2012

SETI INSTITUTE Explorer

SETI Institute

The mission of the SETI Institute is to explore, understand and explain the origin, nature and prevalence of life in the universe.

We believe we are conducting the most profound search in human history — to know our beginnings and our place among the stars.

SETI INSTITUTE

Contents

Explorer

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SETI Institute

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On the Cover

Illustration of a B-type star rising over an Earth-like planet and its two moons.

Illustration by
Gabriel Alvarado-Marín

Letter from the CEO

Thomas Pierson

Dear SETI Institute Friend:

The SETI Institute is widely known for its quest for evidence of intelligence elsewhere, but what few members of the public realize is that nine of ten scientists here are actually engaged in the wider discipline known as astrobiology.

While some have called astrobiology a research field without data, that's simply not the case.

It's true that science has not yet discovered compelling proof of extraterrestrial life of any type – whether microbes, mammals, or anything in between. But there's a tremendous effort to study what types of habitats could spawn and support life, and where such habitats might be found.

Walk the corridors of the SETI Institute, and you'll note that the single most popular research topic is Mars – a world that once bore a greater resemblance to our own planet. Mars may not only have generated life, but might still harbor it today.

Other astrobiologists working here study the moons of the outer solar system, several of which are now strongly suspected of being favorable for biology. You'll also find Institute researchers investigating the biochemistry of life – how it began, and how it works.

In collaboration with NASA's Kepler mission, we are discovering thousands of planet candidates, and examining each one in our SETI program at the Allen Telescope Array.

All of these investigations collect large amounts of data. And many of us expect that such efforts will soon uncover not just more habitats and more biological mechanisms, but life itself.

This is an exciting place to be, because these are questions of interest to anyone. You can read about a small sampling of the Institute's research in this magazine.

And one more thing: we can continue to explore the cosmos and learn its composition and contents thanks to you. And for that we are highly grateful.

With warm regards,

Thomas Pierson
Chief Executive Officer

From the Editor's Desk

Seth Shostak

The Drake Equation, which was cooked up to serve as an agenda for the first real conference on SETI, has now entered its second half-century. Few specialist meetings have produced such durable legacies, and today Frank Drake's famous formulation can be found in just about every introductory astronomy text. It has been called the second-best-known equation in science (number one is – surprise – $e=mc^2$).

The formula is most closely associated with SETI, of course. But it also defines an entire field of interdisciplinary research that really didn't exist in 1961: astrobiology. Of the seven parameters in the Drake Equation, five deal with the frequency of biological habitats or the mechanisms and evolution of life – research areas that are the large print in any astrobiologist's job description.

Once disparagingly called "a discipline without data," astrobiology is now anything but. The accelerating search for extrasolar planets, and in particular planets where life could gain a foothold, now has cachet. The public eagerly follows the relentless rain of new worlds discovered with both the Kepler space telescope and ground-based instruments, particularly any that might be veneered with liquid water. Elsewhere, billions of dollars are spent in both the U.S. and Europe to telemeter back clues to the history of Mars. The reason is straightforward: the Red Planet may have spawned life.

Yes, we send spacecraft to worlds such as Mercury and Pluto where life is not in the cards. But while these missions are both interesting and undoubtedly instructive, a greater draw is the effort to explore Europa, Titan, Enceladus and, of course, Mars. These have special power to stir our souls.

Life is interested in life. At the SETI Institute, there are fifty principal investigators whose research goals include the five terms of the Drake Equation that deal with biology in any of its manifestations. You can read some of their exploits in this issue. And being a bit of biology yourself, I'm sure you'll find them of interest.

Shostak is Senior Astronomer at the SETI Institute

Drake Equation

$$N = R^* F_p N_e F_l F_i F_c L$$

N = the number of civilizations in our galaxy with which communication might be possible

R^* = the average rate of star formation per year in our galaxy

F_p = the fraction of those stars that have planets

N_e = the average number of planets that can potentially support life per star that has planets

F_l = the fraction of the above that actually go on to develop life at some point

F_i = the fraction of the above that actually go on to develop intelligent life

F_C = the fraction of civilizations that develop a technology that releases detectable signs of their existence into space

L = the length of time for which such civilizations release detectable signals into space

From the Board Room

John Gertz

People sometimes ask me how I became involved with the SETI Institute, let alone the chairman of its board. After all, I make my living as an entertainment producer, and am neither a scientist nor a high-tech expert.

Here's my story: By a complete fluke of fate, when my wife Susan was an undergraduate at Berkeley she worked as a babysitter for Jill Tarter's daughter. Jill Tarter, as most of you know, is the SETI Institute's senior SETI scientist. Jill has been named by *Time Magazine* as one of the 100 most influential people on Earth, and she is a recent recipient of the prestigious TED Prize.

She was also the inspiration for Jodie Foster's character in the movie, *Contact.*

Knowing that I had a long-abiding interest in SETI (I am also an amateur astronomer), Susan invited Jill and her husband (and SETI board member) Jack Welch, over for dinner as a birthday present to me. You can imagine how thrilled I was with this present, the opportunity of hosting an idol of mine, Jill Tarter, in my own home. But there was a catch. Jill agreed to come only on the condition that she could solicit me for a financial donation. After all I was a stranger, and she rightly wanted to know what was in it for her cause. After a nice dinner and several bottles of wine, Jill made her ask.

My response startled her. I said, "Jill you are being penny wise, but pound foolish. Instead of getting me to write you a single check, think of how much good I could do if I were on your board. I could multiply your dollars."

> " ... just as I reached out to Jill and inquired how I could roll up my sleeves and really get involved, I am asking each of you to ponder that very question."

"After all," I said with a bravado reinforced by the wine, "I am an entrepreneur with a lot of experience with nonprofits."

My chutzpah did not automatically get me a seat at the table, but after a couple of years of committee work, I was indeed invited onto the board. The rest, as they say, is cosmic history.

If you are receiving this issue of the *Explorer,* the chances are you're already a donor to the SETI Institute. But just as I reached out to Jill and inquired how I could roll up my sleeves and really get involved, I am asking each of you to ponder that very question.

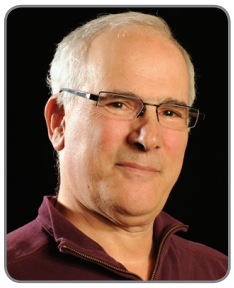
- Maybe you could become a docent and lead tours to our main SETI detection instrument, the Allen Telescope Array.
- Perhaps you could start a Friends of SETI Chapter in your own home town. There is no reason I can think of why our great cause need be restricted to the San Francisco Bay Area.
- Perhaps you could serve on one of our committees such as finance, development, or public outreach.
- Perhaps you can help us organize the next SETIcon.
- Maybe you work for a large corporation and can help organize a company-wide matching gift program, or perhaps your company has computer hardware they would like to donate.
- Perhaps you can be a citizen scientist in our SETIQuest or SETILive programs.
- If you are retired, or otherwise have the time and skills, perhaps you could offer yourself as a pro bono research assistant to one of our 60 plus scientists.
- If you have the financial resources, perhaps you could adopt one of our scientists.

The means and methods of pitching in are endless. Reach out to me with your ideas. Let's start a dialogue and see where it leads.

I am at jgertz@seti.org

Gertz is Chairman of the Board of the SETI Institute

Board of Trustees



John Gertz, Chairman
Trustee since 2000

John Gertz has headed Zorro Productions, Inc. since 1977. Zorro Productions controls the worldwide trademarks and copyrights of the name, visual likeness and the character of Zorro.

John has been guiding this brand for over twenty years through major films, television, stage productions, publishing projects and promotions in addition to hundreds of licensed products. The brand is represented worldwide by over thirty-five licensing agents for all media and ancillary products. The latest stage production, *Zorro, the Musical* has been sweeping through European theatres with rave reviews.

John's been an amateur astronomer and lay student of astrophysics for over 25 years. In addition to the SETI Institute, he also serves as President of the Board of the Berkeley Jewish Community Center.

Andrew Fraknoi,
Vice Chairman
Trustee since 1984

Professor Fraknoi has served on the Board since its inception. He chairs the Astronomy Department at Foothill College, teaching 900+ students per year; and is Senior Educator for the Astronomical Society of the Pacific, where he was Executive Director for 14 years.

He is author of 15 books, including one of the leading introductory college astronomy textbooks and a children's book on space for Disney. He appears regularly on local and national radio, explaining astronomical developments.

He was 2007 California Professor of the Year, and has received several national awards for his educational work — including the Annenberg Prize of the American Astronomical Society and the Gemant Award of the American Institute of Physics. Asteroid 4859 was named Asteroid Fraknoi by the International Astronomical Union to recognize his contributions to the public understanding of science -- but he reassures our readers that it's a boring asteroid and no threat to the Earth!

Tom Pierson, CEO and
Corporate Secretary
Trustee since 1988

In 1984, having met a number of early SETI pioneers, Tom developed the concept of a non-profit research organization that could serve as a home for scientists and engineers interested in the study of life in the universe. In November of that year, he incorporated the SETI Institute as a non-profit organization, and in February 1985 saw the Institute receive its first grant.

Tom is a Member of the International Academy of Astronautics and has received numerous recognitions, including NASA's Public Service Medal. More than any individual recognition, he considers his most prized award to be the NASA Public Service Group Award given to the SETI Institute and its entire staff for excellence in carrying out research and education in the areas of life in the universe and the search for extraterrestrial intelligence.

David Pratt,
Past Chairman
Trustee since 2004

David Pratt is retired Interim President and CEO of Callidus Software Inc. and continues to serve on their board of directors.

Before joining Callidus, he served as Interim President and CEO of AvantGo, Inc., a mobile internet service company; and the YMCA of the Mid-Peninsula, where he also sits on the board of directors.

David was Executive VP and Chief Operating Officer of Adobe Systems, Inc., from May 1988 to January 1998. Prior to that, he provided VP and COO leadership to Logitech, and Quantum. He holds an M.B.A. from the University of Chicago and a Bachelor of Science degree in Electrical Engineering from MIT.

Al Bagley
Trustee since 2002

Al Bagley retired after 37 years of service for Hewlett-Packard in Northern California.

He was General Manager of the Frequency and Time Division (the Santa Clara Division), and served as Engineering Manager of HP's Electronics Instruments Group.

While there, Al invented a high-speed frequency counter which reduced the amount of time required to measure high frequencies from ten minutes to less than two seconds (1951).

With Len Cutler, he co-invented the HP 5528A Laser Interferometer, still used for micro-inch measurements in the Integrated Circuit Industry. He also helped Cutler develop the HP 5060 Cesium Beam Clock, the dominant national time standard in industrial countries.

Linda Bernardi
Trustee since 2002

With leadership experience spanning more than two decades, Linda has a strong vision and passion for emerging and future technologies.

She is founder of the Bernardi Leadership Institute, and is the CEO and founder of StraTerra Partners, LLC; a technology strategy consulting firm, focused on the massive disruption and possibilities of cloud computing, and the critical transformation of global information technology.

She is an active entrepreneur, technologist, investor and trustee. As a visionary entrepreneur, in 2001 Linda founded ConnecTerra, Inc. in Cambridge, MA, the leading software provider connecting RFID technology to large enterprise IT. Most recently she was the Vice President of Strategy and Innovation at Capgemini, involved in building the global technology ecosystem of the company.

In addition to the SETI Institute, she serves on the board of the International Museum of Women, on the council of advisors for Astia, and is emeritus board member at the Anita Borg Institute.

