Publications Watch *by Andrew J. LePage*

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

Astronomical Journal
Volume 115, Number 1, January 1998

"Statistical Dynamics of Solar-Like Binaries," by Wm. D. Heacox, pp. 325-337

About two-thirds of all the stars in our galaxy are part of a binary system. Whether or not the stars in these systems can support habitable planets in stable orbits is highly dependent on the masses of the components and the characteristics of their orbits. While individual binary systems have been examined to determine if they could possess planets in stable orbits, a detailed statistical model of the distribution of the dynamic properties of binary systems is required to determine how frequently habitable planets can exist in such systems.

Recently such statistical models have been produced using data from surveys of nearby stars. But such surveys have observational biases that can affect their results. One bias in radial velocity surveys, for example, is that they are best at detecting large companions in small orbits and can only determine the lower limit of the secondary's mass. Regardless of observation method, binaries with periods in excess of a couple of centuries have poorly determined orbits. In this paper the author extends these earlier works by employing nonparametric statistical models to study classes of binaries for which key parameters cannot be inferred from the observations made.

The author's statistical models are similar to those based on earlier surveys. Heacox concludes that the smooth distribution of various binary system parameters suggests that all binaries, with periods ranging from days to millennia, form by a common mechanism. The author also finds evidence of a dissipative loss of angular momentum and binding energy either prior to or after binary formation. These processes may also have an effect on the formation of planets in these systems.

Astronomical Journal
Volume 115, Number 1, January 1998

"A Possible Companion to Proxima Centauri," by A.B. Shultz, H.M. Hart, J.L. Hershey, F.C. Hamilton, M. Kochte, F.C. Bruhweiler, G.F. Benedict, John Caldwell, C. Cunningham, Nailong Wu, O.G. Franz, C.D. Keyes, and J.C. Brandt, pp. 345-350

Proxima Centauri, the closest known star to our Solar System, has been subjected to extensive searches for substellar companions for many years without any clear detections. Reported here are the results of a pair of observations using the Hubble Space Telescope (HST) that may have finally found something. This group of investigators used HST's Faint Object Spectrograph (FOS) as a coronagraphic camera to image the vicinity of Proxima Centauri on July 1 and October 13 of 1996 (a full description of this instrument and the results of its other searches for faint companions can be found in "The Hubble Space Telescope and the Search for Faint Extrasolar Companions" in *SETIQuest* Vol. 3, No. 2, pp. 1-9).

These images, obtained in red light, showed a bump on Proxima Centauri's image that was partially covered by an occulting bar. Even with an estimated luminosity that is seven magnitudes less than Proxima Centauri, this companion is too bright to be shining by reflected light alone and must be a large brown dwarf. While an accurate determination of an orbit is not yet possible, a fairly circular orbit with a period on the order of a year would be consistent with the observations.

The authors' investigations have revealed that the object is probably not a background star or an instrument artifact. But astrometric observations and precision radial velocity measurements have failed to reveal the effects of a brown dwarf in a short-period orbit.

One explanation for the data gathered to date is that this suspected companion might be in a highly eccentric, multi-year orbit. More observations will be needed to determine the nature of this new object.

Astronomy
Volume 26, Number 2, February 1998

"From Pebbles to Planets," by Tom Yulsman, pp. 56-61

The theme of this issue of *Astronomy* is origins: the origin of stars, the chemical elements, the large-scale structure of the universe, as well as the origin of the universe itself. While all of these articles give excellent reviews of the present understanding of the "big picture" in the universe, this particular piece covers a topic more pertinent to SETI: the origin of planets.

Yulsman describes the new theories of planet formation based on the latest research and observations of everything from stellar nurseries to the recently discovered extrasolar giant planets.

This piece offers a very readable summary of a highly theoretical field that, to the delight of everyone, has finally been given some real data with which to work.

Astronomy
Volume 26, Number 4, April 1998

"Wanted: Life-Bearing Planets," by Doug McInnis, pp. 38-43

For centuries our technology lagged far behind our desire to know if other "Earths" existed in the universe. But new breakthroughs and novel applications of older techniques should finally close this gap within the next few years. This article reviews the various methods available that will allow us to detect Earth-sized extrasolar planets (for a thorough discussion of indirect photometric methods, see "Detecting Habitable Planets: The Next Decade" in *SETIQuest* Vol. 4, No. 1, pp. 1-6). One method proposes looking for the infrared glow emitted by an infant terrestrial planet after the impact of a large planetesimal. Given the many methods currently or soon to be available, we should be able to make a definitive statement about how common Earth-like planets are within the next few decades.

