WHERE ARE YOU, CHUCK BERRY?

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I want to assure everybody that this is definitely not a paper about Rock and Roll music! Tonight, I want to address the "X" factor in the SPHEX acronym and talk about a subject about which nothing is definitely known. To quote T.H. Huxley: "The known is finite, the unknown infinite; intellectually we stand on an islet in the midst of an illimitable ocean of inexplicability. Our business in every generation is to reclaim a little more land." Tonight, I want to address one of our generation's attempts to "reclaim a little more land": namely the search for extraterrestrial life.

The possibility of life on other planets is a subject that has fascinated me personally ever since I became old enough to stare at the sky on a clear night and imagine what might be out there. I have not been alone in this interest, as we will see. The view of the moonless sky away from city lights on a clear night is truely awe inspiring, and if one has any imagination, one can not help but wonder at the seemingly limitless possibilities that are there. In fact, for thousands of years, humans have believed that there are beings in the sky, and many have believed that we have been visited by extraterrestrials. The multiple reports of UFO sightings through the years have certainly lent credence to the thought that even today we are being visited by alien creatures of extremely high intelligence. This idea is at once intriguing, mystifying, and frightening. In my own lifetime, there have been many fictional accounts which

appeal to mankind's longing to communicate with other worlds and their civilizations - Buck Rogers, the Star Trek TV series and movies, the Star Wars trilogy, the movie E.T., and my favorite, Invasion of the Body Snatchers, just to name a few.

In 1938, Orson Welles' famous radio broadcast of the H.G. Wells story War of the Worlds had literally thousands of people believing that Earth was being invaded by Martians. Thousands cried, prayed, sealed their homes against poison gas, or fled to shelter. We might reasonably ask why so many people were so quick to believe that we had been invaded by Martians. To answer that question, we need to look at the history of the question of extraterrestrial life and how humans have looked at it.

Even in the Bible, we can find stories that seem to recount the visitation of the Earth by travelers from outer space. The Book of Ezekiel in the Old Testament reports a tale of visitation from beings that could well represent visitors from another planet. To quote from Chapter One of the King James version of the Bible:

> "And I looked, and, behold, a whirl-
> wind came out of the north, a great
> cloud, and a fire infolding itself,
> and a brightness was about it, and
> out of the midst thereof as the colour
> of amber, out of the midst of the fire.

Also out of the midst thereof came
the likeness of four living creatures.
And this was their apprearance; they
had the likeness of a man. And every
one had four faces, and every one had
four wings-----

The story continues, and it is not my purpose here to recite stories from the Bible, but suffice it to say, that the tale <u>does</u> sound like a scriptural encounter of the third kind. This is just but one of the many curious stories that have been passed down from ancient times that can't help but make even hard core skeptics wonder whether perhaps, some time in the distant past, we may have been visited by an alien civilization.

Such ancient stories are not limited to Western cultures. For example, there is an ancient Babylonian account which tells the story of a fish like animal with the head of a man which came to the people with great knowledge which it imparted to them - knowledge that we could not reasonably expect them to know if they didn't have technological knowledge.

Then there is the case of the African tribe called the Dogon, who live in Mali. These people claim to have been visited by beings from the star Sirius, and they further say that the star has a companion that moves around it every fifty years. The interesting fact is that indeed Sirius does have a companion star that orbits it every fifty years

and that this companion is invisible to the naked eye. Furthermore, the companion star was not discovered until the 19th century. Although there has been scientific skepticism concerning this account, it certainly does invite speculation.

In 1968, Erich von Daniken published his book Chariots of the Gods? In this book, he not only raises the possibility that we have been visited by beings from outer space, but he postulates that early religions were based on visitations from aliens and worship of their material goods. He not only cites the passage from Ezekiel to which we have already alluded, but he quotes other passages from the Bible which he claims support the concept that we have been called upon by creatures from outer space. He goes on to tell many tales of ancient civilizations that appear to worship deities that could conceivably represent ancient astronauts from other worlds.

von Daniken's book seems quite incredible, and it has been panned by serious scientists. However, I think that it is worth noting that there is a strikingly similar parallel in modern history. The November, 1974, issue of National Geographic contains a remarkable article entitled Tanna Awaits the Coming of John Frum. This article relates the bizarre but true story of the natives of this South Pacific island and their strange religion. These people worship and await the arrival of a hoped for messiah of material riches whom they call John Frum. All followers of John Frum

believe he will someday appear on their island and magically usher in a prosperous, work-free millennium of unlimited "cargo" - pidgin English for Western material goods. Their faith began with the arrival of Captain James Cook in 1774, but it blossomed in 1942, when American troops landed on nearby islands, bringing food, arms, pre-fabricated houses, jobs, and legions of jeeps. With the war's end, the cargo disappeared, but the islanders have kept a vigil ever since in hopes of luring "John Frum" and his cargo-laden ships back to their shores. Their ritual is loosely based on American military drills, and the followers paint the initials "U.S.A." on their backs as they perform their rites. Although we may smile at their naivete, it is really not too difficult to see how Stone Age South Pacific islanders could mistake American soldiers and sailors with their plethora of worldly goods for deities. Furthermore, it does not take a great leap of the imagination to see that a similar sudden and strange visitation from outer space could have led to an ancient pagan religion.

These tales all represent what I would call psuedo-scientific speculation and even sensantionalism of the subject of extra-terrestrial life. There has also been a remarkable body of science fiction literature on the subject. "Gort, Klaatu berada nikto!" Thus spoke Patricia Neal in the unforgettable 1951 film classic, <u>The Day the Earth Stood Still</u> as she saved the world from the rampaging alien robot Gort. This film is a beautiful example of 20th

century science fiction, but this literary genre has deep roots in the 19th century, which was a time of rapid and impressive scientific and technological advances.

