THE "MARS BOTTLE"–
THE FIRST INTERACTIVE STUDENT RESEARCH LABORATORY
FOR MARTIAN ENVIRONMENTAL SIMULATIONS

Robert E. Strong*

ABSTRACT

The Sir Arthur C. Clarke Near Earth Object Observatory is establishing an Exobiology Research Laboratory to study and conduct basic research concerning the origin, evolution, and distribution of life in the universe. The purpose of the Exobiology Research Laboratory is two-fold. The first purpose is to perform basic research in exobiology. The second purpose is to engage elementary, middle, and high school students directly in these exobiology real-time investigations via interactive Internet based video observations, submitting proposals for experiments - including procedures and environmental conditions, and manipulate simulated extraterrestrial environments.

INTRODUCTION

The initial interactive Exobiology Research Laboratory student component is the "MARS BOTTLE". The idea of the MARS BOTTLE is to create a simulated environment as close as we can currently get to putting our 'experimental hands' on the surface of the planet Mars. The MARS BOTTLE will enclose a small environment simulating the conditions found on surface of the planet Mars.

The proposed MARS BOTTLE will create a miniature Martian atmosphere with pressure, temperature, and component gases in their proper proportions for any surface location of given the latitude and longitude, elevation, season, and local time.

The MARSBOTTLE will include a simulated "Sun" having the same luminosity and radiation characteristics of the real Sun seen from Mars. The simulated "Sun" will rise in the east and set in the west. Additionally, there will be an ambient background radiation field inside the MARS BOTTLE that will simulate the soil background radiation, the solar wind, and cosmic radiation levels found on the surface of the planet Mars.

A few kilograms of Mars Simulant, soil chemically and physically similar to soil found on Mars by the two Viking Landers, will act as a substrate upon which to test various chemical,

* West Liberty State College SMART-Center, email:Strongro@wlsc.wvnet.edu
biological, and terraforming (areoformation) ideas and research.

The Mars Bottle will contain:
1) an atmosphere having the same pressure as found on the surface of Mars. The Exobiology Research Laboratory is planning to create a computer program that will predict the atmospheric pressure at any surface location: given the latitude and longitude (thus the mean elevation), orbital position (for season), and local time.
2) atmospheric component gases in their proper proportions for each location, seasonal and local time.
3) the expected atmospheric and surface temperatures for each location, seasonal and local time.
4) a simulated Sun which will have the same radiation and behavioral characteristics of the Sun as seen from Mars for each location, season, and local time. The simulated Sun will rise in the east and set in the west, have the same luminosity, and radiation characteristics of the Sun seen from Mars.
5) an ambient background radiation field inside the Mars Bottle will simulate the soil background radiation, the solar wind, and cosmic radiation field found on the surface of the planet Mars.
6) a few kilograms of Mars Simulant; a simulated Mars soil chemically and physically similar to what was found on Mars by the two Viking Landers. The Mars Simulant is to act as a substrate upon which to test various chemical, biological, and terraforming (in this case areoformation) ideas and research.

Figure 1. Mars Bottle Laboratory.
The principle investigator (author) and several of the co-investigators and advisors (see Acknowledgements) have extensive professional experience working with vacuum systems, vacuum vessels, gases at low pressure, telepresence, environmental chambers, furnaces, radiation fields, and cryogenics. This hands-on experiential base coupled with a desire to create a "little piece of Mars on Earth", has led to the conceptual creation of the Mars Bottle; built out of off-the-shelf components used in industrial and laboratory vacuum and cryogenic systems. Eventually the fully implemented project calls for three Mars Bottles to be produced. As funding is secured a second and a third Mars Bottle will be built hopefully over a three-year period.

Figure 2. Mars Bottle Core
Once the second Mars Bottle is created, we envision the first of the Mars Bottles being tied up performing on-going long term Mars research. The other (eventually two) Mars Bottle(s) will then be available to simulate the environments of other worlds real (atmospheres and surfaces of Mercury, Luna, Near Earth Asteroids and Comets, satellites of Mars, Minor Planets in the Main Belt, upper atmosphere of the planets Jupiter and Saturn, their satellites and trojans) and imagined (terraformed worlds in the solar system and hypothetical or recently discovered worlds pristine or terraformed beyond the solar system).

The Exobiology Research Laboratory envisions these Mars Bottles as a unique way to create exotic, real, or hypothetical micro-environments by having control over various levels of temperature, atmospheric pressure and composition, light - including IR/Visible/UV, electrical and magnetic fields, electrical discharge, different material substrates by compositions, background radiation, solar wind and cosmic radiation simulation. All of these environmental components will be able to differ independently in duration as desired. The only in situ environmental condition not meet by the Mars Bottle is the ambient gravitational acceleration. To simulate a smaller than one Earth gravity we will need to utilize the Space Shuttle of International Space Station environments and utilize a centrifuge in microgravity.

A dividend of this research direction will be a better understanding of the probability of finding extant microbial life on Mars with its present environmental conditions assuming that life arose during a warmer and wetter epoch in the past.

