WEIRD CAREERS IN SCIENCE

Astrobiologist

Mary Firestone

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Animal Therapist
Astrobiologist
Computer Game Developer
Pyrotechnician
SETI Scientist
Virus Hunter
Volcanologist

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CHELSEA HOUSE PUBLISHERS
A Haights Cross Communications Company ®
Philadelphia

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www.chelseahouse.com

First Printing

9 8 7 6 5 4 3 2 1

Library of Congress Cataloging-in-Publication Data

Firestone, Mary.
Astrobiologist / Mary Firestone.
p. cm. — (Weird careers in science)
Includes bibliographical references.
ISBN 0-7910-8971-1
1. Space biology—Juvenile literature. 2. Exobiology—Juvenile literature. 3. Space biology—Vocational guidance—Juvenile literature. 4. Exobiology—Vocational guidance—Juvenile literature. I. Title. II. Series.
QH327.F545 2005
576.8'39—dc22

2005017658

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Chapter 1

Introduction

ASTROBIOLOGIST KEVIN HAND has climbed inside a tiny **submersible**, which is about to lower him slowly down through the waters of the Pacific. When he finally reaches the ocean floor, he'll get a close look at some strange ocean organisms that actually love living next to the smelly, superheated, smoky vents in the ocean floor called "**black smokers**" (Figure 1.1). Hand is exploring these areas as part of the research team for the IMAX film *Aliens of the Deep*.

Black smokers look like thick tubes with bumpy sides. Dense clouds of iron, copper, and hydrogen sulfide flow out of them. In an article about Kevin Hand's work on this film, a writer for

