WHERE IS EVERYBODY?

A TENTATIVE JOURNEY IN AN UNCERTAIN TIME

March 15, 2004 **John A. MacLeod**

This is not a war story - at least that is not my intention. But my starting point does take me back to the Spring of 1944 when I was finishing up my pre-medical studies at the University of Chicago. I was in the Army, in the Army Specialized Training Program - ASTP - wearing the lamp of learning patch on the left shoulder of my uniform, "The Flaming Piss Pot". Our premed unit lived in Green Hall just across 57th Street from Stagg Field. One afternoon my always active curiosity led me to explore the squash courts located under the grandstands on the west side of the field. My brief college experience at Amherst had included an introduction to the game of squash and the possible convenience of nearby courts broadened the recreational opportunities. So I wandered through the courts area and indeed they appeared available until, that is, I abruptly encountered a floor to ceiling concrete wall. The lamp of learning seemed to bum a little brighter and I decided to explore what might occupy the north side of the grandstand. So I left the courts and sauntered down University Avenue.

Many of you will recognize this situation but I didn't at the time and I was surprised to have my explorations terminated as I ran into a guard house well supplied with a squad of armed soldiers. This was my close encounter with the first atomic pile which I later learned had been built and activated just on the other side of that concrete wall in the squash courts. I did wonder, or I have since wondered, what a Geiger counter would have had to say if it had accompanied me on that walk. My wanderings occurred in April 1944 and the first activation of the atomic pile took place in December 1942. A bronze commemorative plaque can be seen now mounted at the site.

This lead in to my journey this evening is for the purpose of introducing a principal player, Enrico Fermi, whose pioneering work in nuclear physics became a major influence enabling the generation and to some extent the harnessing - of atomic energy. He was one of an extraordinary group of physicists, almost all Europeans, who came together shortly before World War II and worked collaboratively and with great dispatch on the fundamental issues leading to the development of atomic energy.

Enrico Fermi was born in Italy in 1901. The two biographies of him that I found most illuminating - of his life and work - are "Atoms in the Family" by his wife Laura, published in 1954 and "Enrico Fermi - Physicist" by his friend and colleague of many years, Emilio Segre, published in 1970. These biographies describe the very interesting development of a most brilliant and gifted scientist who from an early age showed a remarkable capacity for learning and problem solving. From the age of 14 he began independent learning, reading physics and mathematics in English, French, German and Latin as well as Italian and quickly coming to the attention of mentors who helped him plan his advanced education. These mentors also made it possible for him to locate

advantageous professional positions. His talents included designing and constructing the scientific apparatus necessary for his experiments, talents you will see employed most critically as he focused on an understanding of small particle physics. All these developments took place in an Italy that was roiling in the aftermath of World War I and then the difficult environment of the Mussolini years. His accomplishments are indicated by his achieving an appointment with lifetime tenure, in Rome, at the age of 26.

Fermi's work, and that of his associates, rapidly gained international recognition and he gave presentations and seminars in many parts of the world. During the thirties he recognized the limited opportunities available to him and his family in Italy and he and his associates began to focus on the possibilities of relocating, especially to America. All this came to a head in the Fall of 1938 when he learned he was high on the list of candidates for that year's Nobel Prize in Physics. Careful and confidential plans were made to proceed directly from Stockholm to New York City, after the possible awarding of the Prize, where he was to give some presentations, but actually planned a permanent immigration.

In November 1938 Fermi was notified he had received the Nobel Prize "for the discovery of new radioactive substances belonging to the entire range of elements and for the discovery made in the course of that work of the selective power of slow neutrons". He received the Prize December 10th, 1938, with his wife and children accompanying him. Shortly after that the family boarded the Franconia in Southampton and landed in New York on January 2nd, 1939. At that time he assumed a Professorship at Columbia University.

Fundamental work in physics regarding nuclear fission and chain reactions went on in several European areas but increasingly in the United States during 1939, leading to some conclusions regarding the generation of atomic energy and then the famous letter of Albert Einstein's to President Roosevelt, alerting the President to the early potential for the construction of extremely powerful bombs. Increasingly after that the investigative work became nationally organized and more or less simultaneously with the event of Pearl Harbor the scientific work related to the construction of the atomic pile and the creation of the chain reaction was reorganized and centered under Arthur Compton, a Professor of Physics at the University of Chicago. All of the workers and work were brought to Chicago under the name Metallurgical Laboratory. Fermi gradually transferred his work from New York and he and his family moved to Chicago during 1942.

