IS THERE LIFE ON MARS? PATRICIA ANN STRAAT '58 THOUGHT SO.

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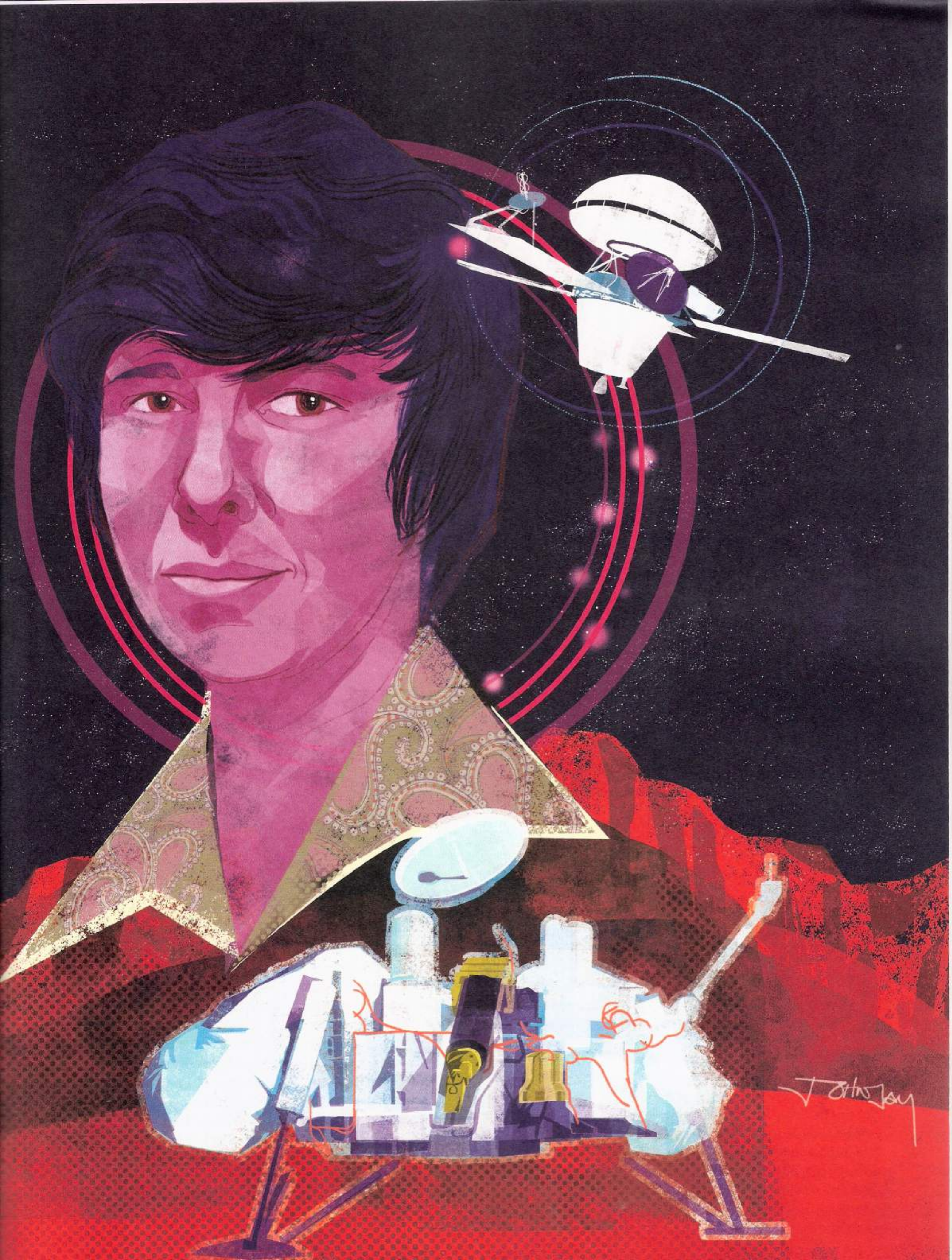
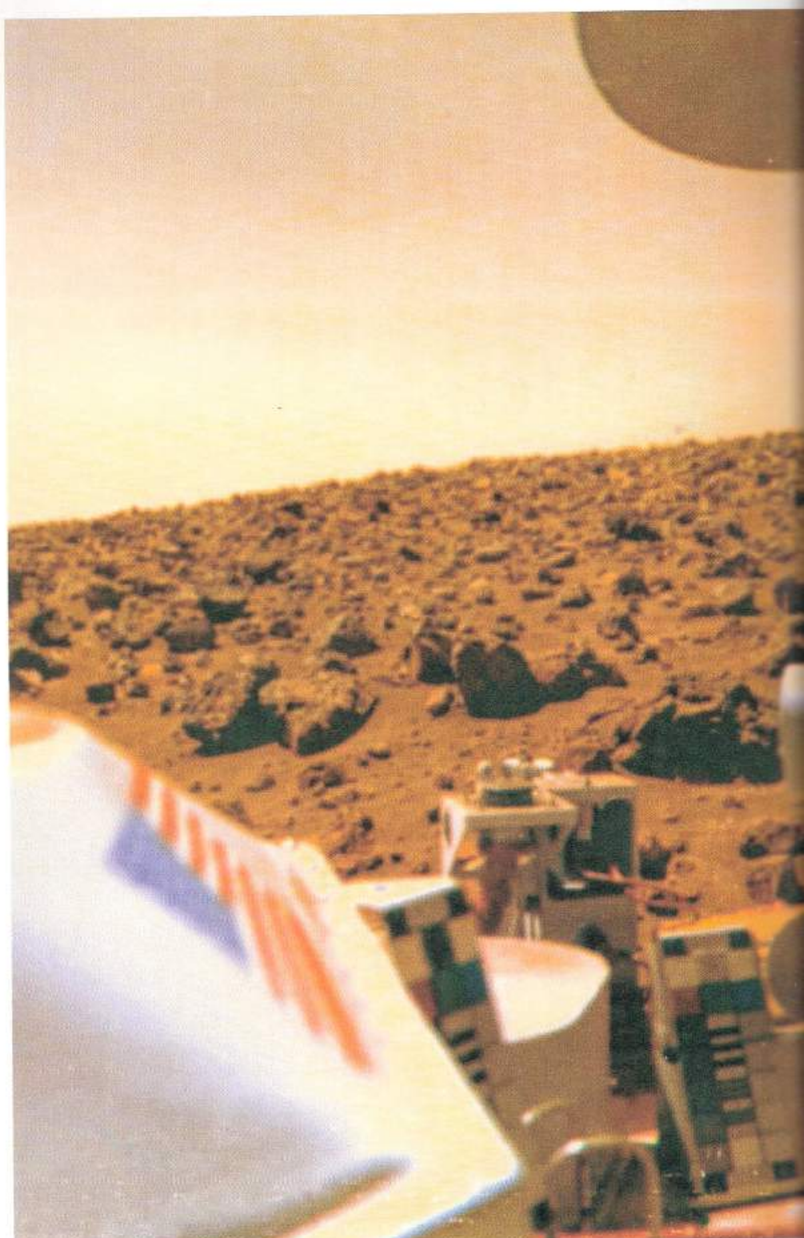
Imagine you're a scientist, and you think you've made one of the greatest discoveries of all time. Working with a team of engineers, you have built an experiment, miniaturized it, automated it, and flown it to Mars. Against all odds, the instrument works as planned in a hostile, frigid environment and returns the first strong evidence for life on another planet.

