

# The Life in the Universe Series

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Students, young and old, find the existence of extraterrestrial life one of the most intriguing of all science topics. The theme of searching for life in the universe lends itself naturally to the integration of many scientific disciplines for thematic science education. Based upon the search for extraterrestrial intelligence (SETI), the Life in the Universe (LITU) curriculum project at the SETI Institute developed a series of six teachers guides, with ancillary materials, for use in elementary and middle school classrooms, grades 3 through 9. Lessons address topics such as the formation of planetary systems, the origin and nature of life, the rise of intelligence and culture, spectroscopy, scales of distance and size, communication and the search for extraterrestrial intelligence. Each guide is structured to present a challenge as the students work through the lessons. The six LITU teachers guides may be used individually or as a multi-grade curriculum for a school.

Integral to the development process was the collection of evaluation data on draft materials from field test teachers, students, and scientists. These data led to revisions and further field tests. Responses indicate that the objectives for the materials were achieved, and that the materials were well received. The LITU project was conducted by the SETI Institute in Mountain View, CA; the project was funded by the National Science Foundation (NSF) and the National Aeronautics and Space Administration (NASA). The LITU Series is being published by Teachers Ideas Press, a division of Libraries Unlimited, Englewood, Colorado, USA.

## 1. Introduction

Dr. Jill Tarter walked into the classroom and 27 ten and eleven year-old students turned to look at her expectantly. They had been told by their teacher that Dr. Tarter was a nationally recognized radio astronomer specializing in SETI, the search for extraterrestrial intelligence. Many thoughts probably went through their lively minds: "Stephen Spielberg's movie ET about an extraterrestrial!" "Is it possible to visit an extraterrestrial civilization?" "What do scientists do when they search for extraterrestrial intelligence?" Most of the students had very naive conceptions about SETI but all of them had ideas and questions about it. After her presentation, Dr. Tarter responded to dozens of questions. As she worded careful answers it dawned on her that, no matter to whom she talked about SETI, there was always a great deal of interest in the subject.

Other SETI scientists concurred. During their talks, briefings and lectures they had also discovered that the topic of extraterrestrial intelligence stimulated more interest and excitement than most. It was obvious that an excellent way to capture the interest of students of all ages was to approach the teaching of science through the topic of SETI.

## 2. The Project

A plan to design a curriculum for pre-college students was proposed. Participation was solicited from the local community. The team organized to explore the possibilities consisted of scientists, curriculum developers, professors of preservice science teachers, and educators from elementary and middle schools. All agreed that exploring SETI in age-appropriate activities and lessons would motivate diverse students to study science. The planning team also saw the opportunity for thematic and integrated instruction as the topic of SETI uniquely combines many scientific disciplines and communication skills. Astronomy, biology, anthropology, physics, chemistry and paleontology are all part of SETI research. A curriculum based on SETI would help to fill the needs of teachers being pressed by state and national guidelines[Kober, N. (1994)] to improve the quality of science teaching and to increase student science literacy. These guidelines direct that science be taught, not as a collection of facts to be memorized, but as a lively, interactive subject appealing to all students regardless of race or gender. As stated in the guidelines, "Students (should be able to) connect science concepts with the natural world and explore how science and technology affect their lives and their society"[American Association for the Advancement of Science (1993)].

Table 1 Drake's Equation:  $N = R_* \cdot f_p \cdot n_e \cdot f_l \cdot f_i \cdot f_c \cdot L$

Factor	Subjects relevant to study of this factor
$R_*$ = number of new stars formed in our galaxy each year	Astronomy, Chemistry, Mathematics, Physics
$f_p$ = fraction of stars that have planetary systems	Astronomy, Mathematics, Physics, Planetary Science
$n_e$ = average number of planets in each system that can support life	Astronomy, Chemistry, Physics, Planetary Science
$f_l$ = the fraction of such planets on which life actually originates	Astronomy, Biology, Chemistry, Ecology, Geology, Meteorology, Exobiology
$f_i$ = the fraction of life sustaining planets on which intelligent life evolves	Anthropology, Evolutionary Biology, Geology, Meteorology, Paleontology, Ecology, Atmospheric Sciences, Neurophysiology
$f_c$ = the fraction of intelligent life bearing planets on which the intelligent beings develop the means and the will to communicate over interstellar distances	Language Arts, Mathematics, Physics, Social Sciences, Behavioral Sciences, History
$L$ = the average lifetime of such technological civilizations	Astronomy, History, Mathematics, Paleontology, Social Sciences, Behavioral Sciences

The planning team requested joint funding from the National Science Foundation

(NSF) and the National Aeronautics and Space Administration (NASA) to develop a series of six teachers guides for use by teachers of 8 -16 year-old students. As proposed, each guide would focus on an aspect of the search for extraterrestrial intelligence in a way guaranteed to intrigue. Each guide would present a variety of scientific disciplines in the integrated manner exemplified by the Drake Equation which is the thread which binds the LITU series together. The Drake Equation provides a method of estimating the number of intelligent civilizations in our galaxy with whom we might make contact.

