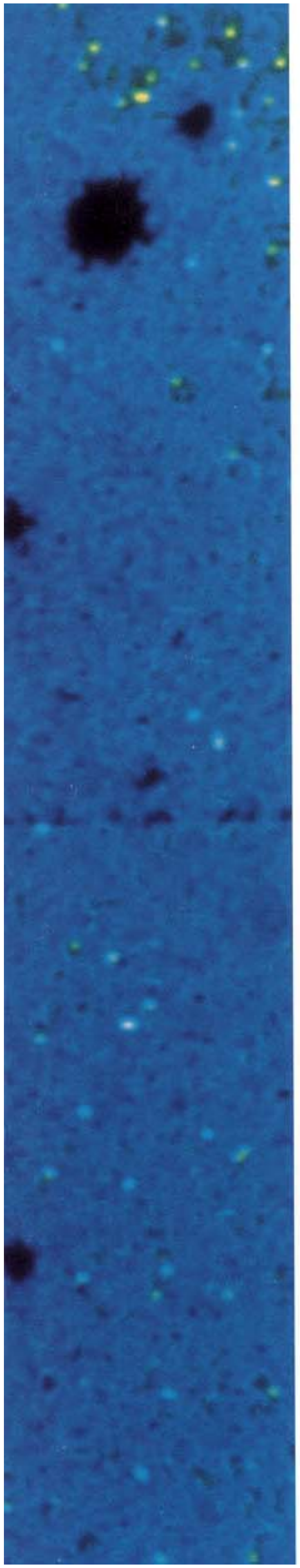
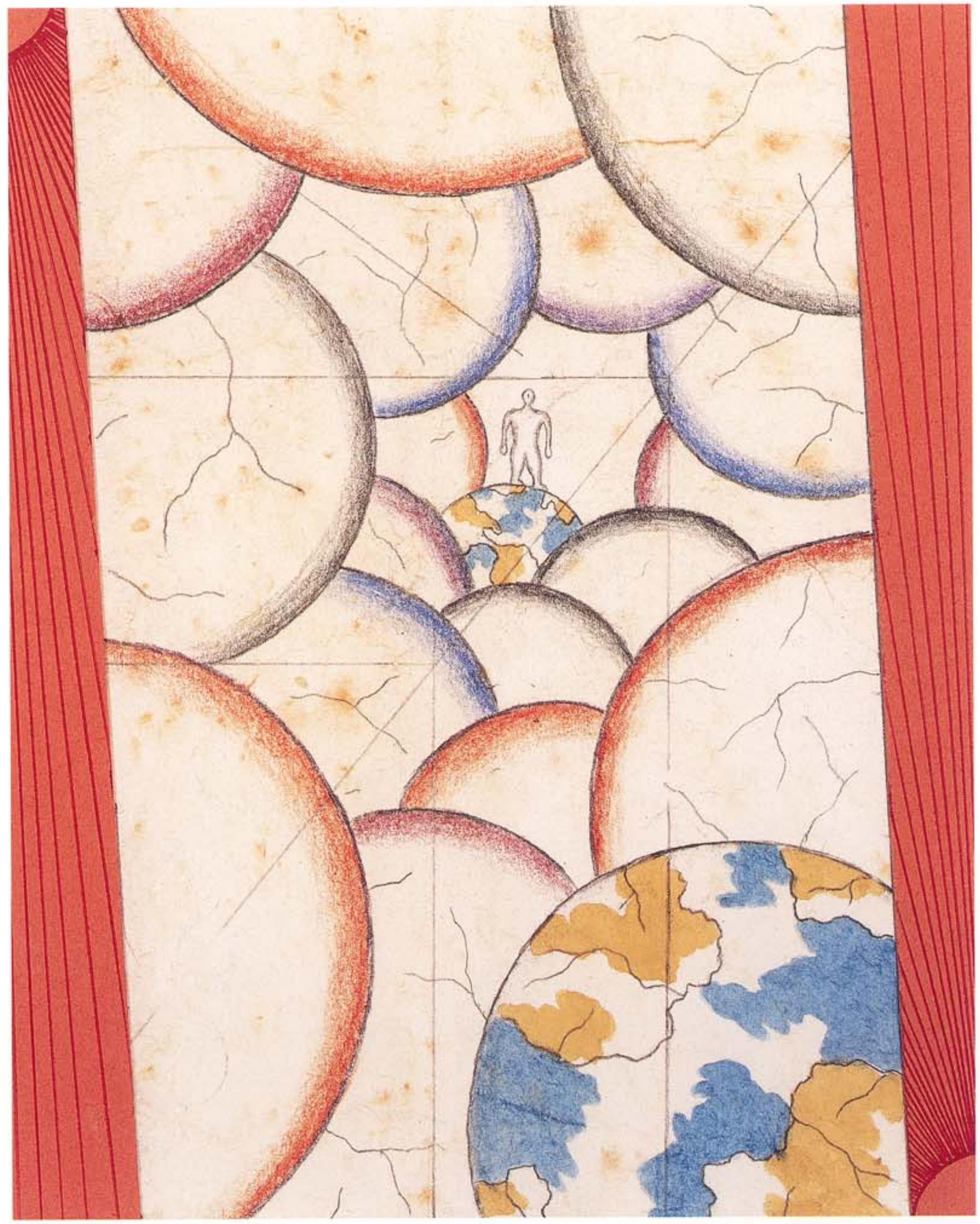


SETI Institute

Perspectives



A PIONEER'S PERSPECTIVE

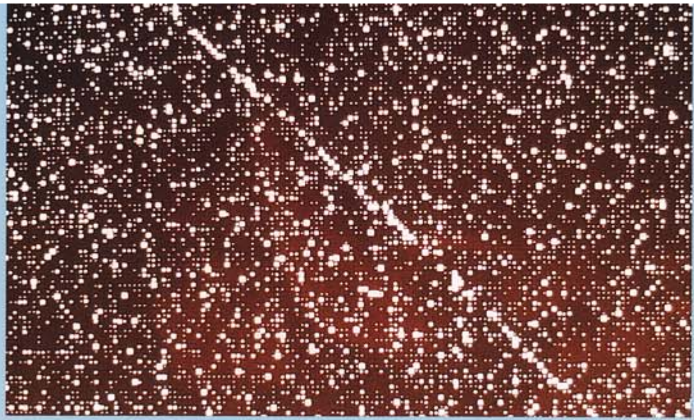
In this age of the new millennium, the people of Earth possess the scientific and technological ability to explore one of history's oldest and most profound questions: Are we alone in the universe? Through research, education and outreach, the SETI Institute leads the international effort to answer this question.