But many of your scientific colleagues remain unconvinced, as does NASA. So you propose experiments to follow up this tantalizing finding, waiting for the next mission. And you wait, and wait, and wait…for 44 years. >





Welcome to the world of Patricia Ann Straat '58, who, at age 84, passed away from lung cancer on October 23, 2020, shortly before this article was prepared for publication. Straat played a pivotal role in developing the Labeled Release (LR) experiment aboard NASA's twin Viking landers, which touched down on Mars in 1976. Each lander's LR experiment tested Martian soil samples for metabolizing microbes and returned positive results, fulfilling all the pre-mission criteria for claiming the discovery of extraterrestrial life.

These results have remained front and center of a controversy that has lingered for four decades. And the unresolved question of life on Mars has major ramifications for the future. As Straat repeatedly pointed out in the later years of her life, NASA adopted a conservative approach to its multibillion-dollar Mars exploration program, refusing to fly any instruments that could detect living microorganisms. And she contended that bringing Mars samples back to Earth, without knowing if they contain dangerous pathogens, was a risk not worth taking. Yet NASA and its European counterpart are planning to do just that.

On this key point, the highly respected astrobiologist Christopher McKay of NASA's Ames Research Center concurs with Straat: "We cannot rule out that the LR experiment did detect life and that there are dormant life forms in the Martian soil. This has implications beyond the science debate. Are we confident enough that the Martian soil is lifeless to send astronauts? And then to bring those astronauts back to Earth?"

