Publications Watch *by Andrew J. LePage*

Notes on recent articles, papers, and research pertaining to SETI and bioastronomy

The Astronomical Journal
Volume 116, Number 1, July 1998

"Wide Field Planetary Camera 2 Observation of Proxima Centauri: No Evidence of the Possible Substellar Companion," by David A. Golimowski and Daniel J. Schroeder, pp. 440-443

A paper written by A.B. Schultz et al., and published in the January 1998 issue of *The Astronomical Journal*, announced the possible detection of a substellar companion orbiting the closest known star, Proxima Centauri (see "A Possible Companion to Proxima Centauri" summarized in *SETIQuest* Vol. 4, No. 2, p. 19).

The claim was based on the presence of an apparently moving "bump" on the side of the red dwarf's point spread function as seen in a pair of coronagraphic images obtained by the Hubble Space Telescope's Faint Object Spectrograph in 1996.

The changing position of the bump did not correspond to any background star in the vicinity or to previously observed instrumental effects. In order to agree with earlier astrometric and radial velocity measurements, the presence of a large brown dwarf in an eccentric, multi-year orbit was proposed to explain the observations.

In this paper, the results from images taken in March and April 1997 by the Hubble Space Telescope's Wide Field Planetary Camera 2 (WFPC2) are presented (for a thorough discussion of the capabilities of WFPC2 and the Faint Object Spectrograph, see "The Hubble Space Telescope and the Search for Faint Extrasolar Companions" in *SETIQuest* Vol. 3, No. 2, pp. 1-9).

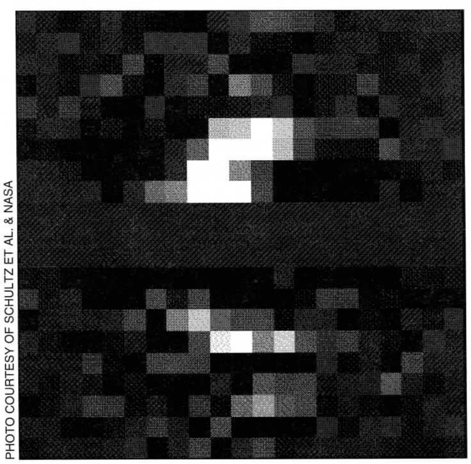

PHOTO COURTESY OF SCHULTZ ET AL. & NASA

Figure 1: *The bright spot in this highly processed Faint Object Spectrograph image of Proxima Centauri was thought to be due to a substellar companion. New observations with the Hubble Space Telescope's Wide Field Planetary Camera 2 now suggest that it is an instrumental artifact instead.*

Golimowski and Schroeder obtained these images of Proxima Centauri as part of a program searching for faint companions orbiting nearby stars (see Figure 1). For Proxima Centauri, filtered images with exposures of 10 and 40 seconds at a central wavelength of one micrometer were obtained on dates three weeks apart. These images should have allowed the detection of the companion spied by the Faint Object Spectrograph (FOS) anywhere from 0.09 to 0.85 arc seconds from Proxima Centauri (which translates to an apparent distance of 0.1 to 1.1 AU). Down to a brightness level 3.2 magnitudes lower than that expected for the putative companion, no object was seen by WFPC2. It is the authors' opinion that the earlier FOS images had not detected a substellar companion orbiting Proxima Centauri but were being fooled by some sort of subtle instrumental effect instead.

Astronomy
Volume 26, Number 6, June 1998

"Interstellar Trekking," by Ken Croswell, pp. 46-51

With the discovery of extrasolar planets and mounting indirect evidence that life exists elsewhere in our Solar System, there has been increasing interest in interstellar travel. Just as the first reconnaissance of the outer planets during the 1970s and 1980s vastly increased our knowledge and understanding of these worlds and their moons, a close-up investigation of another star system would yield a treasure trove of new data. But the immense distances that must be crossed to reach even the nearest stars makes such a venture almost impossible with our present technology.

