

**A Historical Account of the Origin, Evolution, and  
Demise of NASA's Oxymoronic "Astrobiology"/  
The "Arsenic Monster" of Mono Lake/ and a Modest  
Proposal to Educate Dabblers in Microbiology Research**

*A Select Time Line of Speculations on Extraterrestrial  
Life, from Elephants on the Moon to Phantom Microbes  
on Mars; Earth's Bacteria in the Guise of Life  
"Elsewhere" and the Death Knell of the  
"Arsenic Monster" of Mono Lake*

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## INTRODUCTION

**This essay presents a select Time Line for early speculations on “extraterrestrial life” and attempts to obtain experimental evidence for past or present life on the Moon and Mars. To date, there is no credible evidence for “life elsewhere,” even the simplest forms (microbes). Nevertheless, NASA continues to trumpet “astrobiology,” an oxymoron that suggests or implies that life has actually been found beyond Earth. NASA exploits the fallacious notion that the existence of terrestrial bacteria able to live under “extreme” chemical or physical conditions (“extremophiles) provides *hope* for “astrobiology.” In December 2010, NASA announced, in a massive publicity event, that their grantees isolated a bacterium from sediment mud of Mono Lake (CA) that defies basic biochemical principles of all known forms of life on Earth in that arsenic replaces phosphorus in its DNA and other P-containing essential metabolites. After the December 2,**

**2010 press extravaganza, the so-called evidence for the “Arsenic Monster Bacterium” was described in an on-line paper in *Science* magazine. Almost immediately, there was an unprecedented outpouring of news reports and Internet blogs that soon became an avalanche, even for Google. Aside from opinions of science-fiction buffs, comments from microbiologists and biochemists were mainly dubious. Attempts are being made to confirm basic aspects of the “Arsenic Monster Story,” a presumed harbinger of “life elsewhere,” but thus far they have not been successful.**

### **What is “astrobiology” ?**

**“NASA’s Astrobiology Roadmap” [see D. Goldin] modestly describes “astrobiology” as “study of the origin, evolution, distribution and destiny of life in the universe. Astrobiology represents a synthesis of disciplines from astronomy to zoology, from ecology to molecular biology, and from geology to genomics.”**

**Since there is no biology of any kind known other than on Earth, the buzzword “astrobiology” is an oxymoron that does not represent a coherent scientific**

field. The word simply expresses a *hope* that life will be found beyond Earth. Philosopher-journalist A.C. Grayling (see ref. below) has said of *hope*: “The deceitfulness of *hope* gives it a bad name; for every ten thousand men there are a million hopes, but very few are realized. It offers lies as truth, and traps people in vain pursuits, which leads them on greater disillusionments later....the fact that hope always applies to the future makes it a cheaply purchased, endlessly renewable commodity.”

Goldin, D. *Astrobiology Roadmap. Undated NASA (Ames Research Center) brochure.* <http://astrobiology.arc.nasa.gov>

See also <http://astrobiology.arc.nasa.gov/roadmap/index.html> 2003.

Grayling, A.C. *Meditations for the Humanist, Oxford University Press, Oxford (2002).*

## OXYMORON

“A rhetorical figure, in which an epithet of a quite contrary signification is added to any word”

*Samuel Johnson’s Dictionary, 1755*

**Variation of an oxymoron [W.C. Fields]:**

**“The best cure for insomnia is to get a lot of sleep”**

**Why “astrobiology” is an oxymoron**

**Words beginning with “astro” define subjects dealing with stars and celestial bodies. Since there is no biology of any kind known other than that on Earth, “astrobiology” is an oxymoron. The word is exploited to generate public excitement and interest, and conveys the false idea that life has actually been discovered somewhere other than Earth.**

**For biologists, the most spectacular news story of 2010 has a very long background. It started with speculations about life on other worlds and goes back at least 2000 years. Many philosophers, theologians and “natural scientists” assumed that *life*, even intelligent life, was not confined to Earth. The organisms postulated on extraterrestrial locales were usually quasi-human and presumably had souls.**

**1670** In his satire *The Elephant on the Moon*, Samuel Butler (1612-1680) described detailed observations made by a “virtuoso” of the Royal Society of London, using a telescope, of an elephant and human armies battling on the moon. These turn out to be perceptions of a mouse (the “elephant”) accidentally trapped between two lenses of the telescope.