Although most people think only of Jules Verne and H.G. Wells when thinking of 19th century science fiction writers, the amazing fact is that most of the greatest American writers of the time, as well as some of their European counterparts wrote science fiction. Such authors include Edgar Allen Poe, Sir Arthur Conan Doyle, Herman Melville, Honore de Balzac, Nathaniel Hawthorne, Jack London, Ambrose Bierce, Edward Bellamy, Mark Twain, Mary Wollstonecraft Shelley, James Fenimore Cooper, Henry James, Stephen Crane, Washington Irving and even Fyodor Dostoyevsky. It is beyond the scope of this paper to review their writings in any detail, but it is important to note that there was a strong 19th century science fiction school that has continued down to our present time. None of this literature would have succeeded if there were not a strong human desire to believe in the existence of alien civilizations.

Although the many science fiction accounts of alien beings and civilizations are entertaining, amusing, and even edcucational, the real purpose of this paper is to examine the serious scientific searches for extra terrestrial life. Before we can do that, I believe it is necessary for us to attempt to define life and what it is that we are talking about. Webster's dictionary defines life as "That state of an animal or a plant in which its organs are capable of

performing their functions , or in which the performance of functions has not permanently ceased; animate existence; vitality; the time during wlhich such a state continues; the period during which anything continues to exist ---". The Encyclopedia Britannica defines life as "a phenomenon almost impossible to define or to explain in all of its varying aspects," a definition sufficiently broad certainly to encompass any alien life.

Would life on another planet have to be like life on earth? Before we dismiss that concept out of hand as hopelessly geo-chauvinistic, we should stop for a minute to consider the biochemical basis of life on Earth and the astonishing diversity of life forms that exist here.

The key important biochemical fact about life on Earth is that at the atomic scale, earthly life consists almost entirely of a sparse handful of elements - hydrogen, nitrogen, oxygen, phosphorus, sulfur, and most importantly, carbon. Carbon is by far the most important element, because it easily forms multiple bonds with other atoms and therefore acts as a kind of glue, cementing together the pieces of life's complex molecules. Carbon bonds so easily because it has relatively few electrons - only four in its outer shell which theoretically has the capacity for eight electrons. Therefore, each Carbon atom can bond with as many as four other atoms at once. Even the language of chemistry acknowledges the primacy of carbon. Compounds

containg carbon are called organic; all others are termed inorganic.

Many organic molecules are relatively simple, and small organic compounds are commonly found in space, where they have been detected in dust clouds, on comets and meteorites, and even floating in the atmosphere of Jupiter. But complex, self-regulating organisms that live, reproduce, and die require far more sophisticated molecules, some of which contain more than 10,000 atoms. These compounds are called organic polymers - giant chains, rings, lattices, and globules which are built from units known as monomers. There are four classes of organic polymers: carbohydrates, fats and oils, nucleic acids, and most common of all, proteins. Proteins are composed of long chains of amino acids, and one of the remarkable facts about life on earth is that there are only 20 different amino acids which are found in all living things, both plant and animal, on earth. There are many more than 20 amino acids which are at least theoretically possible, and it is conceivable that carbon based life on another world could well employ an entirely different set of amino acids.

Living things require a genetic code that can be passed from generation to generation, so that each species can replicate itself. Terrestrial life accomplishes this coding function by means of a molecule called DNA. Like proteins, DNA is composed of long chains of simpler compounds, in this case called nucleotides. A nucleotide contains a phosphate,

a sugar and a section called a base. These nucleotides are linked together in long double spiral chains, called the double helix, and it is the bases which link to each other to form this double helix. Incredible as it seems, there are only four bases which link this genetic code together, and these four bases are found in the genes of all living things on earth. I somehow find it astounding to think that we humans have the same basic genetic code as trees, spiders, snakes, grass, bacteria, and all the rest of Earth's living organisms. It does not take a great leap of the imagination to suppose that life on another planet could have a similar genetic code which is based on four or more other bases.

Could there be alternatives to carbon based life? The most promising element, based on what we understand about the biochemical basis of life here on earth, is silicon. Like carbon, silicon is a versatile element that can knit together complex chemical chains. It too has an outer shell of only four electrons and thus has room for four electrons from other atoms with which to make compounds. It also bonds with oxygen in long molecular chains which are called silicones. Like organic compounds, silicones come in several varieties which depend on the organic groups attached to the silicon atoms. Silicon-oxygen bonds are very strong, however, and once formed, silicones tend to be self-contained and rarely react with other compounds. This fact bodes poorly for silicon as the chemical building block

for life. Other elements such as germanium, tin and lead, which occupy the same relative place in the periodic table of elements, and thus have an outer shell of only four electrons, are even less promising, because their chemistry is not suitable to the formation of multiple compounds that can react with others to form the complex chemicals that seem to be necessary for life. Finally, the cosmic abundance of carbon exceeds that of silicon, germanium and all the other alternatives. Therefore, it seems reasonable to assume that any search for life beyond the Earth should focus on carbon based life and as a result that we should look for environmental conditions roughly equivalent to ours. Nevertheless, as we shall see from an examination of earthly forms of life, even carbon based life could be dramatically different from life as we know it.

In addition to a basic organic element, such as carbon, life also requires <u>solution</u> chemistry, that is - material in the liquid state. The gas state does not permit definite mechanical structure, and the solid state is too organized; it does not allow atoms and molelcules to move around freely enough for the the things that have to happen in a living creature. In short, the essential chemistry of life occurs in a solution - in our case in compounds in a water solution. Other solvents are at least theoretically possible in planets with a significantly different temperature range, but it seems clear that any form of complex life must exist in some sort of solution.

Finally, I believe that any form of intelligent life that we might communicate with would have to be an upright species with hands that have thumbs. The upright position has freed us to use our hands to make tools and the other trappings of technology. The thumb is very important, because it allows us to grasp objects and use them for our purposes. Those people who doubt the importance of the thumb should attempt to drink a glass of water or write a letter without using their thumbs.