Excerpted from Croswell's book, *Planet Quest: The Epic Discovery of Alien Solar Systems*, this piece presents a concise summary of the problems involved with interstellar travel. Interestingly this article also discusses the economic barriers associated with interstellar travel: An estimated cost of trillions of dollars to launch even a modest one-ton probe to the closest star.

Astronomy
Volume 26, Number 7, July 1998

"Planet Hunters," by Sally Stephens, pp. 58-63

Published before the most recent spate of extrasolar planet discoveries this past summer, this piece describes the work of the most prolific planet hunters to date, Geoff Marcy and Paul Butler. In addition to the standard accounts of their discoveries that have been published over the past couple of years, this article also delves into some of the finer points of the spectroscopic techniques that have allowed Marcy and Butler to measure radial velocities accurately enough to detect the reflex motion of Jupiter-sized planets orbiting nearby stars. Of particular importance to these planet hunters is the detection of extrasolar giant planets in Jupiter-like orbits as is the case in our Solar System.

Only Geoff Marcy and Paul Butler's recently expanded survey has been collecting needed data with the accuracy required to detect true Jupiters. While they have identified a few unannounced candidates among the stars observed, they will still need a few more years of data collection in order to confirm their results.

Astronomy & Astrophysics
Volume 334, June (II) 1998

"Planetary Systems or Double Stars?," by M. Imbert and L. Prevot, p. 371

One of the problems with using only radial velocity measurements to detect extrasolar companions is that only the *minimum* mass of the companion can be determined. Without any knowledge on how much the companion's orbit is tilted to our line of sight, it could almost as easily be a red dwarf in a nearly pole-on orbit as a large planet in a nearly edge-on orbit.

In this paper the authors present the results of their statistical models of the data gathered for 47 Ursae Majoris, 70 Virginis, and 16 Cygni B. Each of these stars has displayed a radial velocity signature that has been interpreted as being due to the presence of a Jovian to super-Jovian planet in orbits with periods ranging from a few months to years. The authors conclude that there is a low probability that the companions orbiting these stars are not substellar and that the planetary explanation would seem to be most likely.

Astronomy & Astrophysics
Volume 334, June (II) 1998

"A Search for Substellar Companions Around Nine Weak-Line T-Tauri Stars with the Planetary Camera 2 of the Hubble Space Telescope," by Paola Sartoretti, Robert A. Brown, David W. Latham, and Guillermo Torres, p. 592

In addition to searching for substellar companions orbiting nearby stars, the Hubble Space Telescope has also been used to search for such bodies orbiting more distant stars. While normally an increase in distance would make such detections more difficult, for the survey described in this paper the authors are searching for newly formed substellar companions that still shine brightly by their own light.

The authors secured I-band images of nine weak-line T-Tauri stars in the Taurus-Auriga star-forming region more than 400 light years away using the Planetary Camera portion of the WFPC2. These stars are only 10 million years old and any substellar companions that they would have seen should have just formed in the clearing protoplanetary disk.

To complement the Hubble Space Telescope images, precision radial velocity measurements were also obtained using the Center of Astrophysics Digital Speedometers. Except for a single stellar companion orbiting the star HBC 407 and the discovery that HBC 392 was a double-line spectroscopic binary, no companions were discovered within eight arc seconds of these stars down to a mass of 18 to 55 $M_{♃}$. More surveys like these should help astronomers determine how frequently large substellar companions form around stars.

The Astrophysical Journal

Volume 499, Number 1, Part 2, May 20, 1998

"EROS and MACHO Combined Limits on Planetary Mass Dark Matter in the Galactic Halo," by C. Alcock, R.A. Allsman, D. Alves, R. Ansari, E. Aubourg, T.S. Axelrod, P. Bareyre, J.-Ph. Beaulieu, A.C. Becker, D.P. Bennett, S. Brehin, F. Cavalier, S. Char, K.H. Cook, R. Ferlet, J. Fernandez, K.C. Freeman, K. Griest, Ph. Grison, M. Gros, C. Gry, J. Guibert, M. Lachieze-Rey, B. Laurent, M.J. Lehner, E. Lesquoy, C. Magneville, S.L. Marshall, E. Maurice, A. Milsztajn, D. Minniti, M. Moniez, O. Moreau, L. Moscoso, N. Palanque-Delabrouille, B.A. Peterson, M.R. Pratt, L. Prevot, F. Queinnec, P.J. Quinn, C. Renault, J. Rich, M. Spiro, C.W. Stubbs, W. Sutherland, A. Tomaney, T. Vandehei, A. Vidal-Madjar, L. Vigroux, and S. Zylberajch, p. L9