**1877** Italian astronomer G. Schiaparelli describes “canali” (grooves) on Mars. He believes these were constructed by intelligent beings.

**1898** *The War of the Worlds*; classic science fiction book by H. G. Wells. Martians, in search of human blood they require, invade England and cause great devastation. Eventually, the Martians die, succumbing to infections caused by terrestrial microbes. The story line is described in Gest: *Microbes/An Invisible Universe*, ASM Press (2003); Appendix III: Microbes in Early Science Fiction.

**1907** Amateur astronomer P. Lowell (founder of the Lowell Observatory) is convinced that intelligent beings built canals on Mars.

**1938** A fake “newscast” drama on radio (produced by Orson Welles), based on *The War of the Worlds*, describes an invasion of Earth by Martians, causing panic in New York and New Jersey.

**1954** Astronomer H. S. Jones declares that there is no doubt that there is plant life on Mars, but is not sure about other life forms.

**1969** Apollo 11 lands astronauts on the Moon. Samples of moon dust brought back to earth are thoroughly examined for living and fossil microbes. All tests give negative results.

**1976** The Viking Mission to Mars. A very complex (and extremely expensive) “Lander” arrives on Mars. It is equipped to make many scientific tests and measurements. Surface life greater than a few mm in diameter is absent. Automated devices designed to

**detect the presence of a wide variety of microbial species in Martian “soil” give negative results.**

**1986 The book *To Utopia and Back/The Search for Life in the Solar System* by Prof. Norman Horowitz (Cal Tech), director of the life sciences tests of the Viking Missions, explains why living organisms cannot exist on Mars: “ Viking found no life on Mars, and, just as important, it found why there can be no life. Mars lacks that extraordinary feature that dominates the environment of our own planet, oceans of liquid water in full view of the sun; indeed it is devoid of any liquid water whatever. It is also bombarded with short wavelength UV radiation. Each of these circumstances alone would probably suffice to ensure its sterility, but in combination they have led to the development of a highly oxidizing surface environment that is incompatible with existence of organic molecules on the planet. Mars is not only devoid of life, but of organic matter as well.”**

**1996 NASA scientists claim they have discovered fossils of very small “worm like” microbes in a 4 pound meteorite that originated in Mars and landed on Antarctica some 13,000 years ago. In a press conference President Clinton and NASA scientists talk about**

**the NASA report one week before the details are published in *Science*. Clinton vows that the U.S. will “put its full intellectual power and technical prowess behind the search for further evidence of life on Mars....if confirmed the finding would surely be one of the most stunning insights into the universe that science has ever uncovered.” The claim of existence of past life on Mars receives unprecedented publicity (“media mayhem”) including commentary with philosophical and religious overtones.**

**1997 H. Gest: Microorganisms are ubiquitous on Earth--Did they also evolve on Mars? ASM News 63: 296--297.**

**“Our fascination with Mars as a possible habitat for extraterrestrial life has a long history, but evidence recently cited for past microbial life on Mars is vague and elusive.” In fact, experimental tests on the 1996 Mars meteorite in a number of independent laboratories made it clear that the so-called “worm like microbial fossils” were simply bits of inorganic debris.**

**2000 NASA is trumpeting the word “astrobiology” louder and louder. The aim of the NASA “Astrobiology Institute” is said to be “the study of the origin, evolution, and distribution of life in the universe.”**

**Printed NASA publicity, aimed at grade school children, emphasizes extremophilic terrestrial bacteria and strongly implies that such organisms were only recently discovered. In fact, extremophiles living in the Dead Sea were described in the 1940’s, and many other kinds in the 1960’s.**

**2005 H. Gest: Microbes in the search for extraterrestrial life. ASM News 71: 560-561.**

**“Failures in obtaining unambiguous evidence for ‘life elsewhere’ have led to more researches on terrestrial microbial ecology in ‘extreme environments.’”**

**Remarks (in 1918) of the eminent historian of science George Sarton are quoted: “The chief requisite for the making of a good chicken pie is chicken; no amount of culinary legerdemain can make up for the lack of chicken. In the same way, the chief requisite for the**