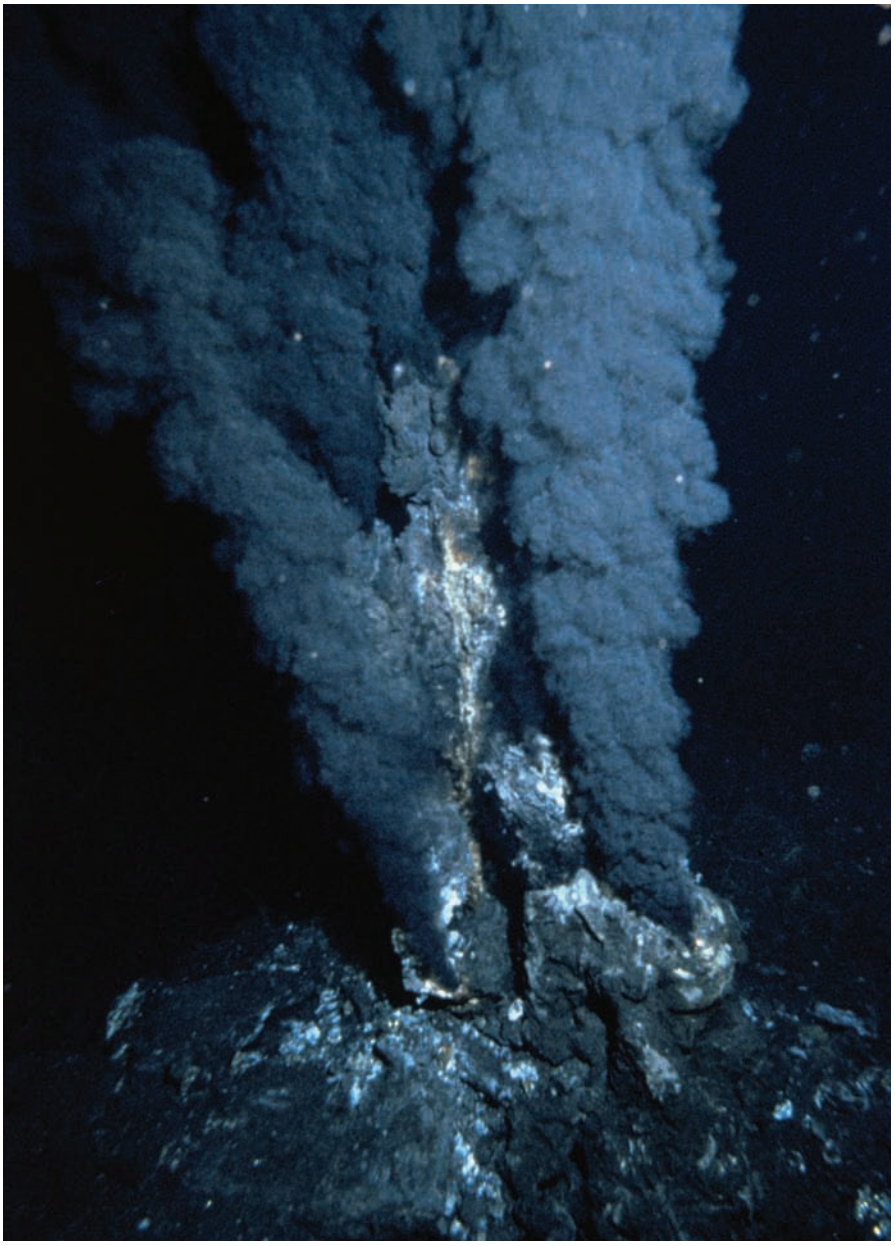

Figure 1.1 Scientists have recently discovered strange new life forms that not only survive but thrive near black smokers on the ocean floor, like the one seen here.

the *Stanford (University) Report* describes groups of black smokers as an "upside-down power plant where microbes eat scalding exhaust." And that's exactly what many organisms do.

Until recently, scientists didn't know life could exist in the extreme environment of the ocean, where there is no light and where temperatures reach a blistering hot 345°C (653°F). But the **microbes** that live there are like no others. They are newly discovered organisms that scientists are just finding out about, called "**extremophiles**."

To help film *Aliens of the Deep*, Hand worked with other astrobiologists, marine biologists, planetary scientists, and geophysicists from the National Aeronautics and Space Administration (NASA). He completed eight different dives into the Pacific and Atlantic oceans in the tiny submersible, to visit smoker sites with names like "Lost City" and "Snake Pit." He spent up to 15 hours at a time under the sea, where the film crew recorded images of 6-foot-long tubeworms, blind white crabs, and massive quantities of heat-sensing white shrimp.

But why, you may ask, are **astrobiologists** here? What do these strange undersea creatures have to do with life in outer space? Astrobiologists are very interested in this project, because extreme conditions near **hydrothermal vents** may resemble life on other planets and moons. The weather in outer space is extreme. If organisms can survive and thrive in similar extreme conditions here on Earth, then maybe similar life-forms exist in outer space.

Kevin Hand says of the extremophile discoveries, "This perhaps reflects the most important lesson learned from the discovery of the vents back in the late 1970s." It has "caused the biological community to scratch its head and rethink things [about places where life might exist]."

WHAT IS ASTROBIOLOGY?

Astrobiology is the study of life in the universe. It includes the fields of astronomy, physics, biology, geology, paleontology, and many others, such as microbiology. The curiosity of scientists who wonder if life exists somewhere besides Earth has created this new science. Since we cannot yet travel to other planets, astrobiologists must begin with the only life we know about: life on Earth.

The recent discovery that there is a whole chain of life thriving on the heat and chemicals boiling up out of the bottom of the sea floor has caused a big leap in research activity for astrobiology (Figure 1.2). These hot spots are energizing long food chains, which begin with little microbes that eat hydrogen sulfide from the black smokers. Then other bigger creatures come and eat the microbes, and the chain of life continues, with little fish being eaten by bigger fish.

In an interview with PBS for his book *The Universe Below: Discovering the Secrets of the Deep*, *New York Times* science writer William Broad described the vast area now being explored by astrobiology: "The **biosphere** is the habitable part of the Earth. If you take all the stuff we have on land—the trees, all the stuff we know and love, the

Black Smoker

A strange type of shrimp was discovered near black smokers. Called *Rimicaris exoculata*, this shrimp has eyes on its back! Biologist Cindy Van Dover made the discovery while she was exploring the sea floor in a submersible. The submersible was used to collect samples from the areas near black smokers, to be analyzed later by scientists.

