Editorial: A Call to Action

by Andrew J. LePage

When I initially looked back on 1996 I thought that so many goals related to exobiology and SETI had been achieved: The discovery of extrasolar planets and the finding of possible signs of ancient life in the Martian meteorite ALH84001 (see "The Case for Ancient Life on Mars," *SETIQuest*, Volume 2, Number 4, pp. 14-18). These are the more generally recognized significant events in 1996.

The recent discovery of extrasolar planets is important because it answers the question: "Do planets indeed circle other stars?" Now it seems that life has a possible home in other solar systems. The discovery of possible fossil life in ALH84001 indicates that life may once have existed on Mars which is the only other planet in our solar system with evidence of a more Earth-like or habitable past. One of the major implications of this find is that life may inevitably form anywhere where reasonably habitable conditions exist in the early days of a solar system. Taken together, these two major discoveries have sparked optimism that life may be more common in the universe than we could have ever hoped for.

In the light of this new optimism, it now seems possible that life thrives in previously unsuspected places even in our own solar system. One new candidate is the ice-covered Jovian moon Europa. Data taken nearly two decades ago during the *Voyager* flyby missions and recent additions by the *Galileo* spacecraft in orbit around Jupiter indicate that Europa may have a kilometers-deep ocean of liquid water below a relatively thin crust of ice. The water is believed to be kept liquid by tidally generated heat. This same heat source may also produce active hydrothermal vents that could, in theory, feed thriving ecosystems just as we see near hydrothermal springs deep in the Earth's oceans.

While these discoveries and the possibilities they raise certainly feed our imaginations, institutional inertia makes it unlikely that any drastic changes to SETI or exobiology programs will be immediately forthcoming. In addition, these discoveries only emphasize the vast amount of work that still needs to be done in these fields. The planets that have been found to date are not on the most scientifically secure footing. Almost all of them have been discovered by the indirect means of radial velocity measurements.

While the radial velocity measurements that led to the discovery of several extrasolar planets have been confirmed by other groups, there is still the very real possibility that some of these measurements are corrupted by some previously unrecognized form of stellar activity. This is especially true of the short period "Hot Jupiters" such as the one reported orbiting 51 Pegasi and other nearby stars. While I personally do not believe this to be true in every case, independent confirmation of all these finds by other techniques will not only squelch any remaining doubt of the existence of these bodies, but it will also provide additional information on the nature and properties of these new worlds.

But this information will not be quickly forthcoming. So far, astrometry has failed to detect any of the extrasolar planets found in radial velocity surveys. And in the case of Lalande 21185, the astrometric detection has yet to be confirmed by radial velocity or other measurements. At best these negative observations confirm that these bodies are at least substellar in nature but they cannot eliminate the possibility that they do not exist. The technology (and instruments) needed to independently detect these planets through, for example, ultra-high precision astrometry and direct imaging is just now being developed and built. Significant numbers of confirmations and new discoveries are still several years off.

One healthy outcome from the first extrasolar planet discoveries is that it offers our first peek at possible outcomes of the planet formation process. While we have been getting increasingly detailed looks at the earliest stages of planet formation by observing circumstellar disks surrounding young stars, until recently we only had our own solar system as an example of the outcome of this complex process. Almost without exception, all the older models of this process that were developed by theoreticians reproduced the arrangement of planets we find in our solar system (i.e., small terrestrial planets close by and gas giants further out in the extrasolar planetary system). We are now finding that at least in a few percent of Sun-like extrasolar planetary systems, gas giants can be found deep inside the inner realms of the system. How these planets came to be this close to their suns is unknown but most of the new theories on their origins imply that such planets would eliminate any possibility of finding Earth-like planets in these systems.

There is also the problem of where all the "Jupiters" are. As mentioned earlier, previous theories of planet formation indicated that Jupiter-sized planets will be most common in orbits larger than 5 AU. Except for the companion of 47 Ursae Majoris, all of the radial velocity surveys to date have failed to find any Jupiter-like planets in distant orbits. This dearth of finds troubles some astronomers but I still think it is a bit early to be sounding the alarms. All the surveys to date have failed to find gas giants twice as large as Jupiter in orbits out to about 4 or 5 AU. There could still be plenty of "Jupiters" or "Saturns" out there that the radial velocity surveys have not detected. High-precision astrometry is the best means of detecting these sorts of bodies but the technology needed to find such planets around significant numbers of Sun-like stars is just now becoming widely available; years of data will be needed to either confirm or allay the fears of astronomers.

The new extrasolar-planet finds should help us develop more realistic models of solar system formation and definitively determine the possible arrangements of planets in other solar systems. These new models should finally help us get a better feel for the frequency of Earth-like planets like Jovian planets as cometary "shields" to prevent post-accretion bombardment.