Various pieces of indirect evidence suggest that the halos of spiral galaxies like our own are filled with nonluminous or dark matter. While a number of exotic forms of matter have been proposed as the primary constituent of dark matter, until recently concentrations of normal baryonic matter of planetary proportions could not be ruled out. In an effort to detect rogue planets in our galactic halo, a number of teams have set about monitoring the brightness of thousands to millions of stars in distant concentrations in the hopes of spotting a short-lived brightening caused by gravitational microlensing. Gravitational microlensing occurs when a planet or star in our galactic halo passes almost directly along our line of sight to a much more distant star. When properly aligned, the gravity of the halo object acts as a celestial lens that causes a temporary increase in the apparent brightness of the more distant object.

Two such programs include EROS (Experience de Recherche d'Objets Sombres) performed at the European Southern Observatory at La Silla, Chile, and the MACHO (Massive Compact Halo Objects) Program run by an international collaboration of astronomers. EROS monitors the brightness of 150,000 stars 20 times per night in the Large and Small Magellanic Clouds while MACHO observes 8.6 million stars in the Large Magellanic Cloud less frequently. Both programs have already been able to place limits on the total mass of rogue planets and brown dwarfs in the galactic halo (see "The MACHO Project: Limits on Planetary Mass Dark Matter in the Galactic Halo from Gravitational Microlensing" summarized in *SETIQuest* Vol. 3, No. 1, p. 18, and "Search for Planetary Mass Objects in the Galactic Halo through Microlensing" summarized in *SETIQuest* Vol. 4., No. 1, p. 18).

In this paper, the EROS and MACHO data sets have been combined to provide even more stringent limits. The two largely complementary programs have little overlap in their exposures, thus making the task of combining observations easier. The authors' analysis indicates that objects in the 10^{-7} $M_{\odot}$ to 10^{-3} $M_{\odot}$ (0.03 $M_{\oplus}$ to 1 $M_{♃}$) mass range make up less than 25 percent of the galactic halo mass for most mass distribution models considered. Assuming a "standard" spherical halo model, less than 10 percent of its mass is composed of objects in the mass range of 3.5×10^{-7} $M_{\odot}$ to 4.5×10^{-5} $M_{\odot}$ (0.12 $M_{\oplus}$ to 15 $M_{\oplus}$). This new combined result places the strongest limits so far on the total mass of isolated planetary-mass objects in the galactic halo.

The Astrophysical Journal

Volume 500, Number 1, Part 1, June 10, 1998

"The Use of High Magnification Microlensing Events in Discovering Extrasolar Planets," by Kim Griest and Neda Safizadeh, p. 37

In the previous paper reviewed, EROS and MACHO were searching for isolated planetary bodies. On the rare occasions that a star in the galactic halo is responsible for a microlensing event, the presence of any large planets in orbit around it could be revealed by a short-term brightening superimposed on the primary microlensing event. In this paper the authors present the results of calculations to determine the chances that a suitably placed planet with various masses could be detected by its own secondary microlensing event.

According to their results, there is nearly a 100 percent chance of detecting a planet as large or larger than Jupiter when it lies inside the "lensing zone" around its primary star. The lensing zone is defined in terms of an annulus with an apparent angular radius of 0.6 to 1.6 "Einstein radii". For a star in the galactic halo lensing another, more distant one in the Magellanic Cloud, the Einstein radius corresponds to an apparent distance of several astronomical units from the lensing star.