Astronomy & Astrophysics
Volume 330, February (III) 1998

"Beta Hydri (G2 IV): A Revised Age for the Closest Subgiant," by D. Dravins, L. Lindgren, and D.A. VandenBerg, p. 1077

One of the closer Sun-like stars that has been included in many targeted SETI programs is a type G2 star called Beta Hydri. Using the latest distance estimates based on Hipparcos astrometric measurements, the authors have been able to make more refined calculations of this star's properties. The latest distance measurement places Beta Hydri about 24.4 light years away which, when combined with photometric data, yields a new luminosity of 3.70 $L_{\odot}$. Comparing these data with new models of stellar evolution allowed the authors to estimate the age of Beta Hydri to be about 6.7 billion years. While younger than the previous estimate of 9.5 billion years, this system does not appear to be a promising candidate for SETI since it has begun to evolve off the main sequence and into a subgiant star.

Astronomy & Astrophysics
Volume 332, April (III) 1998

"Planetary Orbits in the Elliptic Restricted Problem IV: The ADS 12033 System," by D. Benest, p. 1147

This paper presents the author's latest work on determining the stability of plane-

tary orbits in specific binary systems (see Benest's previous work in *Astronomy & Astrophysics*, "Planetary Orbits in the Elliptic Restricted Problem III: The η Coronae Borealis System" reviewed in *SETIQuest* Vol. 3, No. 1, pp. 17-18). Benest found that this system, also known as BD +33 3318, can support planets in stable orbits around either Sun-like component out to more than half of the periastron distance. Most importantly, the author found that stable, nearly circular planetary orbits can exist in the habitable zones of each star.

As long as there are no impediments to planet formation, this binary system would be a viable SETI target.

The Astrophysical Journal

Volume 494, Number 1, Part 2
February 10, 1998

"A Search for Line Shape and Depth Variations in 51 Pegasi and τ Bootis," by Timothy M. Brown, Rubina Kotak, Scott D. Horner, Edward J. Kennelly, Sylvain Korzennik, P. Nisenson, and Robert W. Noyes, p. L85

The announcement of the discovery of a closely orbiting gas giant around the Sun-like star 51 Pegasi (see *SETIQuest* Vol. 2, No. 1, p. 5) sent ripples throughout the astronomical community. The existence of this and similar planets discovered in the following years has forced astronomers to develop new theories of solar system formation. While a consensus has yet to be reached, they all involve processes that seriously complicate the origin and survival of habitable terrestrial planets.

More than a year ago David Gray presented his analysis of high resolution spectra he took of 51 Pegasi that seem to show periodic distortions in the shape of a particular spectral line, thus suggesting the presence of pulsations instead of a planet (see "Absence of a Planetary Signature in the Spectra of the Star 51 Pegasi" in the February 27, 1997, issue of *Nature* reviewed in *SETIQuest* Vol. 3, No. 2, p. 19). A later, more detailed analysis of these data by Gray and Hatzes confirmed the initial findings (see "Non-Radial Oscillations in the Solar-Temperature Star 51 Pegasi" in November 20, 1997's issue of *The Astrophysical Journal* reviewed in *SETIQuest* Vol. 4, No. 1, p. 19).

In this paper the results are presented of a detailed analysis of data obtained with the AFOE (Advanced Fiber Optic Echelle). For this work, 59 spectra of 51 Pegasi obtained from November 1995 to July 1996 and 90 spectra of τ Bootis taken between June 1996 and March 1997 were used. Since this instrument's spectral resolution is not good enough to directly measure spectral line shapes, the authors relied upon mathematical methods to characterize the shapes of 60 distinct lines in each star's spectra. Their detection limits are small enough to rule out nonradial oscillations in τ Bootis so the presence of an extrasolar giant planet (EGP) is still the most likely explanation for the observations.

The analysis of the data from 51 Pegasi could not totally rule out oscillations but the investigators feel that given the situation with τ Bootis, an EGP is still the most likely explanation for the data.

Earth

Volume 7, Number 1, February 1998

"Life's Crucible," by Peter Radetsky, pp. 34-41

Like the February 1998 issue of its sister publication, *Astronomy*, reviewed above, this issue of *Earth* is devoted to origins. Of interest are articles on the origin and evolution of the Earth's core, continents, and how the arrangement of the land can affect ocean circulation and regional climates. This article by teacher and author Peter Radetsky on the origin of life should be of particular interest. In this piece, the many theories on the origin of life running from Stanley Miller's first experiments in the 1950s to the latest discoveries of the biochemistry in deep sea hydrothermal systems are comprehensively reviewed in a readable fashion. The article concludes with a section about what this research has to say about life on other worlds and how its discovery can affect the search for our origins.