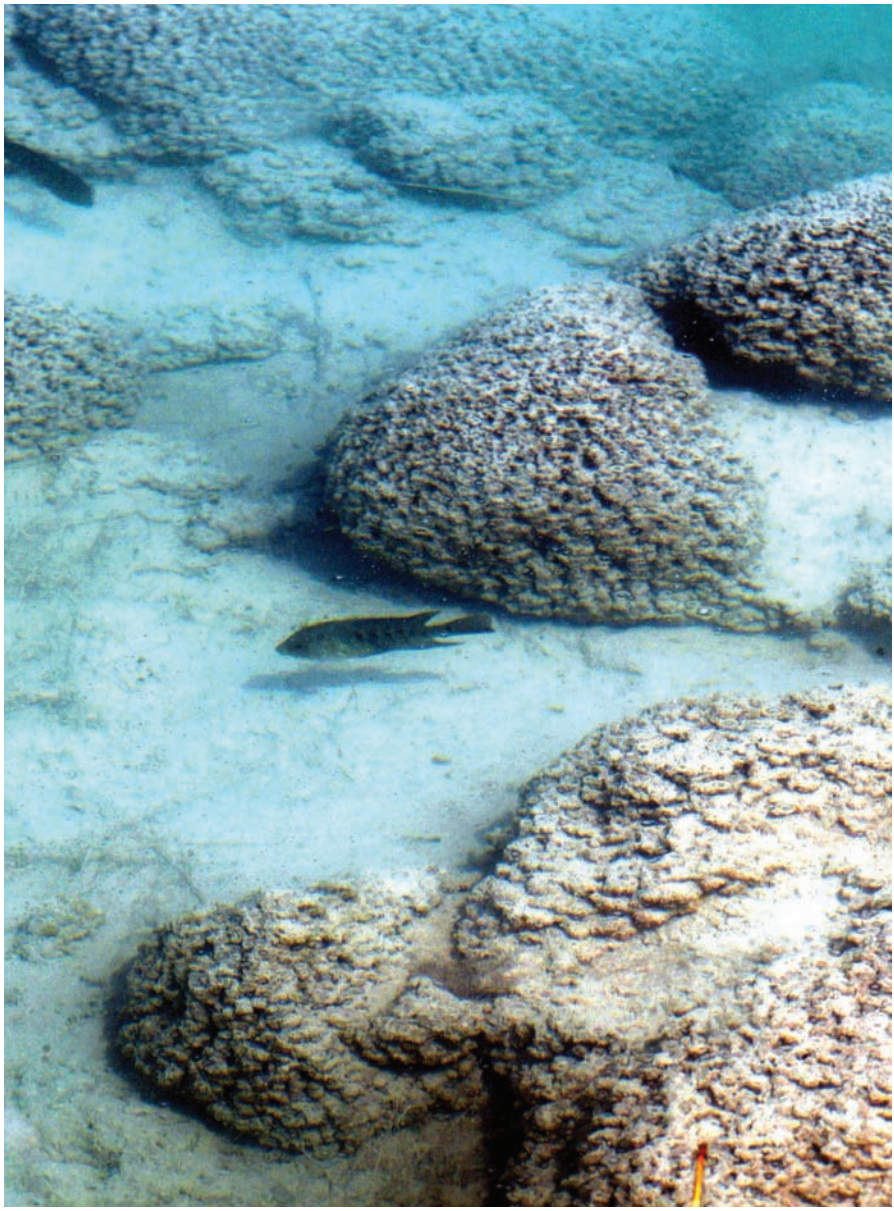

Figure 1.2 Astrobiologists study life on the ocean floor because it may closely resemble conditions in which life may exist on other planets. Coral-like formations like these found in Cuatro Cienegas, Mexico, are home to ancient colonies of bacteria very similar to the ones that first arose on Earth over 3 billion years ago.

fields—you put all that together, and then you take the upper part of the ocean and mix that into the equation. That's about 3 percent of the biosphere, of the habitable part of the Earth. And the other 97% of that is cold and wet and dark and virtually unknown."