The chances of detecting smaller planets remains high down to a Saturn-mass planet and remains substantial even for planets with a mass of only 10 $M_{\oplus}$. While such a detection method will not be able to spot planets in or near the habitable zones of extrasolar systems, a large enough survey could determine the mass and distance distributions of gas giants in these system's outer portions. For a thorough discussion of the microlensing planet detection technique and its limitations, see "Detecting Habitable Planets: The Next Decade" in *SETIQuest* Vol. 4, No. 1, pp. 1-6.

The Astrophysical Journal

Volume 500, Number 1, Part 1, June 10, 1998

"Orbital Evolution and Migration of Giant Planets: Modeling Extrasolar Planets," by D.E. Trilling, W. Benz, T. Guillot, J.I. Lunine, W.B. Hubbard, and A. Burrows, p. 428

One of the most important recent events in astronomy was the detection of the first extrasolar planet about three years ago. Contrary to the previously held conventional wisdom, this and subsequent discoveries have demonstrated that extrasolar giant planets (EGPs) can be found anywhere in the inner portions of extrasolar systems and not just in the cool outer reaches as is the case with our Solar System. How these EGPs formed can have a profound influence on the number of habitable terrestrial planets that exist in the galaxy. At the same time, they also offer the possibility that families of planet-sized moons that should circle close-orbiting EGPs could be habitable (for a thorough discussion of this topic, see "Habitable Moons: A New Frontier for Exobiology" in *SETIQuest* Vol. 3, No. 1, pp. 8-16).

One of the leading theories to explain the presence of close-orbiting EGPs is planetary migration. The theory proposes that as an EGP forms, tidal interactions between it and the protoplanetary disk can cause the disk and planet to spiral inward toward its sun.

In this paper the authors consider the details of EGP evolution during the migration process. In particular they found that a bloated protoplanet can lose mass as it migrates because its Roche lobe shrinks with decreasing orbital radius.

Taking this effect into account, the authors found that migrating EGPs can have three different fates. In the first case, a forming EGP migrates rapidly and loses all its mass. In the second case, an EGP migrates inward but does not lose too much mass and survives in a very small orbit. In the last case, the forming EGP does not lose any mass because it either does not migrate far or migrates very slowly.

These calculations indicate that a wide range of fates are possible for EGPs that depend critically on the properties and mass distribution of the original protoplanetary disk and the size of the EGP. While small terrestrial planets would probably not survive the inward migration of an EGP, it has yet to be determined if Earth-like planets might still form in their wake.

Journal of the British Interplanetary Society

Volume 51, Number 5, May 1998

This issue is the seventh in a series of issues of *JBIS* devoted to the topic of exobiology (the previous one was the July 1997 issue and was summarized in *SETIQuest* Vol. 3, No. 3, pp. 18-19).

The first paper of interest is "The Fermi Paradox: An Approach on the Percolation Theory" by Geoffrey A. Landis. The Fermi (or more properly the Fermi-Hart) Paradox states that if extraterrestrial civilizations exist and eventually become capable of colonizing over interstellar distances, they could completely colonize the galaxy in only a few million years. And, since we have no scientific evidence for such visits from alien beings on the Earth, therefore extraterrestrial civilizations cannot exist.

In this paper, Landis posits that not all colonies will themselves become colonizers and has made use of a "percolation theory" to determine the eventual distribution of colonies in the galaxy. Depending on the exact parameters assumed, several outcomes are possible but none result in the complete colonization of the galaxy. Uncolonized voids always seem to exist and the Earth could easily reside in one.

Another paper, "The Possibility of Finding Traces of Extraterrestrial Intelligence on Asteroids" by Csaba Kecskes, approaches the Fermi Paradox from a different perspective. Kecskes hypothesizes that colonizing extraterrestrial civilizations do exist but that colonizers only remain in a system long enough to build more ships or repair and replenish their own ship. Remnants of such activity might exist on the largely unexplored but resource-rich asteroids in our Solar System.

A paper by A.V. Arkhipov titled "Earth-Moon System as a Collector of Alien Artefacts" follows a similar line of reasoning. The author believes that the Moon has served as a possible collector of alien artifacts for four billion years. A thorough search of the Moon could provide a good indicator of the presence of colonizing extraterrestrial civilizations.