The development of these models and gathering the data needed to confirm their predictions will, however, take time. Even if a few percent of Sun-like stars cannot have terrestrial planets due to the presence of close orbiting gas giants, they do offer a previously unrecognized home for extraterrestrial life: Habitable moons. I discussed this possibility in detail in the last issue of *SETIQuest* (Volume 3, Number 1, pp. 8-16) but even in this case there are a significant number of questions involving habitability and planet formation that will require time to answer.

One major question that is still left to be answered is the ubiquity of Earth-like planets. None of the current or soon-to-be-started projects is capable of finding Earth-like planets. Earth-based searches for microlensing events are being contemplated but it will be years before a significant enough number of events are observed to draw any conclusions. Kepler, a proposed space-based telescope that will photometrically search for transits of Earth-like planets in front of their suns, is the most likely candidate to indirectly detect another Earth but its launch is several years away—assuming it receives funding from NASA. Solar orbiting interferometric arrays that could directly image Earth-like planets and determine the composition of their atmospheres are at least a score of years away. Dreams of building instruments that could resolve surface details on such planets certainly capture the public's imagination but in the end it appears that such plans are impossible to implement with any foreseeable technology. In any case, much work remains to be done before we will know how common Earth-like planets really are in our galaxy.

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The discovery of possible fossils in ALH84001 is still quite controversial. Already dozens of papers are working their way through the process of peer review that in some cases support, and in others refute, the nature of the discovery of Martian fossils. The greatest concern is that of Earthly contamination that could invalidate the results to date. It will be years before any consensus is reached in the scientific community about the true nature of this find. While there have been predictions by many space exploration enthusiasts that funding for unmanned Mars missions will be increased and the time line for a Mars sample return mission will be pushed up by several years, NASA management and those in Congress do not share this view. The truth of the matter is NASA and other government-funded science organizations are going to have to contend with ever-tightening budgets in an effort to rein in spending and balance the federal budget.

This is not to say that federally financed programs will not take place but space exploration and SETI advocates will have to contend with stark budgetary realities. Nonetheless, the United States has two spacecraft currently en route to Mars. While they are not designed to specifically answer the question of life, past or present, on Mars, they will supply a vast amount of information on current conditions on Mars and help planetologists determine the nature of its atmospheric, geologic, and hydrologic cycles, and how they have changed over the long history of this planet.

Unfortunately the Russian-led Mars 96 mission has failed and with it Russia's once great planetary exploration program seems to have died. The loss of this important contribution to Mars exploration will be felt for years to come. Still, there is a continued commitment by NASA to send ever more sophisticated probes to Mars at every launch opportunity in an effort to systematically explore the Red Planet and unravel its many mysteries. Eventually a sample return mission will return pristine samples for examination and maybe a crewed expedition will be launched in the next century. But all this will have to be done within realistic budgets over many years and decades.

In the meantime, there are signs that the American efforts are beginning to come into focus. A consensus is now building on what NASA calls the Origins Program. All of the previously unrelated programs ranging from the Hubble Space Telescope to Mars probes to laboratory studies are now being redirected to help determine the origins of the universe, the Earth, and life. While this new focus for NASA will most likely not be accompanied by larger budgets, it will provide a common vision that over the years will come to help us discover our origins and determine if we are alone.

While things look more promising for changing the focus of federally funded programs, privately funded ventures and amateur activities will still be needed. Personally I would be surprised to see any major new federal spending on SETI despite all the recent headlines. Current professional SETI programs such as Project BETA, SERENDIP, PHOENIX, and others will still have to rely on private financing. Hopefully the increase in public interest in potential ETI from the latest spurt of scientific discoveries and popular movies will be followed by increased willingness to donate funding for these and future worthwhile SETI projects.

For centuries astronomy has relied heavily on amateurs to fill in the gaps left by professionals. Even today amateur astronomers are responsible for gathering data on Martian weather conditions for NASA and they make the majority of comet discoveries such as Comet Hyakutake that appeared in early 1996 and Comet Hale-Bopp that graced our skies earlier this year.

In light of the current and future budgetary situations, amateur SETI activities will be needed more and more to complement larger, privately funded projects. Radio projects like BAMBI and the SETI League's Project Argus are two examples of how radio enthusiasts can help with only modest equipment. Optical SETI using equipment like that found in Stuart Kingsley's Columbus Optical SETI Observatory demonstrates that even amateur optical astronomers can make meaningful SETI observations. Increased awareness of these sorts of projects should help swell the ranks of amateur SETI and possibly make the find of a lifetime.