Project on the origins of life launched

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Harvard joining debate on evolution

By Gareth Cook, Globe Staff | August 14, 2005

Harvard University is launching a broad initiative to discover how life began, joining an ambitious scientific assault on age-old questions that are central to the debate over the theory of evolution.

The Harvard project, which is likely to start with about $1 million annually from the university, will bring together scientists from fields as disparate as astronomy and biology, to understand how life emerged from the chemical soup of early Earth, and how this might have happened on distant planets.

Known as the "Origins of Life in the Universe Initiative," the project is still in its early stages, and fund-raising has not begun, the scientists said.

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But the university has promised the researchers several years of seed money, and has asked the team to make much grander plans, including new faculty and a collection of multimillion-dollar facilities.

The initiative begins amid increasing controversy over the teaching of evolution, prompted by proponents of "intelligent design," who argue that even the most modest cell is too complex, too finely tuned, to have come about without unseen intelligence.

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President Bush recently said intelligent design should be discussed in schools, along with evolution. Like intelligent design, the Harvard project begins with awe at the nature of life, and with an admission that, almost 150 years after Charles Darwin outlined his theory of evolution in the Origin of Species, scientists cannot explain how the process began.

Now, encouraged by a confluence of scientific advances -- such as the discovery of water on Mars and an increased understanding of the chemistry of early Earth -- the Harvard scientists hope to help change that.

"We start with a mutual acknowledgment of the profound complexity of living systems," said David R. Liu, a professor of chemistry and chemical biology at Harvard. But "my expectation is that we will be able to reduce this to a very simple series of logical events that could

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have taken place with no divine intervention."

Exploring the natural order
The theory of evolution has been both fascinating and religiously charged since its very beginnings, because it speaks directly to the place of people in the natural order. In another era, the idea that humans are the close cousins of apes -- a scientific fact now supported by overwhelming evidence -- was seen as both offensive and preposterous.

Today's research of origins focuses on questions that seem as strange as the study of "ape men" once did: How can life arise from nonlife? How easy is it for this to happen? And does the universe teem with life, or is Earth a solitary island?

At Harvard, the origins of life initiative is part of a dramatic rethinking of how to conduct scientific research at the university.

Many of science's most interesting questions are emerging in the boundaries between traditional disciplines such as physics, chemistry, and biology, yet universities are largely organized by those disciplines. Harvard's president, Lawrence H. Summers, is a proponent of the view that universities must develop new structures to encourage interdisciplinary science. And new science laboratories based on this are at the center of the plans for a sprawling new campus in Allston.

The Harvard origins initiative is on a short list of projects being considered for this campus, along with the widely discussed Harvard Stem Cell Institute, which aspires to bring together biologists, chemists, doctors, and others.

Today, scientists said, Harvard is considered something of an underdog in the field of the origins of life, compared with powerhouses such as the University of Arizona, the California Institute of Technology, and the Scripps Research Institute in La Jolla, Calif.. But the university has tremendous resources, including leading scientists who work in related areas.

"I hope that Summers is batting for a home run," said Steven Benner, a University of Florida scientist who is considered one of the world's top chemists in origins-of-life research. "It is quite gratifying to see Harvard is going for a solution to a problem that will be remembered 100 years from now."

A look far afield
Harvard has made its move at a time of increased interest in the possibility of life on other planets. Over the past decade, astronomers have discovered more than 150 planets orbiting distant suns, suggesting that the galaxy is littered with them. At the same time, biologists have been finding that life can survive in much more hostile environments than thought possible -- such as microbes that live deep in rock or in searingly acidic water -- meaning that planets with more extreme environments might support life.

NASA has been driving the field forward, said Jonathan Lunine, a codirector of the University of Arizona's Life and Planets Astrobiology Center, which was officially launched in June.

NASA has been funding astrobiology research and the Mars mission that found evidence that tremendous amounts of water once existed there. The agency has plans for missions to search for evidence of life on other planets.

Within the next decade, NASA plans to launch the first of two Terrestrial Planet Finders, space telescopes designed to pick out the flickering light of planets near the bright blaze of distant stars. President Bush has also laid out a manned exploration of Mars as a national goal.

Nature of life's signs
These plans have researchers grappling with the question of what might constitute a sign of life, especially because life elsewhere may

not look like life on Earth. One of the central goals of the Harvard initiative is to understand the different ways that life might form, according to Dimitar Sasselov, a Harvard astronomer who is organizing the university's origins-of-life initiative.