A brief piece of correspondence included in this issue by Mark D. Nussinov and Salvatore Santoli also addresses the possibility that the Polycyclic Aromatic Hydrocarbons (PAHs) found in the Martian meteorite, ALH84001, could have been produced during a shock event on Mars.

Other relevant papers in this issue of the *JBIS* include: "Small Smart Interstellar Probes" by Allen Tough; "A Classification of Quadric Wormholes According to the 'Matter' Requested for Interstellar Travel" by Claudio Maccone; and "Man/Alien Dialogues—A Nanobiologist's Perspective" by Salvatore Santoli.

Nature

Volume 392, Number 6678, April 23, 1998

"Submillimetre Images of Dusty Debris Around Nearby Stars," by Wayne S. Holland, Jane S. Greaves, B. Zuckerman, R.A. Webb, Chris McCarthy, Iain M. Coulson, D.M. Walther, William R.F. Dent, Walter K. Gear, and Ian Robson, pp. 788-791

The excess infrared emissions from stars tens to hundreds of millions of years old have generally been interpreted as coming from a disk of debris left orbiting these stars after the formation of planets. Of all these "Vega-type" stars, only the disk surrounding Beta Pictoris has actually been imaged and studied to date. In this paper, the authors describe their efforts to image the disks of the Vega-type stars Beta Pictoris, Fomalhaut, and Vega at submillimeter wavelengths where the disks' thermal emissions should outshine that of their suns'.

For their observations made between April and October of 1997, Holland et al. used the Submillimeter Common-User Bolometer Array (SCUBA) on the James Clerk Maxwell Telescope (JCMT) on Mauna Kea, Hawaii.

Images made at a wavelength of 0.85 millimeters clearly revealed dust disks extending out for tens of astronomical units with a total of a few lunar masses each. These dust disks are roughly analogous to that which probably existed in our Solar System's Kuiper Belt billions of years ago. Based on supplementary observations the team made, they estimate that there is less than a 2.5 percent chance that a background galaxy is masquerading as a disk.

Interestingly, a hole was observed in the center of the disk surrounding Fomalhaut. This hole could have been cleared out by newly formed planets orbiting within 30 AU of the star. Calculations are still required to determine if ice sublimation or Poynting-Robertson drag from light absorption are responsible for this hole instead. Estimates for the masses of these dust disks clearly show that they decrease with age without exception.

Additional observations of this and other disks at submillimeter wavelengths should help in determining their significance in the history of planet formation when combined with observations at other wavelengths.

The Planetary Report

Volume 18, Number 3, May/June 1998

"The Mars Rock: Some of its Chemistry is from Earth," by Gene McDonald, pp. 9-10

"Earthly Contaminants Don't Rule Out Martian Life," by David S. McKay, Everett M. Gibson, and Kathie L. Thomas-Keprta, pp. 10-11

Ever since a NASA-led team of scientists presented evidence that the Martian meteorite ALH84001 harbored signs of what could be fossilized extraterrestrial nanoorganisms two years ago, groups have scrambled to perform additional tests to confirm or refute the claim (for the latest news on these efforts, read "ALH84001: The Case Continues" in *SETIQuest* Vol. 4, No. 2, pp. 9-11).

This pair of brief articles presents the most recent round in the ongoing debate over ALH84001. The first article is a popular level summary of a pair of recent papers that appeared in the January 16, 1998, issue of *Science* (see "A Search for Endogenous Amino Acids in the Martian Meteorite ALH84001" by Bada et al. and "Isotopic Evidence for a Terrestrial Source of Organic Compounds Found in the Martian Meteorites Allan Hills 84001 and Elephant Moraine 79001" by Jull et al. summarized in *SETIQuest* Vol. 4, No. 2, p. 23).

Gene McDonald, who coauthored one of the papers, claims that the organic compounds in ALH84001 have a terrestrial isotopic fingerprint, indicating that they are contaminants instead of the chemical remains of Martian life.

In the second piece by McKay et al., the authors state that a Martian origin for the PAHs (Polycyclic Aromatic Hydrocarbons) and carbonates that are central to their claim has not in fact been ruled out by these papers.