Do we have the answer? Not yet. But we do know that extrasolar planets—only a theory a few years ago—are common. We believe that liquid water once flowed on Mars and may still flow beneath the icy crust of the Jupiter moon Europa. And we know that life here on Earth is hardier than we ever imagined, able to thrive in the most extreme environments.

What's next? The discovery of living organisms under the ice on Europa or in the soil of Mars? The discovery of a planet very much like our Earth, circling some other star much like our own Sun? Or perhaps the ultimate discovery: the detection of extraterrestrial technology, communicating its creators' existence across the vastness of space.

We at the SETI Institute believe these discoveries may lie just beyond the horizon. This pursuit requires hard work, vision and the proper resources. Perhaps most of all, it requires curiosity; an exhilaration in attempting to know what is now unknown. As you read *Perspectives*, I hope you will share our sense of joy and wonder in this great exploration of our world, our universe, and ourselves.

Frank Drake
President, Board of Directors
SETI Institute

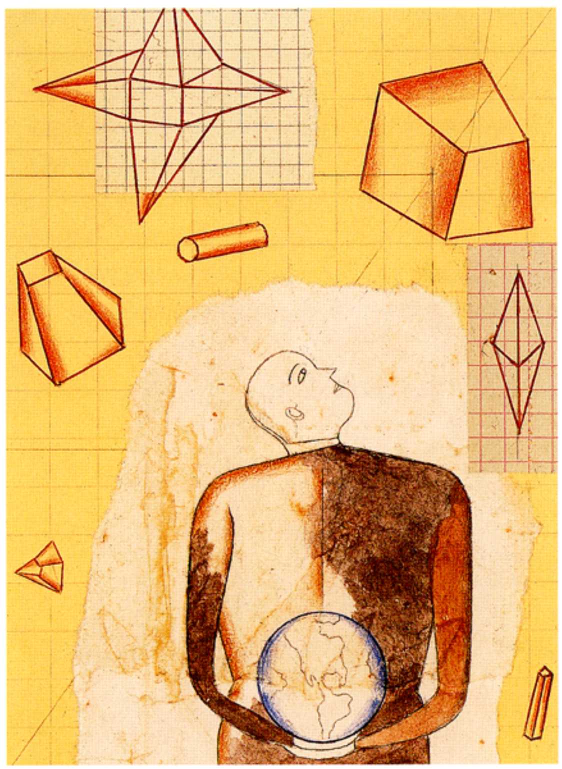


In a sea of radio noise, SETI seeks a narrow-band signal characteristic of extraterrestrial intelligence.

PUTTING EARTH IN ITS PLACE

No. 1

For most of Western history, people believed that the Earth was the center of the universe and the Sun and planets orbited around us. In 1543, however, the Polish astronomer Nicolaus Copernicus asserted that the planets orbited the Sun. His theory, published in a treatise that year, caused a commotion and was immediately rejected by those with a stake in the philosophical and religious status quo—which is to say, most everyone in Renaissance Europe. By the beginning of the next century, evidence showed that Copernicus was correct; the Earth does orbit the Sun.



Are we alone?

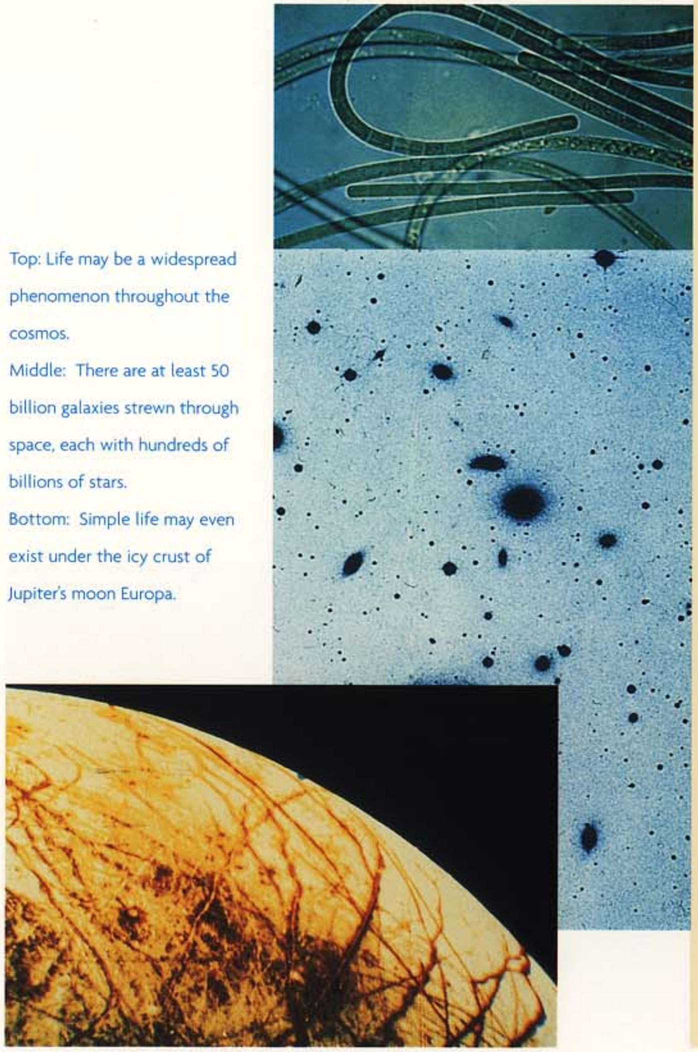
It's a question as old as humankind. As long as people have walked the Earth, they have gazed at the heavens and wondered about the pinpoints of light that emerge overhead each night. *Does life exist beyond Earth? Are humans the only form of intelligent life in the universe, or do we have company? What might our celestial companions be like?*

Virtually every civilization has developed its own answers to these questions. Most of these answers have been fanciful and, in recent centuries, have spawned entire literary, artistic and cinematic genres. Throughout history, scientists have sifted fact from mythology and contributed to the ever-growing body of knowledge about the universe and our place in it. But while scientific discoveries bring us closer to answering the fundamental questions about the prevalence of extraterrestrial life, each discovery challenges many of our assumptions and raises even more questions.

