's sister planet, but is just too hot for life. The surface is a sterile, rocky desert, with temperatures of 400 C. As further dissuasion to settlement, the clouds contain, amongst other things, sulphuric and hydrochloric acid.

Thus we come to Mars, not only the scene of the teeming inhabitants of science-fiction fame, but also of the most sensitive scientific experiments to find life beyond Earth. Unfortunately, I have no time to describe the ingenious and thorough tests for biological activity made by the two Viking landers. The negative results of these probes could be questioned by the sceptical, but to quote one researcher: "it's possible that the experiments did indicate life, but it's also possible that the rocks seen at landing sites are actually living organisms which look like rocks." Despite centuries of speculative literature, Mars appears distressingly dead.

Unlikely as it may sound, Jupiter could be our last hope for company in the Solar System. It's conceivable that deep in the 1000 km thick atmosphere of this planet, a sort of microbal life floats in the churning mists. Here, in a never-never land between the Jovian cloud-tops above and a gloomy, bottomless black sea of liquid hydrogen below,



Earthlings watch as alien does push-ups in "This Island Earth".

these postulated suspended life forms would enjoy temperatures not much different from that of this room. This is a long shot for life, of course, but a space probe has been planned.

Taking the hard-nosed view, our Solar System appears lifeless beyond Earth, although as a final thought we should note Papagiannis' suggestion that extraterrestrials could be purloining our raw materials by secretly mining the asteroid belt. (As a personal aside, I do not begrudge the aliens our asteroids, but would draw the line upon the sudden disappearance of, say, Neptune.)

The "active" searches used to reconnoiter our Solar System lose their appeal once we move into the realm of the stars. This is because of the enormous distance-scale differences between the local planets and the not-so-local stars. Even so, the ploy has been tried: Carl Sagan's Pioneer plaque is moving into space at a few tens of kilometers per second. Still, it will be about a hundred thousand years before it has gone as far as the nearest stars. Even assuming the message is retrieved and correctly decoded (and who knows? Perhaps they'll interpret the nude couple as a map, and assume the inhabitants of our planet resemble sea urchins), we might have the wretched luck to make our presence known to an aggressive culture which will destroy civilization to obtain our chlorophyll or other commodity. In this view, Carl Sagan may be destined for eternal fame as the man responsible for the obliteration of Earth.

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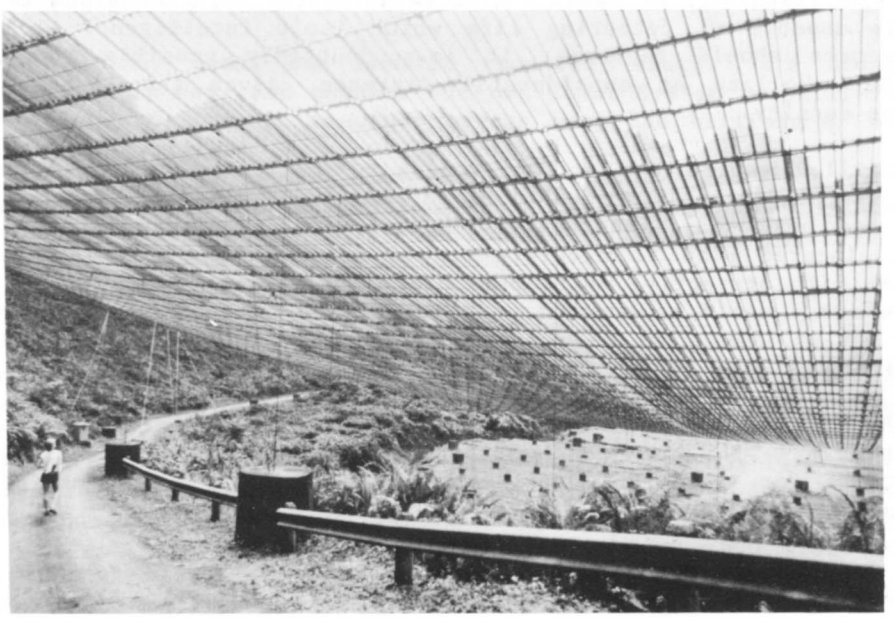
But a hundred thousand years is a long time, and Carl isn't worried: "Après moi, le déluge". Even his more audacious effort, the beaming of a radio signal to a globular star cluster, a communication travelling at the speed of the light, cannot possibly elicit a reply for about 500 centuries. In other words, active searches are truly implausible; if we wish to find the extraterrestrials within our lifetime, we must play the part of eavesdropper.