Obviously the debate of what has been found in ALH84001 will continue.

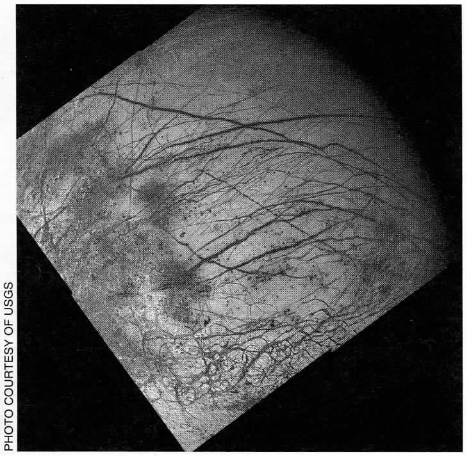

Figure 2: *Spectra of Europa's surface suggest that fractures in its crust like these lines above are covered with evaporite salt deposits from a salty subsurface ocean. These deposits offer clues to the chemistry in the proposed Europan ocean.*

Science

Volume 280, Number 5367, May 22, 1998

"Salts on Europa's Surface Detected by Galileo's Near Infrared Mapping Spectrometer," by T.B. McCord, G.B. Hansen, F.P. Fanale, R.W. Carlson, D.L. Matson, T.V. Johnson, W.B. Smythe, J.K. Crowley, P.D. Martin, A. Ocampo, C.A. Hibbitts, J.C. Granahan, and the NIMS Team, pp. 1242-1245

The Galilean satellite Europa has been the center of attention for exobiologists during the past couple of years because of mounting evidence for a tidally heated ocean of water that may exist beneath its icy exterior. Recent observations made by the Near Infrared Mapping Spectrometer (NIMS) carried by the Galileo spacecraft in orbit around Jupiter may supply important evidence for the chemistry that may exist in this putative Europan ocean.

Spectra obtained by NIMS over the Europan surface between the wavelengths of 1 to 2.5 micrometers exhibited distorted water-absorption bands resulting from hydrated salt minerals (see Figure 2). The best match to date for these spectra are from an icy mixture of the hydrated magnesium sulfate salts hexahydrite ($MgSO_4{\bullet}6H_2O$) and epsomite ($MgSO_4{\bullet}7H_2O$) in combination with the hydrated sodium carbonate salt, natron ($Na_2CO_3{\bullet}10H_2O$). It is also possible that a very cold mixture of even more hydrated versions of these salts not found on Earth (e.g., $MgSO_4{\bullet}12H_2O$) could make an even better match.

These distorted spectra are most prevalent along Europa's lineaments which are thought to be cracks in Europa's ice crust that were filled with material from below. If this material came from an ocean, it would be expected to be rich in dissolved salts in which case the observed absorption features are from evaporite deposits.

The presence of magnesium sulfate salts had been predicted by earlier models of Europa's evolution that assume an initial carbonaceous chondrite composition. The presence of carbonates hints that the inorganic chemical processes in the Europan ocean are similar to those thought to exist on Earth earlier in its history. While more data are required to definitively prove that there is an ocean on Europa and to determine its properties, this latest paper is not inconsistent with its existence and hints at a chemistry conducive with the formation of life.

Science

Volume 280, Number 5369, June 5, 1998

"Deuteronomy?: A Puzzle of Deuterium and Oxygen on Mars," by Yuk L. Yung and David M. Kass, pp. 1545-1546

"Detection of Atomic Deuterium in the Upper Atmosphere of Mars," by Vladimir A. Krasnopolsky, Michael J. Mumma, and G. Randall Gladstone, pp. 1576-1580

"Atmosphere-Surface Interactions on Mars: $\Delta\,^{17}O$ Measurements of Carbonate from ALH84001," by James Farquhar, Mark H. Thiemens, and Teresa Jackson, pp. 1580-1582

There is an ever-growing mountain of evidence that Mars was a much wetter and warmer place in the distant past (see "Ancient Mars: Latest Evidence for a Habitable Past" in this issue of *SETIQuest*). But with today's total atmospheric water inventory equivalent to a global layer only a few micrometers thick, one is forced to ask where all of Mars's water went. As important is trying to determine how much water there was originally. The first technical review article by Yung and Kass presents a fully referenced summary of what the papers by Krasnopolsky et al. and Farquhar et al. have to say on this question.