**history of science is intimate scientific knowledge; no amount of philosophic legerdemain can make up for its absence.” Gest notes that “evidence for ‘extraterrestrial chicken’ has still not been found, and in the meantime NASA’s endeavors in exobiology have yielded ‘astrobiology,’ an oxymoron.”**

**H. Gest: A microbiologist’s view of astrobiology. Microbiology Today 32: p. 156. Quotes remarks by G. G. Simpson in “The non-prevalence of humanoids,” Science 143: 769 (1964): “We can learn more about life from terrestrial forms than we can from hypothetical extraterrestrial forms.” Stimson stressed the need for experimental facts, “not improbability piled on improbability.”**

**2006 H. Gest: The “Astrobiology” Fantasy of NASA**  
**<http://sites.bio.indiana.edu/~gest/astrobiology.html>**

**This essay is a review of the 1996 NASA claim that evidence has been found for “past” microbial life on Mars, in meteorite ALH84001. “I was invited to attend a meeting in March 1997 of the “Martian Meteorite**

**Working Group,” organized by the Lunar and Planetary Institute, to evaluate applications from independent scientists who requested small samples of ALH84001 for further study. The invitation was probably based on my membership (1967-1969) in a National Academy of Sciences-National Research Council committee on “Microbiological problems of man in extended space flight” and my long term interests in the origin of life, biochemical evolution and Precambrian paleobiology. As already noted, by 1998 it became clear that that the NASA claims could not be substantiated.**

### **2006 H. Gest: The 2006 Astrobiology**

**Follies/Return of the Phantom Martian Microbes**

**[http://www.bio.indiana.edu/~gest/Gest\\_Astro\\_at\\_Ten.pdf](http://www.bio.indiana.edu/~gest/Gest_Astro_at_Ten.pdf)**

**This article notes a new claim of NASA scientists that they have now obtained evidence of organic remains of life in another Martian meteorite that fell to Earth in 1911 in Egypt, *where it collided with a hairy dog!***

**Scientists at the Carnegie Geophysical Laboratory**

conclude that the “organic remains” were simply terrestrial contamination.

“*Astrobiology at Ten* is the title of a recent editorial in *Nature* (vol. 440, p. 581, 2006), which must compound the confusion emanating from ‘astrobiology’ publicity. The editorial notes that ‘the field [*astrobiology*] was cooked up, in part, out of political necessity as a means of bundling together research programmes on exobiology, other life sciences, and planetary science.’ The editors believe that ‘many microbiologists with an interest in extremophile microbes have suddenly become astrobiologists because astrobiology is—or was—where the money is ....Some second-rate research may have been funded on occasion, thanks to the astrobiology monikers modishness.’”

**2007**; From the 9 October, New York Times: *In*

*NASA’s Sterile Areas, Plenty of Robust Bacteria*

By Warren E. Leary, Washington, Oct. 6

“Researchers have found a surprising diversity of hardy bacteria in seemingly unlikely place—the so-called sterile clean rooms where NASA assembles its

spacecraft and prepares them for launching. Samples of air and surfaces in the clean rooms at three NASA centers revealed surprising numbers and types of robust bacteria that appear to resist normal sterilization procedures, according to a newly published study....Samples taken from clean rooms at the Jet Propulsion Laboratory, the Kennedy Space Flight Center in Florida and the Johnson Space Center in Houston revealed almost 100 types of bacteria.... While some were common types that thrive on human skin such a Staphylococcus species, others were oligotrophs, rarer microorganisms that that have adapted to grow under extreme conditions by absorbing trace nutrients from the air or from unlikely surfaces like paint.... NASA tries to protect its spacecraft and their delicate components from dust and bacteria by assembling and testing them in rooms that are meticulously cleaned of dust and dirt by having their air continuously filtered to reduce fine particles. People working in these rooms wear coveralls with gloves and sometimes wear face masks [*sometimes!*]....Identifying and cataloging what

**microbes might survive sterilization is important in interpreting results of sampling missions to other planets, scientists said. If similar microbes turn up in alien samples, researchers could disregard the results as contamination and not evidence of extraterrestrial life.”**

*The first exam in Microbiology 101 will be given next week. Please bring your face masks.*

**2008; From the 6 August, New York Times:**

**“Dashing Hopes of Martian Life”** Rumors swirled over the weekend that NASA had informed the White House of a major discovery bearing on the possibility of life on Mars. But Tuesday, NASA called a hasty telephone news conference to announce the tentative identification of a class of minerals that has nothing directly to do with the habitability of Mars. ‘We are here today to announce a non-announcement,’ a NASA scientist said.