Increasingly, scientific discoveries on Earth suggest that the conditions that gave rise to life here are not unique, that life may be prevalent in countless locations across the vast expanse of the universe. And now, for the first time in history, the technology exists for humankind to learn how it fits into the cosmic fabric. In the last half of the 20th century, growing numbers of scientists from many disciplines have devoted some, or all, of their careers to seeking evidence of life beyond Earth.

For many of the world's leading investigators in this field, the SETI Institute serves as their intellectual home.

Life in the universe: Exploring the possibilities



Top: Life may be a widespread phenomenon throughout the cosmos.
Middle: There are at least 50 billion galaxies strewn through space, each with hundreds of billions of stars.
Bottom: Simple life may even exist under the icy crust of Jupiter's moon Europa.

For most people, discovering evidence of extraterrestrial intelligence is the ultimate prize in space exploration and research. But we are only now beginning to understand how our universe works and, consequently, what it takes for life to exist at all. The questions are profound: How did life begin on Earth? How many stars have planets, and how many of those planets might support life? Many of these questions are among the oldest in science.

These and other fundamental questions are explored through a broad range of experiments conducted by the Institute's Life in the Universe science team. A commitment to such research is part of the Institute's original charter; in fact, Life in the Universe research has complemented the Institute's SETI research since its inception.

Today, the Institute's Life in the Universe research program consists of more than 30 externally funded, peer-reviewed projects led by independent principal investigators. These scientists conduct basic research into many of the astronomical, geological, chemical, physical and biological factors that could affect the presence and distribution of life in the universe—a field often known as exobiology and, more recently, astrobiology. The Institute is widely considered to be an international leader in this field, and each Life in the Universe research project is related in some way to understanding the origins of life or the extent to which life may be present beyond Earth. Each project relates to one or more of the factors in the Drake Equation.

Nearly all Life in the Universe scientists generate their own funding through outside grants, usually from NASA or the National Science Foundation. The SETI Institute has built a strong reputation as an efficient home for researchers, with excellent management and a demonstrated ability to keep overhead to a minimum—thereby maximizing the funds available to conduct the actual research. The focused, cross-disciplinary nature of the Institute also gives our Life in the Universe team a cohesiveness and unity of purpose that might not easily be replicated elsewhere.

The following scientists represent examples of the diversity of research being conducted by the Life in the Universe team and the exciting exploration of fundamental issues related to determining the existence and prevalence of life off Earth.

Rocco Mancinelli

Microbial ecologist Rocco Mancinelli investigates microbial life living in environments that we consider extreme, ranging from the acid and alkaline thermal springs in Yellowstone National Park to frozen lakes in Antarctica. By examining the life forms and survival strategies of the inhabitants of these locations, Dr. Mancinelli is attempting to understand the depth and breadth of the conditions that may be capable of harboring life

beyond Earth. He also simulates these extreme environments and grows organisms in the laboratory to ascertain the limits of life.

In addition, collaborating with colleagues at the German space agency, DLR, Dr. Mancinelli has been studying the effects of the space environment (especially ultraviolet radiation and vacuum desiccation) on microbial survival. An experiment developed by Dr. Mancinelli has flown on the ESA-sponsored BIOPAN series of missions.

In his laboratory, Dr. Mancinelli performs differential thermal analysis to develop a database on Mars analog minerals. Because Mars shares many common attributes with Earth, particularly with regard to its early planetary history, it is believed to be the only other planet in the solar system with significant potential for life to exist. This makes Mars a particularly appropriate test-bed for assessing the probability and the environmental parameters necessary for the origin and early evolution of life.

Margaret Race

Margaret Race, a biologist, is an expert in the field of planetary protection, analyzing issues of cross-contamination both in space and on Earth. Dr. Race works closely with NASA in studying scientific, policy and public concerns related to the return of samples from Mars and other celestial bodies.

As a member of an interdisciplinary team, Dr. Race is working to determine the technological and scientific methods for handling, quarantining and testing extraterrestrial samples when they arrive on Earth. Her studies also focus on legal and regulatory aspects of sample return proposals; public involvement in the review and approval process for sample return; and educational communication about astrobiology both through the schools and the mass media.

Jeff Moore

Focusing principally on Mars and Europa, a moon of Jupiter, geologist Jeff Moore is searching for evidence of life beyond Earth in our own solar system. Specifically, he is trying to create an analog of the geological record of Mars, which could help determine whether there was once liquid water on the planet. By analyzing this record and comparing it to actual data coming from Mars missions, Dr. Moore is attempting to learn whether conditions on Mars might once have been conducive to the origin and evolution of life.

In addition, Dr. Moore is examining the topography of Europa revealed in photographs from the *Galileo* spacecraft, attempting to determine the presence and extent of liquid water under its icy surface.

Laurance Doyle

Using ground-based telescopes, astronomer Laurance Doyle is conducting a search for Earth- and Jupiter-size planets beyond our solar system, measuring changes in the brightness of stars and using computer models to verify these data. Dr. Doyle also studies what constitutes a habitable zone around a star—in other words, what size planet at what distance from its sun would be in a zone that would allow life to develop, flourish and evolve.

Chris Chyba

Recognized as one of *Time* magazine's "Fifty for the Future" in 1994, Chris Chyba was the ideal choice for the first holder of the SETI Institute's permanently endowed Carl Sagan Chair for the Study of Life in the Universe. Appointed in August 1998, Dr. Chyba, who earned his doctorate under Dr. Sagan at Cornell University, was most recently a member of the faculty of planetary sciences at the University of Arizona. In December 1996, Dr. Chyba received the Presidential Early Career Award, "for demonstrating exceptional potential for leadership at the frontiers of science and technology during the 21st century." He chairs the Science Definition Team for NASA's 2003 Europa Orbiter, a mission to determine whether Europa has an ocean beneath its ice and, if so, to help identify likely sites for future landers. He also chairs the NASA working group considering the scientific objectives for outer solar system lander missions to Titan and Europa—missions that will likely search for signs of life.