It is largely because our eavesdropping technology has suddenly come of age that SETI has developed respectability. After all, astronomers always demand observational proofs, and proof is now possible. If we make the (in our view) not unreasonable assumption that aliens use electromagnetic waves to communicate, it soon becomes obvious that for solid engineering reasons we should be listening for signals at decimetric wavelengths.

To date, several dozen searches have been conducted using radio telescopes on an occasional basis to weed out narrow-band signals emanating from, mostly, nearby stars. Other search objects have included neighbouring galaxies and the centre of the Milky Way. Most of this work has been done on an ad hoc basis, using equipment designed for astronomy, although specialized receivers and occasionally even an entire antenna are made available.

You will not be surprised when I tell you that no conclusive evidence for intelligent signals has been found to date (unless you are



Underside of the 1000-foot diameter Arecibo Telescope.

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committed to the idea of a conspiracy of secrecy between radio astronomers and the US Air Force, as some are). Does this failure to hear the aliens mean anything? Probably not. The experiments done until now could generally detect transmitter powers of 100 MW or more, and the stars searched are still numbered in the hundreds only. Frank Drake has talked about the "cosmic haystack" having 8 dimensions: 3 spatial, 1 temporal, 1 frequency, 2 polarizations and 1 transmitter power. If you like to think in such terms, then we have investigated about $10^{-17}$ of the haystack for the Milky Way. This may, in view of later remarks, be unnecessarily pessimistic.

Radio searches have got most of the publicity, but there are other ways to find aliens, or at least life. As a first step, we might deal with the assumption that life originates on planets. Gatewood and others have stressed that, in fact, no fully reliable detection of planets around other stars has yet been made. Improved astrometric techniques and the advent of the Space Telescope may soon change this situation, but in the meantime we cannot fully deny the advertising claim that ET was 3 million lightyears from home. Maybe that's the nearest other planetary system, and it's beyond Andromeda. All the more reason to admire ET's tenacity in coming here to play with our kids.

Assuming that we do find other planets, if we could somehow measure their optical spectra then life might reveal itself in the planet's atmospheric composition. Oxygen, for example, is abundant in the air only because of the biomass. Methane in the atmosphere derives mainly from the flatulence of cows. A nice advantage of this technique is that it is capable of detecting life which isn't intelligent. While no inferences should be made, it is undoubtedly possible to detect northern Holland at considerable distance, given the locally high bovine density.

Still, despite the attractiveness of optical observation, radio remains the "technology of choice" for SETI, and several large projects have been proposed, if not built. Cyclops, for example, was a thoroughly engineered plan to decorate untold square kilometers of American desert with attractive white parabolas. Failing that, this very, very large array could be erected on the far side of the moon; a site not only out of sight, but also out of the direct influence of terrestrial interference.

But wait a minute. Before we risk Senator Proxmire's wrath by funding large SETI projects, perhaps it is worthwhile to ask whether searching for the aliens really makes sense. This brings us to the second subject....