Geophysical Research Letters

Volume 24, Number 22, November 15, 1997

"Titan Under a Red Giant Sun: A New Kind of 'Habitable' Moon," by Ralph D. Lorenz, Jonathan I. Lunine, and Christopher P. McKay, pp. 2905-2908

Saturn's largest moon, Titan, with its dense organic haze–laden atmosphere of nitrogen, methane, and other compounds, has all the basic ingredients for life. The one stumbling block is that Titan receives only a small fraction of the sunlight the Earth receives resulting in a numbing surface temperature of 94 degrees K. But when the Sun ends its life on the main sequence and becomes a much brighter red giant, Titan will change drastically. Using the latest theories of solar evolution and models of the Titanian atmosphere's response to the Sun's increased luminosity and redder spectrum, the authors explore Titan's climate in the distant future.

Their calculations indicate that in about seven billion years Titan will become warm enough for its icy mantle to melt, forming a deep ammonia-water ocean. Combined with the organic deposits that have built up on its surface over billions of years, Titan will have a colder, more reducing and alkaline version of a "primordial soup" which the authors have dubbed a "primordial gazpacho." Given that these conditions are expected to last for at least 500 million years, life might manage to arise on this world after being frozen for 11 billion years. For a thorough discussion of the implications of this work on planetary habitability in general, refer to "The Extremes of Habitability" in this issue of *SETIQuest*.

Geophysical Research Letters

Volume 25, Number 3, February 1, 1998

"Solar Irradiance Since 1874 Revisited," by S.K. Solanki and M. Fligge, pp. 341-344

A long-held belief among astronomers is that the Sun's luminosity is constant. This belief is reflected in the term "solar constant," referring to the 1368 watts a square meter receives from the Sun on the Earth. For some time now, however, it has been known that in reality the Sun's luminosity does exhibit temporal variations large enough to affect the Earth's climate.

In this paper the authors examine previous models and improved sunspot and facular data to determine how the Sun's luminosity has varied in the past 115 years. The authors' analysis indicates that the Sun's luminosity varies in sync with the solar sunspot cycle by as much as 0.08 percent or 0.8 millimagnitudes. Superimposed on the luminosity variations from the 12-year sunspot cycle is a long-term increase amounting to about 3 percent or 3 millimagnitudes in the past century. While these variations in luminosity are tiny compared to those seen in classic variable stars, the observed long-term trend in solar luminosity hints that it can vary by significant amounts on time scales of centuries or much longer.

Icarus

Volume 131, Number 1, January 1998

"Oligarchic Growth of Protoplanets," by Eiichiro Kokubo and Shigeru Ida, p. 171

The details of the planet formation process can have a profound influence on the size and arrangement of planets (including habitable planets) in a system. In this paper the authors describe some interesting results from three-dimensional, N-body simulations of the growth of protoplanets in a swarm of planetesimals. Kokubo and Ida performed two sets of calculations with different initial conditions. In the first they used a system with 4,000 planetesimals each with a mass of 1.5×10^{23} grams (2.5×10^{-5} $M_{\oplus}$) plus two protoplanetary seeds with a mass 40 times greater than an individual planetesimal. In the second a swarm of 4000 identical

planetesimals with a mass of 10^{24} grams (1.7×10^{-4} $M_\oplus$) was examined.

First they observed that the protoplanets (whether introduced at the beginning of the simulation or grown inside it) grow faster than the planetesimals. The net result is that once a protoplanet forms it experiences runaway growth. Gravitational interactions between the growing protoplanets in the planetesimal swarm result in their orbits becoming farther apart over time. During this period of orbital repulsion, the protoplanets remain separated by at least five Hill radii (with one Hill radius providing one definition of the minimum separation between bodies for a stable orbit).

In addition, it was found that large protoplanets grow more slowly than smaller ones, resulting in the finished planets having approximately equal masses. The final result of this self-organized runaway growth is a pair of Earth-sized planets in stable orbits similar to the situation with Venus and Earth in our Solar System. While these planets can be positioned almost anywhere in the inner Solar System, one of them can usually be found with a semimajor axis of about 1 AU. If this is the way terrestrial planets in other solar systems form, stars similar to the Sun are almost guaranteed to possess an Earth-sized terrestrial planet in or near the stars' habitable zones.

Icarus

Volume 132, Number 1, March 1998

"Habitable Planet Formation in Binary Star Systems," by Daniel P. Whitmire, John J. Matese, Lee Criswell, and Seppo Mikkola, p. 196

While there are frequently regions in binary systems where planets can have stable orbits, for some time researchers believed that planet formation would be inhibited in most of these systems. This is primarily because the orbits of the planetesimals in a protoplanetary disk surrounding stars in a binary system would be perturbed too much by the presence of a stellar companion. As a result, the typical relative velocity between planetesimals becomes so great that these bodies are disrupted upon collision instead of building into a larger body and eventually into a planet.