**(Page A20)**

**“A Finding, Perhaps, but Not of Mars Life”**

**By Kenneth Chang**      **“The nonfindings come out of data from the Phoenix Mars Lander, which is examining**

whether the northern plains of Mars could ever have been habitable.... Scientists were surprised when signs of perchlorates showed up in June in a chemical analysis of Martian soil mixed with water....They were also hesitant because they had not ruled out possible contamination originating from Earth, including perchlorates in the rocket fuel that lifted the spacecraft into space.” *Note: Perchlorates are very reactive chemicals that are used mainly in explosives, fire works and rocket motors.*

### **2010/2011**

**December 2, 2010: Announcement of the “Mono Lake Arsenic Monster”** This unleashed an unparalleled publicity extravaganza, catalyzed by the Internet. The essence of the announcement was described in H. Gest: **Earth’s Bacteria in the Guise of Extraterrestrial Life, Microbe 6: 153, 2011.**

**“On December 2, NASA held a dramatic, one could say sensational, press conference during which the lead investigator of a paper to be published in *Science***

**claimed that she and her team had isolated a bacterium [from Mono Lake, CA] in which the phosphorus of DNA and various metabolites is replaced by arsenic. Aside from the implausibility of the claim made by Felisa Wolfe-Simon et al., numerous weaknesses in the experimental observations were quickly posted by Prof. R. Redfield of the University of British Columbia. Her comments are summarized in a lengthy article by Dennis Overbye in the *New York Times* of December 14, 2010: ‘Poisoned Debate Encircles a Microbe Study’s Result....Prof. Redfield has summarized the sensational ‘arsenic bacteria’ report as ‘lots of flim-flam, but very little reliable information.... F. Wolfe-Simon, lead author of the ‘arsenic bacteria’ report, is a recent Ph.D. in oceanography, and her coauthors are mainly geologists. It would not be surprising to learn that they know little about the history of microbiology and biochemistry research since current textbooks are widely recognized to be deficient in this respect. The existence of arsenic-resistant bacteria has been known for many decades and can be accounted for by**

**reasonable biochemical explanations....Clearly, the Internet and the blogosphere have created new problems in communication of scientific advances to the public.”**

**I hasten to add that biochemists have known for many decades that arsenic analogues of organic molecules containing P are extremely unstable. Organic P compounds are essential for the energy metabolism and various other important metabolic aspects of all forms of life on Earth. Is there really an Arsenic Monster in the mud of Mono Lake?**

**Finally, six months after the sensational December 2 NASA press conference, the Wolfe-Simon et al. paper was actually published in *Science* (A Bacterium That Can Grow by Using Arsenic Instead of Phosphorus, 3 June 2011, vol. 332, p. 1163). The same issue contained *on-line* references to critical comments on the paper by 8 independent investigators and a response to the comments by F. Wolfe-Simon et al. (listed on p. 1149), as well as an article by E. Pennisi entitled “Concerns**

**About Arsenic-Laden Bacterium Aired” (pp. 1136-1137).**

**June 16, 2011 A *Scientific American* blog by Prof. Redfield appears:**

**<http://www.scientificamerican.com/blog/post.cfm?id=from-the-shadows-to-the-spotlight-t-2011-06-16>**

**From the Shadows to the Spotlight to the Dustbin-the Rise and fall of GFAJ-1 [*i.e., the Mono Lake Monster*] Prof. Redfield reviews the history of the “NASA publicity hoopla,” and follows with “an attempt to pull all the scientific issues together.” She gives a detailed assessment of the short-comings of the Wolfe-Simon et al. paper and indicates her experimental plans to test the claims. A few of her remarks follow: “So, big disappointment, GFAJ-1 is part of the normal biosphere, not a new life form....The most shocking error was omission of standard steps from the DNA purification....In the absence of the final purification steps it’s impossible to know whether the DNA really contained arsenic....The chemists were right. The**