Krasnopolsky et al. have used high resolution spectra of Mars obtained by the Hubble Space Telescope's Goddard High Resolution Spectrograph to determine the ratio of atomic deuterium to the lighter isotope of hydrogen consisting of a single proton (called "protium") in the upper atmosphere of Mars.

These data have been used to fine-tune the models for how water escapes from Mars's upper atmosphere. Farquhar et al. have performed detailed measurements of the various isotopes of oxygen in a sample of carbonate that came from ALH84001.

Not only do their results imply that these carbonates are not terrestrial contamination (thus supporting the case that these carbonates harbor the fossilized remains of Martian nanoorganisms), but they indicate that there were two separate oxygen isotope reservoirs on Mars at the time the carbonates formed—its atmosphere and lithosphere.

Taken together, these data have helped to clarify the exchange mechanisms between isotopically distinct sources of water on Mars and how they have fractionated (or sorted) themselves by the weights of the various isotopes. The bottom line from the analysis of these papers is that Mars currently has an ice layer with a globally averaged thickness of five meters that interchanges with the atmosphere. The results also imply that Mars has lost a layer of water equivalent to a thickness of at least 80 meters globally over its history. This is still much lower than the estimated 300 to 500 meters of water based on an analysis of Martian geology.

Science

Volume 280, Number 5372, June 26, 1998

"Perennial Antarctic Lake Ices: An Oasis for Life in a Polar Desert," by John C. Priscu, Christian H. Fritsen, Edward E. Adams, Stephen J. Giovannoni, Hans W. Paerl, Christopher P. McKay, Peter T. Doran, Douglas A. Gordon, Brian D. Lanoil, and James L. Pinckney, pp. 2095-2098

The McMurdo Dry Valleys of Antarctica, with temperatures as low as –43 degrees C and less than 10 centimeters of precipitation annually, are one of the most hostile environments on the surface of the Earth. Despite the conditions, microbial life has been able to find niches where it can not only survive but thrive.

One of the more benign microenvironments in the Antarctic Dry Valleys exists in a group of lakes that are covered with three to six meters of permanent ice cover. In the last decade these lakes have been found to be filled with communities of microorganisms that survive on dissolved gases, the minute amount of light that filters through the ice, and annual influx of dissolved minerals in the meager runoff from melting ice and snow.

In this paper, the authors describe another microenvironment in the ice that covers these lakes. About two meters below the ice surface lies a zone where wind-blown minerals and organic debris are concentrated. This zone marks the point where an equilibrium is reached between ice ablating from the top of the ice cover and the formation of new ice from the water below. This equilibrium allows dust and debris that collects on the surface to eventually sink to this point and no further. During the austral summer, pockets of melt water form at this layer for up to 150 days at a time. Cores recovered from this zone were examined for biological activity, biomass, sediment, and nitrous oxides.

Much to the surprise of the authors, thriving communities of microorganisms were found in these pockets of water despite the temperatures that hover around 0 degrees C. At the base of the food chain of this ecosystem are photosynthetic bacteria that subsist off the nutrient-rich debris and the tiny amounts of sunlight that can make it through the ice. During the austral winter when these pockets of water freeze solid, the ecosystem shuts down to wait for the next summer.

This discovery may shed light on the possibility of biocompatible environments that could exist on Europa or that existed in ice-covered bodies of water on Mars in its past.

Science News

Volume 153, Number 17, April 25, 1998

"Scooping Up a Chunk of Mars: Fresh Samples from the Red Planet," by Ron Cowen, pp. 265-267

Sometime during the next decade, NASA plans to return the first samples from the surface of Mars. Current plans call for a pair of rover-equipped landers to be launched to Mars—the first in 2001 and the second in 2003—that will each secure 91 rock samples and 13 soil samples weighing with a combined mass of one half kilogram. In 2007 another spacecraft is slated to fly to Mars to pick up the more interesting collection of samples for return to Earth (see Figure 3).