In this paper, the authors examine the details of the orbital evolution of a pair of closely orbiting planetesimals in binary systems with various dynamic parameters. The authors wanted to determine under what conditions the orbits of these planetesimals will cross so as to promote building larger bodies instead of resulting in disruption. In all these four-body simulations, the primary was a Sun-like star. Computer runs were made using secondaries with various masses, semimajor axis sizes, and orbital eccentricities.

According to the results of the simulations with a pair of Sun-sized stars, for example, a planet will not form at 1 AU when the periastron of the stellar companion is less than 16 AU. If we assume that the outer bounds of such a star's continuously habitable zone lies at 2 AU, the minimum periastron distance that allows planets to form anywhere in the continuously habitable zone is about 28 AU. As expected, these distances decrease with decreasing secondary mass. Simulations of the Sun-Jupiter system are consistent with the formation of a planet at 1 AU but not at the inner edge of the asteroid belt at 2.2 AU or closer. According to surveys of nearby Sun-like binary systems, 57 percent will have periastrons large enough to allow a habitable planet to form.

Another situation examined was the case of planetesimals orbiting a pair of Sun-like stars locked in a small orbit. These simulations indicate that the maximum separation of these components that allows the formation of a planet with an insolation of 1 $S_\oplus$ is about 0.10 AU. Surveys indicate that about two percent of Sun-like binary systems meet this criterion. While this work is just the first step toward studying the details of planet formation in binary systems, it appears that 59 percent of Sun-like stars in binary systems can form a planet 1 AU from its primary.

Mercury

Volume 27, Number 1
January/February 1998

"The Peroxide Planet," by Aaron Zent, p. 11

This research review briefly describes the quest for oxidants in Martian surface materials. The presence of peroxides, superoxides, or other strong oxidants is the currently favored explanation for the results of the Viking biological investigations two decades ago (see "Viking and the Question of Life on Mars, Part 2: The Mission to Mars" in *SETIQuest* Vol. 3, No. 4, pp. 1-7).

Identification of the putative oxidants and their potential toxic effects in humans is required before crewed missions to Mars are mounted. The pair of landers carried by the ill-fated Russian Mars 96 probe were each equipped with an instrument to make some of these measurements.

In 1999, NASA plans to land a spacecraft near the Martian south pole that will carry an instrument to measure the amount of oxygen released from a soil sample as it is heated. Future Mars landers will also be equipped to look for oxidants in the Martian environment. If these oxidants do exist we should finally learn much more about them in the next few years.

Monthly Notices of the Royal Astronomical Society

Volume 291, Number 3, November 1, 1997

"Stability of Planets Orbiting BD+31 643," by Adrian Brunini, pp. L47-L48

More than a year ago the discovery of a dust disk surrounding BD+31 643 was announced in a paper published in the March 6, 1997, issue of *Nature* (see "A Candidate Dust Disk Surrounding the Binary Stellar System BD+31 643" by Kalas and Jewitt reviewed in *SETIQuest* Vol. 3, No. 2, pp. 19-20). While this distant pair of young 6 $M_\odot$ B5V stars is not likely to harbor any habitable planets, it does offer astronomers the opportunity to study planet formation in binary star systems.

According to the author's calculations, planetary embryos can exist beyond 1,000 AU from the system's center of mass while any material closer to the binary will be cleared away. This result agrees with the observed 2,300 AU size of the inner depleted region of this system's dust disk and hints that planet formation might be possible in this system.

National Geographic

Volume 193, Number 3, March 1998

"The Rise of Life on Earth," by Richard Monastersky, pp. 54-88

This excellent piece presents a very readable outline of our current understanding of the origin of life and its first couple of billion years of evolution on our planet. Richly illustrated with photographs by O. Louis Mazzatenta and drawings by the *National Geographic* staff, this article is a must for scientists and laymen alike who are interested in learning more about our origins and the possibility of life elsewhere in the universe. More information on the rise of life on Earth can be found at the *National Geographic*'s online forum at www.nationalgeographic.com

Nature

Volume 391, Number 6663, January 8, 1998

"A Planetary Companion for 51 Pegasi Implied by the Absence of Pulsations in the Stellar Spectra," by David F. Gray, pp. 153-154

"Further Evidence for the Planet Around 51 Pegasi," by Artie P. Hatzes, William D. Cochran, and Eric J. Bakker, pp. 154-156

As described in the earlier review of *The Astrophysical Journal* paper by Brown et al., the recent round of debate on the origin of the short-period radial velocity variations observed in Sun-like stars such as 51 Pegasi began more than a year ago with Gray's

paper in *Nature* (reviewed in *SETIQuest* Vol. 3, No. 2, p. 19). Described in these papers are the results of two new analyses of spectra of 51 Pegasi independently taken by Gray and by Hatzes's team at the University of Texas McDonald Observatory that seem to have swung the balance back in favor of a planetary explanation for the observations to date.