I think that we should pause to examine the remarkable diversity of life forms that are found on Earth before proceeding with a discussion of the search for extra-terrestrial life, if only to realize that life can thrive in the seemingly most hostile environments. From the subfreezing Antarctic desert to the sulfurous waters of a hot spring, terrestrial organisms grow and prosper in environments that seem almost as inimical as those exisitng on other planets and moons of the Solar System.

For example, Antarctica is by far the least hospitable continent on Earth. It also happens to be the closest terrestrial analog to the planet Mars. It is thus intriguing to exobiologists that Antarctica is home to thriving populations of lichen, algae, fungi, bacteria, and insects, and there is a strong belief among exobiologists that we may one day find fossilized remains of microscopic life on Mars. Some even hope that we might find living microbes at the borders of the Martian permafrost.

As another example of the extraordinary variety of life that we find on Earth, consider the fact that fish and shrimp have been sighted 35,000 feet below sea level in the Pacific Ocean, swimming easily in spite of water pressure of eight tons per square inch, which is more than a thousand times the atmospheric pressure that we find at sea level. There have also been found organisms that live in the complete absence of sunlight, as well as bacteria that grow in the 212 degree waters of thermal springs such as those found in the geysers of Yellowstone National Park. As a physician, I know all too well about anerobic bacteria - organisms that not only do not require oxygen for their life, but for which oxygen is actually poisonous. It is important to remember that all of these living creatures have the same basic genetic code and that they use the same fundamental protein structure and the same chemistry based on carbon compounds as do more common life forms.

With that background information, I now want to proceed to actual theories and searches for extra-terrestrial life that have occurred and which have been the subject of serious research by serious scientits. This topic has often been called a science in search of a subject. But I believe that it is in fact a true scientific discipline. Whether it will ever bear fruit in the sense that we will someday find intelligent life remains to be seen. One thing is certain, however, and that is that the search has begun, and it will continue.

As we have seen, there are many ancient accounts which may describe contact with extra-terrestrial life, but it is safe to say that in the Middle Ages and for many centuries before, accepted wisdom held that the Earth was the center of the universe. Although ancient astronomers had known for centuries that the planets had anomalous paths in the sky, the Egyptian astronomer and mathematician Ptolemy had devised an elaborate and artificial explanation for these observations. The Ptolemaic system was used by the medieval church and medieval scholars to buttress the thought that the Earth was really the center of the universe. As long as this belief held, there was no real incentive to even speculate on the existence of life on other worlds.

However, in 1543, the Polish astronomer Nicolaus Copernicus pusblished his monumental work -On the Revolutions of the Celestial Spheres. In this book, Copernicus attributed to the Earth a daily motion around its own axis and a yearly motion around the Sun. In so doing, he developed an idea that had far reaching implications for the rise of modern science. Henceforth, the Earth could no longer be considered the center of the cosmos; rather it became one heavenly body among many. This concept caused profound shock in its day, because no longer could the Earth be considered the epitome of creation. This challenge to the entire system of ancient authority required a complete change in man's philosphical conception of the universe, and has rightly been called "the Copernican Revolution."

Copernicus himself died at the time of the publication of his great work, so he did not suffer any consequences from his own revolution. The Italian astronomer Galileo Galilei was not so fortunate. He was the inventor of the telescope, and as such, he amassed evidence in support of the Copernican theory that the Earth revolves around the Sun and is therefore not the center of the universe. He even informally stated the principles that were later embodied in Newton's laws of gravity. His position represented such a radical departure from accepted thought that he was tried by the Inquisition in Rome, ordered to recant, and forced to spend the last eight years of his life under house arrest. Nevertheless, his ideas formed the basis of modern mathematics, physics, and cosmology, and his place in history is secure.

As the primacy of Earth in the cosmos dimmed, it became virtually certain that humans would begin to consider the possibility of life elsewhere. Perhaps inevitably, the longing to prove than mankind is not alone in the universe came to focus most intensely upon Mars - a world that seemed to observers as remarkably Earth-like. As the advent of telescopes allowed astronomers to study that planet and its habits more closely, various similarities appeared. Although Mars has a year that is nearly twice as long as Earth's, it has a twenty-four and a half hour long day that seems to mimic ours. Furthermore, there are dark regions on Mars that wax and wane seasonally, thus evoking thoughts of

oceans, continents, and vegetation. The fact that Mars has polar ice caps that advance and retreat before the Sun adds further fuel to the thought that Mars is similar to the Earth. Mars' distance from the Earth varies; at its most distant it is 248 million miles away, but every 15 to 19 years it draws to within 35 million miles of Earth.

It was at such a time in 1877 that the Italian astronomer Giovanni Schiaparelli studied Mars. He focused on one feature of the planet at a time, looking away to make a meticulous drawing, then returning to the eyepiece. Gradually, an astonishing pattern seemed to emerge: Mars appeared to be covered by a planet-wide network of geometrically ordered lines. Schiaparelli called these lines canali, which in Italian means "channels", but which the English speaking public inevitably took to mean "canals". This concept staggered the public imagination, for in a day when the 107 mile long Suez Canal was less than 10 years old and still a cause for wonder, people began to imagine beings capabale of digging canals that would span an entire planet.

Schiaparelli's musings and the popular support for them were immediately buttressed by the French astronomer Camille Flammarion. Fifteen years earlier he had written a book about extraterrestrial life, and therefore had established himself as a kind of sage on the subject. He quickly supported the theory of Schiaparelli and thus reinforced the belief in intelligent life on Mars. Across the Atlantic,

the influence of Schiaparelli and Flammarion was felt by an amateur American astronomer named Percival Lowell.

Lowell was the son of a prosperous Boston family who had devoted his adult life to oriental scholarship and travel. However, at the age of 39, he abruptly changed careers and turned to astronomy and the study of Mars. Immediately he grasped the idea of the canals of Mars as the work of highly intelligent beings, and in 1894, just in time for the next close encounter of Mars to Earth, he established the Lowell observatory near Flagstaff, Arizona. It was here that he spent the rest of his life pursuing the elusive inhabitants of the Red Planet.

