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News Release

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Mechanism of evolution of the primordial metabolism discovered:

Avalanche of reactions at the origin of life

The origin of life is seen as the formation of the first biomolecules which may be subject to multiplication and further development. Hitherto it was unclear, which reactions could have triggered the evolution of this ur-metabolism. Now scientists at the Technische Universitaet Muenchen (TUM) revealed mechanisms, by which a few biomolecules may bring forth new products in the style of an avalanche to initiate a self-expanding metabolism. „Chemistry – A European Journal“ now published their results.

Volcanic-hydrothermal flow channels offer a chemically unique environment, which at first glance appears hostile to life. It is defined by cracks in the crust of the earth, through which water flows, laden with volcanic gases are contacting a diversity of minerals. And yet – it is precisely this extreme environment, where the two mechanisms could have emerged, which are at the root of all life: The multiplication of biomolecules (reproduction) and the emergence of new biomolecules on the basis of previously formed biomolecules (evolution).

At the outset of this concatenation of reactions that led eventually to the formation of cellular forms of life there are only a few amino acids, which are formed from volcanic gases by mineral catalysis. Akin to a domino stone that triggers a whole avalanche, these first biomolecules stimulate not only their own further synthesis but also the production of wholly new biomolecules. “In this manner life begins by necessity in accordance with pre-established laws of chemistry and in a pre-determined direction”, declares Günter Wächtershäuser, honorary professor for evolutionary biochemistry at the University of Regensburg. He developed the mechanism of a self-generating metabolism – theoretically, alas, an experimental demonstration has been lacking so far.

Now, scientists around Claudia Huber and Wolfgang Eisenreich, at the Chair of Biochemistry in the Department of Chemistry at the TUM in close cooperation with Wächtershäuser, managed for the first time to demonstrate experimentally the possibility of such a self-stimulating mechanism. A catalyst consisting of compounds of the transition metals nickel, cobalt or iron has the lead role in these reactions. It provides not only for the formation of the first biomolecules, but it also initiates the concatenation of reactions. The reason: The

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biomolecules just newly formed from the volcanic gases engage the center of the transition metal catalyst to enable further chemical reactions bringing forth wholly new biomolecules. “This coupling between the catalyst and an organic reaction product is the first step”, explains Wächtershäuser. “Life arises, if subsequently a whole cascade of further couplings takes place, and this primordial life leads eventually to the formation of genetic material and of the first cells”.

The scientists simulated in their experiments the conditions of volcanic-hydrothermal flow channels and established an aqueous-organometallic system that produces a whole suite of different biomolecules, among them the amino acids glycin and alanin. Here the carbon source was provided by a cyano compound and the reducing agent by carbon monoxide. Nickel compounds turned out to be the most effective catalysts in these experiments. The scientists then added the products glycin and alanin to another system, that generated again two new biomolecules. The result: The two amino acids increased the productivity oft he second system by a factor of five.

In future experiments the scientists intend to recreate more precisely the conditions of volcanic-hydrothermal systems, wherein life could have arisen billions of years ago. “For this purpose we simulate first certain stages in the development of a volcanic-hydrothermal flow system in order to determine essential parameters”, explains Wächtershäuser. “Only thereafter we may engage in a rational construction of a flow reactor”.

The results of the scientists around Wächtershäuser and Eisenreich show that an origin and evolution of life in hot water of volcanic flow ducts is feasible. The results reveal advantages of the theory compared to other approaches. Within the flow ducts temperature, pressure and pH change along the flow path, and thereby a graded spectrum of conditions is offered that is appropriate for all stages of early evolution up to the formation of genetic material (RNA/DNA).

The most important property of the system is its autonomy: As opposed to the notion of a cool prebiotic both, the first metabolism was not dependent on accidental events or an accumulation of essential components over thousands of years. As soon as the first domino stone is toppled, the others will follow automatically. The origin of life proceeds along definite trajectories, pre-established by the rules of chemistry – a chemically determined process giving rise to the tree of all forms of life.

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