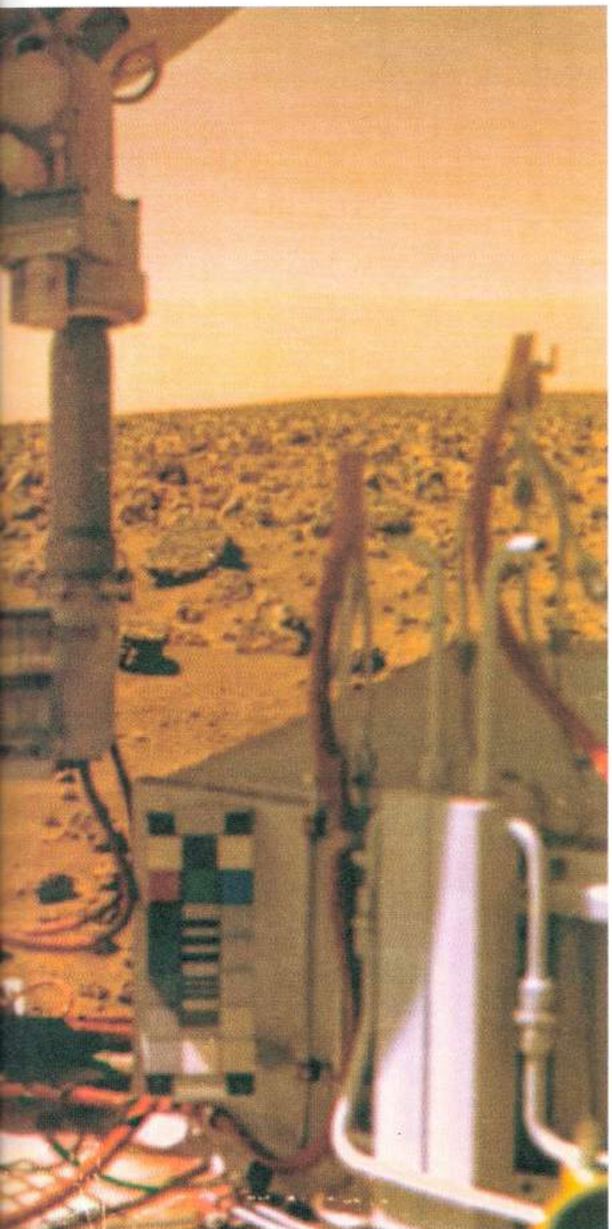
AT OBERLIN

Straat (rhymes with Pat) grew up in Rochester, New York, where she developed a fondness for horses in very early childhood. Although Straat didn't have any specific interest in biology in her formative years, she wanted to move away from upstate New York and explore the world.

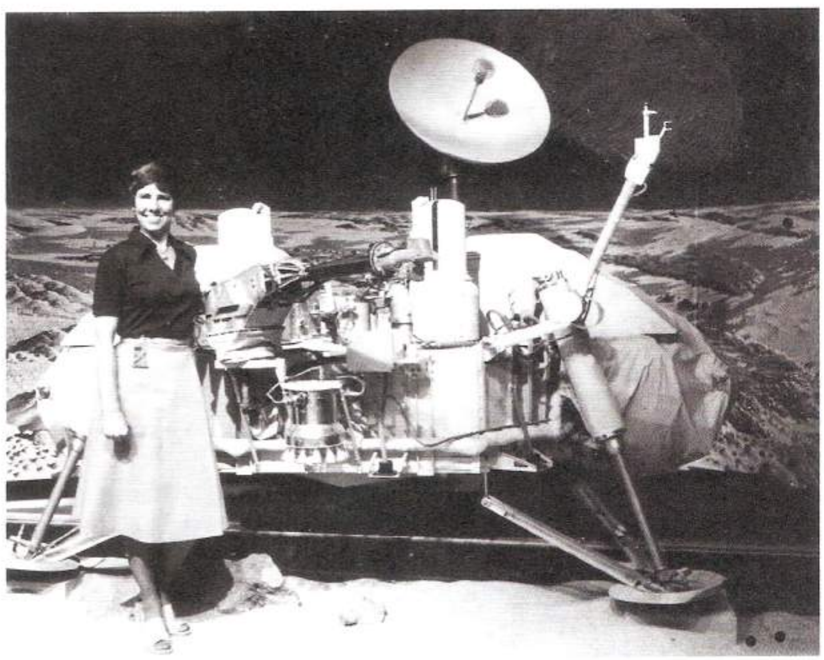
When she read Oberlin's brochure, it sounded like a fascinating place. She liked the idea of mock political conventions—a staple of campus life at the time—along with the absence of cars and alcohol on campus. She enrolled as a freshman in 1954.