THE EXOBIOLOGY RESEARCH LABORATORY

West Liberty State College is seeking to establish an Exobiology Research Laboratory.

The Exobiology Research Laboratory will serve three objectives:

1) to serve as an Exobiology Research Laboratory to study and conduct basic research concerning the origin, evolution, and distribution of life in the universe;
2) to function as a working research laboratory to demonstrate to local area students and teachers research laboratory techniques and to stimulate interest in mathematics, science, research, and technology; and
3) in addition to the basic research conducted by the principle investigator and co-investigators, time will be allotted to use the Exobiology Research Laboratory's facilities and equipment for supervised experimentation and research by local area educators and students after initial safety training. The experimentation and research time in the Exobiology Research Laboratory will be made available via project proposals. The principle investigator will be responsible for the scheduling of teacher and student experimentation and research time.

To accomplish this task, the Exobiology Research Laboratory is seeking funds to purchase a gas chromatograph and related equipment to chemically identify product compounds created in simulated prebiotic Earth (and other world) atmospheric environments (i.e. the Miller/Urey and
Funds and equipment are being sought to create three MARS BOTTLES (Miniature Aries Research Simulator for Biological Observations in Terraforming Techniques via Laboratory Environments) from off-the-shelf laboratory vacuum equipment. The Mars Bottles will be simulated surface environments having the potential for a wide variety of atmospheric pressures (less than 1 Atm), compositions, and temperatures found on worlds out to the orbit of the planet Saturn.

Within the first objective of the Exobiology Research Laboratory, (i.e. that of studying and conducting basic research concerning the origin, evolution, and distribution of life in the universe) the investigators will primarily be concentrating exobiology research efforts in three directions; I) prebiotic evolution II) the early evolution of life, and III) the evolution of advanced life.

I) Research in the area of prebiotic evolution seeks to understand the pathways and processes leading from the origin of a planet to the origin of life. The strategy is to investigate the planetary and molecular processes that set the physical and chemical conditions within which living systems arose. The Exobiology Research Laboratory will concentrate on three major objective areas in prebiotic evolution. These objective areas are to:

1) determine constraints on prebiotic evolution imposed by the physical and chemical histories of planets;
2) develop models of active boundary regions in which chemical evolution could have occurred; and
3) determine what chemical systems could have served as precursors of metabolic and replicating systems both on the Earth and elsewhere.

To reach our research goals in the area of prebiotic evolution, the Exobiology Research Laboratory intends to create two stations to perform updated classical experimental research already done in the areas of examining prebiotic / primordial atmospheric mixtures and subjecting them to various energetic states and analyzing the products. The Exobiology Research Laboratory using library research will update the classical experimental research of A) The Miller/Urey Experiment and B) Sagan/Khare's Titan Tholin Experiment.

It is hoped that in setting up and running these two classical experiments of prebiotic evolution in union with library research and the added fresh input of educators and students, will lead to many other productive and informative experiments that will add to our knowledge in this field.

All of the equipment to create these experimental research environments will be donated from the laboratory storerooms of West Liberty State College and its sister agency, the WLSC SMART Center.

To complete and complement the two stations, the Exobiology Research Laboratory needs a gas chromatograph and related equipment to analyze the chemical nature of the products produced at the two stations and those experiments that will evolve out of this research.
It is desired that the two stations be set up very early in year one, and that the gas chromatograph be set up in such a time frame as to analyze the first products.

The evolution of the initial two stations and the development and use of daughter stations over the following two years of the project will progress as the library research indicates and new ideas and suggestions arise.

Note: this is an area that can be easily taken over to a great extent by trained educator and student assistance at the end of the requested three years of proposed funding.

II) The goal of the research into the early evolution of life conducted by the Exobiology Research Laboratory is to determine the nature of the most primitive organisms, the environment in which they evolved, and the way in which they influenced that environment. Using the concept of the Mars Bottle (a "bottle" containing a simulated Mars environment), as a working physical model for primitive environments, the Exobiology Research Laboratory hopes to better understand the early evolution of life in the universe. Using library researched information gathered on the two natural repositories of evolutionary history available on Earth, the molecular record in living organisms and the geological record in rocks, the Exobiology Research Laboratory will use the Mars Bottle as a tool to better understand boundary conditions within which simple present Earth based life may perish, be sustained, or thrive. The findings for these boundary conditions for life derived from the Mars Bottle and the paired molecular and geological records will be used to concentrate on five major objective areas in the study of the early evolution of life. These objective areas are to:

1) determine when and in what setting life first appeared;
2) determine the characteristics of the first successful living organisms;
3) understand the phylogeny and physiology of microorganisms thought to be analogs of primitive environments;
4) determine the original nature of biotic energy transduction, membrane function, and information processing through study of extant microbes; and
5) elucidate the physical, chemical, and biotic forces operating on microbial evolution.

To reach the research goals in the area of early evolution of life, the Exobiology Research Laboratory intends to create three Mars Bottle stations.