John Billingham, MD
Trustee since 1995

Dr. Billingham obtained his M.A. and medical degree from Oxford University in England in 1954. He specialized in aviation medicine and physiology for the Royal Air Force before coming to the US in 1963 to take charge of environmental physiology research at the Johnson Space Center in Houston, TX. Three years later, he moved to Ames Research Center in Moffett Field, CA, becoming Chief of the Biotechnology Division.

In 1970, he was co-director, with Bernard Oliver, of Project Cyclops, A Design Study of a System for Detecting Extraterrestrial Intelligent Life. In 1976, he became Chief of the Extraterrestrial Research Division at Ames, which included SETI and exobiology. He spent most of the rest of his career at Ames establishing and directing the NASA SETI Program. He retired from NASA in 1994.

In 2009, he was inducted into the NASA Ames Hall of Fame for his work in Astrobiology and SETI.

Franck Drake
Trustee since 1984

Dr. Drake started his career undertaking radio astronomical research at the National Radio Astronomy Observatory (NRAO) in Green Bank, West Virginia, and later the Jet Propulsion Laboratory.

In the 1960s, Drake spearheaded the conversion of the Arecibo Observatory to a radio astronomical facility, later updated in 1974 and 1996. As a researcher, Drake was involved in the early work on pulsars.

In this period, Drake was a professor at Cornell University and Director of the National Astronomy and Ionosphere Center (NAIC) – the formal name for the Arecibo facility. In 1974 he wrote theArecibo message.

Drake is a member of the National Academy of Sciences where he chaired the Board of Physics and Astronomy of the National Research Council. He was Emeritus Professor of Astronomy and Astrophysics at the University of California, Santa Cruz where he also served as Dean of Natural Sciences.

Dr. Drake also served as the Director of the Carl Sagan Center for the Study of Life in the Universe at the SETI Institute.

Board of Trustees

Elizabeth Garrett
Trustee since 2010

Elizabeth Garrett specializes in the legislative process, direct democracy, the federal budget process, the study of democratic institutions, statutory interpretation and tax policy. She is an expert on state, national and presidential politics.

Elizabeth Garrett was appointed provost and senior vice president for academic affairs on October 28, 2010, having served in that capacity on an interim basis since the previous August. As the university's second-ranking officer, she oversees the USC Dana and David Dornsife College of Letters, Arts and Sciences as well as the Keck School of Medicine of USC and 16 other professional schools, in addition to the divisions of student affairs, libraries, information technology services, research, student religious life and enrollment services. She also sits on the governing board of the USC hospitals.

Paul Elliott
Trustee since 2007

Most recently a distinguished engineer at Cisco Systems Optical Technology Business Unit, Paul has been active in communications systems design for over 20 years.

His experience focuses on SONET, high-speed optics technology, RF, ASIC design, timing and synchronization standards, and compliance engineering. He holds fourteen patents in the areas of frequency generation, system synchronization, and product architecture.

Paul was a founding member of Cerent, which was acquired by Cisco in 1999. As Director of Systems Engineering at Cerent, Paul helped build and lead the engineering team, and was the principal architect of Cerent's flagship product, now known as the Cisco ONS15454. This MultiService Provisioning Platform (MSPP) provides the functions of multiple network elements in a single platform. He was also a leading engineer at DSC, Optilink, and Harris.

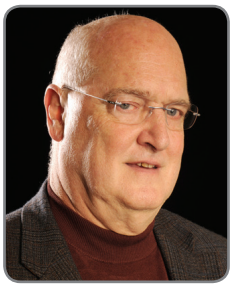
Dane Glasgow
Trustee since 2007

Dane Glasgow is vice president of the eBay Buyer Experience Product Management Team. This worldwide group works to surface the best deals on eBay, drive increased business conversion, and grow customer satisfaction through great search and buying experiences.

He joined eBay in December 2008 through the acquisition of Positronic, a company he co-founded, that developed a sophisticated machine learning and natural language processing platform in the finance sector.

Before Positronic, Dane was the director of program management for Microsoft's core Live Search product. He led the team responsible for delivering fast, relevant search to customers worldwide. He also served as general manager of the Information Services Client team, which delivered near-instant search results for PCs through Windows Desktop Search.

Dane joined Microsoft in April 1999 through the acquisition of Jump.com, where he was president, which provided the first completely connected, Internet-based email, calendar and tasks service.



David Liddle, Ph.D.
Trustee since 2000

Dr. Liddle is a partner in U.S. Venture Partners, working with entrepreneurs in the markets of information technology, cleantech and healthcare.

He is the former President and CEO of Interval Research Corporation, a Silicon Valley-based laboratory and incubator for new businesses focused on broadband applications and advanced technologies that he co-founded with Paul Allen in 1992.

He's been a consulting professor of computer science at Stanford, and is credited with heading development of the groundbreaking Xerox Star computer system.

David has served on many boards, including Sybase, Broderbund Software, Borland International and Ticketmaster, and is currently on the board of the New York Times Company.

David has served on the DARPA Information Science and Technology Committee, and as chair of the NAS Computer Science and Telecommunications board. He was chair of the board of trustees of the Santa Fe Institute, a not-for-profit research and education center, from 1994 to 1999.

Michael Moradzadeh
Trustee since 2010

Michael is a retired intellectual property and public policy attorney. A graduate of Stanford University and UC Berkeley's Boalt Hall, Michael was most recently employed at Intel Corporation as a senior executive, with a range of responsibilities from counsel for Internet and Microsoft-related matters, to electronic privacy, to leading an industry coalition on digital content protection. He served as general counsel for the large desktop products group and as director of home architecture.

Prior to Intel, he served as a senior attorney at Cetus (later Chiron) Corporation in Emeryville, CA, focusing on licensing and protecting inventions in the field of biotechnology.

Since retirement in 2000, Michael and his wife Noëlle Leca have focused their energy on shared interests, including environmental organizations, public broadcasting (Noelle served as chair of NCPB/KQED in 2009), education, and politics.

Michael has been very active is sailing, racing five times across the Pacific to Hawaii and serving as the head of several yachting organizations.

Russel Holdsteing
Trustee since 2010

Russ is an angel investor and adviser who helps young technology companies develop their management teams and maintain strategic focus as they grow. His investments have included such companies as ask.com, StubHub, Trulia, and Jawbone.

Founder and past CEO of Payday, one of the largest payroll software service bureaus in the U.S., Russ grew his company onto *Inc. Magazine*'s list of the 500 fastest growing private companies in America and was named one to the Top Ten Entrepreneurs in San Francisco by the Chamber of Commerce. Russ became the Chief Financial Officer of *Rolling Stone Magazine* after a stint as a CPA with Ernst and Young.

A former Lecturer in Entrepreneurship at the Haas business school at U.C. Berkeley Russ was also Adjunct Associate Professor at the University of San Francisco School of Business. He holds an MBA degree in Marketing.

Pierre R. Schwob
Trustee since 2009

Pierre Schwob was born in Los Angeles and was reared in Geneva. He has lived in New York, Hong Kong, and now Palo Alto, CA. He has written books on history, calculators, and chess, and he holds several US and foreign patents.

Pierre founded a software and technology R&D company in 1978, where he developed the ID LOGIC® technology incorporated into the RBDS national standard.

He was adjunct assistant professor in computer science at NYU. In 1994, Pierre created ClassicalArchives.com – a popular music website dedicated to classical music. He produced and co-wrote the narrated symphony *Cosmic Reflection*, telling the history of the universe in 40 minutes, which recently premiered to great acclaim at the Kennedy Center in Washington DC.

His interests include the latest advances in particle astrophysics and cosmology, and foreign policy research. Asteroid 32890 Schwob has been named after him.

William J. Welch. Ph.D.
Trustee since 1984

Professor Welch joined the faculty of UC Berkeley's Electrical Engineering and Computer Sciences Department in 1960, and in 1971 became a faculty member of the Astronomy Department. He retired in 2005 and is currently a professor in the graduate school.

Jack was the director of the Radio Astronomy Lab at UCB from 1971-1996 and continues to participate in both the CARMA millimeter-wave astronomy project and the Allen Telescope Array project, conducted jointly with the SETI Institute. He has served on the Board of the SETI Institute since its inception. Jack is the author or co-author of over 150 journal articles and conference papers.

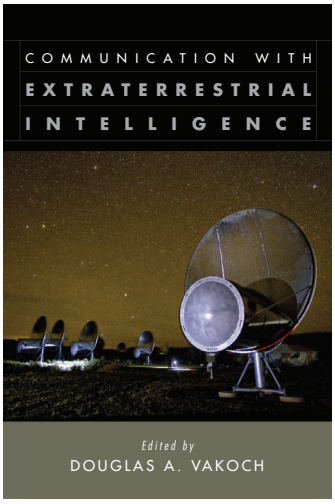
Elected to the National Academy of Sciences in 1999, his citation reads: "He started the field of millimeter-wave interferometry and remains one of its most active practitioners. His discoveries in star formation include the first hot cores associated with massive protostars and their subsequent evolution into ultracompact HII regions."

Douglas A. Vakoch

Preparing for SETI Success

> "...we might send digital avatars of ourselves via radio signals who could serve as diplomats in encounters with extraterrestrials."

In the past year, two complementary books have been published that provide new insights into the search for intelligent life in the cosmos. The first book, Communication with Extraterrestrial Intelligence (SUNY Press, 2011), includes essays by such SETI leaders as Frank Drake, Jill Tarter, and Seth Shostak, covering critical issues on a range of topics in interstellar communication.



In the opening section, scientists from around the world examine the latest developments in observational SETI programs—both radio and optical SETI—including experiments being conducted at the Allen Telescope Array in northern California.

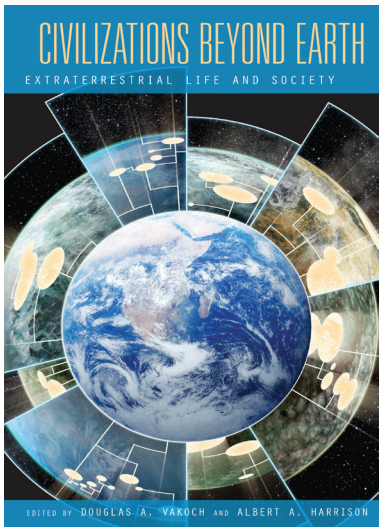
But perhaps SETI researchers shouldn't simply listen; maybe all civilizations are listening and none transmitting. In the next section, proponents and opponents of "Active SETI" debate whether humankind should be sending intentional signals to other possible civilizations, as a complement to traditional SETI projects.

Communication with Extraterrestrial Intelligence closes by examining the challenges of creating messages that would be meaningful to an independently evolved civilization. For example, mathematician Carl DeVito argues that natural numbers (1, 2, 3, …) may be universal, but the rest of mathematics may vary tremendously from world to world. While the first section of the book provides technical details geared to professional astronomers and engineers, the last two sections are aimed at readers without scientific backgrounds.

Culture in the Cosmos

The second new book, *Civilizations Beyond Earth: Extraterrestrial Life and Society* (Berghahn Books, 2011), helps us prepare for the events that would unfold after first contact. Written in an accessible style, the book begins by asking "Does extraterrestrial life exist?" Astronomer Seth Shostak starts by recounting the major reasons that so many people are optimistic about the existence of extraterrestrial civilizations, noting among other factors the many extrasolar planets discovered in recent years. He and other scientists explore the relevant variables using the Drake Equation, a heuristic for estimating the prevalence of intelligent civilizations. They emphasize two variables that are often relatively neglected by astronomers and biologists: f_i, the fraction of life-bearing planets on which intelligent life evolves, and L, the average longevity of civilizations, measured in the number of years they broadcast their existence into space.