"There is no reason to think that biology would be the same from planet to planet, but physics and chemistry should be the same," Sasselov said.

Yet even understanding the path to life on Earth is daunting. Researchers have sketched out a version of the story that begins 4 billion years ago, when Earth was a hot, young planet, with no oxygen to breathe. Evolution forms the basis of modern biology.

Still, there are many points in the story of life's origins in which there is a mystifying leap that has escaped explanation. One of the first is the appearance of complex organic molecules, such as those that form membranes around cells; these are the building blocks of life.

New look at an experiment
Every high school student learns of the 1953 Miller-Urey experiment: A flask, containing elements of the early Earth's atmosphere, was jolted with electricity, like bolts of lightening. This simple setup created a wealth of organic molecules, but since, the prevailing view of the makeup of the early atmosphere has changed, and the experiment doesn't work well with the new recipe.

Some researchers have suggested that organic molecules could have been carried to Earth in the icy core of comets, or that life began near the intense heat of deep sea vents, an environment that drives unusual reactions.

But on the third floor of Harvard's Engineering Sciences Laboratory, a chemist, Scot Martin, has pursued a different theory. He believes that ultraviolet light from the sun, shining down on tiny mineral crystals floating near the surface of the early ocean, may have generated organic compounds.

In his flask, he has shown that molecules of bicarbonate, common in the early ocean, attach themselves to a mineral called sphalerite. When the ultraviolet light hits the sphalerite, it sets off a chain of events that makes the bicarbonate more reactive, and that leads to a wide range of organic compounds in Martin's flask.

A scientist's elation
"I was elated," said Martin, a professor of environmental chemistry at Harvard who only recently became involved in origins-of-life research. "This area as a whole is drawing more interest."

Even with Martin's and others' work, though, there remains another profound and unsolved problem in the story of life's development: how the environments with just the right chemicals might have come to be.

For example, chemists have long wondered how the early Earth environment could have produced large amounts of a sugar known as ribose, a building block of RNA, a molecule that carries genetic information and that is crucial to life on Earth.

Last year, Benner published a paper in Science finding that a common mineral, borate, could collect ribose, concentrating it in the environment. Benner has been studying how minerals may have played other roles as well, helping to create special environments where the key ingredients of life could have come together and formed larger structures.

One of the biggest puzzles is discovering a way that the natural chemistry of the early Earth could lead to the building of structures, such as cells, that can evolve.

Scientists have long known that, under the right conditions, molecules called fatty acids come together and form membranes, like the skin of a water balloon. Over the past few years, a Harvard

scientist, Jack Szostak, has made important progress in understanding how a process like this may have led to the first cell. In a paper in the journal Science, he has shown that a clay common on the early Earth, called montmorillonite, speeds this process by serving as a scaffold.

The Szostak team has also built on the work of other scientists, who have shown that the same clay can help the formation of RNA, thought to be a precursor to the DNA that now serves as life's instruction book. Szostak showed that when fatty acids and RNA were mixed with the clay, these balloons formed with RNA trapped inside. A process like this, Szostak said, may have led to the first cell.

Szostak, who is an investigator with the Howard Hughes Medical Institute and a researcher at Massachusetts General Hospital, is also part of the push across traditional academic boundaries. He depends, for example, on the work of chemists, who can tell him what chemical building blocks may have been available. Andrew Knoll, another member of the Harvard initiative, built his career as a specialist on Earth's most ancient fossils, but now finds himself a part of the team deciding where the Opportunity rover travels on the Martian surface.

And Sasselov is an astrophysicist who is a specialist in finding planets around other stars, and in creating models of their makeup, yet he is organizing the Harvard effort to explore some of the most fundamental questions in biology.

Doubt over a divide

There is a deep philosophical divide between this scientific community and the advocates of intelligent design.

Szostak recalled that he had been surprised to see his own research, which he interprets as progress in understanding life's origins, on religious websites, which cite the work as evidence of how difficult it would be to create life without a designer -- because, Szostak said, "not even Harvard scientists can do it."

Michael Behe, a biologist at Lehigh University in Pennsylvania and one of the leading proponents of intelligent design, said he was glad that Harvard was going to try to address the issue.

"If, as I suspect will happen," Behe said, "they fail to find a plausible answer without invoking intelligence, then maybe science will be less hostile to folks who see intelligent direction in the history of life," he said.

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