"I just loved my four years at Oberlin," Straat recalled in a summer 2020 interview. "I blossomed within the Oberlin environment. I was kind of shy before I went there, but it encouraged me to be myself. Oberlin appreciated individuality. I gained confidence that I could do anything."

Straat was known as the "horse woman" on campus. She bought a young mare for $75 from a farm outside town, a horse she owned for 17 years. To her, riding a horse was a way of life. "I would often be seen galloping around Tappan Square," she said.



Left, Viking 2 on the surface of Mars. Below, Straat poses in front of the test lander at NASA's Jet Propulsion Laboratory.



raat majored in psychology but came to e it was not for her. But by then it was too o change her major. She took an ductory course in chemistry her senior year, h she "absolutely loved." She also took al advanced biology courses, which she also l. That set her on a career path to pursue emistry.

raat had personal reasons to attend uate school at Johns Hopkins University in more. She had a meeting with the director e McCollum-Pratt Institute, where emistry was taught. He questioned Straat hether a psychology major could pass uate courses in biochemistry. "By now, I pretty confident in myself, so I said, 'Sure, why not.' He thought that was the funniest thing he ever heard," she recalled.

The director told his secretary that he would teach this young woman a lesson, but he also instructed the secretary to enroll Straat. The director made bets that Straat wouldn't last a semester, but she proved him wrong. "I studied like I had never studied before. It was really hard going," she said.

Straat earned her PhD in six years, completing a thesis on enzyme characterization and nitrogen metabolism. She moved into a postdoctoral fellowship at Johns Hopkins' medical complex, where she specialized in molecular biology, biophysics, and the use of radioactive isotopes as tracers. She later accepted an assistant professorship, only the third woman to achieve that position at Hopkins. But after about two years, she decided she had been at Hopkins long enough and that it was time to "spread my wings."

It was at this moment that an opportunity arose that would change her life.

PREPARING FOR MARS

In the spring of 1970, Straat was offered a job with the Maryland firm Biospherics Inc. The company was owned by Gilbert Levin, an engineer who had developed an ingenious low-cost experiment that enabled municipalities to test water supplies for bacterial contaminants. Straat was not really thinking of going into private industry, but when she met Levin, she vividly recalled, "He very much inspired me."

Levin needed a biochemist who worked with radioactive isotopes, which made Straat the perfect fit. He told her about his plan to send his experiment to Mars aboard a NASA spacecraft to look for signs of life. But as Straat remembers, "At the time, looking for life on Mars was as far out as you could get. I talked it over with colleagues, and they all thought I was insane. But it sounded like so much fun."

Straat accepted the job offer, despite knowing it was a risky career move. But she never had regrets, noting that it led to "a wonderful career."

Straat became Levin's co-experimenter on the Labeled Release experiment. She worked directly with the engineers at TRW, the company in Redondo Beach, California, that built the biology instrument. Building an instrument that would operate autonomously in a hostile environment where temperatures were far below freezing and the atmospheric pressure was close to vacuum was no trivial feat.

The LR experiment is straightforward in concept. Each Viking lander carried a robotic arm that scooped up small soil samples and dropped them into a hopper, which would distribute them to the life-detection experiments and another instrument for detecting organic (carbon-based) molecules. The LR experiment added a nutrient of seven organic compounds to the sample. The nutrient's carbon atoms were labeled with the radioactive isotope ^{14}C. Any living microbes in the sample would metabolize the nutrient and produce radioactive carbon dioxide gas, which would be monitored with a radiation detector.

As Straat describes in great detail in her book *To Mars With Love*, the LR experiment and the entire life-detection package encountered one technical difficulty after another. Straat spent long stretches of time living in Southern California as she worked with the TRW engineers to resolve problems. Early on, as troubles mounted and costs rose, it became clear that one of the original four life-detection experiments would have to go. Straat and Levin had to sweat it out until they found out that another experiment was given the axe.

Straat enjoyed working with the scientific and engineering teams even though they operated under intense pressure to meet stringent size, weight, budgetary, and schedule constraints. And despite being one of only two women on the project, she said the men treated her with respect, especially when they realized her high level of competence. She said Levin, in particular, treated her as an equal. They remained lifelong friends.