Having contemplated the likelihood that extraterrestrial life exists, the next section of Civilizations Beyond Earth asks how humankind would respond if we discover an advanced extraterrestrial civilization. For example, sociologists present the latest findings of novel surveys, tapping into the public's attitudes about life beyond Earth to show how religion and education influence beliefs about extraterrestrials. (As a general rule, more religious people are less likely to think extraterrestrial life exists.)



An interstellar message using three-dimensional animation shows how humans use a lever on a stone fulcrum. Cover by Michael H. Mower.

The book closes with some innovative proposals for bridging the cultural gap between us and any extraterrestrials, even without the luxury of face-to-face contact. Most previous interstellar messages have started with scientific principles that extraterrestrials are likely to have in common with humans. Chemist Harry Letaw suggests that once we can convey some basic principles of physics, we can show how human beings use machines like levers and pulleys in the real world, going on to describe the range of our everyday activities through three-dimensional animation sequences we could transmit.

Sociologist William Sims Bainbridge suggests we might send digital avatars of ourselves via radio signals who could serve as diplomats in encounters with extraterrestrials. While it could take millennia for signals to traverse the distance between Earth and the home planet of an extraterrestrial, we might speed up the process of mutual comprehension by sending sophisticated computer programs that could interact in virtual "embassies" on the recipient's home world.

Reviews

"Communication with Extraterrestrial Intelligence offers a comprehensive snapshot of news and views from the SETI community."
Guru Magazine

"For those who are familiar with SETI and who wish to take their reading on the subject in a new direction, Civilizations Beyond Earth is a brave attempt at doing something different ..."
Astronomy Now

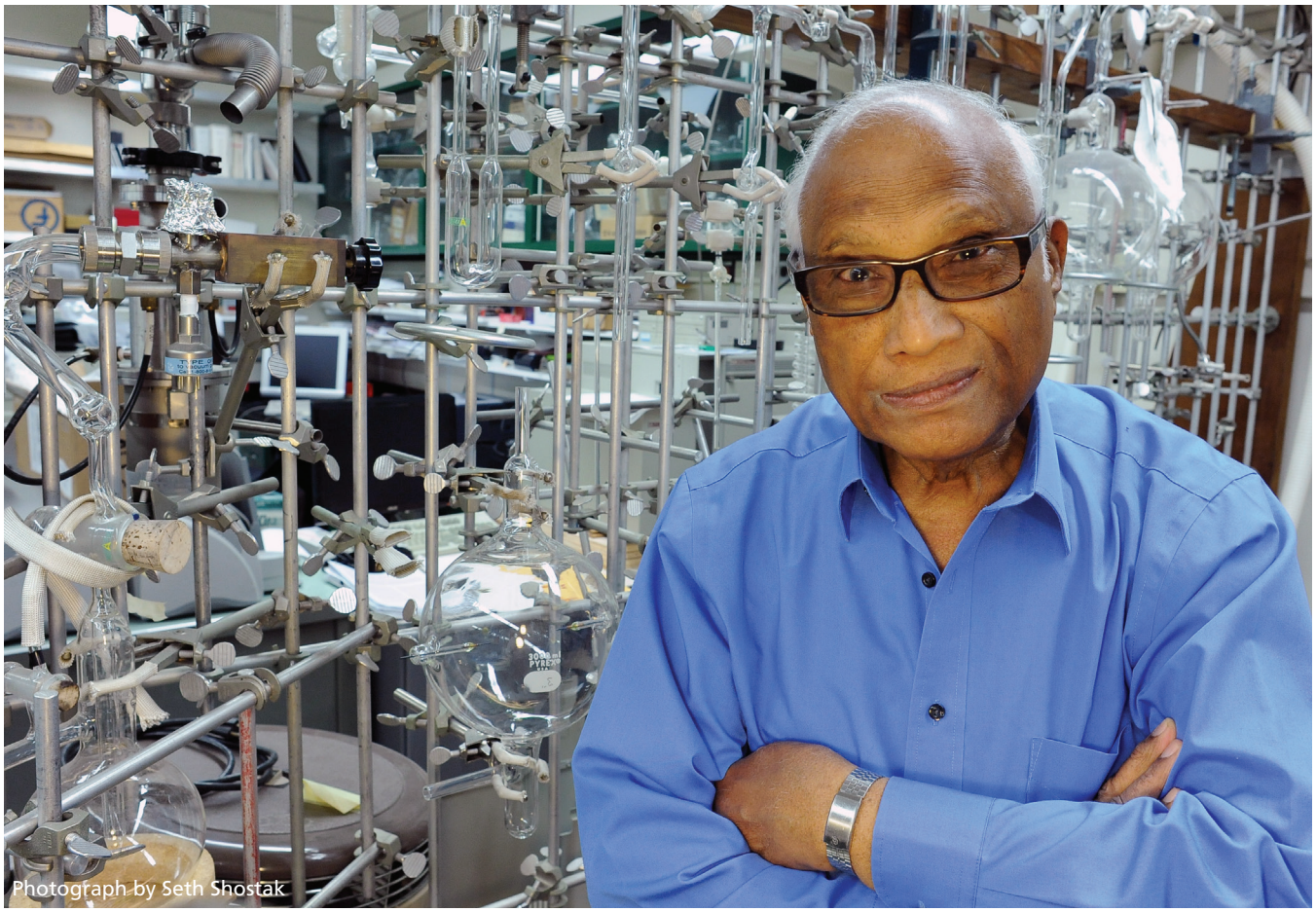
Book information:

Communication with Extraterrestrial Intelligence, edited by Douglas A. Vakoch, SUNY Press, 2011, $39.95 paperback.

Civilizations Beyond Earth: Extraterrestrial Life and Society, edited by Douglas A. Vakoch and Albert A. Harrison, Berghahn Books, 2011, $70.00 hardcover.

As we reflect on a half century of SETI research, we are reminded of the expansion of search programs made possible by technological and conceptual advances. In this spirit of ongoing exploration, the dozens of contributors to these two books advocate wide-ranging approaches to make SETI increasingly more powerful and effective, while also helping get ready for first contact.

Vakoch is the editor of both books described here, and is the SETI Institute's Director of Interstellar Message Composition and editor of *Psychology of Space Exploration: Contemporary Research in Historical Perspective* (NASA, 2011, $27.00 hardcover).



Bishun Khare works to reproduce the chemistry of Saturn's smoggy moon, Titan, in the lab.

Organic Matter on Titan

by Bishun Khare

Saturn's large moon Titan is the only world in the solar system besides Earth that has liquid on its surface, in the form of lakes. The liquid is thought to be composed primarily of ethane with methane and nitrogen in solution. The clouds above are thought to be liquid methane drops. Surface liquid is present in polar lakes and in surface materials at equatorial sites.

Studying the chemical processing that might result from potential organic material interacting with this liquid is one of the main goals of proposed missions to Titan, such as the Kraken Mare Lander mission. Our research is intended to further the aims of such missions.

We have been engaged in producing tholin – complex organic molecules that form in Titan's atmosphere thanks to ultraviolet light from the Sun. We've been doing this under Titan-like conditions for more than three decades, first at the Laboratory for Planetary Studies at Cornell University in collaboration with the late Carl Sagan, and more recently in collaboration with Chris McKay at the Laboratory for Planetary Studies at the NASA Ames Research Center and the SETI Institute's Carl Sagan Center for the Study of Life in the Universe. Our focus is to understand whether robotic instruments sent to Titan could analyze tholin solubility in liquid methane and ethane. Our results are expected to contribute to an understanding of the organic chemistry on Titan, and to

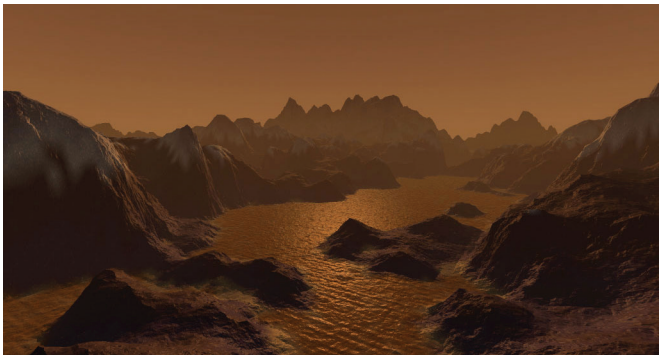
> "Titan is a prime target for future outer solar system missions is the combination of both organic material and liquid on the surface; liquid that could offer a medium for further organic synthesis."

the development of an explicit and targeted scientific strategy for near-term analysis of the products of organic-liquid interactions on this moon.

Organics are produced as a haze in Titan's high atmosphere due to photolysis of methane with the Sun's extreme ultraviolet light and subsequent reaction with nitrogen, the major constituent of Titan's atmosphere. Tholins are also formed as charged particles from Saturn's magnetosphere interact with this atmosphere. However, the presence of these organics is not the only feature that makes Titan significant for astrobiology; after all, organics are widely present in the outer solar system. The reason Titan is a prime target for future outer solar system missions is the combination of both organic material and liquid on the surface; liquid that could offer a medium for further organic synthesis. Note that this liquid is readily accessible for near-term missions, which is in contrast to subsurface liquid layers on icy moons such as Europa or Enceladus.

An advantage of the increasing focus on the outer solar system as a potential site for life is that the likelihood of biological exchange ("panspermia") is much less than for Mars; any life in the outer solar system is more likely to be a second genesis. More specifically, on Titan life in liquid methane-ethane seas would certainly be of different origin than water-based life on Earth.

NASA recently selected a Discovery proposal named TiME to investigate the chemistry of the lakes on Titan.



An artist's conception of the icy and rocky terrain on the surface of Saturn's largest moon Titan. Image credit: Steven Hobbs (Brisbane, Queensland, Australia)

As described by the team's press release: "The TiME capsule would launch in 2016 and reach Titan in 2023, parachuting into the moon's second-largest northern sea, the Ligeia Mare. For 96 days the capsule would study the composition and behavior of the sea and its interaction with Titan's weather and climate. TiME would also seek evidence of the complex organic chemistry that may be active on Titan today, and that may be similar to processes that led to the development of life on the early Earth."

Our work on how tholins might interact with the liquids on Titan's surface will improve our chances of detecting any possible biology on this cold and distant world.

Khare is a scientist at the SETI Institute

Images by NASA

Pluto's P4: Still Nameless

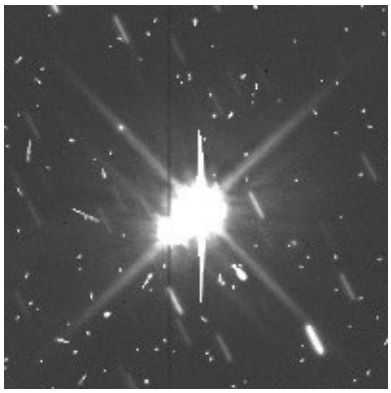
By Mark Showalter

Rings around Pluto? The idea's not as crazy as it sounds. All the outer planets, starting with Jupiter, have rings of some sort. Most are just faint clouds of dust, visible only with powerful telescopes. And although Pluto has been officially "downgraded," a dwarf planet is still a planet.

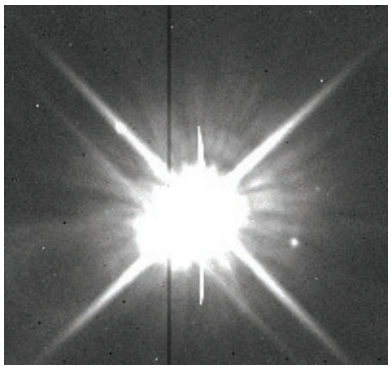
Finding rings around Pluto would be very timely. The New Horizons spacecraft will fly past this distant object in July, 2015. The more we can learn about where to point the cameras, the better.