In the first paper, Gray discusses the results of 30 additional high-resolution spectra he took between July 20 and October 29, 1997, of the Fe I line at 6,253 angstrom. An analysis of these data alone, and these data combined with Gray's earlier measurements, indicate that there are *not* any periodic changes in the shape of the line. The previously reported periodicity was probably the result of chance alignments of a limited number of noisy data points.

Hatzes et al. made 120 independent measurements on 18 nights between July and September of 1997 using McDonald Observatory's 2.7-meter Harlan J. Smith telescope. Their analysis also shows the lack of any periodic changes in the spectral line shapes. All of these new papers seem to rule out stellar pulsations as the cause of what has been observed and the presence of a planet is now back in favor. Although independent confirmation of the existence of these "hot Jupiters" is still welcomed, it seems that theorists will have to continue their efforts to explain the origins of these new worlds and their effects on habitable terrestrial planets.

Nature

Volume 391, Number 6665, January 22, 1998

"Evidence for a Subsurface Ocean on Europa," by Michael H. Carr, Michael J.S. Belton, Clark R. Chapman, Merton E. Davies, Paul Geissler, Richard Greenberg, Alfred S. McEwen, Bruce R. Tufts, Ronald Greely, Robert Sullivan, James W. Head, Robert T. Pappalardo, Kenneth P. Klaasen, Torrence V. Johnson, James Kaufman, David Senske, Jeffrey Moore, Gerhard Neukum, Gerald Schubert, Joseph A. Burns, Peter Thomas, and Joseph Veverka, pp. 363-365

"Geological Evidence for Solid-State Convection in Europa's Ice Shell," by R.T. Pappalardo, J.W. Head, R. Greeley, R.J. Sullivan, C. Pilcher, G. Schubert, W.B. Moore, M.H. Carr, J.M Moore, M.J.S. Belton, and D.L. Goldsby, pp. 365-368

"Evidence for Non-Synchronous Rotation of Europa," by P.E. Geissler, R. Greenberg, G. Hoppa, P. Helfenstein, A. McEwen, R. Pappalardo, R. Tufts, M. Ockert-Bell, R. Sullivan, R. Greeley, M.J.S. Belton, T. Denk, B. Clark, J. Burns, J. Veverka, and the Galileo Imaging Team, pp. 368-370

"Episodic Plate Separation and Fracture Infill on the Surface of Europa," by Robert Sullivan, Ronald Greeler, Kim Homan, James Klemaszewski, Michael J.S. Belton, Michael H. Carr, Clark R. Chapman, Randy Tufts, James W. Head III, Robert Pappalardo, Jeffrey Moore, Peter Thomas, and the Galileo Imaging Team, pp. 371-373

In recent months the possibility that Europa has an ocean of tidally heated water beneath its crust of ice has sparked much interest among exobiologists. Liquid water and the presence of tidally generated hydrothermal activity are considered two important ingredients for life. This series of papers details the latest analysis of the Galileo spacecraft's imagery of Europa. While an ocean of water has not been directly observed, the indirect evidence strongly suggests that Europa has (or did have in the recent past) such a body of water. The extent of resurfacing, the morphology of a range of surface features, and the global distribution of these features all point to a layer of ice underlain by a deep layer of liquid water. Additional data from the ongoing Galileo Europa Mission and ongoing analysis of data in hand promises to further build a case for a Europan ocean.

Nature

Volume 392, Number 6671, March 5, 1998

"The Hydrogen Hypothesis for the First Eukaryote," by William Martin and Miklos Muller, pp. 37-41

The prevailing view of the origin of eukaryotes (the kingdom of life that includes all "higher" life forms from fungi to humans) is that they arose when an anaerobic proto-eukaryote engulfed an aerobic prokaryote. Sometimes instead of being digested, the prokaryote became an endosymbiont that supplied respiration-derived APT (the primary source of cellular energy) to its new host in exchange for easily metabolized raw materials and protection. These early endosymbionts eventually evolved into mitochondria and the other organella present in eukaryotes today. This arrangement gave early eukaryotes a metabolic advantage over their less advanced predecessors.