After less than a year of formal observation, Lowell published a book in which he described the Martians as a serious race bound in peace and common effort by the relentless desertification of their planet to create the now famous canals for irrigation. He also concluded that any race that could create such an elaborate planet wide irrigation system must be more intelligent than humans.

Lowell's work and his conclusions were an immediate popular success, and his influnece in the popular psyche continues to this day. However, most scientists of his time were skeptical, and many serious studies of Mars not only failed to confirm the presence of the canals, but showed that there was no water vapor in the atmosphere of Mars and therefore no need for canals to serve as irrigation ditches.

In spite of the increasing body of contrary evidence, the belief that Mars harbored life died hard. In the late 1950's, for example, the discovery of slight perturbations in the orbits of the two Martian moons, Phobos and Deimos, prompted a prominent Soviet astronomer to state categorically that the two moons were in fact artificial satellites of Mars. They could, he pointed out, be either present-day artifacts of an advanced civilization or the relics of a vanished society.

The advent of interplanetary space flight has dealt a virtual death blow to the concept of intelligent life on Mars, and probably even to the thought of microscopic life there. Early unmanned flights to Mars by the Mariner series of spacecraft sent back pictures of a hostile world that appeared more similar to the Moon than to the Earth, although they did show evidence of significant geologic activty, thus keeping alive the thought that there might be living microbial forms or at least evidence that life had once existed on Mars in an earlier epoch.

But it was the Viking Mars landers that became the world's first real life-search vehicle. These space crafts were designed not only to fly to and land on Mars, but their mission was to conduct experiments that might be able to detect life - either currently living or extinct - on the planet. Viking I landed on Mars on July 20, 1976, and on September 3, 1976, Viking II landed half a world away. Both space craft were equipped with soil samplers and biochemical

testing apparattuses that were designed to test for life on Mars. I do not intend to go into the technical details of these experiments, but suffice it to say that not only was there found no evidence of life, there was strong evidence to indicate that the Martian environment is self-sterilizing. The surface of Mars contained even less organic material than the most inhospitable patches on Earth, the nearly sterile soils of Antarctic dry valleys. Not only were organic compounds evidently not being produced on Mars' surface, but any organics imported by meteroites, an occurrence common on Earth, were apparently being destroyed in the Martian environment. In this vast red world, richly marked by old signs of planetary vitality and ancient floods, seemingly so Earth-like that human imagination had populated it with a race of noble, intelligent beings, nothing lived. This finding was a great disappointment to exobiologists, but even today, years after the fact, some scientists still argue that life might exist in at least some areas of Mars. Martian life, having survived for centuries in human imagination, will not be easily exterminated. And, in fact , Mars still retains some of its age-old luster as an abode of life. It has huge channels that are reminescent of earthly riverbeds, which fact suggests that liquid water was present in significant quantities at some time in the past. Some scientists argue that we may well find fossillized remains of life in more thourough searches of the planet. To that end, the Soviet

Union has launced the Phobos space mission to further study the Red Planet.

In the meantime, the United States has also sent other planetary explorers in an effort not only to study the other bodies in the Solar System, but also to search for possible environments that would possibly be conducive to the development of life. Not incidentally, these spacecraft also contained mankind's first conscious effort to communicate with alien civilizations. These space travellers were known to be destined to go beyond the Solar System when their planetary exploration was completed. Ultimately, they would leave the Sun's influence and sail to the domain of other stars. It was inevitable that those interested in the concept of extraterestrial intelligence would decide to send a message on these vessels.

Our first deliberate note in a space-bottle was on NASA's Pioneer 10 spacecraft, which was the first vessel to fly close to the planet Jupiter. Important as that fact was, from the exobiologist's point of view, it was even more important that Pioneer 10 would also be the first object from our civilization that would leave the Solar System forever. With this realization came the idea of sending a message to any alien civilization that might find the spacecraft, even millions or billions of years into the future. Consequently, there was etched onto the Pioneer spacecraft a plaque which showed a picture of a naked man and woman along with a description of our Solar System and

its location in our galaxy. The identical message was also sent on Pioneer 11.

In 1977, the two Voyager planetary explorers were sent on their epic journeys, with their ultimate destinations also being the vast reaches of our galaxy. These space ships carried another message from Earth - a kind of videodisk. Encoded in the grooves of this disk are some of the sights and sounds of Earth. It includes recordings of greetings from the then Secretary-General of the United Nations, Kurt Waldheim, and Jimmy Carter, the President of the United States. Messages in dozens of languages are given, as well as photographs of people and places from all over the planet. In addition, there are recordings of representative music from all over the earth, including Chuck Berry's classic Rock and Roll hit, Johnny B. Goode. Even as we speak tonight, these spacecraft continue on their endless journey into the far reaches of interstellar space, perhaps someday to be interecpted by another civilization.

The Pioneer and Voyager space ships have given planetary scientists marvelous close-up views of Jupiter, Saturn, Uranus, and Neptune, as well as their rings and many of their moons. Although these pictures have been fascinating and tantalizing, none of the data that has thus far been studied from any of the other planets in our Solar System has shown any evidence for the existence of life of any kind, much less intelligent life. In fact, all of the other planets and their satellite systems have been shown to

be very inimical to the formation of any kind of life. Therefore, it seems that if we are to find an extraterrestrial civilization, we will most likely find it orbiting some star other than our Sun.

For life to thrive and evolve into intelligent forms at other locations throughout the universe, there would certainly have to be an abundance of extrasolar planets - preferably planets similar to Earth orbiting other stars similar to the Sun. Earth-like planets would have all the crucial ingredients: a stable source of energy (the parent star) which is far enough away to allow molecules to form, but not much farther; and plenty of raw materials in readily usable forms. Some people also think that the existence of a large moon is crucial, because of the tidal forces which it exerts. These forces create tidal pools, which many biologists feel were essential in the initial formation of life out of the primordial solution of chemicals.

