

# DISCOVER

Science, Technology, and The Future

## The Origin of Breathing

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by Zach Zorich

Some 3.5 billion years ago, a single-celled organism now named LUCA (for the Last Universal Common Ancestor of all life on Earth) developed the ability to pull oxygen out of its environment. Although LUCA is long gone, University of Hawaii microbiologist Maqsudul Alam has taken a step toward understanding the secret behind this world-changing feat of chemical engineering.

LUCA evolved in an oxygen-free, or anaerobic, environment. But as oxygen levels rose in the ocean and atmosphere, the cell had to develop a way to neutralize what was, in essence, a poison. Alam hit on that defense while studying archaea—another type of primitive, single-celled creature. Alam studied two species of archaea, one aerobic and the other anaerobic. He isolated a crucial compound called protoglobin that protects anaerobic species of archaea from the toxic effects of oxygen. “Protoglobin is the nose and the hand of the archaea,” he says. “It senses oxygen, binds it, and removes it from the cell before it can do any harm.” Protoglobin, or something much like it, apparently provided a similar defense for LUCA. But that is only half of the story. When Alam purified the protoglobin to study its structure, he saw that the molecule looks surprisingly like diluted blood. In fact, protoglobin binds and releases oxygen the same way that hemoglobin does as it transports oxygen through blood. Alam believes that while LUCA initially evolved protoglobin for protection from oxygen, the organism’s descendants developed a variant of the molecule—hemoglobin—that transformed oxygen from a poison into a nutrient. That innovation enabled life to expand into new environments and set the stage for all oxygen-breathing organisms, Alam says.

The next step is to create a computer model that will explain how protoglobin works. Alam hopes such a model will allow him to unravel the genetic changes that transformed protoglobin and answer what he calls the \$64 million question: How did protoglobin evolve to transport oxygen through the bodies of multicellular organisms?