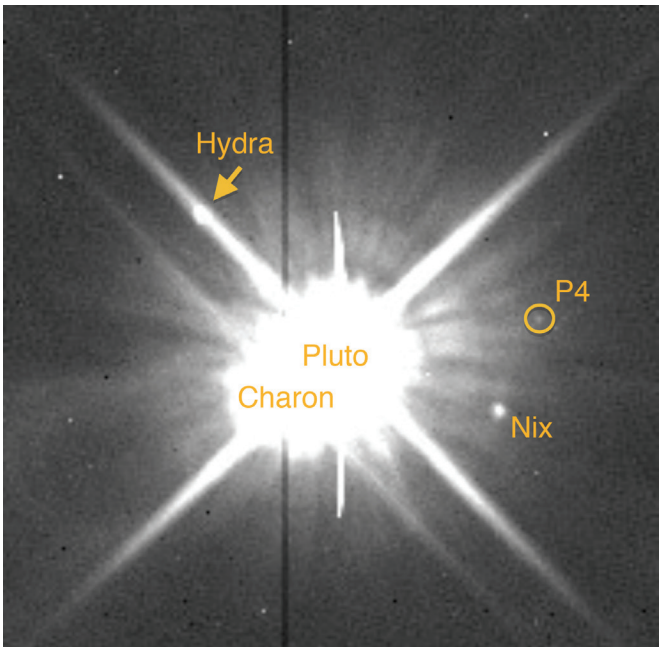
In a recent proposal we made for observing time on the Hubble Space Telescope, we added a brief throw-away line, "... our observations will also reduce the current detection threshold for unseen moons by a factor of two." Although rings were our intended target, small moons and faint rings often go together. We already know that Pluto has two 50-km diameter moons, Nix and Hydra.

BEFORE:
Fig 1. Pluto and its companion moon Charon are the overexposed central features in this Hubble photo. The short streaks are background stars, which move while Hubble tracks Pluto across the sky.



AFTER:
Fig 2. Same as figure 1, but the background stars have been subtracted out.





ANNOTATED:
The subtracted field of figure 2, with the newly discovered moon P4 labeled.

My heart sank just a little when I saw our first images in June. Everything executed exactly as planned, but I was not quite prepared for the number of bright stars filling the field of view. Pluto sits in front of the galactic center, where background stars are abundant. Nevertheless, with many identical exposures, it became possible to identify and subtract out the stars.

Within a few minutes, I had a clean, starless image of Pluto. It and its large companion moon Charon were at the center, overly bright in the long exposures. Hydra and Nix were just where they ought to be. However, an extra dot caught my eye. After six long days of waiting, we received our second set of images, and the dot was still there, having moved just about the right distance to be orbiting Pluto. P4 was real, our consolation prize for a system lacking any apparent rings.

The existence of P4 raises interesting questions for the New Horizons planners: What else might be out there? A single grain of dust in the path of the spacecraft could be catastrophic. The science team is now planning further observations, while we still have time to avoid anything that might be dangerous.

Meanwhile, P4 remains nameless, beyond its official designation "S/2011 (134340) 1." This is our own doing. We have been searching the data to see what else might turn up. So far, nothing, so we will turn our attention to naming the moon shortly. Meanwhile, the work of uncovering Pluto's (literally) darkest secrets will continue through 2015.

Showalter is a Senior Research Scientist at the SETI Institute

Seth Shostak

Tuning in to Science

If you don't know about it, you should. It's a radio and podcast program – *Big Picture Science* – produced by the SETI Institute, and it brings you an hour of entertaining and enlightening science each week. *Big Picture Science* is now broadcast on sixty stations, and downloaded 100 thousand times a month from the internet. That latter number is increasing, having doubled in the past two years.

Conceived a decade ago by San Diego radio disk jockey Bill Oxley, the program began as a low-profile call-in show which aired on Sunday evenings. Oxley and the author were the hosts, and we usually had a single guest for the entire hour (which, in commercial radio, amounts to only 41 minutes of actual content.) The program was called *Are We Alone?*

Several years into this, we switched formats, dispensing with the small group of AM stations that were carrying the program and joining the Sirius Satellite lineup as part of Discovery Network's radio offerings. Although Sirius reached most of North America, we were never sure how many people were listening – feedback was close to nil. Meanwhile, we brought on Molly Bentley as our part-time executive producer.

Molly is a reporter for the BBC that I had met years earlier, and she eventually replaced Bill Oxley as co-host of the show.

Stability being a rare thing in the radio business, we were soon confronted with a management shake up at Discovery. With little warning or fanfare, the network killed its Sirius channel, sending us back to square one. But not for long. Tucker Hiatt, of the SETI Institute's IT Department, told us of a new distribution mode for radio called podcasting. He coded up some software that soon made our shows available to a nucleus of mostly young people who –eschewing the traditional radio paradigm – actively chose what to listen to, and when.

The rest is relentless history. Our audience began to grow as the shows improved. A major change came in the summer of 2011, when the title was changed to *Big Picture Science* in an effort to make its themes and content more obvious to the decision makers at radio stations.

> "The guests are the best around – among them are Nobel Prize winners, *New York Times* reporters, and A-list authors. And, of course, our own SETI Institute researchers."

It had also became a produced show, rather than live. In other words, it was a crafted product. A produced radio show can fool you: it sounds as if the hosts are sitting in front of their microphones and mix consoles, smiles on their faces as they smoothly transition from one guest to another, wrapping the whole thing up with a clever remark and a felicitous goodbye at the end of the hour.

But that's not the way it is. Every component of the show – each sentence spoken by hosts, guests, and anyone else – is edited. And each edited sound file is adjusted to a uniform volume, and then moderately compressed to increase intelligibility in noisy environments. The program is an engineered, highly refined product, cut to a rigid clock.

The Big Picture Science staff. Left to right are Seth Shostak, Marissa Fessenden (intern), Gary Niederhoff, Molly Bentley, Barbara Vance, Jay Weiler.

Photograph by Seth Shostak

Programmatically, each hour of *Big Picture Science* typically comprises five separate interviews with scientists (often "on location"), humorous banter between the hosts, a skit, and a plug for the Institute's TeamSETI membership program. The guests are the best around – among them are Nobel Prize winners, *New York Times* reporters, and A-list authors. And, of course, our own SETI Institute researchers.

The staff is small, and all part-time. In addition to Molly Bentley, who is the executive in charge of production as well as co-host, there's producer Gary Niederhoff, an experienced radio professional and bottomless reservoir of talent. Need a voice that will double for Charles Darwin? Bring in Gary. Have a cameo part for Aristotle? Gary's your guy. A quick editor, he's able to smoothly enrich an interview or snippet of banter with other sounds and effects. Good editing is like music, and I have occasionally wondered if Gary's editing skills can be attributed to the fact that he plays in two bands.

Then there's volunteer Jay Weiler – a young fellow who makes sure that our podcast and social media content are kept appealing and up to date. His talent is exceeded only by his sunny disposition. The show also gets the help of able student interns from the University of California at Santa Cruz's Science Communication Program.

And finally, there's Barbara Vance, whose principal job is as Grants Coordinator for the Institute. Barbara performs the essential tasks of converting all the show's content to the appropriate distribution formats, and uploading these by Monday morning (without fail) to the various networks where both podcasters and broadcasters access the program.

If you're at the Institute on Fridays, you'll find a very hard-working radio production staff, because that's when the Michelins meet the macadam. Before we leave the building and begin our weekend, the program must be completed. Excuses are interesting but irrelevant. The show must go on.

It's said that to make science attractive, the first thing to do is make it interesting. *Big Picture Science* unabashedly uses humor and drama to convert the most arcane research subjects into exciting stories. Of all the ways in which the SETI Institute reaches out to the public, no other activity consistently touches as many people for substantial amounts of time. Every day we get e-mails from listeners around the world. And this is just the beginning.

Check it out at bigpicturescience.org

Shostak is Senior Astronomer at the SETI Institute, and host of *Big Picture Science*

Closing in on E.T.'s Home

By Edna DeVore

Is Earth unique in the universe? How many Earth-size planets might exist? NASA's Kepler Mission seeks to answer these questions by searching for Earth-size planets orbiting in the habitable zone of Sun-size stars.

Launched in 2009, the Kepler spacecraft is a specialized telescope that acts like a very precise light meter, a photometer. By carefully measuring changes in a star's brightness, the Kepler team discovers planets as they cross in front of their stars. The crossing is called a transit, and these are seen as a dip in a graph of the star's brightness. Of course, only a fraction of planetary systems will be correctly aligned with Earth to be seen in transit, but since Kepler is continuously staring at more than 150,000 stars, many will – by chance – have this desired alignment. By measuring the depth of the dip and knowing the size of the star (using conventional astronomical methods), Kepler scientists can determine the size of the planet. From measuring the time elapsed be-

Photograph by Seth Shostak

tween repeated transits, they can also determine the orbital period. One orbit is the planet's year length which, using Johannes Kepler's third law, tells us the average distance of the exoplanet from its star. Combined with Earth-based observations, the planet's mass, density and possible surface temperature may determined for larger planets.

Almost twenty SETI Institute scientists and educators are key members of the Kepler team, leading the data pipeline analysis, managing the instrument characterization, combing the data for planet candidates, publishing discoveries, and communicating Kepler's exciting discoveries to students, teachers and the public.

As of February, 2012, the Kepler team has released three catalogs of planet candidates, and its accomplishments are remarkable. The space-based telescope has already identified four times as many potential exoplanets as have been discovered by all previous methods. Kepler's candidate worlds await further ground and space-based observations to eliminate false positives (such as an eclipsing binary star in the background field of the exoplanet system), but Kepler scientists estimate that more than 90% of the candidates will turn out to be true exoplanets.

Giant Jupiter-size planets dominated the early days of radial velocity exoplanet discoveries, and astronomers wondered if small, terrestrial planets were indeed rare. Today, Kepler is closing in on the frequency of Earths—a parameter known as eta Earth—and, perhaps, E.T.'s home is coming into view.

A quick look at Kepler's planet candidate list reveals a fundamental discovery: giant worlds like Jupiter and Saturn are actually less common than smaller planets. As of February, 2012, about 250 Earth-size (radius = 1.25 Earth's or smaller) candidates are already teasing us as potential homes for E.T. Even more—676—super-Earth size candidates are worlds unlike any in the solar system. They are too large to be like Earth or Venus, and too small to become a Neptune or Uranus. Neptune-size worlds dominate the planet candidate list (more than 1,000), and are clearly more common than giant and super-giant planets (less than 300 combined). Many candidates are found in multiple-planet systems: the total of 2,321 planet candidates are orbiting 1,790 stars in Kepler's field of view. For more information, visit kepler.nasa.gov.

> "... giant worlds like Jupiter and Saturn are actually less common than smaller planets."

There's been a steady march of discoveries and SETI Institute scientists are authors on the publications. Kepler-10b, the first Earth-size planet, is a molten world racing around its star in only 20 hours. It's definitely not E.T.'s home. The star Kepler-11 hosts six planets that all orbit closer than Venus does to the Sun, pulling and tugging on each other in a gravitational dance that reveals their masses.