By October 1942 it was apparent that there was enough uranium and graphite, the essential materials, to begin to build an actual reactive atomic pile. The work in fact began in October 1942 with the physicists working in twelve hour shifts around the clock under Fermi's supervision. Each layer of the pile was built up after discussions with Fermi and after extensive calculations by "him. By the end of November measurements clearly showed that completion of the 57th layer of the structure would result in a neutron density leading to a self sustaining chain reaction.

On the morning of December 2nd, 1942 the procedure was started, under Fermi's direction, to approach criticality in a perfectly controlled way, with Fermi calculating and ordering the size and placement of each step. The first self-sustaining chain reaction began at 2:20 p.m., as had been calculated.

An interesting vignette is reported immediately following that epic event. Arthur Compton, the principal organizer of the Metallurgical Laboratory, telephoned James Conant, a chemist and President of Harvard University, who was a member of the national coordinating group, with the message "Jim, you'll be interested to know that the Italian navigator has just landed in the new world--the world was not as large as he had estimated and he arrived at the new world sooner than expected". "Is that so?" Conant asked, "Were the natives friendly?" "Everybody landed safe and happy," Compton assured him.

Fermi's style of personally tackling or estimating everything amenable to analysis and his enormous technical and personal prestige contributed to a remarkable period of theoretical and practical progress.

Now, I want to fast forward to the summer of 1950 and move from Chicago to Los Alamos. Here again we find Fermi, having lunch with several colleagues, including Edward Teller. He, Fermi, had become prized for his uncanny ability to see straight to the heart of a physical problem and describe it in simple terms. His friends and colleagues called him "the Pope", because he seemed infallible. Always impressive was the way he estimated the magnitude of an answer, often by doing complex calculations in his head. During the luncheon a serious discussion took place about whether flying saucers could exceed the speed of light. Fermi asked Teller what he thought the probability might be of obtaining evidence for supraliminal - that is faster than light travel - by 1960. Fermi said that Teller's estimate of one in a million was too low; Fermi thought it was more likely one in ten. The discussion turned to other matters and then in the middle of the conversation, and out of the clear blue, Fermi asked, "Where is everyone?" His lunch companions immediately understood that he was talking about extraterrestrial visitors. They recalled that he had made a series of rapid calculations, again in his head, and had concluded that we should have been visited long ago and many times over by such visitors.

Thus we come to the title of this evening's paper and also that of a recently published book by Stephen Webb, an English physicist, "Where is Everyone?".

The Fermi question can be - and I ask that you do this reasoning in your head -- How many communicating civilizations exist in our galaxy? If we can estimate (1) the yearly rate at which stars form, (2) the fraction of stars that possess planets, and - (3) for planet-bearing stars the number of planets with environments suitable for life - (4) then estimate the number of such planets on which life actually develops and (5) the fraction of those planets on which life develops intelligence, (6) the fraction of life forms that develop a culture capable of interstellar communication, and (7) the time and years that such a culture will devote to communication - a simple equation can be created. And Webb, proceeding along these lines, comes to the estimate that in our galaxy, at this time, there could be one million extraterrestrial civilizations trying to communicate with us. The galaxy should be swarming with extraterrestrial civilizations, we'll call them ETCs - yet we see no sign of them. Thus the Fermi Paradox. We see no signs of such ETCs when we might expect to.

In 1979 a conference was held to discuss the Fermi Paradox and the proceedings were published in a book. The volume contains a variety of views but it is difficult to

read it without concluding that ETC's have the means, motive and opportunity to colonize the Galaxy. The means: interstellar travel seems to be possible, if not easy. The motive: some ETC's would be forced to interstellar travel by the death of their star, and in any case it seems a wise idea for a species to expand into space to guard against the possibility of planetary disaster. The opportunity: the galaxy is thirteen billion years old, but colonization can take place over a period of only a few million years, yet we do not see them. As Stephen Webb says, "If this were a murder mystery, we would have a suspect but no body. We have been searching, in an organized way for, ETCs for forty years."

Webb then organizes the possible solutions to the Fermi Paradox into three principle groups. The first group of solutions starts, humorously, with the solution that extraterrestrials are already here - and they are Hungarians. He then reviews seven other possibilities of the presence of extraterrestrials on earth, more seriously.

The second group of paradox solutions, some twenty-two possibilities, is titled, "They exist but have not yet communicated."