NASA launched Viking 1 on August 20, 1975, and Viking 2 on September 9. Each spacecraft included an orbiter and lander. On July 20, 19 Viking 1 made history by becoming the first spacecraft to land successfully on Mars. Viking followed suit on September 3.

MY GOD, IT'S POSITIVE!

Before Viking 2 had even landed, Viking 1's LR experiment had already produced spectacular results. For the first soil sample, the radiation detector registered a strong active response, w a long plateau of ^{14}C lasting several days. This was exactly the result the experiment produce in terrestrial soils with active microbes.

"My God, it's positive!" Straat thought as t first results were radioed back from Mars.

Better yet, when the team heated the next s sample to 160 degrees C (320 degrees F), the t yielded a negative result—indicating that the high temperature had killed any microbes tha might have been present. Taken together, the t tests fulfilled pre-mission criteria for Martian

Levin and Straat conducted five LR tests o Viking 1 and four on Viking 2, changing the temperature and other conditions in an effort distinguish between biological and chemical responses. Overall, the results of the nine tests were fully consistent with biology.

Unfortunately, the other two life-detection experiments yielded negative results. And eve more worrisome, the experiment designed to detect organic molecules came up empty. How could there be life without organics? To NASA officials and many scientists, these were signs that the LR experiment detected some kind of reactive chemical in the Martian soil rather th metabolizing microbes.

And yet Straat and Levin remained fairly confident that their LR experiment had found life on Mars, especially because NASA mission have since found water vapor in Mars's thin atmosphere and trace amounts of liquid water Straat insisted that the LR experiment "has ne produced a false positive" on Earth. She favore the idea of cryptobiosis, in which microbes remain in a state of hibernation until revived with water. "Nobody knows how long somethi can survive in a cryptobiotic state, but it may b millions of years," she said.

Straat pointed out that Viking's other two life-detection experiments were designed to detect a different kind of metabolism, meanin their negative results had no bearing on LR's positive outcome. Subsequent NASA rovers ha found small amounts of water and complex organics in the Martian soil. No scientist has e identified a chemical agent that could reprodu both the LR experiment's positive results and temperature controls. And even more tantalizi subsequent telescopic and spacecraft

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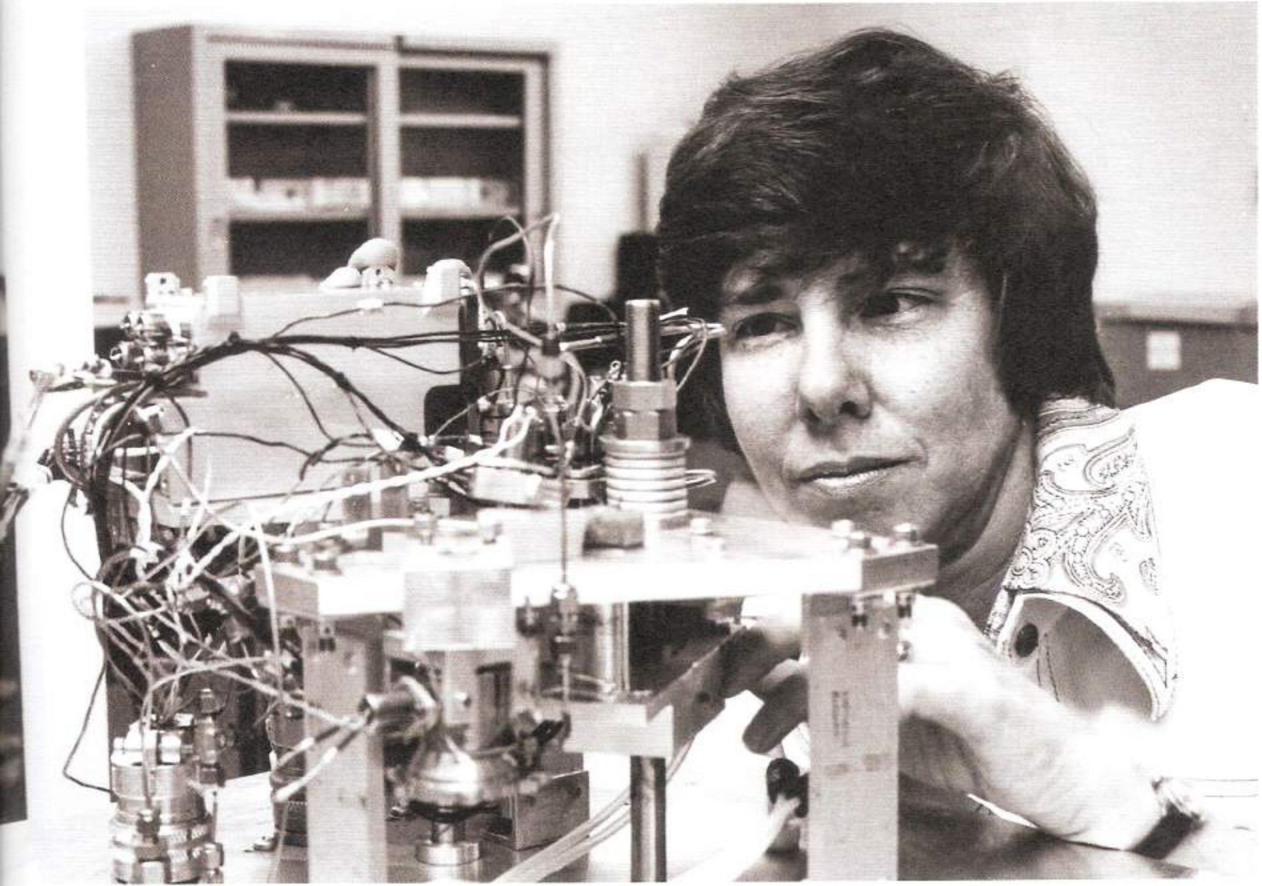