**arsenic bonds needed in DNA and RNA are spectacularly unstable with half-lives of less than 0.1 second....Any one of these problems is big enough to send the prior probability of arsenic use into the basement. In any case, unless the fundamental principles of chemistry are wrong, bond instability is a death-knell to the author's conclusions." Redfield notes: "I'll be openly blogging about this work as I do it-you can follow along at my RRResearch blog."**

**August 11, 2011**

**Blog from Nancy Atkinson: "Replication of arsenic life experiment not successful so far....To date, Redfield is finding that the bacteria, called GFAJ-1 is not living and growing in arsenic, but dying....Redfeld's two major early criticisms of the original paper were that the authors had not ruled out the possibility that the bacteria were feeding on phosphorus contaminating their growth medium; and that the DNA was not properly purified, so that the arsenic detected might not have actually been in DNA,"**

**November 25, 2011**

**From a RRRedfield blog: Redfield is still having great difficulty in repeating growth experiments with GFAJ-1. “At present the cells grow fine in medium without arsenate, and so far only in small volumes. When they do grow in arsenate they grow just as well as in the control cultures without arsenate.” Redfield includes many messages sent to her blog from various people who try to explain why she is not getting reproducible growth results.**

**Physical scientists attracted to biological research and speculations From Gest: The Treacherous Road from Physics to Biology, Persp. Biol. Med. 37: 347-358 (1994).**

**“The fallibility of scientists is well known and documented. Famous savants are sometimes completely mistaken in their predictions on particular questions, even in their own fields of expertise. When scientists make pronouncements about basic issues in areas far-removed from their own bailiwicks, watch out! Why is it that biologists never advance hypotheses on problems of physics relating to quarks, gluons, black holes etc., whereas many physical scientists (*physicists*,**

*astronomers, geologists etc.)* have attempted to explain major complex unsolved problems of biology to the public and to biologists who keep struggling to unravel the complex mysteries of life?.... To be sure, a handful of physical scientists have made notable –in fact, spectacular-contributions to biology, the hard way. That is, by taking the trouble to master the biological background, and then do experiments in the laboratory or pursue meaningful theoretical work as they progressed in their productive phases. Linus Pauling, Max Delbruck, Leo Szilard, Seymour Benzer, and Francis Crick are good examples of scientists who successfully made the transition....One of the most accomplished and candid physicists of the twentieth century, Richard Feynman (Nobel Prize, 1965), has described in amusing fashion his occasional expeditions into biology [*“Surely You’re Joking Mr. Feynman,”* Unwin Paperbacks, 1986] and he confirmed how difficult it is to do meaningful research in a field completely different from your own. At one point, he went so far as to take a course on how to do research

**with bacterial viruses (bacteriophages), and this taught him something useful for daily life: “There was one useful lab technique I learned in the course which I still use today. They taught us how to hold a test tube and take its cap off with one hand (you use your middle and index fingers), while leaving the other hand free to do something else...Now, I can hold my toothbrush in one hand and with the other hand, hold the tube of toothpaste, twist the cap off, and put it back on.”**

**Working with experienced biologist friends at Cal Tech, Feynman participated in experiments that at the time were at the “cutting edge” of molecular biology. These experiments would now be described as seeking purely descriptive information about the mechanism of protein synthesis by ribosomes. He says: “It would have been a fantastic and vital discovery if I had been a good biologist. But I wasn’t a good biologist. We had a good idea, a good experiment, the right equipment, but I screwed it up....My ribosomes had been in the refrigerator for almost a month, and had become contaminated with some other living things...We were**

there at the right place, we were doing the right things, but I was doing things as an amateur—stupid and sloppy. You know what it reminds me of? The husband of Madame Bovary in Flaubert’s book, a dull country doctor who had some idea of how to fix club feet, and all he did was screw people up. I was similar to that unpracticed surgeon...I learned a lot of things in biology, and I gained a lot of experience. I got better at pronouncing the words, knowing what not to include in a paper or a seminar, and detecting a weak technique in an experiment. But I love physics and I love to go back to it.”