And the third and final grouping of solutions is ETC's do not exist, with nineteen possibilities presented. Webb then offers his own solution to the paradox. In doing this he describes a number of steps beginning with estimating that (1) one hundred billion stars exist in our galaxy and that (2) the average number of planets per star is 10. The next step (3) is to state that only twenty percent of the stars provide a habitable zone that can give rise to a viable planetary system. Then, further, for life as we know it (4) we need consider only stars like our sun and only five percent of the stars in our galaxy are similar to the sun. As you can see we are rapidly diminishing the possibilities of extraterrestrial life and (5) a further reduction occurs when Webb estimates that only one percent of the remaining planets will be both suitable for life and remain in a continuously habitable zone for billions of years, a necessary stipulation. Even so, a million planets remain as possible candidates.

More should be said about the concept of the Galactic Habitable Zone (GHZ). Investigators have modeled the evolution of the Milky Way Galaxy to trace the distribution in space and time of four prerequisites for complex life: The presence of a host star, enough heavy metal-like elements to form terrestrial planets, sufficient time for biological evolution and an environment free of life-extinguishing supernova or exploding stars. The investigators identified the Galactic Habitable Zone as an annular region some distance from our galactic center that widens with time and is composed of stars that formed between 8 and 4 billion years ago. This GHZ yields an age distribution for the complex life that may inhabit our Galaxy. The investigators found that 75% of the stars in the GHZ are older than the sun.

Of the million candidate planets how many may be estimated to be home to life that is biologically reproducible. (6) If you believe the genesis of life is exceptionally rare then the answer is none. If you believe a special set of circumstances is required, such as life originating on a planet like Mars and then being transported by an impacted ejecta to an earth-like planet, then the answer is not many. Webb prefers to believe that life is a probable occurrence; that if conditions are suitable, then there is a good chance of cells

evolving. Maybe a fifty percent chance - that leaves us with a half a million planets which may have life.

But the universe is a dangerous place. (7) And the rate of planetary disaster may be significant. He proposes that as many as twenty percent of possible planets may suffer such a fate leaving four hundred thousand planets to be considered.

However, (8) special factors have influenced the genesis of life on earth - factors which we may not ordinarily consider such as the influence of plate tectonics on the development of life on earth and also the fact that earth has had a moon for billions of years. But even if life does begin as some type of cellular activity (9), the development of the modern nucleated cell took of years on earth, which perhaps indicates that this step - the development of nucleated cells – is far from inevitable. No one knows (10) what fraction of planets with nucleated cells will go on to host complex multicellular life forms, Webb's estimate is that one in ten would be a generous estimate. This leaves us some ten thousand planets possibly possessing complex multicellular life but the final sifting process remains to be considered.

Development of complex civilizations requires that (11) advanced life forms learn tool use and the ability to continuously improve technology. Advance life forms would have to move to the development of abstract high level intelligence as we are familiar with in humans. And finally, (12) advance life forms would have to develop complex, grammatical language - all of these developments are considered far from inevitable by most scientists in the field. Language is the key that enabled all of the other achievements in our civilization to take place.

So - Webb's guess is that none of the planets make it through this final sifting process and the planet Earth remains as the only civilization in the galaxy. He believes we are alone. As he states it, "I believe that the Fermi Paradox tells us mankind is the only sapient, sentient species in the Galaxy." The picture he offers is of a Galaxy in which simple life is not uncommon; complex, multicellular life is much rarer, but not vanishingly rare. There may be tens of thousands of exceptionally interesting biospheres out there in the Galaxy. But only one planet - Earth - has intelligent life forms.

I find myself inclined to be persuaded by Webb's sifting process but indeed his argument is based on a series of estimates and many scientists believe that the incredible number of stars and their planets make the odds favorable for the development of ETCs. And while I may be persuaded by Stephen Webb's reasoning that our planet's civilization is singular, there are many who are not and an increasingly well organized and sophisticated effort exists to prove him wrong.

In 2002 the SETI Institute published "the SETI - 2020 - A Road Map For The Search For Extraterrestrial Intelligence". The material in this book gives detailed consideration and plans for a continuous organized monitoring for this search.

Let me provide some background. Modern scientific investigations of intelligent life in the universe had their beginnings some forty years ago. At that time researchers began to direct their attention to distant planetary systems beyond our solar system. A number of investigators concluded that radio waves would be a remarkably efficient means of communicating across the Galaxy. The common threads in the search for

primitive life and intelligent life were brought together in 1984 with the formation of the Search for Extraterrestrial Intelligence (SETI). It is a non-profit research and educational organization dedicated to a search for Extraterrestrial Intelligence and to the general study of "life in the universe". Located in Mountainview, California, the SETI Institute also conducts educational and public outreach programs in these two disciplines. In 1997 SETI Institute decided to re-examine its mission and objectives, in the light of the many recent advances in science and technology. The results of a two year study are gathered in the volume SETI 2020.