Most of Dr. Chyba's current scientific research addresses conditions relevant to the origin of life on early Earth and life elsewhere in the solar system. In his new position as holder of the Sagan Chair at the SETI Institute, Dr. Chyba will continue research into extraterrestrial biology and provide intellectual leadership for the Institute's many sponsored research projects investigating the phenomenon of life in the universe.

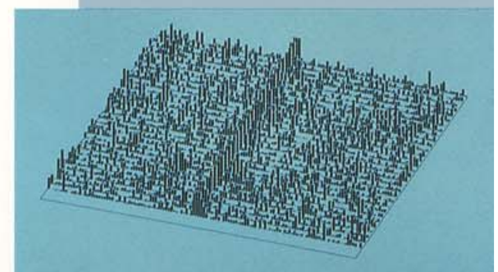
In addition to his space science work, Dr. Chyba served on the national security staff of the White House from 1993 to 1995. He has continued to work as a consultant on matters of emerging infectious diseases and biological terrorism.

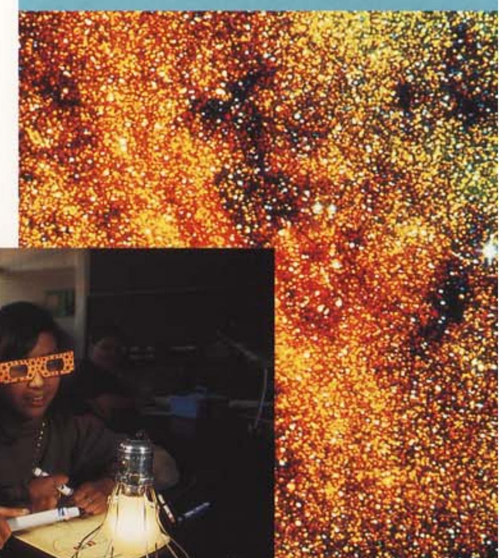
Spreading

Top: A weak signal in the noise.

Middle: Our own Milky Way is home to tens of billions of Sun-like stars.

Below: Hands-on science is a key component of the Institute's award-winning *Life in the Universe* curriculum series.





the word...

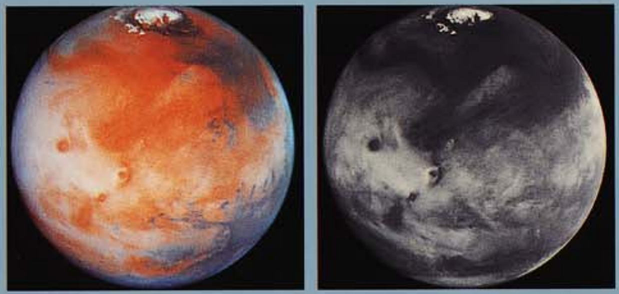
The fascination with extraterrestrial life and the basic science underlining SETI and Life in the Universe research place the Institute in a unique position to communicate the excitement of science to individuals of all ages.

The Institute currently conducts an active education program focused on students from grade 3 through high school. A series of science curriculum materials called *Life in the Universe* introduces students in grades 3 through 9 to concepts in biology, chemistry and physical science by asking them to consider life on Earth and the possibility of life elsewhere. Development of the *Life in the Universe* materials was funded by the National Science Foundation (NSF) and NASA. The series, which is being used in the United States, Canada and Australia, won two awards in 1997 from the American Association for the Advancement of Science (AAAS). The Institute has also produced a traveling planetarium show for the Pacific Science Center in Seattle and is developing the education and public outreach programs for the Stratospheric Observatory for Infrared Astronomy (SOFIA) Project, a 747 jumbo jet that is being converted into an infrared observatory and is scheduled to begin flying in 2001. SOFIA is being developed under the joint leadership of NASA and the German space agency, DLR.

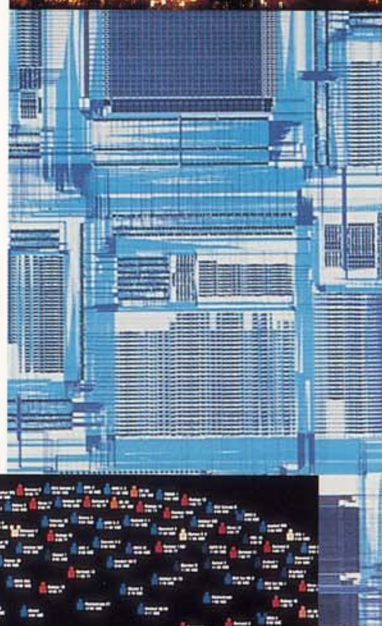
With a new NSF grant and private funding, the Institute is developing *Voyages Through Time*, an innovative year-long high school curriculum with evolution as its overarching theme. The Institute is collaborating on this project with the California Academy of Sciences, San Francisco State University and the NASA Ames Research Center. When published, *Voyages Through Time* will provide a complete curriculum, along with CD-ROM-based resource materials that students can manipulate for experiments and presentations, and projects for sharing local field research with other schools via the Internet. The SETI Institute will maintain a Web server to enable teachers using the curriculum to interact with each other and with the Institute's science and education staff, and to share student field research. *Voyages Through Time* will be completed in 2001.

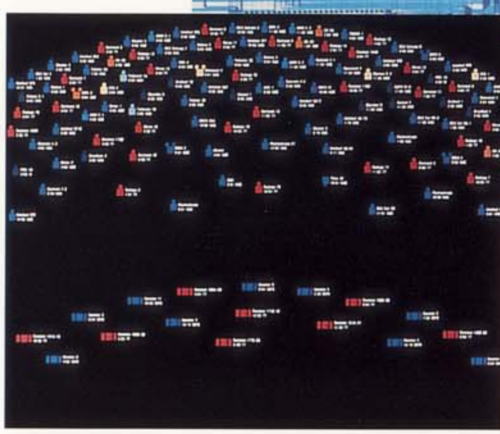
Less formally, the SETI Institute serves as a clearinghouse for scientific information about the search for extraterrestrial life, fielding numerous general inquiries from the media and the public. The Institute also maintains a popular Web site, which receives thousands of visitors daily.

The Institute's science education program focuses on students from grade 3 through high school.



Mars, possibly a home to simple life billions of years ago.





Top: The Parkes Telescope
Middle: Digital technology is the key to extending SETI.
Bottom: A growing phalanx of telecommunications satellites causes increasing difficulties for SETI's sensitive search.

What if?