With the crucial role that extrasolar planets play in our search for extraterrestrial life, it is disappointing to learn that we don't even know if such planets exist. Although most astronomers expect that they are there, the fact is that as yet there is no hard evidence for the existence of even one planet outside the solar system.

Although this fact may seem surprising, it should not be so when one considers just how small and insignificant planets really are. For example, Jupiter is more than three hundred times the mass of Earth, but the Sun is more than

one thousand times the mass of Jupiter. Furthermore, the mass of Jupiter is more than the combined mass of all the other planets of the Solar System and their satellites.

Not only does the huge difference in mass matter, but there is also the consideration of the amount of light that is radiated from a planet. Planets produce essentially no energy of their own, and they are visible only through the tiny amount of starlight that they reflect. At interstellar distances, even a Jupiter sized planet would be completely lost in the glare of the parent star and would thus be virtually impossible to see. There had been some hope that the Hubble Space Telescope might have good enough resolution to directly see planetary systems around other stars, but unfortunately that telescope's well publicized mirror problems have thus far precluded that possibility.

There are other theoretical ways in which an extra-solar planetary system might be detected. These are indirect methods, such as measuring so called "wobbles" in stars' motions that would be caused by an orbiting planet's gravitational effect on the star. Although there have been some tantalizing observations made, at this point no definite extra-solar planetary system has been discovered.

In the absence of any direct observations of other planets, astronomers have been forced to assume that they do in fact exist - a leap of faith that is somehow difficult for scientists who are used to testing hypotheses by reproducible experimentation. This assumption is greatly

helped by the cosmological principle, also known as the assumption of mediocrity. This principle basically states that there is nothing special about our place in the Universe and that every place in the Universe is pretty much like every other place, and that furthermore, the same basic laws of chemistry and physics apply everywhere in the Universe. As far as we are able to tell by direct observation, the assumption of mediocrity is true, and if it is so, then it seems reasonable to deduce that there are other planets which support life, even if we have not as yet found them.

In an effort to determine the number of civilizations that are technologically capable of communicating with us, Cornell astronomer Frank Drake devised an equation which is known as the Drake Equation. Although in my opinion it is impossible to acurately fill in the numbers of this equation, the Drake Equation remains a widely used tool for speculation. No discussion of extraterrestrial intelligence would be complete without at least mentioning it. The equation is as follows:

$$N = R.\ f(p)\ n(e)\ f(l)\ f(i) f(c) L$$

N = the number of technological civilizations in our galaxy

R.= the number of new stars formed in our galaxy each year

f(p)= the fraction of those stars that have planetary systems

n(e)= the number of planets in each system that can support life

f(l)= the fraction of such planets on which life actually originates

f(i)= the fraction of life-sustaining planets on which intelligent life evolves

f(c)= the fraction of intelligent life-bearing planets on which the beings develop the means and the will to communicate over interstellar distances, and

L= the average lifetime of such technological civilizations.

This equation has been used by all serious students of the subject, but in my opinion, it has been used to suport each person's pre-conceived ideas. For example, Carl Sagan, who fervently wants to believe in extra-terrestrial civilizations, has assigned large numbers to each of the variables and has concluded that the number of civilizations is 200 million, just in our galaxy alone. A more conservative estimate would place the number at one million, while the pessimistic judgment states that in effect we are alone. This range of opinions from serious students of the subject demonstrates that the Drake equation, while useful as a starting point, does not really answer any questions. In fact, it raises more questions than it answers.

The development of the field of radio astronomy in the 1950s marks the actual beginning of the modern era of searches for extraterrestrial intelligence. The first cosmic radio signals were detected by Karl Jansky in 1932, while he was studying radio interference from terrestrial sources at the Bell Telephone Laboratories in New Jersey. The first actual radio telescope was built in 1938, by an amateur astronomer in his back yard in Illinois. World War II saw great development in radio equipment which was developed for wartime usage, and after the war, there was a great burst of activity in the then new field of radio astronomy.

In 1959, the radio search for alien life was launched by an article in the British scientific jounal Nature by Giuseppe Cocconi and Phillip Morrison, in which they concluded that the easiest way to communicate across interstellar distances would be by radio signals. They suggested that we should begin our search by listening near the hydrogen line frequency, which, they concluded, would be a frequency known to all intelligent civilizations. They realized that the hunt would be difficult and that the technical problems were enormous. The whole problem has come to be known as the Cosmic Haystack, in an obvious analogy to the proverbial needle in a haystack. Cocconi and Morrison concluded their paper with the following statement, which probably summarizes the thoughts of most exobiologists: "The probability of success is difficult to

estimate, but if we never search the chance of success is zero."

The first serious scan for alien radio signals was started in 1960 by Frank Drake, whom we have already met as the author of the Drake Equation. A young radio astronomer working at the National Radio Astronomy Observatory in Green Bank, West Virginia, and working independently of Cocconi and Morrison, he conceived of what he called Project Ozma, "named for the queen of the imaginary land of Oz - a place very far away, difficult to reach, and populated by exotic beings." He began his search in the radio frequency that is known as the water hole, because it falls between the wavelengths of hydrogen and the hydroxyl radical, the components of water.

In a dramatic episode, Drake became the first person to hear radio signals fraom an extraterrestrial civilization. Or so he thought. Eventually he discovered that the signals were not from another intelligence, but for two weeks he thought that he had succeeded. The story is worth telling in some detail, because it gives us a glimpse of what it might be like when and if we do successfully detect signals from another civilization.