Moore's Law, which postulates that the power of computing systems doubles approximately every eighteen months, is expected to remain valid during the next two decades. Growing computational capacities make possible the plan for the whole sky to be continuously covered seeking signals, a concept termed Omni directional SETI System and operating 24/7 year-round.

On the basis of these considerations the working group came up with three principle recommendations. 1) The development and construction of a One Hectare Radio Telescope to carry out targeted searches of candidate stars and some sky surveys in the galactic plain or flattened area over the next twenty years (a hectare is 10,000 square meters). 2) To undertake extensive feasibility studies and test bed demonstrations of an omni directional sky survey telescope designed to search for strong microwave signals. 3) The working group recommended that the SETI Institute set aside funds for small scale experiments to detect infrared/optical signals of ETI origin using existing telescopes and direct photon detection techniques.

As noted above, much of the impetus for SETI at the start of the 21st Century derives from the galloping speed of computer technology. Moore's Law, noting the exponential growth of computational power, is built into the planning so that by 2020, SETI instrumentation could be ten thousand times faster than that used in the best current experiments. This is an exciting prospect, where it offers the hope that our grasp may soon equal our reach. Scrutiny of hundreds of thousands, or even millions, of nearby stars will be possible.

SETI has important implications for the future of society on earth. The actual discovery of a signal will lead to sociological, intellectual and practical changes in our civilization. At least there should be immediate questions to answer, for example: "Should, or how, we respond to a signal?" "What type of follow-up SETI project should be implemented?" These considerations go on with the awareness that the extra solar systems being studied are tens of light years away meaning that signals coming from such systems would require ten years to reach Earth and any response from Earth would require ten additional years to reach the star sending the signal. It is obvious that a multi generational project is being constructed. The rationale behind the development and current programs of SETI is clearly expressed by Dr. Barney Oliver, a long time member of the SETI board, who wrote in March 1990, "To me SETI is a search for proof that natural selection and evolution are ubiquitous and that they frequently lead to beings as complicated as humans. We SETI buffs are enthralled by the knowledge that on this little planet the wonderful laws of physics have, and in a few billions years, converted the ravening chaos of the Big Bang into the most delicate and complex of structures; into spider webs and apple blossoms and leaping trout; and above all into brains capable of

modeling the exterior world and puzzling out its origin. We want to know if this astonishing transformation is a local freak event or an inherent property of the universe. We very much suspect the latter."

Some of the speculations about ETCs are motivated by very gloomy forecasts of the future of our planet, such as contained in Martin Rees's recently published book, "Our Final Hour - A Scientist's Warning: How Terror, Error, and Environmental Disaster Threaten Human Kind's Future In This Century - On Earth and Beyond". One of Martin Rees's notions, and not his alone, is that developing spaceships that can exist away from the earth, indefinitely, and provide for self perpetuating human communities, may become an important avenue for the survival of human kind.

Martin Rees warns that human kind is potentially the maker of its own demise - and the demise of the cosmos. He maps out ways technology could destroy our species and thereby foreclose the potential of a living universe whose evolution has just begun. Rees forecasts that the odds are no better than 50/50 that humankind will survive to the end of the 21st century. Rees, a recognized scientist, notes that science is advancing at an accelerating rate but with a dark side, and our increasingly interconnected world is vulnerable to new risks, "bio" or "cyber", terror or error. The dangers from 21st century technology could be graver and more intractable than the threat of nuclear devastation that we faced for decades. And human induced pressures on the global environment may engender higher risks than the age-old hazards of earthquakes, eruptions and asteroid impacts.

At the heart of Rees' book is his vision of the infinite future that we have put at risk - a cosmos more vast and diverse than any of us has ever imagined. If we are the only sentient means in the universe, our world's fate takes on a truly cosmic significance. The wider cosmos has a potential future that could be infinite. Will these vast expanses of time be filled with life or as empty as the Earth's first sterile seas. The choice may depend on us in this century.

Clearly for many years I have been mildly entertained by reports of flying saucers, aliens kidnapping unsuspecting citizens, Buck Rogers and space travel and outpourings of science fiction literature, TV programming and films, depicting worm holes, alternate universes and time machines. And increasingly my aging mind has been bewildered by the proliferating theories of space-time, string theory, the impact of quantum theory developments, etc. But putting aside science fiction and the struggle to understand new developing theory, it is important - what could be more so - to answer the question, "Are we alone?" or "Do we share the universe with creatures with whom we might one day communicate?". As Stephen Webb states, "Either way it is a staggering thought.".