A significant portion of that 97% is made up of volcanic vents that harbor previously unknown life forms that exist in enormous quantities. According to Broad, "There's 46,000 miles [74,000 km] of them. That's like seven times around the Moon. It's the biggest feature on our planet, and we know virtually nothing about it, except that every once in a while when we go down . . . you find there are these lush ecosystems that thrive in total darkness."

When these volcanic sea floor areas and their life forms were discovered, people started to wonder if life on Earth might have started there. Broad says, "It's hot and it's constant. It's down there, cooking the whole time. It's like a test tube, a scientist's test tube. And the reasoning has evolved now . . . and evidence keeps building stronger and stronger that these places, these hot vents and these black chimneys—with all this hot—enormously hot water coming out—are the place where life began on this planet."

ASTROBIOLOGY'S MAIN QUESTIONS

To answer the questions posed in astrobiology, NASA has organized its research into a series of goals.

How Does Life Begin and Develop?

One of the key goals of astrobiology is to understand how life began on Earth; to explore how life evolves on the molecular, organism, and ecosystem levels; and to determine how the **terrestrial** biosphere has coevolved with Earth.

Does Life Exist Elsewhere in the Universe?

This is perhaps the biggest question for astrobiologists. Some goals for answering this question include determining what makes a planet habitable and figuring out how common habitable places are in the universe. Other goals include learning how to recognize the "**signature**" of life on other planets and to find out if there is, or ever was, life anywhere else in our solar system. Some places of special interest to astrobiologists are the planet Mars and also Jupiter's moon Europa.

What Is Life's Future on Earth and Beyond?

This question spurs the imagination. What will life on Earth be like in the year 10,000 or 50,000? NASA hopes to find out by studying how **ecosystems** respond to environmental change and understanding how terrestrial life responds to conditions in space or on other planets.

Chapter 2

History of Astrobiology

SCIENTISTS AND NONSCIENTISTS alike have speculated about the possibility of life on other planets for centuries. But since there was no means of exploring and testing their ideas, astrobiology did not become a science until fairly recently. Most of the first ideas of astrobiology were set down in the late 1950s: the notion that comets brought the first water and perhaps life to Earth from space, that nucleic acid was the first molecule that could replicate itself, and that Mars had life in some form.

Space technology was not developed enough during the 1950s to test and prove these theories: No space stations were available for deep-space observation; no space probes could

orbit Mars; no rovers existed to travel over Mars's surface to send back samples. Astrobiology (which was called "**exobiology**" at the time) remained nothing more than an idea until space travel became a reality.

However, the delay in astrobiology research was not caused by the lack of technology alone. Many scientists in the 1950s thought exobiology was too much like science fiction. The only public discussion of life on other planets that was going on at the time happened in novels and fictional radio broadcasts. Scientists didn't want to risk not being taken seriously.

Without observable data, astrobiology lacked a firm foundation as a scientific discipline. On top of that, no one knew what to call it. Its name changed from *bioastronomy*, to *exobiology*, and finally, to *astrobiology*, as we know it today. In scientific literature, it was described as "life on other celestial bodies" or "**extraterrestrial** life."

Astronomers had noticed changing colors on the surface of Mars, which suggested to scientists that plant life might be growing there, perhaps being harvested by intelligent beings. There were also some ideas floating around the scientific community about comets. Scientists knew they were made of ice—frozen water—and so they were capable of carrying life around the universe. But aspiring astrobiologists needed technology to prove these theories, and that technology didn't exist.