Laurance Doyle, a SETI Institute principal investigator, discovered the first planet in orbit about a binary star system, Kepler-16, uncovering what had previously only been imagined: a Tatooine-like world. Kepler-34 and 35 are binary stars with planets; this suggests that there are millions of these in the galaxy. Kepler-20 has four planets, two are Earth-size. Kepler-22 b is the first habitable zone world discovered around a Sun-like star. At 2.4 times the diameter of Earth, it's probably more like Neptune than Earth, but could have liquid water on its surface.

From Kepler's work so far, it's apparent that the Milky Way is teeming with planets, more planets than stars. So, E.T. may indeed have a home.

Jill Tarter, Bernard M. Oliver Chair for SETI, is leading the hunt for E.T. in the Kepler field. With the support

of SETI Stars—a crowd-sourced fund raiser—the ATA came back online in December, 2011, and is now observing the Kepler planet candidate list. Tarter's team is looking where we know there are planet candidates, searching for the elusive signature of alien technology amongst Kepler's potential worlds.

How can you get involved? You can search Kepler light curves for the signature of an exoplanet as a citizen scientist using your own computer with PlanetHunters.org. And, you can help our SETI team search the radio astronomy observations of the Kepler stars by joining SETI Live (setilive.org), the citizen science project that combs through data from the ATA.

DeVore is Co-investigator for Education and Public Outreach on the Kepler Mission, and the SETI Institute's Director of Education and Outreach

Johannes Kepler and the Transit of Venus

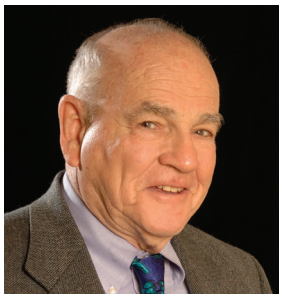
The Kepler Mission is named for Johannes Kepler (1571 -1630), who is often said to be the first astrophysicist. He was a German astronomer and mathematician whose three laws of planetary motion were key discoveries in establishing modern science.

Laws 1 and 2 stated that planetary orbits are elliptical, and that the orbital speed of a planet varies according to its distance from the Sun. Law 3 states that the average distance (semi-major axis) of a planet from the Sun can be proportional to the planet's year length. Today, Kepler Mission scientists use law 3 to determine how far an exoplanet is from its star.

In 1627, Kepler published the *Rudolphine Tables*, a star catalog and tables of planetary positions, and first predicted the transits of Mercury (1631) and Venus (1639). On June 5-6, you too can observe Venus transit the Sun, something Johannes Kepler never saw. For information see: www.transitofvenus.org. It's your last chance for more than a century! The Kepler Mission uses transits to discover planets circling distant suns. Surely, Johannes would be pleased and amazed that a space telescope bearing his name is making such amazing discoveries.

Baruch Blumberg (1925 – 2011)

By Carl B. Pilcher



The world lost a true explorer with the passing of Nobel Laureate and NASA Astrobiology Institute (NAI) founding Director Baruch S. "Barry" Blumberg at age 85 on April 5, 2011 during a conference at Ames Research Center.

That Barry spent his last day conceptualizing an International Research Park on the moon befits his unflagging curiosity. That curiosity led him, as a young medical student, to question why some people get sick while others in the same environment and circumstances remain healthy.

He studied how genes, environment, and behavior interrelate in the context of disease in populations around the globe, not expecting to unravel the mystery of one of the world's most serious infectious diseases. But when he found a correlation between a mysterious blood antigen and occurrences of serum hepatitis, he knew he'd uncovered something that must be pursued. That pursuit led to his discovery of the hepatitis B virus and the development of a vaccine credited with saving hundreds of millions of lives since it came into widespread use in the early 1980s. For this he was awarded the 1976 Nobel Prize in Physiology or Medicine.

Barry's appreciation of the importance of interdisciplinary research drew him to astrobiology in his later years, as did the profound questions about life that astrobiology addresses. He accepted an invitation to lead the nascent NAI in 1999, and quickly became a leader and advocate for astrobiology research. His wisdom, kindness, warmth, and probing intellect are dearly missed.

Pilcher is Director of the NASA Astrobiology Institute

Exterior view of the SETI Institute at night
Photograph by Seth Shostak

Shining Star of the Silicon Valley

By Linda Bernardi

During the last decade I have had both the privilege and honor to be part of perhaps one of the most significant scientific institutions in the world today: the SETI Institute, located in the heart of the Silicon Valley. I want to share the joy and excitement of my connection to the Institute, and explain why it is such a superb and critically important organization.

Formed almost 30 year ago, the Institute was intended to focus its research on astrobiology and extraterrestrial life. It draws inspiration from Frank Drake's famous equation that delineates those factors necessary to the emergence of life – including intelligent life – on other worlds.

From its inception, the SETI Institute has been able to attract prodigiously talented people to work in or with the organization. As a result, the Institute has been able to focus on several key areas of scientific exploration.

Its astrobiology research has brought together over 40 of the brightest minds, doing critical research in the appropriately named Carl Sagan Center for the Study of Life in the Universe. We are extremely proud of their accomplishments, and I invite you to follow each of our scientists and their area of focus on our web site.

I hope that, like me, you will be amazed and enthralled by the extreme diversity and breath of our research. Try to imagine a world where this would not be possible. I simply can't!

Our education and outreach efforts, as well as our radio program, have been instrumental in bringing the complex science of astronomy and astrobiology to the general public and to schools during the last several decades. I hope many of you are aware of this work, but if not tune in and get details on our web site. We view science education as extremely important.

Our SETI research group has made advances in astronomy and the study of life beyond Earth not only by decades of observation, but by building the most advanced SETI radio receiver technology and the Allen Telescope Array, leading to joint projects with the University of California, Berkeley and SRI in the Bay Area. We are much richer today as a result of the accomplishments of this group.

And there's more … Every Wednesday at lunchtime, a prestigious speaker presents new findings and observation about the topics of astronomy, astrobiology and beyond. These talks at the Institute are free, and open to the public. This is true science in action! Can you imagine a world where this would not happen? I can't!

The Board of Trustees of the SETI Institute firmly believes in the critical mission of the Institute in the pursuit of science and its impact on our civilization. As a not-for-profit organization, we rely on our membership and partnerships to help us maintain the breadth of our activities. We hope to shine brightly in the Silicon Valley and look to partner with many of its luminous technology beacons.

We look forward to seeing all of you at our upcoming June 22-24 SETIcon event.

Linda Bernardi is a member of the Institute's Board of Trustees and the author of *Provoke: Why the Global Culture of Disruption is the Only Hope for Innovation*

Right Time, Wrong Budget

By Jill Tarter

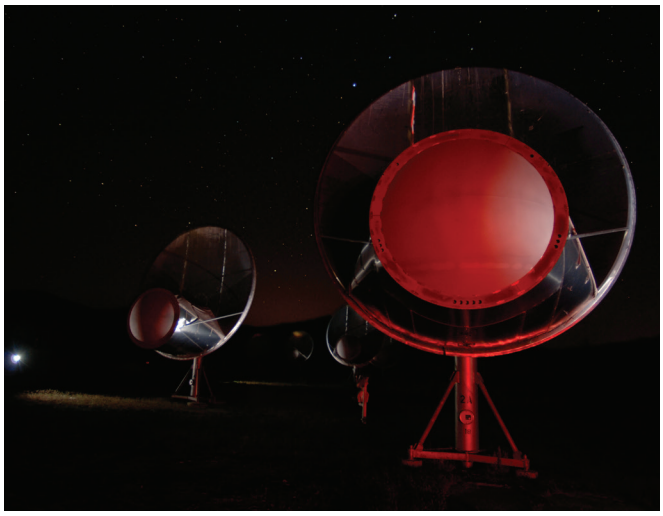
Now is a spectacularly opportune time to be trying to detect evidence of life beyond Earth. As a species, we've been thinking and dreaming about this topic for millennia, and at the SETI Institute we've been trying to do something about it for more than 25 years.

Since life as we know it is a planetary phenomenon, we expect that the best place to find other examples of life is on the surface of another planet, or perhaps on one of their giant moons.

Microbial life may exist beneath the surface of Mars in some liquid aquifer, or perhaps under the icy carapaces of the giant moons of Jupiter and Saturn. Scientists at the SETI Institute and elsewhere are eagerly awaiting the first results from Curiosity, the Mars Science Laboratory scheduled to land this fall. While not a life-detection mission, this rover takes another step along the path to understanding the potential for life, past or present, on the Red Planet. Other missions will eventually explore Europa and Titan, although they are still two decades in the future.

Until 1992 we didn't know for sure that planetary systems beyond ours existed. Less than twenty years later, there are more than 700 confirmed planets orbiting around 600 stars, and another 2000+ candidate planets found by the NASA Kepler spacecraft.

Photograph by Seth Shostak



Many scientists now feel comfortable suggesting that there are more planets than stars in the Milky Way. An exact Earth-analog, or Earth 2.0, has not yet been discovered, but the search now has enough precision and almost enough of a temporal record to begin delivering on that tantalizing possibility.

Once we know that Earth 2.0 is out there, or indeed many Earth 2.0's, the logical next question is whether anybody lives there. Not so long ago, scientists and engineers were hard at work trying to find solutions to the enormous technical challenges of imaging a distant terrestrial planet, and conducting a chemical assay of its atmosphere to detect any 'biosignatures' that would argue for the presence of some sort of biology. Today, at least in the US, budgetary constraints on both NASA and the NSF have put those technology development efforts on indefinite hold. For at least the next decade, SETI will be the only game in town; we could well detect the activities of mathematicians before we ever get to search for the tell-tale signs of microbes.

In a 1996 talk describing SETI as the archeology of the future Philip Morrison said "We find a site, a tumulus, or a ruin, and we take a spade and dig into the ground. If we are lucky, we discover Ur of the Chaldees or something marvelous. When you've got the spade … it seems very wrong not to dig."

Today we have a splendid spade called the Allen Telescope Array (ATA), and thanks to the generosity of TeamSETI members and other members of the public who responded to our financial challenge on the SETIStars.org website, we are once again able to dig. On December 5, 2011 our SonATA signal detection system once again began searching the skies with the ATA. Now the challenge is to keep on digging; a challenge that is as much fiscal as technological. We have a new partner to help operate the array, but we need to support our SETI team.

December 5th was also the day that the Kepler researchers announced the discovery of Kepler-22b, the first almost Earth-size planet orbiting within the 'habitable zone' of a G-type star similar to the Sun. This conjunction of events is the perfect example of the natural synergy between the search for other habitable worlds, and the search for their inhabitants. Both are valid scientific explorations. The technologies required to detect extrasolar planets were first assessed under the auspices of the Interstellar Communications Working Group at NASA Ames, the earliest NASA SETI team. The recent bounty of discovered exoplanets legitimizes the SETI exploration as never before. We have the spade (actually we have several optical and radio SETI programs), and we know where the planetary systems are. It would be wrong not to dig.

The time is right, but the budget isn't. As astronomers and planetary scientists spent the closing years of the first decade of the 21st century drawing up plans and setting scientific and mission priorities to guide NASA and NSF throughout the second decade, they imagined rising, or at worst flat budgetary allocations. Today's global and national fiscal realities are making even flat budgets seem unlikely, and priorities are being revisited in light of predictions for declining funds. As teams try to hold on to the missions they already have, it is difficult to see how we will be able to reintroduce SETI into the federal funding chain in the near future. This means that there is an opportunity, in fact an obligation, to proactively globalize SETI and set up an endowment to provide long-term stability for this search to find cosmic neighbors, and to know ourselves better.

Our TeamSETI members have helped out in the past and we look forward to working with them to meet this new endowment challenge.