This article reviews these planned missions and the precautions that will be taken not only to protect the Earth from contamination from the samples but to shield the samples from terrestrial contaminants. Such pristine samples will not only help scientists' understanding of Martian geology but quite possibly its biology also. The recent debates over the issue of terrestrial contamination in SNCs illustrate how efforts to study extraterrestrial samples can be complicated by terrestrial contaminants. Also included is a sidebar on the lessons learned from handling Apollo Moon samples and another with a quick review of other missions that will return samples of cometary and interstellar dust.

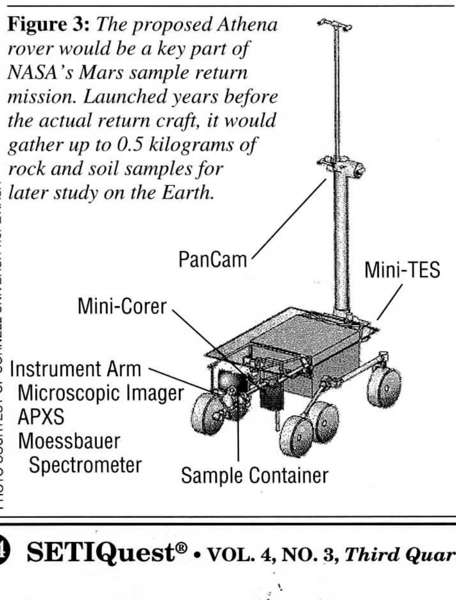

Figure 3: *The proposed Athena rover would be a key part of NASA's Mars sample return mission. Launched years before the actual return craft, it would gather up to 0.5 kilograms of rock and soil samples for later study on the Earth.*

Figure 4: *The Mars Pathfinder lander as seen on the Martian surface by the Sojourner rover in July 1997.*

Sky & Telescope

Volume 96, Number 1, July 1998

"Mars Pathfinder: Better Science," by Jim Bell, pp. 36-43

The new paradigm for NASA-sponsored missions in general and interplanetary ones in particular is "better, faster, cheaper." While there is still much debate if this is really possible in the long run in light of the most recent budget cuts and the natural urge to do more on each mission, the Mars Pathfinder mission was one of the first to embrace the new philosophy and was certainly the first to actually fly. The project was able to borrow heavily from existing hardware and technology development programs and, being the first spacecraft to land on the Red Planet in more than two decades, Mars Pathfinder was almost guaranteed to return new and useful data.

This article, written by a member of the Mars Pathfinder Science Team, summarizes the scientific results of this highly successful mission. It is filled with the latest versions of processed images from the lander and its rover, Sojourner, many of which are published here for the first time (see Figure 4).

For a summary on how the mission's findings have shed light on Mars's biological potential, read "Ancient Mars: Latest Evidence for a Habitable Past," in this issue of *SETIQuest*.

Sky & Telescope

Volume 96, Number 2, August 1998

"The Future of the Universe," by Fred C. Adams and Gregory Laughlin, pp. 32-39

One of the key parameters of Drake's Equation (which is used to estimate the number of technologically advanced civilizations in the galaxy) is the lifetime of such civilizations. While there is much debate over this parameter's value, all would agree that the uppermost bound is probably set by the ultimate evolutionary path of the universe. This article presents a remarkably refreshing perspective on the fate of our universe based on the latest observations and theoretical studies.

The latest estimates for the total mass of the universe indicates that it is open and will expand indefinitely. With a universe that will continue to exist eternally, the last of the stars will die and habitable bodies—as we currently envision them—would cease to exist after 100 trillion years (when the universe is 10,000 times older than it is today).

This article details the steps leading to this stage of the universe's development as well as those for the next 10^{120} years. By this point the universe would be inconceivably large and coherent matter will no longer exist. Instead the universe will be filled with an ever-thinning haze of red-shifted photons.

The article concludes with the question of how long life could continue in our universe. The question, like the universe itself, is still open.