CONCLUDING REMARKS

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It would be flattering to imagine that my invitation to make these concluding remarks was based on some such grounds as superior insight into the prospects for SETI. But to be honest I suspect Mike Papagiannis primarily wanted a less familiar face in these discussions, perhaps also a bit of an agnostic if not even critical comment. And indeed I do worry about our ability seriously to probe the cosmic haystack, partly because of its sheer size and multi-dimensionality, also because--of necessity--we can explore so infinitesimal a slice of its time span.

The entire SETI question reminds me of the legendary argument between a philosopher and a theologian. Losing his temper, the theologian protested that a philosopher is like a blind man in a dark room looking for a black cat. To which the philosopher retorted that a theologian is like a blind man in a dark room looking for a black cat... that isn't there!

SETI has something in common with that dispute. We are in a very tiny corner of an almost inconceivably vast room--and we would like to find some company. However:

- We're not completely blind. We can and do peer around, at least at the very nearby parts of the cosmic room and to be sure through some extremely narrow-band filters.
- Also, the room itself is not entirely dark; in fact at some wavelengths it's annoyingly bright.
- But--what about the cats?! That's really our subject.

In this connection I regret that some notable SETI critics, especially Michael Hart and Frank Tipler, were not here. We often learn, or in any event are stimulated most, from our critics. So it has been interesting to follow the proceedings of this meeting partly in terms of what I suspect they might have said. There appear to me to be at least three major classes of criticism of SETI from such scientists:

1. They contend there should be no other cats anywhere in the room--not just our galaxy, but the entire universe!

M. D. Papagiannis (ed.), The Search for Extraterrestrial Life: Recent Developments, 547–551.

I read Lecompte du Nuoy's Human Destiny in the early 1940's, and was interested in, though not convinced by, his statistical argument of the seeming impossibility of the chance formation of life. Hart has recently put this in sharper modern focus. His argument boils down to the contention that a DNA molecule should include ∿ 100 critically-placed nucleotides for minimally effective reproductive activity. He states the odds to be much worse than 10^{-30} for this to happen by chance in 10^{9} years on any planet in the universe.

During his fine banquet talk at this meeting Carl Sagan stressed the opposite point of view, saying in effect that one can get proto-biological activity from a mere half-dozen appropriate amino acids. The active sites of enzymes are so small that these can be made by abiotic mechanisms, and it is reasonable to believe that an early protoprotein and an early protoribonucleic acid could interact to form the beginning of what became the first self-replicating organism--this being a relatively probable event.

The distinction between these points of view is obviously a vital one which must become more nearly a point of fact rather than opinion. What are the minimum requirements for self-replicating molecules, in order for life to begin? If Hart should be near the correct end of the spectrum, then the only conclusion is the awesome one of our almost indescribable improbability. This would seem to suggest, as Hart has noted, not just one universe but an indefinitely large number of universes arising from an inflationary-universe concept, or something like it, in order for life to have appeared even once--namely here. Countrariwise, if the biologists' Copernican point of view is correct, life could be ubiquitous. The truth probably lies somewhere between these extreme points of view. I gather that most modern biologists are indeed confident that there may be vast numbers of biochemical paths to life, and are not surprised that Mother Earth found one. But in any event we clearly need to give every encouragement and help to those scientists who are unscrambling the chemical and biological origins of life. For what it's worth, this meeting did seem to point more strongly toward "preferred paths" of pre-biological molecular evolution, able to increase radically the possibilities for natural formation of self-replicating molecules.

2. Supposing life is semi-ubiquitous, a second major area of criticism from those who claim that SETI searches are a waste of time and money concerns the chance of any other life forms being able to evolve up to the level of technology. A considerable part of our Symposium touched on various aspects of this question.

Specifically, even if--against whatever odds--scads of kinds of cats are born in the universe, nevertheless for many reasons essentially none may ever get old enough or clever enough to meow loud enough for us to hear--in other words they would truly be "black" cats (in the fundamental sense of not radiating). Here again, Hart and others have been constructive critics by developing arguments showing what a narrow tightrope the Earth has

walked during the 4 x 10^9 years which were required for technical life to develop here, teetering fractionally (a few percent) between run-away deep freeze or greenhouse boiling, with gradual atmospheric CO_2 decrease keeping the place tolerable against increasing solar luminosity--and how dependent all this was on the Earth being just the right size, having just the right amount of atmosphere and water, etc. This amounts to a large unfavorable coefficient for the Drake equation to factor in with many others--including the Kilkenny syndrome.

However, in such connections this conference has helped prospects for SETI by stressing new evidence that other solar systems are quite likely. The presentations on the IRAS and the ground-based IR detections of cool particulate shells or disks around many stars constituted high spots of the Symposium.

Conversely, this week the prospects for SETI were at least confused by paleontologists pussyfooting over the wide range of uncertainty as to what happens during evolution. Questions were even raised as to whether evolution progresses very much at all over extremely long periods of time unless stirred up by major disturbances, and whether the stirring will necessarily lead to much progress.