Long has been the fascination of visiting other worlds. TV, movies, video, radio, books, all forms of media have mirrored our collective interest in visiting and exploring other worlds. No other world has so grasped, held, and stimulated the imaginations of generations of children and adults as has the planet Mars.

Thus, came into being the idea of the Mars Bottle. The Mars Bottle is as close as we can currently get to putting our "experimental hands" on the surface of the planet Mars, without actually going there. The Mars Bottle will enclose a small simulated environment having as close as we can arrange, the conditions on the surface of the planet Mars.
III) The goal of the research associated with the study of the evolution of advanced life by the Exobiology Research Laboratory, seeks to determine the extrinsic factors influencing the development of advanced life and its potential distribution in the universe. The Exobiology Research Laboratory is concerned with two main objective areas in the study of the evolution of advanced life.

The first objective area of interest to the Exobiology Research Laboratory in the study of the evolution of advanced life, is research including an evaluation of the influence of extraterrestrial and planetary processes on the appearance and evolution of multicellular life, conducted by: 1) tracing the effects of major changes in the Earth's environment on the evolution of complex life, especially during mass extinction events and 2) determining the effects of global events and of events originating in space on the production of environmental changes that affected the evolution of multicellular life.

To reach this two-part objective the Exobiology Research Laboratory will perform extensive library research and computer simulations to determine the effects of global events and of events originating in space on the production of environmental changes that affected the evolution of multicellular life. In addition, the Exobiology Research Laboratory intends to use its Mars Bottles to create a series of simulated effects of "micro-global" events and of events originating in space on the production of environmental changes that affect growth, behavior, and development of multicellular life on various Earth environments past, present, and in the future. Additionally, the Mars Bottles, gas chromatograph, and other equipment can be used to create and alter a myriad of hypothetical worlds. This will give us data to fill in the unknown gaps in our understanding of the influence of various environmental effects on various events in various exotic environments that will and will not sustain multicellular life.

To further research in the direction of the first objective (that of research evaluation of the influence of extraterrestrial and planetary processes on the appearance and evolution of multicellular life), the author investigator is presently the director of the k-SkyWatch Survey, a survey of Near Earth Objects (NEO's) having the potential to impact the earth, posing a threat to the earth, our climate, and civilization. The k-SkyWatch Survey has of this writing a modest funding base.

The second objective area of interest to the Exobiology Research Laboratory in the study of the evolution of advanced life is research into furthering our understanding of the distribution of life elsewhere in the universe.

To reach this second objective the Exobiology Research Laboratory will perform extensive library research and computer simulations to create an updated and revised form of the "Drake Equation", including currently known and extrapolated data to answer this most fundamental question: Are we alone in the universe?

To do further research in the direction of the second objective (that of furthering our understanding of the distribution of life elsewhere in the universe), the principle investigator and several of the co-investigators and advisors have been involved in a series of three proposals for
amateur astronomers to gain research time on the Hubble Space Telescope. The proposal is known as SETT (Search for ExtraTerrestrial Technology), and looks for thermal signals from extraterrestrial technologies. As of this writing these proposals have not been accepted.

The Exobiology Research Laboratory sees the first year as one of research into the evolution of advanced life as primarily consisting of library research. The second and third years will continue the library research on a smaller scale as compared to the first year. The second and third years will see the use of Mars Bottles and computer simulations to allow the Exobiology Research Laboratory to arrive at some more definite conclusions.

FACILITIES AND EQUIPMENT

The facility for housing the Exobiology Research Laboratory is a well-equipped chemistry laboratory with benches, water and sinks, full electrical, and gas lines. West Liberty State College and the WLSC SMART - Center will provide all material resources but the major equipment items listed below.

The Exobiology Research Laboratory is pursuing funding to purchase (1) a gas chromatograph and related equipment to analyze the chemical nature of the products produced at the two stations researching prebiotic evolution, and (2) the materials to assemble three Mars Bottles; built out of off-the-shelf components used in industrial and laboratory vacuum systems.

ACKNOWLEDGEMENTS

The author wishes to thank Russell P. Stackpole, II, a co-investigator on the Mars Bottle Project and Mechanical Engineer / Aerospace Engineer / Experimental Electron Microscopist at a local research laboratory. Mr. Stackpole's responsibilities will include: assembly, trouble shooting, and design of the Mars Bottles with Mr. Strong. Russell P. Stackpole, is also a gifted artist and has rendered the drawings seen in this paper. Additionally, Mr. Stackpole will be working with Mr. Strong on the programming to simulate the influence of extraterrestrial and planetary processes on the appearance and evolution of multicellular life.

The author also wishes to acknowledge the help of H.A. (Andy) Cook Ph.D., Dean of Natural Sciences, Health Professions, and Mathematics at West Liberty State College. Dr. Andy Cook (co-investigator on the Mars Bottle Project) will be responsible for coordinating exobiology research activities between WLSC students and faculty and the Exobiology Research Laboratory.