Any day now, Project Phoenix or its successor searches could detect evidence of extraterrestrial intelligence. The first reaction on Earth to this momentous discovery almost certainly would be one of excitement and, possibly, confusion. While fictional close encounters depicted by the popular media have undoubtedly molded most people's conceptions of what the experience will be like, in reality, it would probably be far different. For example, SETI, by seeking to detect other civilizations in their own habitat, precludes scenarios of interstellar alliance or devastating alien invasion. Most likely, the extraterrestrials wouldn't even know that we had detected them—just as we would be totally unaware if an extraterrestrial SETI effort on a planet circling a star three dozen light years away picked up the TV broadcast of President Kennedy's inaugural address. This sort of radio detection is easy and far more likely than the implausible logistics of traversing light years for an actual visit—an endeavor that would require an enormous commitment of time and energy.

It is the general belief that any civilization we detect would probably be far more advanced than our own, possibly hundreds of thousands or more years ahead of us. The reasoning behind this belief is simple: As a civilization, we are in our infancy in terms of our ability to conduct interstellar communication. Humankind has had radio technology for a mere century, and for only 50 years have we possessed the capability to transmit signals sufficiently strong for detection at interstellar distances. Thus, scientists generally believe there is a slim chance that another communicating civilization detectable by us would exist at, or even near, our precise level of technology. That we would detect the radio emissions of a less advanced civilization is virtually impossible.

Although astronomers since Copernicus have been telling us that we are not special in the cosmic scheme, we have continued to consider ourselves unique—primarily due to a lack of contrary evidence. Searching for this evidence is what SETI is all about. Detecting a signal from an extraterrestrial civilization would certainly be one of the most profound discoveries of all time and could have far-reaching ramifications for science, philosophy and religion.

Advancing the quest...

Top: The galaxy continues to produce new stars and, presumably, new planets. Bottom: Arecibo Observatory in Puerto Rico.

Even if researchers discover evidence of extraterrestrial intelligence or of life forms elsewhere in the universe next week, next month or next year, the work of the SETI Institute will be just beginning. As a world-class "think tank" devoted to the possibility of life beyond Earth, the Institute is committed to remaining at the forefront of the various scientific disciplines that encompass this endeavor.

In order to attain this goal, the Institute is striving to achieve an endowment of $100 million and use the annual revenue from this endowment to provide a baseline of financial support to make its mission a reality, now and in years to come. SETI pioneer Bernard Oliver, who passed away in 1995, provided a cornerstone gift of almost one fourth of the endowment goal. Currently, part of the endowment earnings are being used to fund the Institute's first two endowed chairs, thus enabling the Institute to compete with leading research universities and other scientific institutes in attracting and recruiting the best scientific talent.

Complementing the creation of the two endowed chairs is a strategic planning process that the Institute has launched to map out its long-term future. Because the investigations being conducted at the Institute are uniquely open-ended, charting a specific course for the future is a particularly challenging undertaking. As part of that effort, the Institute has convened a SETI Science and Technology Working Group composed of many of the world's most respected astronomers, physicists, engineers, and technology professionals to help think about the future generation of SETI search systems. Among the issues the group is addressing are discoveries about planets outside our solar system; the continuing rapid advances of computing technology; the plans of the international radio astronomy community to introduce very large, conceptually new radio telescopes and receivers; the potential for conducting searches using large arrays of small satellite dishes; and the possibility of searching the cosmos for optical and infrared signals such as pulsed lasers. As a result of the SETI Science and Technology Working Group's early recommendations, the Institute has entered into a memorandum of agreement with the University of California, Berkeley, to begin developing and prototyping new system designs for next-generation SETI.

Like any major scientific endeavor, future SETI efforts will require significant funding. The Institute is continually seeking new resources in order to ensure that the most advanced science and technology can be brought to bear on the search for extraterrestrial intelligence. These resources, most probably from private donors, will be necessary to advance SETI into the next century.

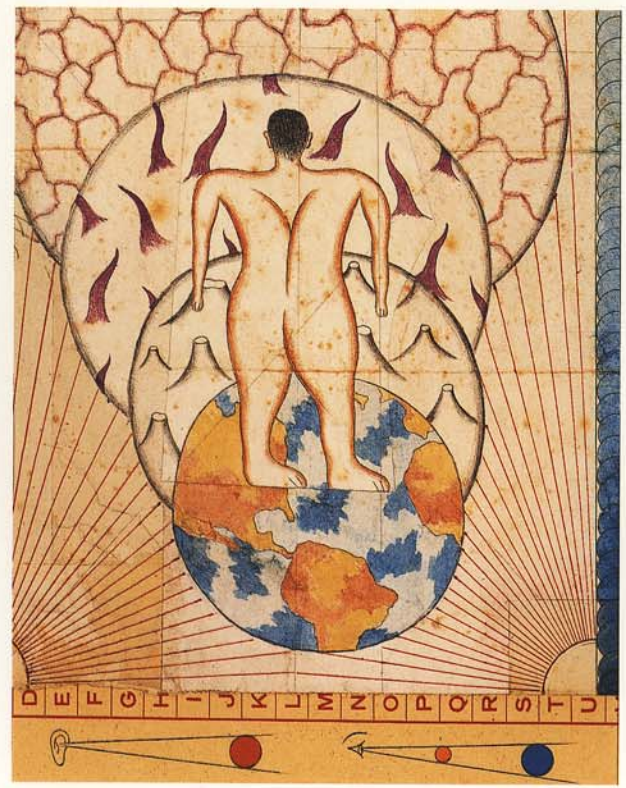
What's next?

While strategic planning efforts will continue to shape the future of the SETI Institute, part of the excitement surrounding the Institute's work stems from never knowing what tomorrow will bring. It might be more noise, or it might be the long-sought signal from a civilization in a distant star system. It might be evidence about life beneath the surface of a neighboring planet, or it might be a new, fundamental understanding of the origins of life and the evolution of the universe.

What we do know is that from a scientific standpoint, it seems unlikely that life on Earth is a cosmic anomaly. And by using increasingly sophisticated technologies and approaching the question of life in the universe in a systematic, comprehensive way, SETI Institute scientists are greatly improving the likelihood of finding evidence of extraterrestrial life.