In this paper Martin and Muller propose a new hypothesis for the origin of eukaryotes. The authors propose that an archean (or a close relative) took on an α-proteobacterium as an endosymbiont. This bacterium originally produced hydrogen and carbon dioxide as byproducts of anaerobic fermentation, which were then used by the archean host as raw materials to drive its metabolic cycles. This would have allowed the archean host to survive in anaerobic environments poor in the raw materials it normally requires. As time went on, this symbiotic pair would evolve a much tighter relationship that eventually allowed the transfer of more complex metabolic products (e.g., APT) and allow its host to exist in aerobic environments as seen in eukaryotes today.

Nature

Volume 392, Number 6674, March 26, 1998

"The Complete Genome of the Hyperthermophilic Bacterium Aquifex Aeolicus," by Gerard Deckert, Patrick V. Warren, Terry Gaasterland, William G. Young, Anna L. Lenox, David E. Graham, Ross Overbeek, Marjory A. Snead, Martin Keller, Monette Aujay, Robert Huber, Robert A. Feldman, Jay M. Short, Gary J. Olsen, and Ronald V. Swanson, pp. 353-358

Presented here is the complete genome of Aquifex aeolicus which is one of the earliest diverging and most thermophylic bacteria known. Its genome contains 1.55 million base pairs and is only a third of the size of more evolved organisms like *E. coli.*

Despite its small size, this chemolithoautotroph supports the complex metabolic machinery needed to use hydrogen, traces of oxygen, carbon dioxide, and mineral salts for biosynthesis and energy at temperatures of 95 degrees C. Even though it requires these high temperatures for survival, this bacterium's genome sports few specific indications for thermophily.

A detailed comparison of this genome with those of the other dozen microorganisms that have also been mapped to date should yield many new insights into the origin of the Earth's three kingdoms of life (i.e., bacteria, archea, and eukarya).

Science

Volume 279, Number 5347, January 2, 1998

"Migrating Planets," by N. Murray, B. Hansen, M. Holman, and S. Tremaine, pp. 69-72

One of the ways to reconcile the existence of extrasolar giant planets (EGPs) in small orbits with the previously accepted theories of planet formation (which had predicted that EGPs would have large orbits like Jupiter) is by means of planet migration. This paper examines in detail the resonant gravitational interactions between a forming EGP and a disk of planetesimals.

The authors' calculations indicate that a Jupiter-like EGP will begin to migrate inward when the planetesimal disk mass within its orbit reaches $6 \times 10^{4}\ M_{\odot}$.

With an interior disk mass as large as $2 \times 10^{-2}\ M_{\odot}$, an EGP would migrate to 0.03 AU from its sun.

When more than one EGP is present in a

system, gravitational interactions become more complex. In such a case migration will start with a lower disk mass and the innermost EGP migrates inward while the others migrate outward.

The authors conclude that it is unlikely that any planets (like potentially habitable terrestrial planets) in the migration path of the EGP will survive. Obviously the mass distribution of a system's protoplanetary disk and the presence of EGPs can have a profound influence on the likelihood that a habitable body will form.

Science
Volume 279, Number 5349
January 16, 1998

"A Search for Endogenous Amino Acids in the Martian Meteorite ALH84001," by Jeffrey L. Bada, Daniel P. Glavin, Gene D. McDonald, and Luann Becker, pp. 362-365

"Isotopic Evidence for a Terrestrial Source of Organic Compounds Found in the Martian Meteorites Allan Hills 84001 and Elephant Moraine 79001," by A.J.T. Jull, C. Courtney, D.A. Jeffrey, and J.W. Beck, pp. 366-369

One of the key pieces of evidence for the existence of the remains of Martian life in the meteorite ALH84001 is the presence of organic compounds associated with the carbonates that hold the putative microfossils. These two papers present the latest isotopic analyses of the organic compounds found in ALH84001 in the hope of determining their origins.

The results reported here indicate that the bulk of the organic compounds found in this meteorite are terrestrial contaminants. While these papers are not good news for the Martian microfossil camp, these results are not necessarily the last word on the subject. The original analysis of the organic compounds in ALH84001 by McKay et al. centered on the concentration and location of a particular class of organic compounds called PAHs (Polycyclic Aromatic Hydrocarbons); this work by Bada et al. looked at amino acids. While it would seem that the search for Martian amino acids will not be possible because of the terrestrial contamination, this research does not directly address the origin of the PAHs which could still be native to Mars.

The analysis by Jull et al. looked at all organic compounds of which PAHs constitute only one percent by weight. Their technique was not designed to look at the isotopic composition of just the PAHs so a Martian origin for these compounds cannot yet be excluded.

Further background information on the debate about the putative microfossils in ALH84001 can be found in the editorial by Julian Hiscox in this issue of *SETIQuest*.