Both NASA and the NSF agreed that the SETI Institutes proposal was worthy, and funded the project, "Life in the Universe - An Exciting Vehicle for Teaching Integrated Science."

### 3. Curriculum Design

The first step was an intensive summer design workshop with a team of teachers, scientists, curriculum developers and project staff. The first few weeks of the workshop were spent brainstorming, listening to content lectures, testing experiments and creating lessons. From this collaboration arose four draft teachers guides: three for the ten to twelve year-olds, and one for the thirteen to fifteen year-olds. As a pilot test, the teachers who participated in the summer design workshop returned to their classrooms and implemented these lessons. They made careful notes on student response, availability of materials, and preparation time involved for each lesson. This process was repeated the following summer. Two additional draft guides were produced: one for eight to ten year-olds, one for fourteen to sixteen year-olds.

### 4. Testing and Evaluation

The original plan was to have the developer teachers spend a week of their mid-school-year vacation revising the draft materials. This proved to be impractical. One week was not enough time to revise materials and make them suitable for national testing. Additionally, most teachers had other commitments. The solution was to hire a former teacher, and later two additional teacher/writers, to collect all the pilot test information and use it to revise the teachers guides and produce consistent looking material. These revised drafts were sent to teachers across the United States for a second round of testing.

One of the most valuable investments made by the LITU project staff was attendance at state and national science teacher conferences. At most conferences, staff members presented LITU materials at a NASA booth in an exhibition area. Providing sign up sheets at these locations netted hundreds of names and addresses of interested teachers; 150 became national test teachers.

Accompanying these draft guides was a battery of carefully designed evaluation materials. First, the teachers completed a written assessment of individual lessons, detailing student reactions, effectiveness, materials and equipment demands, and so forth. A second form of evaluation was obtained from the students themselves. After they completed the unit, they wrote a letter to the project evaluator describing what they liked and didn't like, what they learned, and what changes they would recommend. Finally, the teachers' overall reactions were obtained by an independent consultant who contacted each teacher to conduct a telephone interview. These three sources of evaluation were very useful in producing revised materials.

## 5. Science Review

Lessons were reviewed by scientists who specialized in the subject areas addressed in the lessons including scientists involved in developing the guides and other scientists affiliated with NASA and the SETI Institute. Scientists from other institutions volunteered to review lessons as well. Using a checklist, reviewers evaluated the lessons for accuracy, up-to-date content, and age-level appropriateness of content. They also pointed out misconceptions and suggested additions and revisions.

For some scientists, it was difficult to account for age-level appropriateness in their suggestions due to their lack of teaching experience with younger children. However, the scientists comments on content were invaluable and the recommended changes were incorporated by staff writers.

## 6. Curriculum Product: The Life in the Universe Series

After three years of development and testing, six teachers guides were produced for grades 3-9. They are described briefly below.

In *The Science Detectives* (ages eight to ten), students trace the travels of Amelia Spacehart, an astronaut and radio astronomer, who is searching the solar system for the source of a mysterious radio signal. From her futuristic NASA spacecraft (by way of a videotape), Amelia provides clues that lead the students to explore features of the solar system, states of matter, lenses and magnification, and large scale measurements. Their challenge is to anticipate her destinations and track her journey for NASA.

*The SETI Academy Planet Project* trilogy is targeted for students aged ten to twelve. The three *Planet Project* guides represent an extended, interdisciplinary curriculum when used in series. (They can also be used independently.) In each, students are invited to participate in a "SETI Academy" education and research program in which they act as scientists who are exploring Earths history for clues to the origin and evolution of life to inform investigations about the possible existence of life beyond our solar system. In *The Evolution of Planetary Systems*, students learn about the evolution of stars and planets. In *How Might Life Evolve on Other Worlds?*, students study the evolution of plant and animal life. In *The Rise of Intelligence and Culture*, students explore intelligence, culture, technology and communication. In all three guides, the students learn what scientists have discovered about Earth and the evolution of life, intelligence, and culture. Throughout, they apply their knowledge about the Earth and its life and intelligent cultures to construct a fictitious planet with life forms and culture.