On the very first day of Project Ozma, Drake directed his radio telescope to a sun-like star named Tau Ceti. It was chosen, not only because of its similarity to our sun, but also because of its proximity - 11.9 light years - a stone's throw speaking cosmically. After six hours of

observation, Tau Ceti seemed to have nothing to say, so the telescope was aimed at another close sun-like star, Epsilon Eridani. What happened next is best told in Drake's own words. Even today, 31 years after the event, one can still sense the excitement. "In less than a minute we suddenly heard something remarkable from a loudspeaker connected to the system. We heard a very intense, pulsed noise." It was beating regularly eight times a minute, a frequency not at all characteristic of naturally occurring radio emissions from celestial bodies, and it sent a chill of excitement through the astronomers. "We were all dumbfounded," said Drake. "Could it be this easy? All you need to do is point to a random star and within one minute you get a signal that puts your receiver into overload?" Unfortunately, it turned out to be not that easy. The signal disappeared within a few minutes. When it returned in 10 days, Drake and his colleagues were able to determine that the source of the noise was indeed terrestrial, although they were never able to determine exactly what it was. They searched both of those stars intermittenly for the next several months and never again heard anything remotely sounding like an alien intelligence.

Frank Drake's problems with Project Ozma typify the difficulties that have continued to plague SETI scientists ever since: the difficulty of distinguishing real signals from interference; the prevalence of vast amounts of radio pollution, some of it from people who don't want to announce

their activities to others; the joy of apparent success; and the devastating disappointment when the needle in the Cosmic Haystack turns out to be nothing but a thorn.

In spite of its complete lack of success, Project Ozma stirred imaginations all over the world, and radio astronomers every where began to listen to the heavens for alien signals. The search continues to this day, and there have been some intriguing false alarms. One of the most interesting is the so-called "Wow!" signal, so named because the initial observer was so impressed with it that he wrote "Wow!" in the margin of the chart in which it was recorded. This signal was found in 1977 at a radio observatory at Ohio State University, and it fit all the criteria for a communication from an intelligent extraterrestrial civilization - it was unmistakably strong, it was narrow band, it appeared to come from a far distance, and it had a different transmission pattern than naturally occurring radio signals from space. But the "Wow!" signal was heard only once, and in spite of a dilligent search it has never been repeated. We will probably never know what it was.

Another fascinating story of a SETI false alarm concerns the so-called LGM signals. These signals were discovered by a young Irish astronomer named Jocelyn Bell, who was working at a radio telescope in Cambridge, England. She discovered rapidly and regularly pulsating signals which appeared to be coming from a distant source. Unlike other strange signals, this one did not disappear, and soon other

such sources, now named pulsars were found. Nobody knew their source, and they were dubbed, only half in jest by the scientists, LGMs, standing for "little green men", the classic science fiction aliens. The pulsars were studied for several years, and multiple theories as to their meaning were put forth, including the serious consideration that they in fact represented some sort of alien Morse Code. Ultimately, however, they were proven to be rapidly spinning neutron stars, stars so dense that a flea-sized particle of a neutron star would weigh a million tons. Although pulsars turned out not to be signals from extraterrestrial beings, they are one of the most important discoveries of modern astronomy. Their discovery illustrates that the search for extraterrestrial life, even if it never succeeds, will inevitably expand mankind's knowledge of the Universe.

One of the main problems with the search for alien radio transmissions has been in knowing where to tune. There are literally billions of radio channels in space in which to listen. Furthermore, SETI scientists even have trouble agreeing on which direction we should listen. Many believe that we should spend extra time and effort listening along the plane of the galaxy, because stars are concentrated there. Others contend that stars in our neighborhood our uniformly distributed out to a distance of a few thousand light years and that therefore we should search in this area, because signals coming from nearby

stars would be stronger and thus easier to hear. The best bet seems to be to try to accommodate both approaches.

So far, the most thorough and exhaustive search of the heavens for life has been the META (Megachannel Extra Terrestrial Assay) program, which is run by Dr. Paul Horowitz of Harvard University and financed by the Planetary Society, which is a private organization of space enthusiasts. META has also been given a $100,000 donation by Steven Spielberg, of E.T. fame. META uses a radio telescope that takes 210 days to cover as much of the sky as it can see, and it uses electronic filters to split the incoming radio waves into as many as 8 million channels, each of which is analyzed separately. It looks at a new band every 20 seconds, but even at that rate, it would take 4000 years to look at each frequency. Thus META tries to choose its frequencies with care, because some seem more likely than others to be used for transmittal of alien signals. We have already mentioned the hydrogen frequency and the water hole.

There is, however, yet another complication. Stars move at very high speeds relative to each other, and this relative motion changes the frequency of any signal, just as the motion of a police car shifts the tone of its siren. This phenomenon is known as the doppler effect, and it means that if a remote civilization sends a signal at one of the special frequencies, by the time it reaches Earth, it will have a distincly mundane one. Dr. Horowitz of course

realizes this and thus has adjusted the frequencies he scans in an effort to compensate for this effect.

In October, 1990, the Planetary Society launched META II, which is based in Argentina and thus is searching the southern sky. So far, after five years of searching, META has found no evidence of extraterrestrial intelligence. Undaunted, Dr. Horowitz is planning a bigger system which could look at 6 billion channels at a time.

NASA also has plans to be involved in the search. They had originally wanted to participate much earlier, but funding for NASA to be involved in the search for extraterrestrial intelligence was thwarted largely by the efforts of former Senator William Proxmire, who had given NASA the dreaded "golden fleece" award for their participation in SETI. It required an intensive lobbying effort on the part of many people, as well as several years to convince Senator Proxmire and Congress that this is in fact a worthwhile scientific endeavor. Now, however, NASA has an ambitious program planned which will be vastly more thorough than any previous search. Their plan is basically a two-pronged attack. One prong is a survey of the whole sky at every 30 Hz-wide band between one GHz and 10 GHz, while the other will utilize some of the world's best radio telescopes to take a long, hard look at 700 or so nearby stars which appear suitable for Earth-like planets. NASA's search is scheduled to start on Columbus Day, 1992, the five hundredth anniversary of the discovery of America.