Science
Volume 279, Number 5351, January 31, 1998

"Russian Outpost Readies for Otherworldly Quest," by Richard Stone, pp. 658-661

For decades the dry valleys of Antarctica have served as a terrestrial analog for studying the possibility of life on Mars. Scientists are about to embark on an exploration of another Antarctic environment that may serve as an analog for an ocean thought to exist beneath the icy surface of Europa. This special news report reviews Russian efforts to drill into the Antarctic ice sheet at Vostok station.

In the mid-1970s, a 14,000 square kilometer lake of fresh water, Lake Vostok, was detected by radar about 4 kilometers under the site of the Russians' ice coring operation. The current plan calls for stopping the drilling operation several hundred meters above the lake until a means can be found to reach the lake without contaminating it. Scientists hope to find microorganisms living in the lake that have been in isolation for millions of years. A study of these life forms could shed light on the possibility of life on Europa. This site could also prove to be a useful testing ground for techniques and hardware that may one day burrow through Europa's crust of ice to explore its ocean below.

Science
Volume 279, Number 5352, February 6, 1998

"Organic Shielding of Greenhouse Gases on Early Earth," by S.L. Miller and J.R. Lyons, p. 779

This piece addresses a recent paper in *Science* by Sagan and Chyba on using ammonia shielded by an organic haze layer as a means of enhancing the greenhouse effect on the early Earth and solving the faint early Sun paradox (this paper is reviewed in *SETIQuest* Vol. 3, No. 3, pp. 21-22). The authors of this technical comment point out that Sagan and Chyba's scenario is reminiscent of Miller's early studies of the formation of amino acids in a reducing atmosphere.

The full text of this comment and of Chyba's response can be found online at www.sciencemag.org/cgi/content/full//279/5352/779a

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Science
Volume 279, Number 5355
February 27, 1998

"Preventing a Mars Attack," by Martin Enserink, p. 1309

If everything goes as planned, about 0.5 kilograms of Martian surface samples will be returned to Earth by a NASA spacecraft a decade from now. But what precautions will be taken to prevent terrestrial microbes from contaminating the Martian samples? Although most scientists believe that there is only a remote chance that any Martian microbes present in the returned sample will threaten terrestrial life, what precautions are being taken to prevent them from being released into our biosphere?

This article reports NASA's current plans to handle and isolate Martian samples as outlined at the 150th annual meeting of the AAAS (American Association for the Advancement of Science) held February 12 to 17, 1998, in Philadelphia. The proposed process begins on the surface of Mars where the sample will be hermetically sealed in a double-layered container whose exterior will be sterilized before starting the trip back to Earth. If a leak develops during transit, provisions will be made to sterilize the sample during flight or to redirect the return craft away from the Earth.

Once on Earth, the sample canister will be taken to an as-yet-unbuilt Mars Receiving Laboratory where it will be placed in a low-pressure biological safety cabinet or glove box. The outer shell of the returned canister, which would now be contaminated by terrestrial sources, would then be re-sterilized. After this step, the Martian atmosphere trapped between the two layers of the container will be sampled. Afterward the outer layer of the sample canister will be stripped off and the inner container transferred to a second glove box. At this point the seal of the inner container can be broken and the sample studied.

While this procedure appears to adequately safeguard both the sample and the terrestrial biosphere from contamination, there are still many concerns that will need to be addressed before samples from Mars can be safely returned to Earth for study.

Science
Volume 279, Number 5357, March 13, 1998

"Mars Global Surveyor Mission: Overview and Status," by A.L. Albee, F.D. Palluconi, and R.E. Arvidson, pp. 1671-1672

"Magnetic Field and Plasma Observations at Mars: Initial Results of the Mars Global Surveyor Mission," by M.H. Acuna, J.E.P. Connerney, P. Wasilewski, R.P. Lin, K.A. Anderson, C.W. Carlson, J. McFadden, D.W. Curtis, D. Mitchell, H. Reme, C. Mazelle, J.A. Sauvaud, C. d'Uston, A. Cros, J.L. Medale, S.J. Bauer, P. Cloutier, M. Mayhew, D. Winterhalter, and N.F. Ness, pp. 1676-1680

"Early Views of the Martian Surface from the Mars Orbiter Camera of the Mars Global Surveyor," by M.C. Malin, M.H. Carr, G.E. Danielson, M.E. Davies, W.K.

Hartmann, A.P. Ingersoll, P.B. James, H. Masursky, A.S. McEwen, L.A. Soderblom, P. Thomas, J. Veverka, M.A Caplinger, M.A. Ravine, T.A. Soulanille, and J.L. Warren, pp. 1681-1685

"Topography of the Northern Hemisphere of Mars from the Mars Orbiter Laser Altimeter," D.E. Smith, M.T. Zuber, H.V. Frey, J.B. Garvin, J.W. Head, D.O. Muhleman, G.H. Pettengill, R.J. Phillips, S.C. Solomon, H.J. Zwally, W.B. Banerdt, and T.C. Duxbury, pp. 1686-1692

Presented in this issue of *Science* is a series of papers summarizing the initial scientific findings of the Mars Global Surveyor (MGS) mission. I have listed here those papers with particular relevance to Mars's more habitable past.

