Complex systems and Mars missions help understand how life began

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(PhysOrg.com) -- Understanding how life started remains a major challenge for science. At a European Science Foundation (ESF) and COST 'Frontiers of Science' conference in Sicily in October, scientists discussed two new approaches to the problem. The first applies complex systems theory to the chemistry that preceded early life. The second involves studying Mars, which may yield ample evidence about what Earth was like when life evolved.

Günter Von Kiedrowski, of Ruhr Universität Bochum in Germany, described the new and emerging science of complex systems chemistry. The field takes the opposite approach from that of the genomics pioneer Craig Venter, who wants to build a minimal living cell. "Venter wants to see what is left if you knock out everything but what is needed to survive," says Von Kiedrowski. "We want to look at how you get to that from the bottom up. Darwin's tree of life must have roots, and it is our mission to find them."

Complex systems chemistry uses computer models to simulate combinations of reactions, involving membrane forming reactions, self-replicating nucleic acids and metabolic energy-producing reactions. Then it examines how these systems develop in time and space.

Breaking the symmetry

One promising area is the discovery of reaction systems that lead to the spontaneues generation of chiral asymmetry. It is a universal property of life that compounds such as amino acids and sugars exist exclusively in a one-handed form although both forms are equally likely from an energetic point of view. It is quite difficult to achieve this asymmetry in non-living chemical reactions. Chemistry tends to create equal proportions of the different forms, which behave like objects and their mirror images. “The recipe for asymmetry is the co-occurence of positive and negative feedback loops within such systems,” says Von Kiedrowski.

Complex systems chemistry cannot tell the story of life entirely. “We are in the same position as the physicists trying to understand the origin of the universe,” says Von Kiedrowski. “We will not know exactly how life began, because we do not know the precise conditions at the time, but we can get a good model of how it could have happened with this approach.”

Clues from Mars

Understanding the context of early life from the evidence on Earth is difficult. Because the Earth’s crust is so active, there is very little surface rock remaining from the time when life originated, before 3.5 billion years ago. “There are only two places on Earth where rocks formed at that time are relatively well preserved,” says Tanja Zegers, a geoscientist from Utrecht University in the Netherlands. These are at Pilbara in Australia and Kaapvaal in South Africa.

The pillow basalts at Pilbara provide strong evidence that there was liquid water on Earth at that time, because their shape could only have developed underwater. Liquid water is crucial for life. But, says Zegers, understanding the origin of life from this evidence is a bit like trying to piece together western civilisation from Asterix and Obelix cartoons.

On Mars, by contrast, about 50% of the surface is from before 3.7 billion years ago, so there is a lot more to work with. “Mars may be our best bet to find out about life’s origins on Earth,” says Zegers.

At the time life was evolving on Earth, it seems there was liquid water on Mars too, and a similar environment in many respects. The oldest areas on Mars have hydrated minerals, like clays, which contain water within the mineral structure. They also show signs of surface flows like river networks. But about 3.8 billion years ago, the Martian atmosphere declined and the planet went into a deep freeze. Now, atmospheric pressure on Mars is too low for water to exist as a liquid at all.

Understand habitability on Mars and early Earth requires focused geological research. Several missions to Mars, to map the planet and eventually bring back samples, are ongoing and planned by the European Space Agency (ESA) and NASA in the coming years.

But Zegers argues that, in Europe, Mars research is not well co-ordinated. There is no organisation responsible for managing and disseminating the scientific and survey data resulting from European Mars missions, and the scientific community using the data is not fully involved in the early stages of mission-planning.

“Mars science is key to addressing some of the most fundamental scientific questions we have,” says Zegers. “We need a European programme for missions to Mars, and a European planetary information programme.”

This research was presented at the “Complex Systems: Water and Life” Frontiers of Science conference, organized by European Science Foundation and COST, 29-31 October, Taormina, Sicily.

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