Tarter is Director of the Institute's Center for SETI Research, and holder of the Barney M. Oliver Chair for SETI.

Learning More About the Universe

Photograph by Seth Shostak

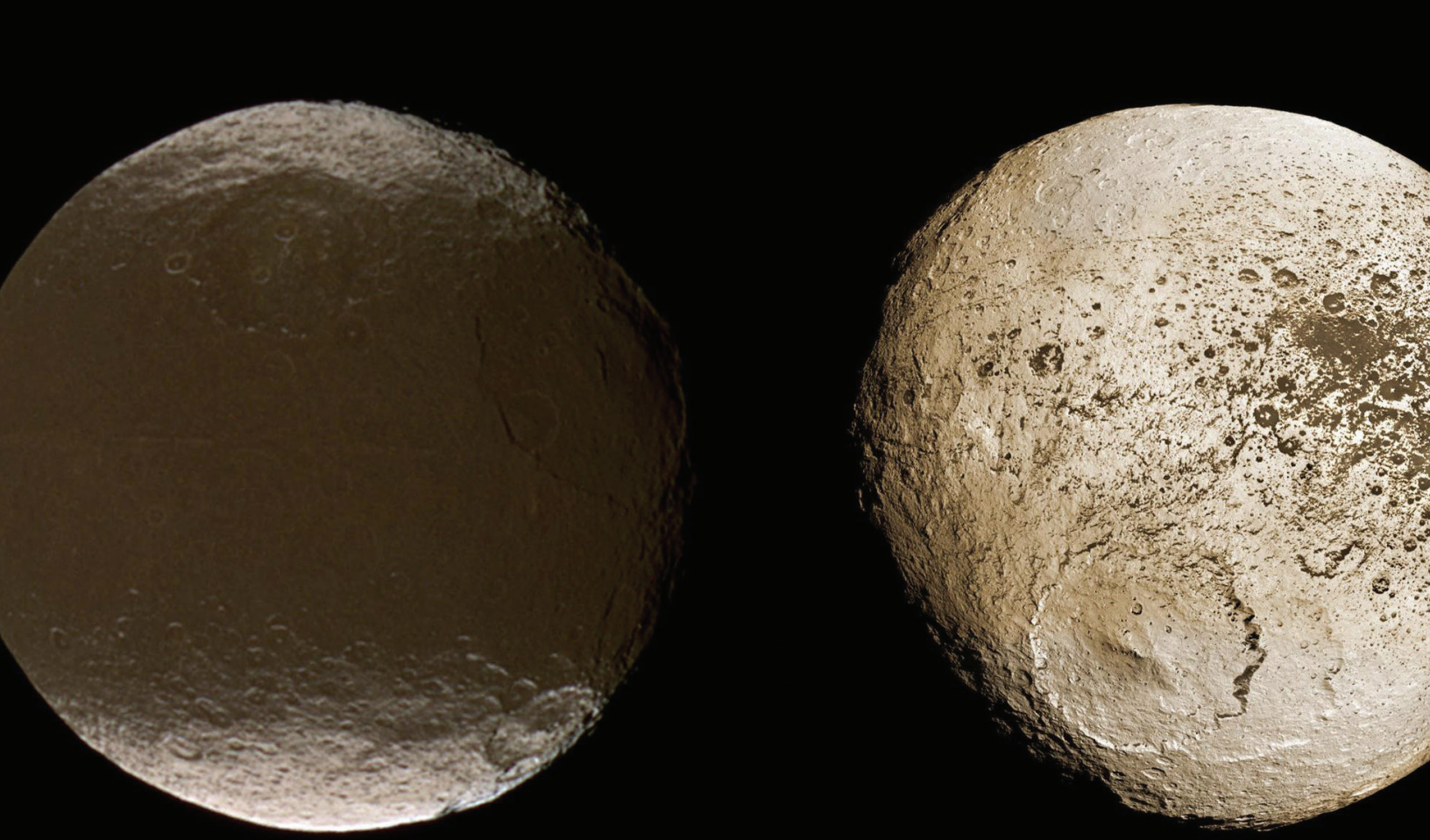
The SETI Institute is proud to be home to the best series of space science talks on YouTube. Every Wednesday at noon (and once per month at 7:00 pm), the Institute plays host to an eminent scientist who gives a one hour talk on their research. The talks are videotaped and put online at: http://youtube.com/setiinstitute

There are more than 185 videos available. Some examples include:

Paul Davies (How To Build a Time Machine)
Jill Tarter (The Allen Telescope Array)
Heidi Hammel (The James Webb Space Telescope)
Andrew Nelson ('XCOR Lynx Suborbital Spacecraft)
Alex Westphal (The Landscape of String Theory)
Geoff Marcy (SETI and the Kepler Project)
Laurance Doyle (How we Discovered Tatooine)
Chung Pei-Ma (Dark Matter)
Rob Dunbar (Climate Change in Antarctica)

Want to see which talks are coming up?
Visit the SETI Institute's talks calendar: http://seti.org/talks or follow us at: @SETI_Talks

— Adrian Brown



Dark and Mysterious

By Cristina Dalle Ore

It's black like coal and very widespread. But not much more is known about the material found on the surfaces of many outer solar system objects, a substance that is the focus of a lot of recent research. It is often identified as 'complex, macromolecular carbonaceous material' or simply 'organic' because it appears to be rich in CH molecules and as such it is thought to be a possible precursor of life.

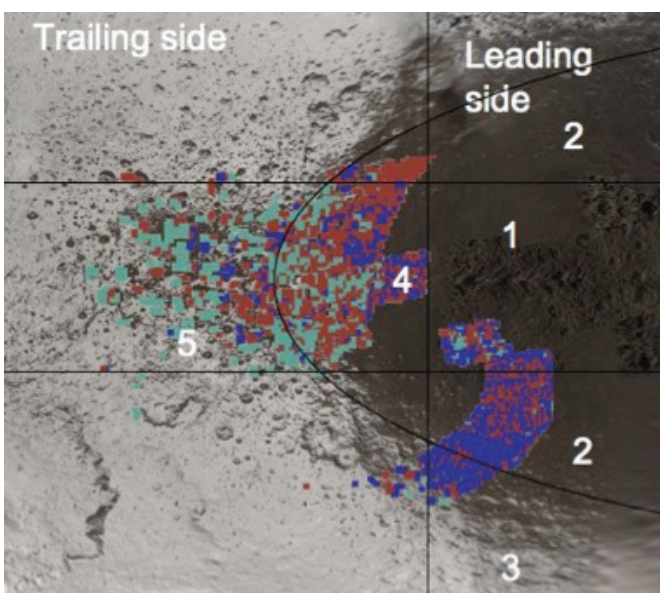
Planetary scientists have been investigating dark material in the outer solar system since its nature was first recognized in the early 1980s. Material of this general kind is found in carbonaceous meteorites and appears to be a common component of interstellar dust.

Of the many carbonaceous compounds that exist, the aromatic and aliphatic hydrocarbons are the ones we are particularly interested in, largely because they have recognizable spectral bands. Detecting these spectral signatures in small, faint bodies continues to challenge infrared technology because the region of the spectrum where they occur (>2.5 microns) is very faint as seen from Earth, and difficult to measure even when observed close-up by a spacecraft. The signatures also appear to change with physical circumstance, such as the radiation environment and temperature, which opens the possibility of tracing the history of a surface with detailed study.

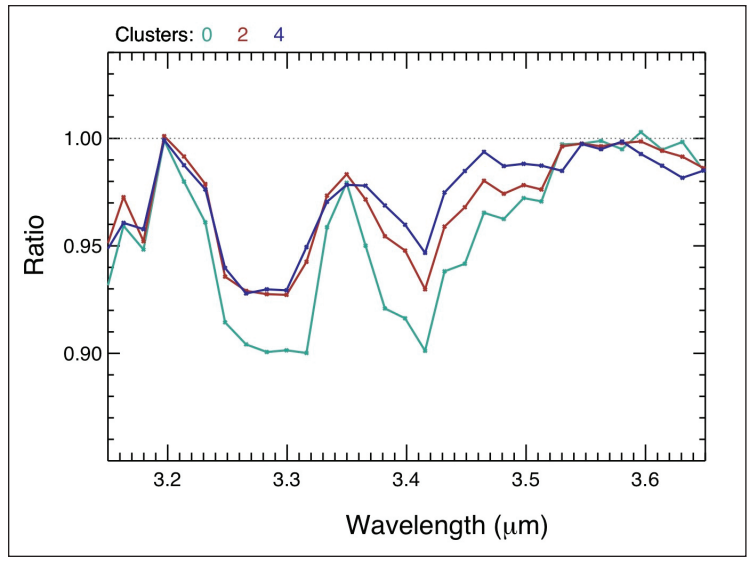
It is now becoming possible to investigate the properties of aliphatic and aromatic hydrocarbons found in the cold regions between stars, and in the solar system in a variety of locales including meteorites, interplanetary dust particles, and comets. And of course they are common in the biologically biased environment of Earth.

A breakthrough has recently come from the detailed analysis of infrared spectral imaging data returned by the *Cassini* spacecraft. *Cassini* has been orbiting Saturn since July, 2004 gathering a wealth of information on the planet, its rings and satellites.

Most Saturnian satellites are completely covered in water ice, but three of them, Iapetus, Hyperion, and Phoebe, clearly show large quantities of dark material distributed in interesting ways on parts of their surfaces. Iapetus, renown for its color dichotomy, is roughly half covered in reddish-dark material that appears to be spiraling in from Phoebe, the most external of the satellites (and likely to be a trans-Neptunian object captured by Saturn.) The material was possibly launched from Phoebe by a relatively recent collision with another small body, forming a gigantic dust ring now filling Phoebe's orbit. The dark dust mostly seems to settle on Iapetus, but some of it might reach as far as Hyperion.



A view of the Iapetus surface in the 'transition zone' between bright and dark material. A color-coded map referring to differing spectral signatures is overlaid.



Spectral signatures of the dark complex organic material detected on the dark side of Iapetus.

The dark material of the Saturnian satellites is indeed rich in aliphatic and aromatic hydrocarbons, but overall their spectral signatures suggest a different mix from the organic materials found on the meteorites and comet dust particles that have been analyzed. So the mystery deepens and the questions remain: What is their origin? How do they form, change, and destruct? Do they have a common relationship? How durable are they in the harsh conditions of space?

We believe that answering these questions could help us trace the beginning of life, whose building blocks, the amino-acids, are related to some of these organic compounds. The detection of hydrocarbons on some of Saturn's satellites seems to put us well on our way to a deeper understanding of fundamental issues of the origin and evolution of the solar system.