Not only are we listening for signals from other civilizations, but we have also sent messages of our own. Perhaps, someday, some other beings will find our communications, which have been likened to a letter in a bottle which has been tossed into the ocean in hopes that somebody on a distant shore will find it. What have we sent? As I have already mentioned, we have attached messages to the Pioneer and Voyager spacecraft, including the Chuck Berry recording, which we hope will some day in the far distant future be intercepted by alien civilizations. In addition, we have been broadcasting radio and television programs for about seventy years. These inadvertent communications are now travelling into outer space at the speed of light, and they could be received by any intelligent civilization within seventy light years of us. One can only wonder at the reaction of an alien civilization as they receive signals from our most popular television programs!

We have also sent at least one deliberate radio message to space. In 1974, scientists from Cornell University broadcast a signal which was beamed to a group of stars known as the Great Cluster, 300,000 stars in the constellation of Hercules, 25,000 light years away. Fundamentally, this message described who we are, what we look like, and where we are in the Milky Way. Obviously, nobody expects to hear a reply, but the mere sending of the message is an act of faith that, in fact, we are not alone.

One might reasonably ask why, if we are not alone, we haven't heard from or contacted any extraterrestrial civilizations. This question is known as the Fermi Paradox, named after the famed Italian physicist, Enrico Fermi, who initially raised the issue. Basically, the problem can be stated as follows: "If they are there, why haven't we heard from or seen them?" His answer, which we will explore a little later, is, simply that we haven't heard from any extraterrestrials because they aren't there. I think that this issue needs to be addressed directly, because it goes right to the core of the entire subject.

In my opinion, one reason why the search for extraterrestrial life has proven to be so difficult is simply the vastness of the Universe. As one observer stated, nobody would have been disappointed if the Milky Way Galaxy, with its great size, had been the entire Universe. Galactic distances are measured in light years, and a light year is defined as the distance in which light travels in one year. The speed of light, which is also the speed of radio waves, is 186,000 miles per second, so it is easy to see that even one light year is a distance that is virtually unfathomable to humans. Furthermore, the speed of light is a cosmic speed limit; nothing can travel faster. The Milky Way is roughly 300,000 light years in diameter, and it contains hundreds of billions of stars. The astonishing fact is that the Milky Way is but one of hundreds of billions of galaxies in the Universe, each of which contains

hundreds of billions of stars. Practically speaking, therefore, the size of the Universe limits our search to our own galaxy. Other galaxies may be teeming with intelligent civilizations, but we simply would not be able to observe or communicate with them.

It is easy to see that no matter how many intelligent civilizations there might be in the Milky Way, the liklihood of their conversing with one another depends heavily on the L, or longevity factor in the Drake equation. Because of the distance between stars and the size of the galaxy, the Drake equation suggests that civilizations are separated by at least hundreds of light years. Centuries would pass between the sending and receiving of messages, so a civilization would have to survive for a long time to even begin to communicate across interstellar distances. As an example, our civilization has had the capability to transmit messages by radio for only about 70 years, even though the Earth is 5 billion years old. Thus only civilizations within 70 light years of us could hear our signals, no matter how advanced they might be. Therefore, in order to carry on any meaningful communication with another world, any civilization must have significant longevity. When one considers that the nearest galaxy to us, the Andromeda Galaxy, is 2 and a half million light years away, the impossibility of intergalactic comminication becomes apparent.

There is also a group of astronomers and cosmologists who believe that we have not contacted any extraterrestrial civilizations for the simple reason that they do not exist. Tulane astronomer Frank Tipler, as well as University of Virginia professors Robert T. Rood and James S. Trefil argue that since we have not been visited by an alien

civilization, they simply do not exist. Their view is that any intelligent, technologically advanced civilization would ultimately begin a program of space exploration, even as, in fact, we have. They further point out that it is only a matter of time before such a society would exhaust the energy resources of their home planet and thus be forced to set out to colonize space. Such beings would become permanent spacefarers, and they would not think it unusual to spend their entire lives in large, travelling space stations. For us, interstellar travel seems improbable, if not impossible. A society of space colonists, however, might view things very differently. Such beings would be born, live their lives, and die in space colonies, never having seen their mother planet. Their autonomous space probes would use materials en route to fuel and rebuild themselves. At 100,000 years per interstellar flight, and 1000 years to construct each new probe, a single probe would take 300 million years to send a descendant to every star system in the galaxy. If you allow 6 billion years from the formation of a planet to the time its intelligent species begins sending out probes, this line of reasoning projects that we should have heard by now from anyone whose star system is more than 6.3 billion years old, the age of about half the stars in the galaxy. Thus Frank Tipler concluded, "If a civilization approximately at our level had ever existed in the galaxy, their spaceships would already be here. Since they are not here, they do not exist."

There are several possible answers to this line of reasoning. One possibility is that they have been here but didn't see anything that interested them and so they left. Perhaps, the galaxy is too big and not old enough, so that aliens haven't had the time to get here yet.

Others have suggested that interstellar colonization might be much more difficult and take much longer that Tipler, Rood, and Trefil think. Not only are the stars far apart, but the real history of expansion would not be in simple, straight lines. Thus it would be unrealistic to believe that one space colonizing society from one planet would visit every star in the galaxy in only 300 million years.

Perhaps the real answer is that interstellar travel is impossible, or at least impractical. For one thing, interstellar space might be filled with debris too small to be seen, but large enough to destroy a spaceship. Most astronomers believe that 90 per cent of the mass in the Universe is not visible, and certainly at least some of this missing mass might be in particles large enough to do just such damage to space craft. Additionally, the economic constraints are staggering. If one considers, for example, the amount of energy that it would require to send a space craft to the nearest star system (four light years away), it immediately becomes apparent that the energy required would be almost unobtainable. A one hundred year trip(at .04 the speed of light, which is 7440 miles per second) to

that nearest star would need enough energy per colonist to support 200,000 people in the United States for their lifetimes. Even for our profligate society, such a committement would be overwhelming, particularly when those people who were left behind, and presumably paying for the trip, would reap no benefits in their own lifetimes. Furthermore, it is not at all obvious where that energy would be derived, since for interstellar travel, solar energy would probably not be available.