Much like the great explorations of the past, today's quest for knowledge about our place in the universe relies on support from visionary men, women and organizations that understand the value of applying science, technology and reason to one of humanity's oldest questions. It may take generations before we have an answer, but this much is certain: The more we seek to learn about life in the universe, intelligent or otherwise, the more we will understand about life here on Earth.

It's an opportunity too marvelous and too valuable to let slip through our hands.



Written by: Sarah Lifton   Design: Denton Design Associates   Illustration: Philippe Weisbecker   Photography: Seth Shostak, Scott Streble, NASA
Cover: The disk of dust around the star Beta Pictoris is a clue that planets frequently form as stars are born. [photo: B. Smith and R. Terrile.]

Listening In

PUTTING EARTH IN ITS PLACE

No. 2

People were not always sure what the stars twinkling in the nighttime sky actually were. By the 17th century, however, scientists realized that the Sun was simply a star and the stars other suns, located at vast distances from Earth. With that insight, it became clear to them just how enormous the universe really was—a discovery that underscored how small our own solar system was and suggested the possibility of similar solar systems elsewhere.

Modern scientific investigations of intelligent life in the universe had their genesis some 40 years ago, when, after half a century of speculation about life on Earth's closest neighbors, researchers began to direct their attention to distant solar systems. In 1959, two Cornell University physicists, Guiseppe Cocconi and Philip Morrison, concluded that radio waves would be a remarkably efficient means of communicating across the galaxy. They published their work in *Nature*. The following year, astronomer Frank Drake conducted the first experiment based on Cocconi and Morrison's theory. Drake used an 85-foot telescope at the National Radio Astronomy Observatory in Green Bank, West Virginia, to search the nearby solar-type stars Tau Ceti and Epsilon Eridani.

Radio waves are inexpensive, easy to produce and can readily travel across vast stretches of the galaxy. If another civilization desired to communicate with its own species over long distances, it would have discovered, as we have, that the microwave region of the electromagnetic spectrum is the quietest provided by nature, and thus the logical place to conduct detectable radio communications. Furthermore, scientists speculated, an extraterrestrial civilization capable of radio communication would know about the astronomical significance of the "universal hailing frequency," 1420 MHz (21cm), the wavelength where hydrogen floating between stars produces cosmic static, enabling it to be used as a tracer for mapping the extent and motions of our galaxy.

Drake did not detect any artificial signals of extraterrestrial origin in his pioneering experiment. But a year later, when the Space Science Board of the National Academy of Sciences convened the first major meeting about the search for extraterrestrial intelligence—SETI for short—Drake established another milestone with his agenda for the conference. The Drake Equation,

$$N = R_* f_p n_e$$

The Drake Equation

as the agenda came to be called, is a formula for characterizing the abundance of intelligent life in the galaxy that might be transmitting radio signals. It is based on such factors as the birthrate of long-lived stars, the fraction of those stars with planets, the number of those planets with an environment suitable for life, the fraction of those planets where life actually appears, how frequently intelligent life actually arises and the lifetimes of intelligent societies. It was grounded in the assumption that Earth's technologies are among the younger ones in the galaxy, that civilizations younger than Earth would not have radio yet, and that those that we might be capable of detecting would very likely be much older. The Drake Equation also assumed that to support life as we know it, a planet would have to have liquid water and sources of energy.

During the early 1970s, under the leadership of Dr. John Billingham, NASA's Ames Research Center—located in Northern California in the heart of what would later be known as the Silicon Valley—began to design the technology necessary for a powerful SETI experiment. A team of outside experts, led by Dr. Bernard Oliver, on leave from his job as vice president and director of Hewlett Packard Laboratories, produced a comprehensive study known as Project Cyclops. This study became the foundation for modern SETI research.

Modest research and development work continued over the next 15 years, and by the end of the 1980s, complementary SETI programs had been established at Ames and at the Jet Propulsion Laboratory (JPL) in Pasadena, California. Ames developed plans to conduct a detailed examination of the nearest 1,000 Sun-like stars in a targeted search capable of detecting weak or sporadic signals. JPL developed a search to systematically sweep all directions. Although much less sensitive than the targeted search (because of less time spent on any given point in the sky), the JPL "sky survey" would be capable of picking up a strong beacon signal that might be beamed at Earth from any point in the sky. By the early 1990s, NASA formally adopted this joint strategy and funded the High Resolution Microwave Survey (HRMS) program, which was intended to continue for ten years.

In 1992, on the quincentennial of Columbus' arrival in the New World, both components began their observations. The Ames search was conducted at the Arecibo Observatory in Puerto Rico and the JPL search at the NASA Goldstone telescope in California. Within a year, a deficit-ridden Congress cut off all funding.

PUTTING EARTH IN ITS PLACE

No. 3

At the beginning of the 20th century, astronomers knew of only one galaxy, the Milky Way, and they assumed that Earth was at the center of it. But they were wrong. By the 1920s, thanks to the work of Edwin Hubble and the construction of the 100-inch telescope on Mount Wilson in Southern California, they learned that the Milky Way was only one galaxy of many. Furthermore, Earth wasn't located at the center of the Milky Way but near its periphery. More recently, the Hubble Space Telescope has revealed that the number of galaxies in the universe is far greater than was previously thought—that there are at least 50 billion galaxies.

Rising from the ashes

Fortunately for the future of SETI, there was an organization uniquely poised to take over much of the aborted search. The SETI Institute, founded in 1984, was well-established as a private, nonprofit home for research investigating all aspects of life in the universe. With NASA support, the SETI Institute had played a lead role in the eight-year R&D preparation and the operational first year of the NASA targeted search program based at Ames. It was the ideal organization to keep the project alive.

In late 1993, the SETI Institute revived the targeted search*. Using its own sources of private funding and the customized special-purpose signal detection equipment it developed for NASA, the Institute picked up where NASA's brief effort had left off and made a commitment to complete the 1,000-star targeted search. Institute scientists doubled the capacity of the equipment, devised an enhancement to the search strategy using a technique known as pseudo-interferometry, and renamed the program Project Phoenix, for its rise from near devastation after the termination of public funding. Longtime SETI Institute principal investigator and former HRMS chief scientist Dr. Jill Tarter was named project director, and physicist Dr. Kent Cullers left NASA to join her as project manager.