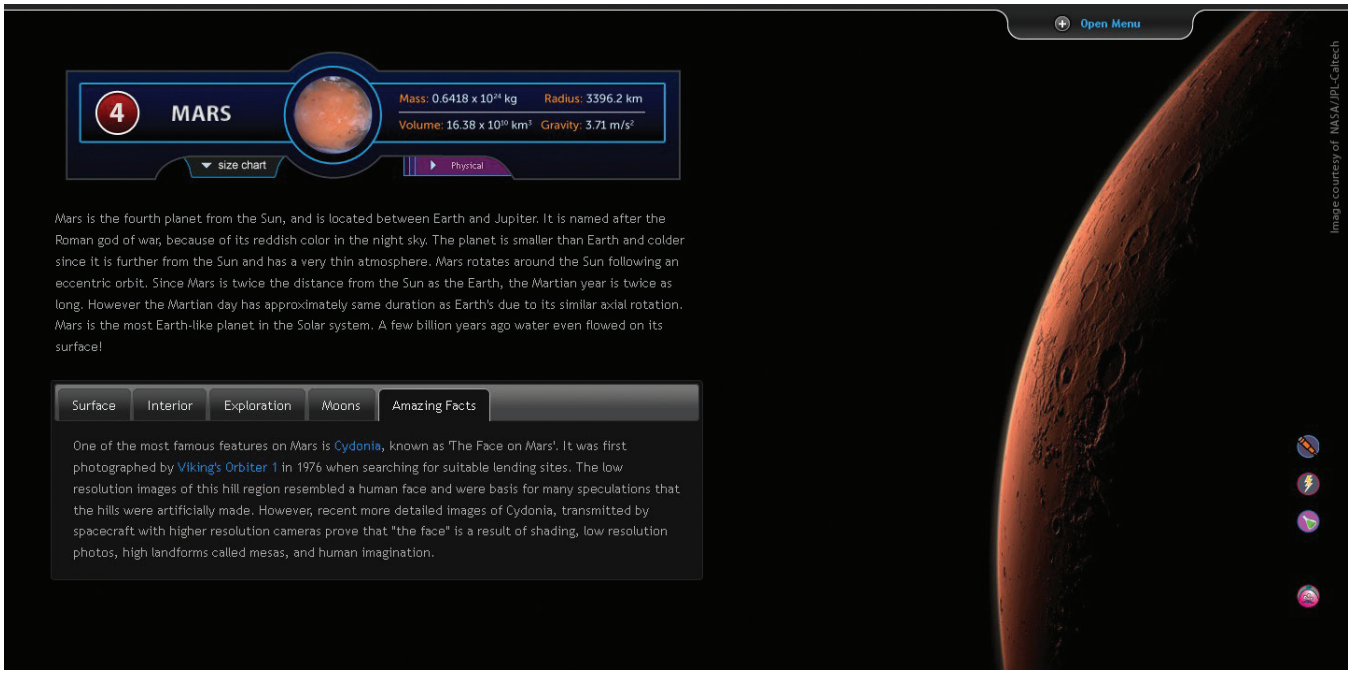
Dalle Ore is a research scientist at the SETI Institute

Web Site to Reach the Next Generation

by Gabriel Alvarado

The project description seemed straightforward: Design a website aimed at introducing astronomy to middle-school kids. As it turns out, once I sat down and started laying out the skeleton, sketching out the thumbnails, and coming up with a few color roughs to flesh out the design, I realized that my usual tricks and shorthand for corporate sites were just not going to work with my target audience. The sedate fiduciary look would be sure to cause a sleeping spell, and making some Expressionist or Bauhaus-inspired site would draw approving nods only from that one, hipster seventh grader sitting in the back of the class, quietly simmering in her own gloom.

Illustrations by Gabriel Alvarado-Marin



Screen shot of the web site

Who then, would the audience be? The problem is that an 11-year old is worlds apart from a 13-year old. A sixth grader is still living in the land of children, where primary colors rule, but an eighth grader is starting to cross into the world of adulthood and has different expectations.

I opted to design for the older side. Making a website that would appeal strictly to younger kids would be quickly outgrown, but making the design a little more open-ended would hopefully still be referred to for a few years, and inspire visitors to dig deeper. Out went the dry, the reserved and the sensible, but also the cute and insubstantial. Instead, to straddle the line, I went with something reminiscent of the big coffee table books that used to keep me huddled up in the local library for hours when I was in these kids' shoes; books that would lure you with big impressive photographs on one side of the binding and also provide enough information to satisfy your curiosity on the other.

And what could be more impressive than the beauty of the universe? At our disposal we have today breathtaking imagery of glittering nebulae and colliding galaxies, as well as close-ups of immense hurricanes churning across the surfaces of gas giants, and a tiny icy moon throwing elegant plumes of water into space. Why not take advantage of that, and let these images introduce themselves?

After several months, multiple revisions and adding in the text, the end result is a 30-page website with over 100 photographs, 50 custom illustrations and charts, scores of icons and over 300 separate definitions pop up windows that will not only educate but also, I hope, inspire the next round of curious minds.

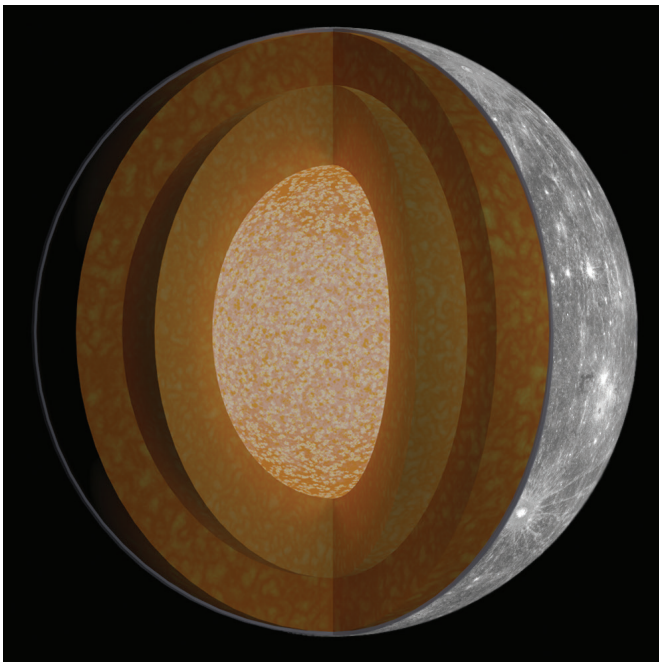


Illustration of Mercury's interior, combined with surface photograph taken by NASA's Messenger orbiter.

Alvarado is a web designer and illustrator at the SETI Institute

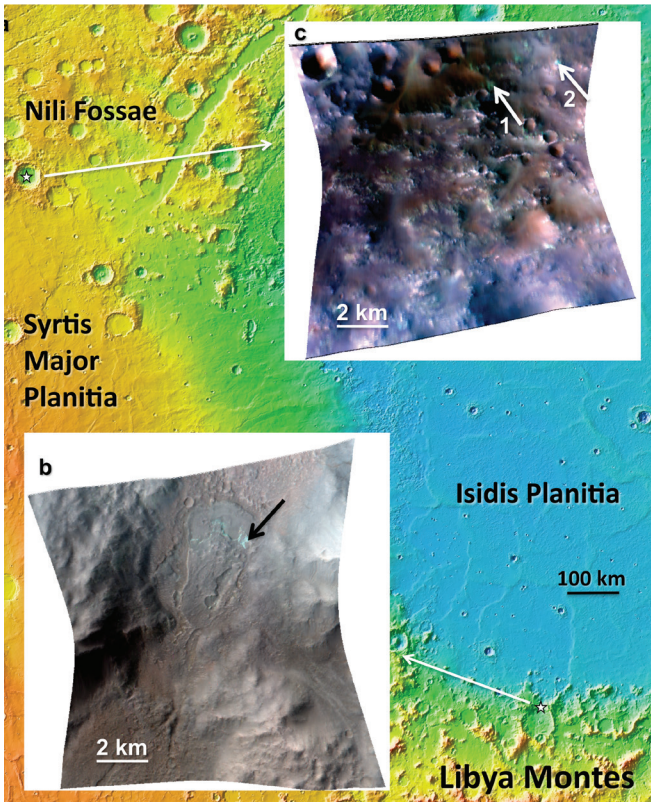
Janice Bishop studies clays that might function as good preservatives for martian biology.

The Clays of Mars

By Janice Bishop

Phyllosilicate clays are great indicator minerals for water and the geochemical environment of Mars. A large variety of phyllosilicates exist, and each forms under slightly different temperature, pH and metal environments.

Photograph by Seth Shostak



Imagery showing beidellite outcrops on Mars where hydrothermal processes may have contributed to clay formation. Image provided by Janice Bishop.

Many phyllosilicates have been detected on Mars using visible/near-infrared spectroscopy from the Mars Express OMEGA and the Mars Reconnaissance Orbiter CRISM missions.

A recent study of a specific family of clays, aluminum smectites, that form under lower and higher temperature conditions (montmorillonite and beidellite, respectively) indicates that these two related minerals have distinctive spectral fingerprints that can be used for identification of these on Mars. These two minerals have been used as geothermometers in soil studies on Earth, and we hope to be able to do that on Mars as well. This is significant because clays that have remained at low temperatures would better preserve any evidence of martian biology. Soil studies in South America have shown beidellite formation at 130 to 200 °C, while montmorillonite formed in waters below 130 °C. Beidellite formation also occurs due to burial diagenesis.

This process is common in soils as montmorillonite converts to beidellite then illite and sometimes chlorite under elevated pressure and temperature conditions.

We've analyzed Martian spectral images collected by CRISM to look for these two related phyllosilicates.

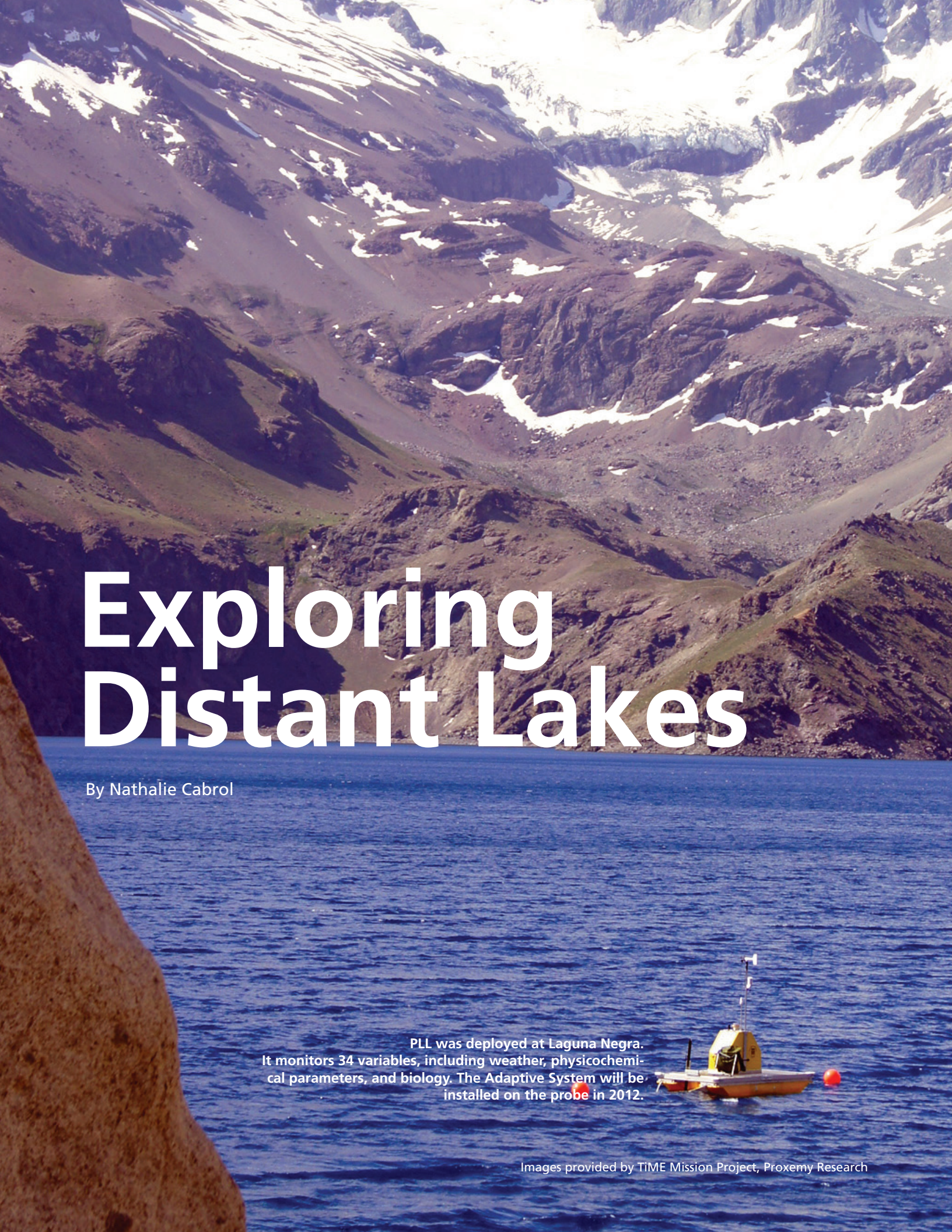
Spectra with a band consistent with beidellite have been observed in aluminum phyllosilicate outcrops in the martian regions of *Libya Montes* and *Nili Fossae*.