## 4. WHO ARE THEY?

How many aliens can we expect, anyway? To begin to answer the question, we have to have some understanding of what kind of extra-

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terrestrials we're talking about. Scientists generally are excruciatingly conservative in postulating alien life, and are inclined to assume that they are built the way we are built. Carbon, the stuff of pencil leads and diamonds, is singularly adept at hooking up with other atoms to form complex molecules, including those of our bodies, given a fluid environment and reasonable temperatures. (As chemists and sci-fi readers know, silicon also has this property, although to a far lesser extent: it tends to get locked up in stable, un-lifelike configurations such as quartz.) We assume, then, more out of ignorance than not, that the aliens are also constructed out of carbon compounds, and consequently that they, too, require a nice watery, not-too-cold and not-too-hot planet.

Now, I hope you will suffer through the following argument, because it has become a critical question in SETI circles. I will present the gist of the matter in a series of steps.

- Our Galaxy -- our home -- has at least one hundred million stars which are similar to the Sun.

- We don't know how many of these stars have planets, but for the sake of argument let's guess that one in a hundred do, each system consisting of ten planets.

- How many planets are like Earth, with water, air and brisk temperatures such as we enjoy in Holland? Who knows, but let's guess one in a hundred.

That already means one hundred thousand "earths" are floating around the Milky Way. And because our own Solar System is still relatively young, most of these other earths have had billions of extra years to develop life.

We have bravely estimated, then, that the number of civilizations in our Galaxy could be as high as one hundred thousand.

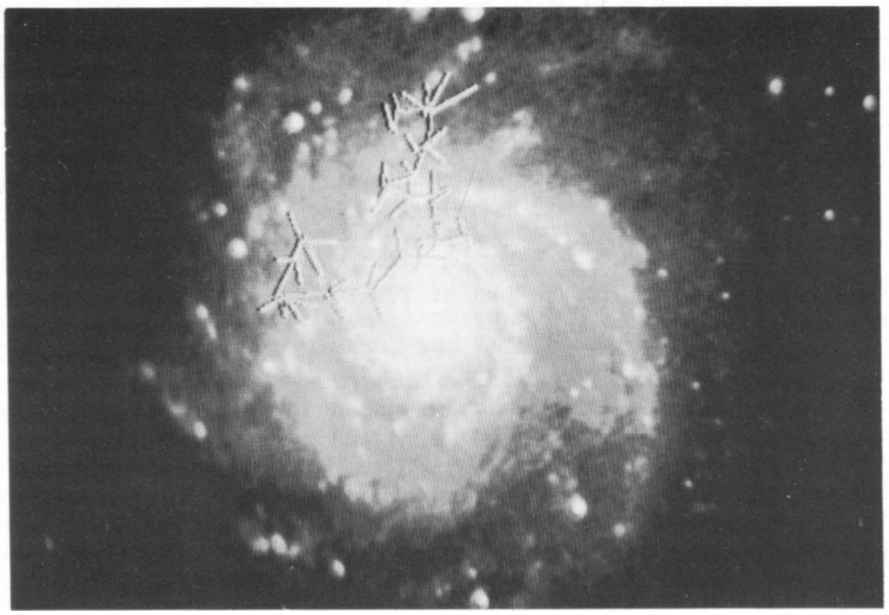
NOW.....

Any advanced civilization will invent medicine, and as a result will soon swamp the planet with a burgeoning populace. Orbiting space stations, each accommodating the population of Groningen, will be built. Contrary to our likely first reaction, it's probable that life in a spinning tube can be made quite pleasant. Children will be born, raised, and will die in this artificial environment without thinking twice about it. "Tube be, or not tube be" will not be a question.

With very little effort, such a space station can be sent off to another star. The stars are far, and the time of travel will be measured in hundreds or even thousands of years. But that's OK. After reaching someplace interesting, these "colonists" can be expected to

take a thousand-year break for R and R, establishing their culture, increasing their population, and availing themselves of the facilities.

Then they, too, will send off some colonists, who will spend a millennium getting to the next star. And so forth. The colony will slowly spread, like coral in the sea.



Colonization of the Galaxy.

Now the point is, they will run out of new stars in ten million years, which sounds like a lot, but is only the blink of an eye in the history of the Galaxy.