In *Life: Here? There? Elsewhere?—The Search For Life On Venus and Mars* (ages thirteen to fifteen), students investigate the characteristics of life through this introduction to the multidisciplinary sciences of comparative planetology and exobiology. Students simulate conditions on Venus and Mars and explore various means of detecting life in the atmosphere and soils of Earth. They apply this knowledge to propose a spacecraft design for detection of life on Mars or Venus. Students also review the results from the Viking missions to do their own analyses of whether there is life on Mars.

In *Project Haystack: The Search For Life In The Galaxy* (ages fourteen to sixteen), students investigate the questions: Are there intelligent civilizations out there and where might they be? If they are out there, how would they communicate with us and what would they say? How should we respond? Students study the scale and structure of the Milky Way Galaxy as they explore the cosmic "haystack". They construct a simple radio receiver, and learn about signal-to-noise problems in making observations. They

study SETI science by using simple astronomical tools to solve some of the challenges of sending and receiving messages beyond our solar system.

As well as being enticing to students, each guide is carefully organized to provide teachers with the information they need to implement the program. The introductory section includes suggestions for preparation, teaching strategies, classroom management, and student assessment. This is followed by ten to fifteen hands-on, activity-based lessons. Every lesson begins with an introductory overview and is followed by a materials list, suggestions for materials preparation, detailed directions for every step of the activity, student worksheets, teacher answer keys, and suggestions for further explorations of the concept or concepts covered. The appendices contain comprehensive materials lists of the consumable and reusable supplies, ordering information and suggestions, annotated bibliographies, glossaries, and teacher information detailing the main scientific concepts underlying each lesson.

Additionally, each guide is provided with ancillary materials:

- all guides have an interactive poster, designed for the LITU Series by artist Jon Lomberg,
- *The Evolution of Planetary Systems, How Might Life Evolve on Other Worlds?, Life: Here? There? Elsewhere?* and *Project Haystack* are supported by video tapes of images of stars, galaxies, life of the past, and more that illustrate the lessons,
- *The Science Detectives* is based on an adventure story presented on video tape,
- *The Rise of Intelligence and Culture*, includes color transparencies of eight ancient human civilizations,
- *Life: Here? There? Elsewhere?* includes a set of orders-of-magnitude activity cards with views of Venus, Earth, and Mars designed by Jon Lomberg.

These ancillary materials were an unexpected but marvelous outgrowth of the curriculum development process. The design team members were exceptional in their capacity to be creative; they couldn't help imagining and inventing exciting accessory materials that enrich the lessons by reaching out to students who prefer a visual learning mode.

## 7. Publication

Publishers were first contacted at the National Science Teachers Association conferences in the exhibition hall. Most science education publishers exhibit at these meetings, and the personal contacts made during the conference were invaluable. As the guides neared completion, the LITU project manager contacted the publishers who had expressed interest in the curriculum materials. Along with an informative letter, samples of the materials were sent for their examination. Acquisition editors from three publishing houses responded. After many months of negotiations, Teacher Ideas Press was selected to publish and market the LITU Series and ancillary materials. The LITU Series is available directly from Teacher Ideas Press, a division of Libraries Unlimited, Dept. 9503, P. O. Box 6633, Englewood, Colorado, 80155-6633, USA.

## 8. Conclusion

The introduction of SETI-based science lessons to the elementary and middle school classes should help to persuade all students, including those in groups underrepresented in scientific fields, that science is interesting, challenging, and an attractive career possibility. The LITU series offers an introduction to the type of logical, disciplined thinking, both creative and analytical, that is the cornerstone of science. Further, by actively involving students-as-scientists throughout the LITU Series lessons, students learn about

the nature of the universe and how scientists go about exploring it. These experiences and knowledge also allow students to discard common misconceptions regarding the search for extraterrestrial life. Perhaps equally important is that by developing a perspective of life on other worlds, students may gain a sense of the unity of life on Earth, particularly among human beings. One of the optimistic views of the SETI scientists themselves is that the discovery of an extraterrestrial civilization will underscore the unity of humanity.

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#### REFERENCES

- AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE *Benchmarks for science Literacy*, 1993, Oxford University Press, New York.
- CALIFORNIA STATE BOARD OF EDUCATION. *Science Framework for California public schools kindergarten through grade twelve*, Sacramento, 1990, California Department of Education.
- RUTHERFORD, R. & AHLGREN, A. *Science for all Americans*, 1990, Oxford University Press, New York.
- KOBER, N. *What we know about science teaching and learning*, 1994, Council for Educational Development and Research, Washington DC.