### **Astronomers are fond of “astrobiology”**

**A 2011 item from *Nature* (17 March, p. 271):**

**“Astrobiology Loss: A well-known research centre has lost its connection to its UK university, and will be run as a private company. Chandra Wickramasinghe who has headed the Cardiff Centre for Astrobiology since it was founded in 2000, last week lost his appeal against Cardiff University’s 2010 decision to close its**

astrobiology department for financial reasons (see [go.nature.com/5rbb5g](http://go.nature.com/5rbb5g)). Wickramasinghe—whose work with astronomer Fred Hoyle pioneered the theory of panspermia, that life on Earth was seeded from outer space—says that the centre will now be privately funded, and will continue ongoing projects with other partners, such as the Russian space agency,”

**Correction:** The above news item is erroneous. Hoyle and Wickramasinghe did not “pioneer” the theory of panspermia; they tried to popularize it as their own. Panspermia is an old idea which is discussed in a scholarly paper by Norman Pirie, “Possible impact of cosmochemistry on terrestrial biology: historical introduction,” *Phil. Trans. Roy. Soc. London A303*, 589-594 (1980). Pirie noted that “The general proposition that all life came here from elsewhere seems to have originated with Richter (1865).”

### **UFMs (Unidentified Flying Microbes)**

**From Gest: The Treacherous Road...(reference above)**  
 “Celestial Pathology was the title of an editorial in the *New Scientist* for November 1977 (p. 396) that began:

**On p. 402 this week we publish an article by Sir Fred Hoyle and Professor Chandra Wickramasinghe suggesting that some disease epidemics on Earth may originate with microbes carried here on cometary dust. *New Scientist* may well be criticized in some quarters for helping to publicize a notion so far at variance with established theories of epidemiology. Both authors are, of course, distinguished scientists. But they are not biologists, and here they have strayed far from their own field, making staggeringly heterodox extrapolations from their more conventional work on the existence of prebiotic molecules in space.**

**Hoyle and Wickramasinghe suggested that the ‘actual origin of life appears to be the surfaces of cometary nuclei and that extraterrestrial biological invasions continue today. These invasions could take the form of new viral and bacterial infections that strike our planet at irregular intervals, drifting down on to the surface in the form of clumps of meteoric material. Hoyle proceeded to develop the argument that the sudden occurrence and spread of ‘plagues and**

pestilences' is more reasonably explained by 'cometary dust infection' than by transmission from person to person. The sudden entrance of gadfly Hoyle into the biological arena from his customary hunting grounds in outer space prompted me to write a letter to the *New Scientist* (Dec. 15, 1977 issue) in which I pointed out that it was difficult to know where to begin in dissecting Hoyle's nebulous and untestable speculations, and I offered microbiological analysis of any 'microbe-carrying specimens' from outer space that arrive on the Earth in the form of 'clumps of meteoritic material' or by any other extraterrestrial conveyance. To date, I have received no samples."

### **Francis Crick proposes "Directed Panspermia"**

After making momentous contributions to molecular biology, Crick moved to the Salk Institute in La Jolla (CA) and turned his attention to new horizons, including the origin of life. This led him to publish a book entitled *Life Itself/Its Origin and Nature* (Simon and Schuster, New

**York, 1981). After reviewing the basic essentials of terrestrial life, Crick resurrects the old idea of panspermia, but with a new twist that he calls Directed Panspermia. The latter “postulates that the roots of our form of life go back to another place in the universe, almost certainly another planet; that it had reached a very advanced form there before anything much had started here; and that life here was seeded by microorganisms sent in some sort of spaceship by an advanced civilization.”**

**On this basis, Crick develops an intriguing scenario with elements characteristic of science fiction stories. Reasons are given why advanced “technocrats” from elsewhere look for other habitable planets and how they might approach the problem of testing for “suitable planets.” The basic idea is to first send microorganisms to see how they would fare. Chapter 11 has the title**

**“What would they have sent?”.... “Since many bacteria would have been sent, it would have made good sense to send more than one variety. Exactly how these would have been chosen is difficult to judge, since it would have depended on what microorganisms were available on the planet from which the rocket was sent.” Sounds like a committee meeting.**