Bernard Oliver also joined the Institute, serving among other functions as its senior technical advisor and primary fundraiser. Under Dr. Oliver's leadership, the Institute secured the financial support of computer pioneers William Hewlett, David Packard, Gordon Moore and Paul Allen to launch the reborn SETI enterprise. Hundreds of other donors from around the world later added their support.

By keeping the targeted search alive, the SETI Institute solidified its position as the world's foremost center for scientific research and education into the question of whether life, particularly intelligent life, exists elsewhere in the universe.

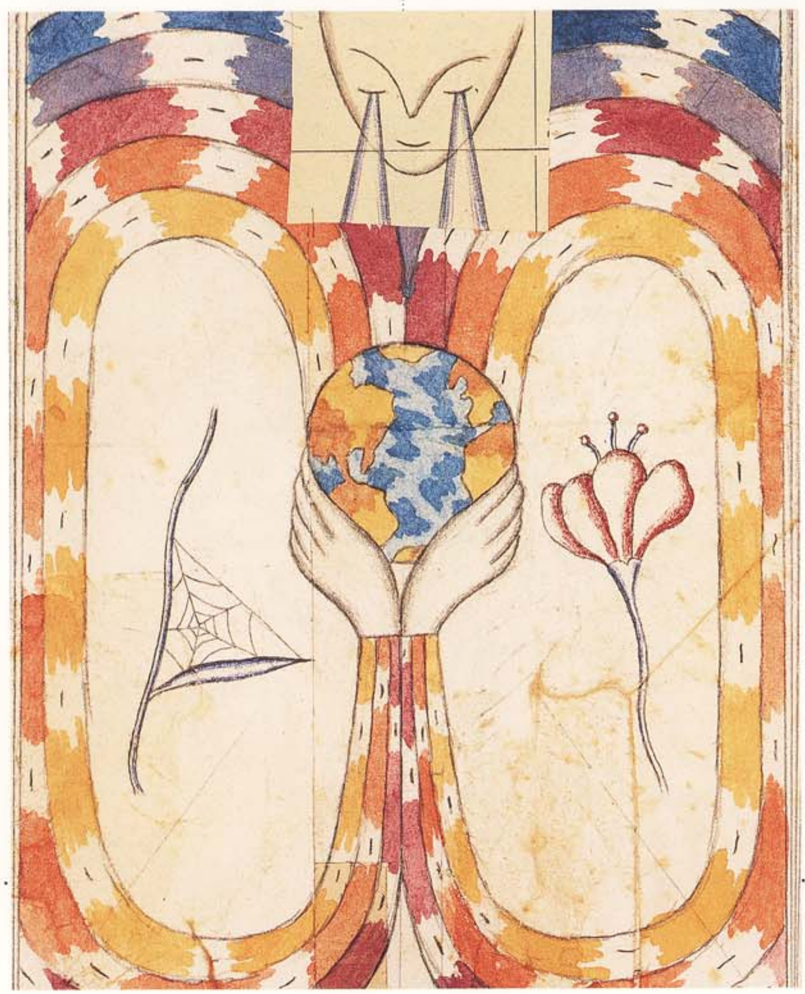
**The JPL sky survey was not revived, although small sky survey programs exist at Harvard and UC Berkeley. The Berkeley program, called SERENDIP, has for several years received the majority of its funding from the SETI Institute.*

PUTTING EARTH IN ITS PLACE

No. 4

For the past few decades, astronomers have assumed that planets were plentiful in the universe, but no one knew for sure if that supposition was borne out by the facts. Recently, however, astronomers examining nearby stars discovered more than 15 stars showing "wobbles" that could only be attributable to the gravitational pull of large planets. The presence of planets around other stars has thus been confirmed. Because these pioneering studies can only detect stars with huge planets greater in mass than our own Jupiter, it is likely that the number of stars with planets is considerably higher than what has been confirmed. This may mean there are billions of planetary systems within our galaxy alone.

"...We are enthralled by the knowledge that on this little planet the wonderful laws of physics have, in a few billion 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....



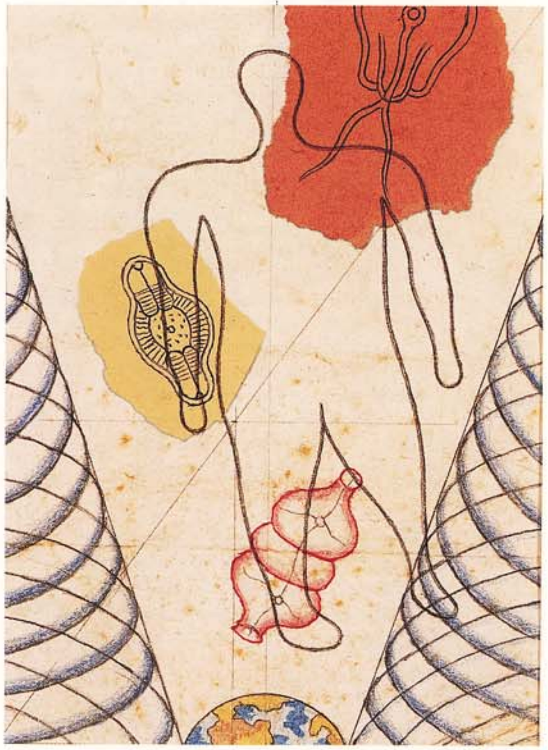
PUTTING EARTH IN ITS PLACE

No. 5

Until recently, the prevailing view of the conditions necessary to support life anywhere was based on the life forms here on Earth. That was before organisms were found thriving in deep ocean thermal vents, adapted to endless darkness and high temperatures. It is now clear that life is hardier, more adaptable and more pervasive than was ever imagined, and capable of subsisting in the harshest conditions on Earth—a finding with extraordinary implications for the possibility of life on or below the surface of other planets.

“...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.” — Bernard Oliver

The 210-foot Parkes Telescope, NSW, Australia



Today's SETI Institute is dedicated to ongoing, systematic efforts designed to discover whether the existence of intelligent life is a widespread, natural consequence of the evolution of the universe. Included in this mandate is related basic research, such as the effort to understand life's origins. By conducting and supporting scientifically rigorous searches for evidence of life on other worlds, the Institute seeks to ascertain humanity's place in the cosmos.

The SETI Institute currently encompasses more than 30 projects. The most visible of these is Project Phoenix, which commands slightly more than half of the Institute's total operation. The balance of projects investigate the questions raised by the Drake Equation in a program collectively known as Life in the Universe science.