You may wish to liken the phenomenon to the Spaniards in the 16th century: once Columbus made his first voyage, the whole Caribbean and Pacific were visited in but a matter of decades. There were Spaniards everywhere.

THE BIG CONCLUSION, then, is that there has been plenty of time for an ambitious group of aliens to colonize the ENTIRE Galaxy. Maybe most aliens are passive, content to contemplate their antennae, and are not interested in space flight. Maybe many blow themselves up with nuclear weapons. Maybe, as Newman and Sagan have said, the colonists forget where they've come from, and waste a lot of time retracing their steps. But only ONE civilization has to do it. Most Europeans in the year 1500 weren't interested in sailing across the Atlantic, but it is enough that one person was.

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Thus, the aliens should have been everywhere, including our own Solar System..... Now, the followers of van Däniken believe they have been here, and the UFO crowd thinks they still are. But the hard-headed, irrefutable evidence is missing. No one has as much as an ash-tray from an alien spaceship. Fact A of the SETI business is that we seem to be alone, and we shouldn't be.

Enrico Fermi summarized the problem in one sentence: "Where Are They?"

We must have made a mistake somewhere. What is it?

- The obvious possibility is that we really are alone in the Galaxy. Hart has pointed out the complexity of the nucleotides which make up DNA, and he figures that the random combining of atoms in the primordial soup of a distant earth will take $10^{32}$ billion years before dishing up something interesting. In his view, not only are we alone in the Milky Way, but probably in all the Universe we can see. An eminent Briton has put it another way: the chance of forming life in this manner is the same as assembling a Rolls Royce by sending a tornado through a junk yard. (I will resist all temptations to make the obvious remarks concerning British workmanship.)

- Frank Drake figures space travel is just too darn expensive. A rocket trip for 100 people will take the energy budget of the entire U.S. for hundreds of years. I can only respond to this argument by saying "more power to you", and note that Columbus' trip was also expensive by contemporary standards. Furthermore, as others have pointed out, an impending supernova would be strong incentive to emigrate, no matter what the cost.

- The Zoo Hypothesis has been offered as an appealing explanation for our apporent isolation: The aliens are leaving us alone because we amuse them, and we may even be seen as a useful exhibit. While I find this a "cagy" theory, it does seem a bit anthropocentric.

- Perhaps we don't know enough physics yet to recognize the aliens. Or maybe we're in a cultural backwater, like central Borneo, only occasionally visited. Von Hoerner has suggested that the only stable civilizations are those that are passive. But again, only one group has to be a bit adventurous.

## 5. A FINAL THOUGHT

Perhaps we're missing the boat. Possibly we should be compared to dinosaurs who sit around and try to consider the breed of dinosaurs which populate other worlds. We are but a stage in evolution, and although man may no longer be evolving as an individual (thanks to

medicine), we may still be in the process of producing the next generation of species. Organic intelligence is fragile, fallible and barbarous. Human intelligence is a tool evolved for survival in a hostile world. But the environment is changing, and intelligence (like great size) may have limits to its survival value. We may disappear, but our progeny -- the machines -- may survive. (And what I mean by machines includes not only the Apple CCCIX, but also bio-engineered humans.)

Technical organic life -- mankind of the last hundred years, in other words -- is but a brief flash in the long night of Earth's existence. If that is also true on other worlds, then the chances of contact are small; neither we nor they are around long enough to arrange communication. But an intelligent machine can in principle overcome the limitations of hostile environments and biological mortality. It was suggested that such machines might leave their home planets to travel to the Galactic Center, where the action is, and where they could hook up with other devices, a kind of interspecies mating thankfully denied humans. In this view, we are on Earth only to give birth to the machines, and it is they that dominate the intelligence in the Galaxy. They may have no more interest in visiting us than we have in visiting the ant colonies in our garden. And their activities may be of a kind which make their detection difficult.

Thus, do not disparage the bus which brings you back to your hotels this evening: that lowly mechanism may be the progenitor of all that's enlightened in the Galaxy.