Both of these border the huge *Isidis* impact basin and are thought to have experienced hydrothermal alteration. No evidence of montmorillonite has been found in these locations indicating that the aluminum phyllosilicates here formed under higher temperature conditions. Perhaps hydrothermal waters were generated by the impact that formed these clays.

In another region of Mars called *Mawrth Vallis*, montmorillonite is much more common than beidellite. This region includes a channel and an impact crater, but as high temperature clays were not found here it is likely that the water was cooler at the time the clays formed.

Phyllosilicates are good agents for preserving biosignatures. However burial diagenesis often disrupts this process. Thus, finding places on Mars where montmorillonite is present rather than beidellite might help lead us to regions where biosignatures could have been preserved. The presence of montmorillonite might also be important for locating sites of potential habitability on Mars as lower temperature waters are more likely to have been supportive of life.

Bishop is a Senior Research Scientist at the SETI Institute



Exploring Distant Lakes

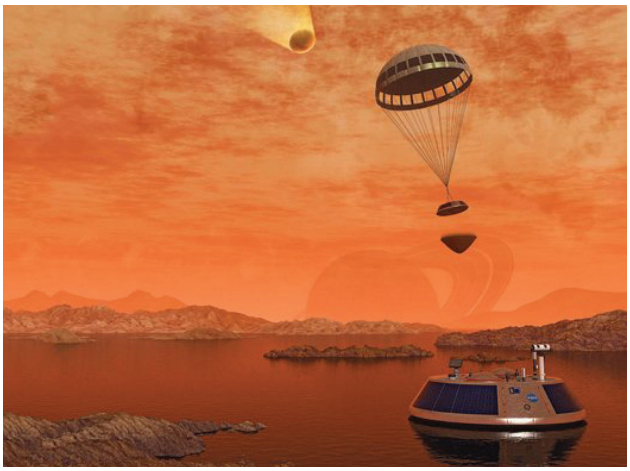
By Nathalie Cabrol

PLL was deployed at Laguna Negra. It monitors 34 variables, including weather, physicochemical parameters, and biology. The Adaptive System will be installed on the probe in 2012.

Images provided by TiME Mission Project, Proxemy Research

How do you explore lakes from afar? The Planetary Lake Lander (PLL) project, which remotely operates a robot for probing environmental changes and their impact on lake habitat and biodiversity in the Central Andes of Chile, is designed to teach us how. The goal is to gain operational experience and a better understanding of the technology, the systems, and the constraints of lake lander missions.

Lake landers are modern, robotic vessels of exploration. For instance, the Titan Mare Explorer (TiME) project led by Ellen Stofan was just selected by NASA as one of three candidates for a Discovery mission. It could be the first lake lander to ever explore an alien sea on Titan, the largest of Saturn's moons.



Artist concept of the TiME mission.

"Yet, if we can prove this concept ... the exploration of Titan will help us document more accurately, and faster, the mechanisms and consequences of climate change on Earth."

Yet, the concept is so new – after all, lakes on Titan were discovered only a few years ago – that there is no body of experience for understanding operational constraints and how to optimize mission productivity. PLL was selected by NASA to do just that.

There are no large methane lakes on Earth to test PLL. But our water-filled lakes are ubiquitous analogs. Our mission focuses on the impact of deglaciation in lake ecosystems. Deglaciation is the loss of ice through melting due to climate change. Disrupted environmental cycles challenge us to identify newly emerging patterns, and to find the most productive methods to investigate them rapidly. In many ways, the rapidity of deglaciation confronts us with the same operational scenario as a planetary mission faced with only limited time to understand the environment it explores and still achieve its objectives. The priority of time, bandwidth, and (frequently) power-constrained planetary missions is to return the most informative data. Such missions would greatly benefit from intelligent, adaptive systems that can rapidly establish environmental baselines, track changes as they happen, adapt the data collection rate to monitor them, and prioritize data return. This concept is applicable to a vast array of planetary missions, and would improve the ability of any robots (orbiters, landers, and rovers) to make decisions on their own between command cycles.

PLL also initiates a new class of research projects that bridge astrobiology, planetary and earth sciences. Developing technology and systems for the exploration of Titan will help us characterize deglaciation on our own

TiME/ PLL Analogy

	TiME	PLL
Goals	Understand carbon cycle through the study of a sea. Investigate a sea to explore the limits of life	Understand the impact of deglaciation on carbon cycle, lake habitat and biodiversity.
Objectives	Determine sea chemistry	Determine lake chemistry
	Determine sea depth to assess volume, thus organic inventory	Determine lake depth, volume, and organic inventory
	Constrain marine processes through physical properties and variation with depth	Constrain lake processes through physical properties and variation with depth
	Determine how local meteorology varies on diurnal timescales, and ties in to global seasonal and longer methane cycling periods	Determine how the local meteorology varies on diurnal timescales and ties to global seasonal and longer water cycling periods
	Characterize the atmosphere above the sea	Characterize the atmosphere above the lake

planet more efficiently, and shed light on the past habitability of Mars when glaciers were present.

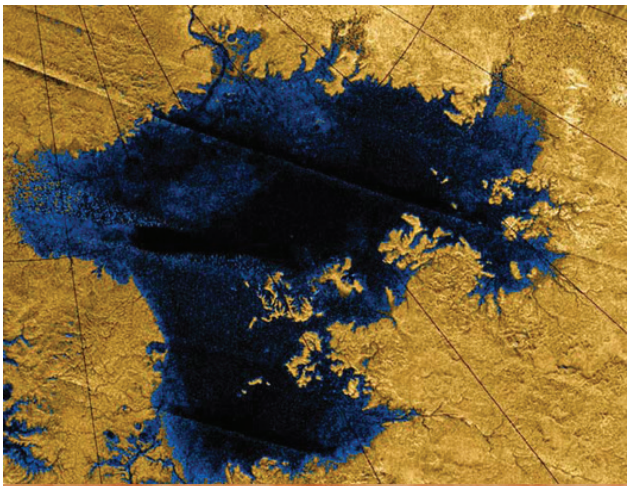
With increasing temperatures, most terrestrial glaciers are rapidly retreating. Currently, precipitation is low in summer while runoff is at its maximum. The mechanism for this asynchronicity is water storage as snow and ice during winter, and its release through melt in summer. The sustainability of the system depends on the balance between ice accumulation, ablation, and melting rate. Climate change is fast altering this balance. As ice fades away, glacial lakes decline with drastic physicochemical consequences for lake habitats and biodiversity. This is a drama in three acts:

1. Increased ice melt produces high water discharges loaded with sediment making lakes turbid.

2. In time, ice loss leads to less melt, thus lower discharges. Sediments settle on lake beds and water becomes transparent, resulting in an ecological disaster for all the species that cannot adapt to increased ultraviolet radiation.

3. With no ice left, lakes become completely dependent on precipitation, and ultimately disappear due to aridification. This is the process that PLL monitors at Laguna Negra.

PLL will deliver the first demonstration of a lake lander with complete systems and science goals and payload analogous to a Titan mission (see table). The project goes a step farther by developing a "brain" for PLL, i.e., the so-called Adaptive System. Without human oversight, PLL will learn about its environment as the mission progresses, and adapt its investigation to respond to environmental and biological nominal and off-nominal events. It will trigger on its own sequences of operations to document these events from onset to conclusion. This will not exclude human planning, but will augment mission productivity as the robot becomes a science decision-maker and remains aware of its energy and data budget.



Mare Ligeia, the candidate sea for TiME.

Sentinel probes such as PLL will greatly improve planetary mission productivity. We are just at the start of an exciting road, and there are complicated issues to address before reaching our goal. Yet, if we can prove this concept, it may be that developing systems to support the exploration of Titan will help us document more accurately, and faster, the mechanisms and consequences of climate change on Earth. And here, time is of the essence.

Cabrol is a Senior Research Scientist at the SETI Institute

SETI Institute

SETIcon II

JUNE 22-24, 2012

SETIcon II is Coming

As summer begins, the SETI Institute is reprising its popular, three-day science and science-fiction event, SETIcon.

SETIcon II will bring together approximately 50 researchers, writers, and media personalities for exciting, informative, and provocative panel discussions, fireside chats, and special events. If science or science-fiction are your thing, you'll not want to miss SETIcon. It's where science and imagination meet.

Among the outstanding speakers in attendance will be planet hunters Geoff Marcy and Debra Fischer, Battlestar Galactica advisor Kevin Grazier, and favorite SETI scientists such as Frank Drake, Jill Tarter, and Seth Shostak. Sci-fi author Robert J. Sawyer will be in there, as will best-selling author Mary Roach. Star Trek fans can meet The Doctor – Robert Picardo – as well as series advisor and writer, Andre Bormanis. You'll also come face-to-face with first-rate astronomers Andy Fraknoi, Alex Filippenko, and Alan Stern.

SETIcon II takes place June 22 – 24, 2012 at the Hyatt Regency Hotel in Santa Clara, California – in the deep heart of the Silicon Valley and about one hour south of San Francisco (nearest airport is San Jose). You can register and find out more at www.seticon.org

SETIcon: It's a great way to begin the summer.

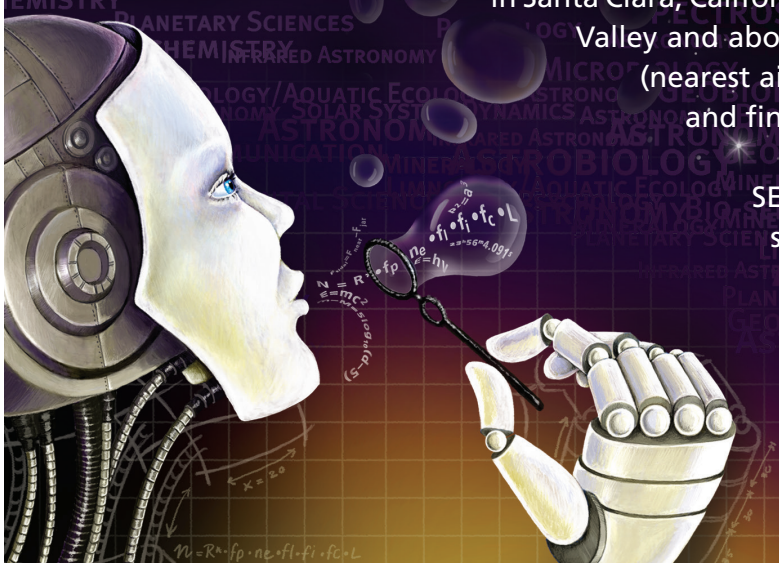


Illustration by Danielle Futselaar

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Photograph by Seth Shostak