One of the first discoveries made during this mission was the lack of any active, magnetic field producing dynamo on Mars today. Interestingly some regions of the Martian crust (on the order of 100 kilometers across) appear to have remnant magnetism from a time when Mars did possess a strong global magnetic field. A detailed mapping of these magnetic anomalies should allow a history of Mars's magnetic activity to be deduced as well as an estimate for when its dynamo became inactive.

While MGS has yet to reach its final mapping orbit, it has nonetheless returned some strikingly detailed images of the Martian surface with resolution as good as a few meters. Images like the one on the cover of this issue of *SETIQuest* indicate that Mars probably experienced extended periods of time where water flowed on its surface. Many of the images returned also show banded outcrops of rock unbroken by asteroid/comet impact craters. While it is still unclear whether these strata are the result of volcanism or sediments laid down in an ancient ocean, it indicates that Mars was a significantly different place 3.5 billion years ago.

Laser altimeter measurements across the mouth of the Ares Vallis channel near the Mars Pathfinder landing site indicate that this one valley carried five cubic kilometers of water each second when it was filled—an order of magnitude larger than earlier estimates. The elevation measurements of Mars's northern hemisphere has shown it to be exceptionally flat with slopes increasing toward the equator. This region's elevation profile is strongly reminiscent of Earth's ocean basins and hints that Mars's northern hemisphere may have also supported an ocean in the distant past. Filled to a depth of only one kilometer, this ocean would have had a volume comparable to Earth's Arctic Ocean. These findings are just tantalizing hints of what is to come from the continuing MGS mission.

Science

Volume 279, Number 5358, March 20, 1998

"Ames Tackles the Riddle of Life," by Andrew Lawler, pp. 1840-1841

With the discovery of extrasolar planets, possible fossils from Mars, a possible ocean on Europa, life in extreme terrestrial environments, and other recent finds, scientists from a wide range of disciplines are beginning to collaborate to fit together these various pieces into a much broader picture. This work is spawning a new science, called astrobiology, which hopes to determine the origin of life and the conditions that lead to it.

This article covers the upcoming unveiling of the Astrobiology Institute at the NASA Ames Research Center. With an initial budget of $4 million and funding commitments for up to five more years, this new institute will help define the focus of this new field and coordinate the research activities of astronomers, biologists, chemists, geologists, and scientists from other specialties to address the most fundamental questions about life.

Scientific American Quarterly

Volume 9, Number 1, Spring 1998

"Giant Planets Orbiting Faraway Stars," by Geoffrey W. Marcy and R. Paul Butler, pp. 10-15

"Searching for Life in Our Solar System," by Bruce M. Jakosky, pp. 16-21

"Searching for Life in Other Solar Systems," by Roger Angel and Neville J. Woolf, pp. 22-25

This (newstand) issue of *Scientific American Quarterly,* whose theme is "Magnificent Cosmos," presents a collection of articles on various aspects of astronomy written by many of the scientists involved. This whole collection is highly recommended for anyone interested in astronomy but the three articles listed here have particular relevance to astrobiology.

Marcy and Butler present a very readable account of the planets discovered to date and their implications for future searches and theories of planet formation.

The article by Jakosky reviews the present thinking on the possibility of life, past or present, on Mars, Europa, Venus, and elsewhere in our own Solar System based on the latest research.

The last piece listed by Angel and Woolf is a more concise and updated version of the article they wrote on searching for Earth-like extrasolar planets which appeared in April 1996 *Scientific American* (for a review, see *SETIQuest* Vol. 2, No. 3, p. 23).

Search Lites

Volume 4, Number 2, Spring 1998

"ET Detection of Earth TV Unlikely," by Dale Lamm, p. 5

Our planet's radio transmissions are often cited as an example of an unintentional beacon that extraterrestrial intelligence (ETI) could use to find us. In this article the author addresses the possibility of extraterrestrials intercepting our television and other radio transmissions over interstellar distances.

Lamm concludes that this is highly unlikely since most of a commercial transmitter's power is directed toward the ground where potential customers have their receivers. Probably the only way ETIs could detect such transmissions would be from an interstellar probe that they have sent to pass close to our Solar System. Our radio transmissions would be much more easily detected from this range and could then be relayed back to the probe's home planet. A much better unintentional terrestrial beacon would be the various space surveillance radars that scan our skies for Earth-orbiting satellites.