There is also the theory of anthropic cosmology. There have been books written on this subject, so it is difficult to summarize it. Basically, the anthropic cosmology school states that the entire Universe exists for us and for us alone. This theory is based on what are called cosmic coincidences, namely that if the Universe had had just a little less mass, and if gravity had had just a little less attraction, the Universe would not have survived long enough for us to have evolved. This theory further states that because it has taken us as long as it has to develop to our present state, it required the development of our entire Universe merely for us to be here. Fundamentally, the Anthropic Principle contends that, because we exist, the Universe must be the age it is, and it must just be big enough for us - and only us - to come into existence.

There are, it appears to me, several fallacies in this argument. In the first place, although the cosmic coincidences may be true, their existence does not preclude

the development of life somewhere else in the Universe. They merely state that these coincidences were necessary for our appearance. Additionally, this argument seems to be the Ptolemaic theory dressed up in modern terms. Once again, according to the anthropic principle, the Earth is the center of the Universe. Surely it is not unreasonable to think that a universe with hundreds of billions of galaxies, each of which contains hundreds of bilions of star, might have plenty of room for many diverse creatures. Certainly the entire thesis of this paper is that there are probably other civilizations out there and that we should attempt to find them.

Finally, we need to address the question of the impact that the discovery of extraterrestrial intelligence would have on us. I well remember the first landing of men on the Moon in 1969 and the unifying impact it had on all of us. For one brief moment in time, human beings around the world were united in their humanity and we all realized that we really do live on an island in space. The planetary encounters of the Pioneer and Voyager space explorers also excited our imagination. We realized that not only were the spots of light in the sky real places, but that our own Earth is indeed a very unique spot in the Solar System, if not in the Universe. The contact with an intelligence from another world would have an even more profound effect. It would change our lives and our view of the world forever, even if imperceptibly at first.

Because of the vast distances involved in any contact, the assumption is that any civilization we may encounter would be more advanced than we, and that therefore we could and would learn many fundamental truths from them. Peter Schenkel, in his book ETI: A Challenge for Change literally rhapsodizes on the possibilities. He believes that any extraterrestrial civilization that we would encounter would be so advanced as to be able to give us the secrets to ending war, poverty, disease, and even death by natural causes. Carl Sagan also believes that such an encounter would be that beneficial, although he is careful not to be so optimistic. My personal belief is that, although such a civilization might be more advanced technolgically than we, there is no reason to believe that they would be any kinder or wiser than we are.

Would the discovery of alien intelligence lead to the kind of clash between science and religion that the discoveries of Galileo and Darwin caused? One would hope not, for there is really no need for a conflict between science and religion. It is certainly not, in my mind, at all incompatible with the power of God to imagine that He would choose to allow the development of more than one planet that sustains intelligent life. To buttress this line of reasoning, I need only to quote the following prayer from the Episcopal Book of Common Prayer: "At your command all things came to be: the vast expanse of interstellar

space, galaxies, suns, the planets in their courses, and this fragile earth, our island home."

There is no doubt, however, that any communication with an other worldly society would have a deep and lasting impact on us. Its effect could be both positive and negative, a gigantic stimulus and a demoralizing revelation; it could stir both hopes and fears on an unprecedented scale. It could involve us in a dialogue of centuries, bringing an incalculable richness of knowledge, physical instuments, and cultural growth - thus opening the door to a galactic society. On the other hand, it could wreck our cultures and endanger our survival. In either scenario, it would be mankind's greatest adventure.

The consideration of contact with extraterrestrial intelligence has also raised several interesting legal and quasi-legal points. The first consideration is how to announce the first contact and the context in which that signal would be placed by whoever would be the announcing authority. One of the most important issues raised has been the question of how we would respond to such a signal, and who would do the responding, thus, in effect, speaking for the entire Earth. Consequently, there have been many recommendations that we develop now an international code of conduct with extraterrestrial life on behalf of Earth for the purposes of sharing and extending knowledge. There is also the concern of how we should respond if the extraterrestrials pose a threat to human health and peace.

Thus far, there has not developed any universally accepted code of conduct for dealing with alien civilizations, should they be encountered.

Finally, what if, in fact, we never make contact with extraterrestrials? Even if all our searches, including NASA's very extensive project scheduled to begin in 1992, fail to find anything, it would not mean that mankind is alone in this galaxy, let alone the universe. It would take a negative result from a search a million times more thorough and sensitive to rule out the possibility of a civilization like Earth's existing anywhere else in the Universe, and even then, we couldn't be sure, simply because of the time lag involved in sending and receiving signals over interstellar distances. For example, if a civilization only 10 light years from us did exist, it would only have to be 100 years behind us technologically for it to be unable to send a radio message to us or to receive one that we have sent. When we consider that the Earth is 5 billion years old, 100 years is equivalent to the snap of a finger. To quote the SETI scientist Martin J. Rees, "The absence of evidence is not evidence of absence." If, however, after decades and decades of thorough observations, we gradually come to the conclusion that we are alone in the galaxy, we would certainly have strong evidence of our importance. I hope that with this realization would come a greater sense of humility and responsibility in our dealings with each

other and in our utilization of the resources of both Earth and outer space.

Tonight, I have tried to address the issue of whether we humans are unique in the Universe. To the question,"Are we alone?", I can only answer: "I don't know, but I have this fantasy that hundreds of millions or even hundreds of billions of years from now, we will receive a message that says,"We have found your Voyager space craft - Send more Chuck Berry!"