Together, these projects comprise an organization that has emerged as an international leader in applying science, technology and reason to exploring the question of whether life exists off Earth.

Tuning in today...

Project Phoenix: Eavesdropping on E.T.

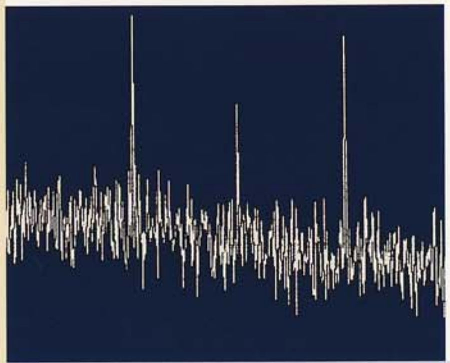
Project Phoenix is the world's most sensitive and comprehensive search for extraterrestrial intelligence. It is an effort to detect extraterrestrial civilizations by listening for radio signals either deliberately beamed our way or inadvertently transmitted from another planet.

Project Phoenix employs the most advanced technology ever used to track down evidence of intelligent life in the cosmos. The project aims its sophisticated signal detection systems (attached to large radio telescopes) at nearby Sun-like stars. For each target star, the SETI system scans billions of frequency channels for signals, feeding this information into powerful computing equipment for real-time analysis.

Project Phoenix looks for signals between 1,000 and 3,000 MHz because the universe is relatively "quiet" in this frequency range, allowing radio telescopes to pick up an artificial extraterrestrial signal unobscured by naturally occurring cosmic static. The Phoenix system looks for two different signal types that are known to be artificially generated: narrow-band continuous wave (or CW, for short) and pulsed signals. When the system detects a CW or pulsed signal, as it routinely does, it compares the signal to those already catalogued in an extensive database. Catalogued signals include those known to be generated by satellites, cellular phones, navigational aids and many other terrestrial technologies. If a signal matches a known terrestrial-based electromagnetic signature, it is recorded as an incidence of interference.

If a detected CW or pulsed signal is not familiar, however, it is passed along to a smaller, follow-up detection device, or FUDD. The FUDD applies more intense signal processing to the candidate signal, and two FUDDs (including one working from a separate, smaller telescope that may be hundreds or even thousands of miles away) work simultaneously to provide a more thorough look at candidate signals. An unknown CW or pulsed signal detected by both FUDDs would be a very convincing candidate for evidence of extraterrestrial technology.

Project Phoenix was launched in February 1995 with a 16-week observing run at the Parkes 210-foot radio telescope in Australia, the largest radio telescope in the Southern Hemisphere. From there, observations moved on to the 140-foot telescope at the National Radio Astronomy Observatory in Green Bank, West Virginia, in 1996. From fall 1998 through the summer of the year 2003, observations will take place at the 1,000-foot radio telescope at Arecibo in Puerto Rico. For the first time ever, the world's most powerful search system is installed on the world's most powerful radio telescope, with the increased sensitivity that the additional collecting area brings to the project.



Top: Narrow-band signals are the signature of deliberate transmissions. Bottom: The first radio telescope used for SETI.

Jill Tarter

Jill Tarter guides the most ambitious SETI experiment in history. As director of Project Phoenix, Dr. Tarter's life and career find close parallels in those of Dr. Eleanor Arroway, the character Jodie Foster played in the movie *Contact*. Dr. Tarter earned a bachelor's degree in engineering physics (with honors) from Cornell University and a master's degree and Ph.D. in astronomy from UC Berkeley, where she became involved in SETI as a graduate student. After completing an NRC Resident Associateship at NASA's Ames Research Center, Dr. Tarter joined the newly formed SETI Program Office at Ames, first as an associate research astronomer at UC Berkeley and then as a principal investigator for the SETI Institute. While employed by the SETI Institute, Dr. Tarter served as the project scientist for NASA's SETI High Resolution Microwave Survey (HRMS), the precursor to Project Phoenix, until its termination by Congress in October 1993. She then became director of Project Phoenix.

Dr. Tarter has written many technical articles and has lectured extensively on SETI, Project Phoenix and related topics in astrophysics and exobiology. She has conducted observational programs at radio observatories around the world, has been elected to many professional societies and has served on a number of scientific advisory committees. In September 1989, Dr. Tarter received the Lifetime Achievement Award from Women in Aerospace, a professional association in Washington, D.C., for her contributions to the field of exobiology and in particular to the search for extraterrestrial intelligence. In March 1993, she received two Public Service Medals from NASA for her contributions to NASA's HRMS Project, and in February 1997, she received the Chabot Observatory Person of the Year Award. On September 15, 1997, the Board of Directors of the SETI Institute appointed Dr. Tarter to the newly created, permanently endowed Bernard M. Oliver Chair for SETI.

Kent Cullers

Blind since birth, Kent Cullers has devoted his career to seeing beyond Earth. The first totally blind Ph.D.-holding physicist in the United States, Dr. Cullers was the inspiration for the character Kent Clark in the film *Contact*. He has played a pivotal role in SETI, devising ingenious schemes for ferreting out faint signals from a large and growing sea of noise. After earning his bachelor's degree in physics from Pomona College and his doctorate in physics from UC Berkeley, Dr. Cullers began working in support of NASA's SETI program. From 1985–90, he worked for the SETI Institute and was the targeted search signal detection team leader. He developed, evaluated and implemented optimized detection algorithms for continuous and pulsed signals originating from distant Earth-like planets. He also created algorithms for both advanced special-purpose and general-purpose computers.

In 1990, Dr. Cullers accepted a NASA civil service position and was the signal detection subsystem manager for the High Resolution Microwave Survey (HRMS) Project at NASA Ames Research Center, supervising the development of hardware and software for signal detection. In 1995, Dr. Cullers rejoined the SETI Institute as a senior scientist and project manager for Project Phoenix.

The recipient of many honors and awards, including the 1994 Federal Employee of the Year award, and the NASA Exceptional Engineering Achievement medal in March 1993, Dr. Cullers is a member of the American Astronomical Society, a board member of the San Francisco Lighthouse for the Blind and Visually Impaired and a member of several scientific committees. He travels extensively to give talks and present papers at national and international science meetings.