**A Modest Proposal: A Validation Workshop to Educate NASA-supported Dabblers in Microbiological Research**

**The workshop would resemble the recent “Mock Mars Mission” recently completed by six astronauts. As reported in the New York Times of November 5, 2011, the astronauts were testing human responses to the confinement, stress and fatigue of a round-trip to Mars, minus the weightlessness. The astronauts emerged from the bus-like modules after 520 days “looking haggard**

**but all smiles, and dreaming of lying in the sun, taking long strolls and driving fast cars.”**

**Personnel: six scientists receiving grants from NASA, who have little or no university training in microbiology or qualifying practical experience in microbiology, willing to justify their previous research support.**

**Time Period: Without earthly distractions, 365 days should be enough.**

**Assignment: To study and learn the fundamentals of microbiological discoveries made from ca. 1870 to the present, which include: How pure cultures of microbes are obtained and characterized.**

**Especially, how generations of microbiologists isolated the thousands of bacterial species described in Bergey’s Manuals, with particular attention to how they determined the nutrient requirements of the numerous species that are “fastidious” (i.e., organisms that require addition**

**of vitamins, amino acids, purines, pyrimidines or various other organic compounds to a basal growth medium). In this connection, to gain some appreciation of the complexities of bacterial nutrition they must pay particular attention to the history of how Winogradsky discovered the chemosynthetic autotrophs, which cannot be grown in the laboratory in media containing organic compounds. There are numerous other examples of bacterial species that were once said to be “unculturable,” until someone did the hard work to unravel their nutritional complexities (especially pathogens).**

**Facilities: As described in the New York Times account of the “Trek to Mars, Mock Mission”; window-less compartments which include living quarters “the size of a bus.” Connected buses would include a substantial library of microbiological and biochemical texts, as well as a**

**large selection of relevant research papers that cover the fundamentals of microbiology. Each participant would also be provided with a personal library of space science books, including Norman Horowitz's book on the remarkable 1976 Viking Missions to Mars.**

**Funding: It seems likely that suspension of grants given by NASA for "astrobiology" and "exobiology" would easily cover the costs of the Validation Workshop.**

**Selection of personnel and evaluation of the program: Ideally, these would be done in collaboration with National Science Foundation programs responsible for basic research in microbiology, biochemistry, and molecular biology.**

**Déjà vu: In 1958, I gave a lecture at Western Reserve University School of Medicine, where I was a faculty member, on theories of the origin of**

**life and biochemical evolution. In this talk, I discussed the ideas of A. I. Oparin and Norman Horowitz in great detail and opened the lecture by quoting some remarks (see page 10) of George Sarton, the eminent historian of science [from his paper “The teaching of the history of science.” Sci. Monthly 7, No. 3 (Sept. 1918) pp. 193-211]. Ninety four years later there is still no evidence for life “elsewhere,” chickens or microbes.**

### **2012 Death Knell of the “Arsenic Monster”**

**This was foretold in a short article published by B. Schoepp-Cothenet and W. Nitschke in Journal of Cosmology, December 2010 (vol. 13, pp. 3609-3612): “Arsenics, Astrobiology and Scientific Deontology.” They noted the “dark side of astrobiology....it is obvious that an astrobiologist needs self-critical attitude towards their own discipline as well as a humble approach to the fields outside their core competencies.” The**

**authors gave technical reasons for believing that the central claims of F. Wolfe-Simon et al. are unwarranted, which are more detailed in a later commentary [Comment on “A bacterium that can grow by using arsenic instead of phosphorus”**

**[www.sciencexpress.org/27 May 2011/Page 1/10.1126/science.1201438](http://www.sciencexpress.org/27_May_2011/Page_1/10.1126/science.1201438)**

**The Final Blow: An article dated January 20, 2012 by E. Check Hayden, “Study challenges existence of arsenic-based life”**

**<http://www.nature.com/news/study-challenges-existence-of-arsenic-based-life-1.9861>**

**This article cites recent results from the Redfield laboratory which show that DNA purified from GFAJ-1 cells grown in the presence of arsenic and a very small amount of phosphorus does not contain arsenic. It also notes: “Redfield and her collaborators hope to submit their work to *Science***

by the end of the month. She says that if *Science* refuses to publish the work because it has been discussed on blogs, it will become an important test case for open science.” The “Arsenic Monster” can be understood simply as still another example of an extremophilic terrestrial bacterium, rather than as a harbinger of exotic organisms living by alternative biochemistries.

