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By Kathryn Bender, Star-Bulletin

Randy Larsen and Maqsudul Alam, right, explain their discovery by using a balloon and box, which represent protein that live in bacteria. The balloon is the sensing domain which senses oxygen, and the box is the signaling domain -- in effect, a transmitter -- telling the bacteria where to move for the best living conditions. The researchers identified a new class of myoglobin-like proteins in the most primitive form of life.

UH find may lead to origin of life

**Manoa profs find new
protein that is a 'gold mine'
for evolution studies**

[Who's on the team](#)

By Helen Altonn
Star-Bulletin



Two University of Hawaii-Manoa professors have discovered a new class of proteins they say may help trace when and where life began on Earth -- and if it exists elsewhere in the universe.

"We found that this protein actually is a gold mine for evolutionary research," said Maqsudul Alam, associate professor of microbiology, who collaborated with Randy Larsen, associate professor of chemistry.

Alam is the lead author of a paper on their findings that appears tomorrow in the British journal [Nature](#).

The researchers, both instructors in the College of Natural Sciences, identified a new class of myoglobin-like proteins in extremophiles, or Archaea, the most primitive form of life.

They believe the newly discovered heme-proteins -- which capture oxygen molecules -- may be ancestors of proteins involved in sensing, transporting and storing oxygen.

"It's a brand new class of heme-proteins that's never been found, very unique," Larsen said.

The UH researchers call them aerotaxis proteins (aero for air or oxygen and taxis for movement) because they sense oxygen and tell bacteria where to go for it.

Alam points out that when the first living organisms appeared on Earth about 3.8 billion years ago, they used other gases because there was no oxygen.

Oxygen appeared in the atmosphere between 1 and 2 billion years ago, produced by blue-green algae, a type of single-celled organism, he said.

"This fundamental change ... basically changed the whole climate of the planet and living organisms."

But while oxygen provides energy for cells to function, it also can be highly toxic, Alam said.

The challenge for bacterial cells is to sense, capture and store oxygen without suffering hazardous side effects.

The newly discovered heme-proteins, able to bind oxygen, initially may have protected their host cells from toxins, then expanded their role, the scientists said.

In 1972, Alam said, Carl Woese of the University of Illinois made a landmark discovery that all living organisms are divided into three kingdoms -- plants and animals; bacteria; and Archaea, or single-celled microorganisms that live in extreme environments.

Woese suggested that Archaea are the most primitive or ancient living organisms on Earth, Alam said.

The UH team is the first to show that myoglobin-like proteins exist in those organisms, he said. "Not

only that, the fascinating part of this protein is it has two domains, or two parts."

One part senses the oxygen and the other takes the information and helps the microorganisms move to an environment with the best oxygen concentration, he said.

The findings will have enormous scientific application, Alam said.

If the protein is "the mother of heme-proteins," as the scientists believe, it may be possible to determine when the split occurred in the three kingdoms of living organisms and trace the changes, he said.

"We're very excited. This is a once in a lifetime happening," Alam said.

"If you think about when in this planet oxygen evolved, and this is the protein that first senses it, now if you want to find other life in the universe, this protein can be used from that point of view."

Alam and Larsen met in faculty housing after arriving at UH in 1992 and they've collaborated about five years.

Larsen, an expert on heme-proteins, said his lab tries to figure out how single protein molecules do what they do.

Working with microbiologists, they can change the proteins, or certain amino acids or parts of the structure, he said.

The microbiologists then determine the effect of changes on the cell and how bacteria starts changing behavior, he said.

The UH group knew several years ago there was an oxygen-sensing system in one of the primitive microorganisms they were working on, Larsen said.

But they weren't very successful in purifying the protein until changing their method in November 1998, he said.

"We realized what we had at that stage, but any time you see something that looks too exciting, too good to be true, you have to be really careful to make sure it isn't too good to be true."

What they discovered became clear after a year of controlled experiments, he said.

It's not only significant from an evolutionary standpoint but for understanding heme-proteins in general, Larsen said.

"Because these proteins are involved in sensing, they may also help us try to understand how our own senses are involved," he said.

Alam attributes the discovery to the combined expertise of the biophysical and molecular biology laboratories and "a dream team ... that the UH can be proud of."

Definitions

- ▶ **Oxygen:** The basis of life, also toxic to some cellular components.
- ▶ **Hemoglobin:** A protein that gives red blood cells their color and binds and transports oxygen to tissues throughout the body.

- ▶ **Heme:** A component with iron that combines with globin to produce hemoglobin or, with a different protein, to produce cytochromes (heme-proteins that use oxygen as energy).
- ▶ **Heme-proteins:** Molecules able to capture, store and transport oxygen.
- ▶ **Myoglobin:** Member of the hemoglobin family found in vertebrates; gives muscles their red color and stores oxygen for use by the muscles.

Who's on the team

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Born and raised in Bangladesh, Maqsudul Alam previously was a visiting scientist at Washington State University, senior research scientist at Russia's Academy of Sciences and Humboldt Fellow at the Max-Planck Institute in Germany.

He is associate director of the University of Hawaii-based Marine Bioproduct Engineering Center (MarBEC), funded by the National Science Foundation.

He has a four-year NSF CAREER grant of \$420,000 to support education and research on primitive organisms. He also has received about \$500,000 in grants and contracts from other institutions.

Randy Larsen, a native of Wisconsin, joined the UH after two years as a postdoctoral research fellow at the California Institute of Technology.

He has received more than \$600,000 during the past five years from the NSF and other organizations for research involving electron- and energy-transfer in proteins, and other interests.

Team members in the aerotaxis protein research include UH Department of Microbiology graduate students Shaobin Hou, who did most of the molecular biology, and Wesley Riley, Alam said.

Others are former UH postdoctoral research fellow Dmitri Boudko, now at University of Florida; George Ordal of the University of Illinois Department of Biochemistry, who provided primitive bacteria strains for the research; and graduate students Ece Karatan and Mike Zimmer.