Some of you may feel that my interests as expressed here in this paper are not quite mainstream but what do you know- on the front page of the "Week in Review" in the New York Times on Sunday, January 11, 2004 is an article carrying the headline "Be Careful What You Look For On Mars". The story of astronomy is one long slow assault on our sense of self importance, writes William J. Broad. The ancients knew they were at the center of things. Their eyes told them that the sun and stars moved around them day and night, eternally circling their snug homes.

It took the abstractions of science to undo the obvious. Copernicus dislodged the earth from its place of glory and put the sun in the center. Before long astronomers discovered that the sun was commonplace in that our own brilliant galaxy, the Milky Way, was actually just one of billions of star parties. Recently astronomers have proposed a new glue for the universe, dark energy. (The Breakthrough Discovery of the Year 2003.) It is incontrovertibly real, they insist, but, so far, beyond human comprehension.

The record of cosmic insult, already staggering, could get worse if the current invasion of the red planet proves successful. While rocks and sands now hold center stage, the ultimate purpose of the work is to track water and what seems to be its nearly inevitable companion, life. Explorations of Mars - relatively dry now, but wet long ago, scientists believe - are considered more likely to uncover fossils than extant forms.

Even the White House has caught extraterrestrial fever. President Bush has announced plans to set up a human colony on the moon and eventually to send Americans to Mars to redevelop the American exploratory push. Even if just one little Martian was to come to light however small and ugly, old and desiccated, its discovery would have ramifications far beyond the scientific. It would suggest that we are not alone in the universe.

"Some eminent people say it will be terribly depressing, that we'll feel ignorant, and they predict a planet wide inferiority complex," said Dr. Frank D. Greg, an astronomer at the University of California at Santa Cruz and a pioneer of the hunt for extraterrestrial life.

"My take is that it could have the opposite effect," he added. “It could motivate us to think that if we worked hard we could be as good as them, motivate us to make progress much more quickly than we are. I'm an optimist. Its more fun." End of the Times article.

And in the Cincinnati Post of October 30, 2003 is a headline "ET, call home by 2025.".

A report by Michael Woods from Block News Alliance

"E.T., the extraterrestrial, may prowl neighborhoods on Halloween with Hollywood's other soft, and, swishy renditions of intelligent aliens life forms. But when might we humans actually, finally encounter the real thing?

Probably in your lifetime. By 2025.

The leading experts in the search for extraterrestrial intelligence at the SET! Institute in Mountainview California, recently completed the most systematic calculations ever performed on when the human race is likely to contact intelligent alien life for the first time.

Their answer: within 22 years.

And they suspect that our first interstellar interlocutor might end up being a super intelligent machine rather than anything biological.

Seth Shostak unveiled SETI's predictions at an astronomy conference in Germany earlier in October. He and co-author Alexander Barnett will go public with their findings December 2003 when their new book "Cosmic Company: The Search For Life In The Universe," is published.

"There are as many stars in the universe as there are grains of sand on earth's beaches," said H. Paul Shuch, Executive Director of the SETI Inc. "About ten percent of these may have planets with intelligent life".

But Shuch joined other scientists in chiding Shostak for so startlingly predicting first contact by 2025. "It is safe to say that by 2025, our newest and greatest SETI technology will have been up and running long enough to make a detection - if," Shuch said. – "If" meaning extraterrestrial life exists in detectible civilizations."

So we have two clusters of motivation: 1) Are there ETCs and how might we communicate, be influenced by them, or influence them? And, 2) Is our civilization at a point when we should be thinking of and developing extraterrestrial communities, self perpetuating into an extended future.

All this speculation has led me to wonder how interested I myself might be in an extraterrestrial existence. I think it would take some getting used to but then I might have plenty of time on my hands - but maybe not - I'm still not clear on what the personal effect is on one who travels at the speed of light or faster - does everything stop with regard to the passage of time? I'm still trying to figure that out - I said this was an uncertain time as I started out. But one thing is clear from my studies - they are going to need a psychiatrist on board – prolonged space travel leads to disorientation, disruption of sleep patterns and difficulties with balance, and otherwise. Those are all my cup of tea. And speaking of tea - they'll have to have tea leaves on board for all those ventures into the unknown. Hey! What better way do we have of looking into the future?