Prospects for other advanced life forms may even have been reduced through the exciting arguments in this conference making it seem probable that sporadic mass extinctions, at least in the case of the Earth, did occur and may have been needed in order to yield the evolutionary spaces into which new and more complex species could radiate. In our case, a semi-regular 27 or 28 million-year trigger may have been the putative "Nemesis star". With all due respect to Rich Muller, I strongly suggest that--if such an object is ever discovered--it should rather be named Shiva for the great Hindu God who destroys with one hand and creates with another. Assuming that Shivas are at least one major kind of stirrer of evolutionary pots, the problem now becomes one of estimating the odds that any arbitrary planetary system will have a distant binary companion in an appropriate highly elliptical orbit penetrating an adequate Oort cloud of comets, leading to just the right amount of Shiva action rather than total Nemesis action--all this at long enough intervals to allow subsequent re-radiations into new evolutionary niches to become established. To me the totality of such factors seems to dim the prospect of there being any technically advanced felines to find, at least in our vicinity.

Our medieval philosopher and theologian would have enjoyed getting into some of these SETI discussions. They could argue just as logically as we do. The difference, of course, is that we put our ultimate faith in experiment. While critics must be heard, and while logic alone may rule out some notions or help to focus our efforts better, nevertheless I believe it is vital that SETI proceed with observing in order to find out whether there are any audible meows. Radio and x-ray astronomy offer classic examples where, in advance of observation, most of the

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logic and revealed wisdom said that nothing very interesting would be found.

3. Somewhere around this level in the arguments our friendly critics reverse field 180 degrees. Instead of addressing the improbability of life, they now raise in strongest form the so-called (and perhaps mis-labeled) Fermi dilemma: if life is really so abundant, then why do we encounter no evidence of the extraterrestrials who long ago should have expanded their civilizations or at least used their robot surrogates to fill the Galaxy? I may be among a minority at this Symposium in feeling this to be a serious question. To put the question in the framework of my present remarks, why haven't the cats multiplied and spread like mice? We should be positively tripping over them even in the small dim corner we inhabit. (Phil Morrison called this the Malthusian motif; in my context the term should perhaps be Maltesian.)

Carl Sagan mentioned one of many possible rebuttals in his banquet talk--"perhaps they just don't care to strip-mine every site in the galaxy." While sympathizing with that sentiment, I do wonder whether Carl would object to the prospect of their having perhaps merely a Holiday Inn or even a simple cat-house at most of the possible sites in the galaxy. John Ball's exhaustive list of possibilities struck me as a compelling discussion of the Fermi paradox. I am inclined to agree with him that, unless we are alone, the weight of the subjective probabilities would seem to leave us as merely a tolerated kitten in the cosmic zoo.

But, again, the only likely way to get some hard answers is to look. We must do so with continuing faith and hope that in time some answers will come. Indeed, a Biblical phrase may be the most appropriate motto for SETI: "Faith is the evidence of things unseen". Or, from another allusion, SETI has a little in common with the search for the Holy Grail. Although it was never found, the concept of and the searches for the Grail may have played a modestly civilizing role in a turbulent period of history.

A couple of concluding thoughts are in order. First, in our searches we should bear in mind not only the mode of listening for catcalls, but also the need to look for what might be thought of as cosmic kitty-litter. So far, I am aware of only three such possibilities:

a. Dyson spheres, or waste IR radiation from Kardashev II civilizations, each of which is using much of the energy of its star, leaving only a very low-temperature residue as the principal final radiation.

b. Spillage from radars, power beams, or powersats, which may involve truly immense energies, and

c. "Claw marks"--skid tracks from decelerating vehicles using the interstellar magnetic field as a braking medium (also proposed by Dyson).

This approach, of search for inadvertent radiation as opposed

to communication signals, represents a good field for vigorous imaginations, as called for by Mike Papagiannis in his concluding remarks.

While listening and looking are obviously the strategy for today, I do suspect that, in the end, we may simply have to go and find out--ultimately sending very intelligent probes or even our human descendents to a great many of the stellar systems near or far. Frank Drake has stressed the inhibiting effects of the gigantic costs of this--but there seem to be no absolute show-stoppers. Such a project is for the millenia rather than the coming decades, but for this and other reasons I welcome the development of space stations--as international as possible--as one early step in this long and perhaps lonely road.

Finally, as an astronomer I am overwhelmingly impressed by the almost indescribable vastness of space and time, and the outrageously prodigal expenditures of energy in it. We are so tiny! And yet our minds can encompass and understand so much of it. Years ago I was struck at how depressed many introductory astronomy students become, upon learning our physical place and scale in the universe. Since then I have always stressed with them the question of why our scale of values should so often be based on mere size or energy. Is it not more meaningful, for example, to value complexity? The human mind is the most complex thing we know of in the universe. In a fundamental way stars and galaxies are trivial in comparison. Besides, they don't care--and we do!

Nevertheless, I doubt that the human mind is the ultimate. Out there may be stupendously more advanced beings and cultures. If the human race should survive, in time we may become worthy to join them. Or, if we are alone, we have the unique opportunity and obligation to spread something truly worthwhile, throughout space and down through time.

After which there really will be ETI.

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This ends the first Symposium of IAU Commission 51. If you agree with me that it has been a real cat's meow of a meeting, you will want to join in thanking Mike Papagiannis and all the rest of his staff who have given us such a fine Symposium.

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