NASA

When NASA was created in 1958, it was the first organization in the world to use rockets strictly for the purpose of space exploration and science. Up until then, rockets had been used only by the military. Beginning in the 1960s and throughout the 1970s, NASA launched many exploration

Figure 2.1 *Explorer 1*, seen here being launched on January 31, 1958, was the first American artificial satellite to orbit the Earth.

satellites into Earth's orbit, beginning with the *Explorer* series. These satellites had instruments that sent back information about the Earth's atmosphere. *Explorer 1* (Figure 2.1) made the major discovery that the Earth was surrounded by a radiation belt, which was later named the Van Allen Belt. The Van Allen Belt is a region of space where the Earth's magnetic field catches radiation, and it extends far into space. More discoveries were made by *Mariner 2*, which reached Venus on December 14, 1962, to scan its surface. *Mariner 2* measured Venus's surface temperature at 800°F (427°C). It also discovered what solar wind is made of.

Mariner 4 was launched on November 28, 1964, and reached Mars on July 14, 1965. It sent back 22 photographs of Mars's rough, reddish, rock-strewn surface. It also sent back data about Mars's atmosphere, which scientists discovered is made mainly of carbon dioxide. The *Lunar Orbiter* was launched in 1967. It orbited the moon and recorded scientific data about temperature, magnetic field, and surface chemistry. *Surveyor 1* made the first successful moon landing and returned to Earth with samples.

Throughout this time, technical advances were being made in **radio astronomy**. Computers were making it possible to process data from telescopes, and space travel got scientists thinking about the possibility of intelligent life in outer space. During the 1970s, after studying the moon, NASA sent *Mariner 6* to Mars, collecting data about its atmosphere. *Mariner 9* was sent into orbit around Mars in 1971. When it arrived there, it sent back information about a huge dust storm that lasted for a whole month. Once the storm cleared, *Mariner* was able to take photos of Mars's surface. These photos revealed giant inactive volcanoes, spectacular canyons, and dried riverbeds (Figure 2.2).

Figure 2.2 **This spectacular image of the Olympus Mons volcano on Mars, the largest known volcano in our solar system, was taken by *Mariner 9*.**

During the 1970s, Search for Extraterrestrial Intelligence (SETI) studies began. With radio telescopes aimed at the skies, scientists waited for signals from other planets. Scientists were now open to the idea that other technically advanced civilizations might be sending signals to let us know of their existence. This program lost its funding with NASA in the early 1990s, but SETI work was continued by the SETI Institute in California and by university programs around the country.

All of the data sent back to Earth from satellites and SETI spawned the modern field of astrobiology. The science of astrobiology could finally begin in earnest, because now there was information to research. The *Cassini-Huygens*

orbiter was launched in 1996, a joint effort between NASA and the European Space Agency. *Cassini*'s goal, to reach Saturn and its moon Titan, has been accomplished.

When NASA established astrobiology research in 1996, it brought together scientists from many disciplines and formed a group called the NASA Specialized Center of Research and Training (NSCORT). This officially began the field of astrobiology at NASA.

Since then, many scientific discoveries have aided research in astrobiology. The Hubble Space Telescope has discovered planets around stars outside our **solar system**, which suggests that there may be other Earth-like worlds out there that could support life.

Here on Earth, scientists have also found life in extreme environments. Some of these extremes include high temperatures, high pressure, very salty or cold water, and high acidity. These extremes were once thought to prevent life. Now scientists have found that certain life forms not only survive but thrive within them.

Space exploration has provided scientists with evidence that liquid water has existed on Mars and on Jupiter's moon Europa. The fact that water was once present on an otherwise dry planet is a sign that life may have existed there at one time. Water must be available for life to happen.

New developments in technology such as **spectrometers**, ultraviolet and **infrared telescopes**, and radio telescopes have made it possible for astrobiologists to see what was once invisible to the eye or even with **optical telescopes**.

In 2005, the Mars rovers *Spirit* and *Opportunity* and their onboard instruments sent back data about Mars's atmosphere (Figure 2.3). Ground-based and space-based remote-sensing devices can detect the chemical signatures