The GFAJ-1 story was certainly the most hyped scientific event of the past decade, and validates remarks made by C. Caryl in the *New York Review of Books*, 1/13/2011 issue: “The Internet has brought countless benefits to mankind, but as we see now, it also creates incalculable potential for mischief...now that data can be shared, linked and exploited with near instantaneous ease, the risks entailed by the publication of information mushroom out of all recognition.” Who is to blame for the “Arsenic

**Monster” fiasco? Many factors contributed, primarily: faulty peer review by *Science* magazine and allowing a publicity-hungry NASA to award self-serving research grants to university scientists.**

**Great is the power of steady misrepresentation—but the history of science shows how, fortunately, this power does not long endure. Charles Darwin [*Origin of Species*]**

**The great tragedy of Science—the slaying of a beautiful hypothesis by an ugly fact. Thomas H. Huxley**

**Those who cannot remember the past are condemned to repeat it. George Santayana**

**Ernest Nagel once referred to the “huge barren intellectual debris” which borders the winding path cut by modern science through the jungle of human ignorance.” [*It still exists, and is no doubt greater now that the Internet blogosphere is readily accessed.*]**

**Westheimer’s Discovery: “A couple of months in the laboratory can frequently save a couple of hours in the library.” Gest’s Corollary: Despite the power of Google,**

**rediscovery of Westheimer's Discovery becomes ever more likely.**

The Norse creation myth or cosmogony (an account of the origins of the cosmos) is perhaps one of the richest in all of world literature. First, let's look at this exceptionally colorful story itself, then consider how the Vikings may have interpreted it and found meaning in it. The Origin of the Cosmos. Ymir is born from the strife between fire and ice and we can surmise that that particular opposition would have had a special poignancy for people living what was more or less a subsistence lifestyle in the cold lands of Scandinavia and the North Atlantic. In order for the gods to fashion the world, they must first slay Ymir. This is the first intentional taking of a life in the universe, and it's performed by the gods themselves. The field involves an understanding of the similarities and differences between humans and other species in their genes, body form, physiology, and behavior. Paleoanthropologists search for the roots of human physical traits and behavior. They seek to discover how evolution has shaped the potentials, tendencies, and limitations of all people. The process of evolution involves a series of natural changes that cause species (populations of different organisms) to arise, adapt to the environment, and become extinct. All species or organisms have originated through the process of biological evolution. 1NASA Astrobiology Institute, USA. 3School of Earth and Space Exploration, Arizona State University, Tempe, AZ 85287, USA. 8Department of Chemistry and Biochemistry, Arizona State University, Tempe, AZ 85287, USA. Here, we describe a bacterium, strain GFAJ-1 of the Halomonadaceae, isolated from Mono Lake, California, that is able to substitute arsenic for phosphorus to sustain its growth. Our data show evidence for arsenate in macromolecules that normally contain phosphate, most notably nucleic acids and proteins. Characterization of the intracellular arsenic chemical environment. We next used synchrotron x-ray studies to determine the speciation and chemical environment of the intracellular arsenic (11). The nature of the universal ancestor and the evolution of the proteome. *Curr. Opin. Struct. Biol.* 10, 355-358. [CrossRef Google Scholar PubMed](#). Forterre, P. & Philippe, H. (1999). The evolution of the Sun's birth cluster and the search for the solar siblings with Gaia. *Mon. Not. R. Astron. Soc.* 457, 1062-1075. [CrossRef Google Scholar](#). Marx, G. (1979). The origin of life, panspermia and a proposal to seed the Universe. *Plant Sci.* 175, 756-760. [CrossRef Google Scholar](#). Vakoch, D.A. (1998a). Constructing messages to extraterrestrials: an exosemiotic perspective. *Acta Astronaut.* 42, 697-704. [CrossRef Google Scholar](#).