Straat eyes the Viking Mission Labeled Release instrument.

ervations have detected low levels of methane Iars's thin atmosphere. On Earth, 95 percent tmospheric methane is biogenic.

Straat and Levin proposed follow-up -detection experiments to fly to Mars, but SA did not send another lander to Mars until Pathfinder mission in 1997. NASA has since wn a series of sophisticated landers and rovers Mars. But none of them have carried ruments specifically designed to detect life, oversight that mystified and frustrated both in and Straat. NASA is touting its upcoming severance rover as a life-detection mission, an ertion that Straat called "misleading." The er will collect samples and store them for urn to Earth a decade from now, a process t Straat said might destroy any life. "That's dly a good experiment for life detection," explained.

In response, NASA's chief scientist James en says that NASA and the scientific mmunity don't want to repeat Viking's biguous life results. NASA has instead sued a "follow the water" strategy, launching iters and landers that have revealed a trove of rmation about the planet's history. These epid robotic explorers have proven beyond doubt that liquid water once flowed across the surface billions of years ago, meaning Mars in its distant past had conditions for supporting life.

This effort is scheduled to culminate in about a decade, when NASA and the European Space Agency will fly a joint mission to return Perseverance's rock and soil samples to Earth. The rover is landing in an ancient dried-up river delta thought conducive for preserving signs of life. By studying these samples in a lab on Earth, some scientists think they can resolve the life question.

But for Straat, that is now too late, and. Levin is in his late 90s. The question of life was not resolved in her lifetime and it is extremely unlikely to be resolved in Levin's lifetime, either.

In what was probably her final interview, Straat expressed strong concern about bringing back Martian life without knowing anything about it. She always advocated sending life-detection experiments first to determine whether or not Mars has extant life before returning samples to Earth. "God help us if we bring back another pandemic," she said.

Straat left Biospherics after the Viking program ended and in 1980 became a scientist administrator at the National Institutes of Health. For years, she worked on-and-off writing her book *To Mars With Love.* But after learning her cancer had returned, she accelerated her efforts, completing the book in 2017 and self-publishing it in 2019. It documents the behind-the-scenes story of the LR experiment, an important chapter in the history of space research.

Straat lived her final years in retirement on a 10-acre horse farm near Sykesville, Maryland. Reflecting back on her heady days with the Viking project, she wrote in her book, "The whole was indeed greater than the sum of all its parts, and I felt like a key part of an enormously integrated body functioning as one to move forward. Never before or since have I felt such unity, such an amalgam of expertise and dedication, working together toward a common goal."

ROBERT NAEYE '85 IS A FREELANCE SCIENCE WRITER BASED IN HERSHEY, PENNSYLVANIA. LEARN MORE ABOUT THE SEARCH FOR EXTRATERRESTRIAL LIFE BY READING HIS COVER STORY IN THE SEPTEMBER 2020 ISSUE OF *ASTRONOMY* MAGAZINE. HIS PROFESSIONAL WEBSITE IS WWW.ROBERTNAEYE.COM.

INTERESTED READERS CAN ORDER STRAAT'S BOOK BY VISITING WWW.TOMARSWITHLOVE.COM.