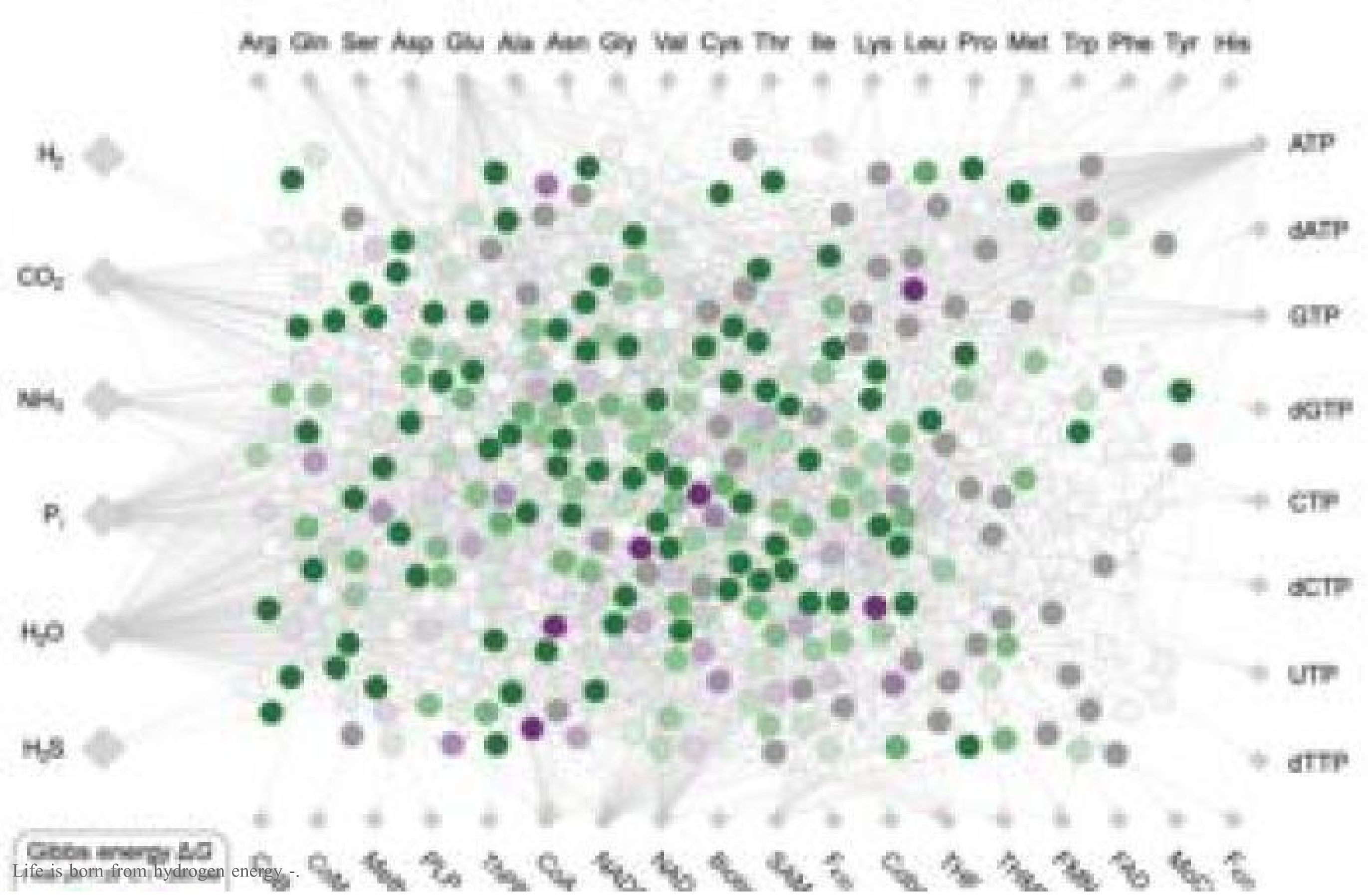
Tanzania On 24 News > Science

Life is born from hydrogen energy -.

SCIENCE Hazel News about 19 hours ago REPORT



Life is born from hydrogen energy -.

image: LUCA metabolism. The research team studied 402 biochemical reactions necessary for the biosynthesis of the molecular building blocks of life. Each circle represents a reaction, its color represents the energy released with each reaction. Green means energy is released, purple means energy is required.
see Suite

Credit: HHU / Jessica Wimmer

December 13, 2021 – How were the first chemical reactions to the origin of life born and what was their source of energy? Researchers at the Heinrich Heine University in Düsseldorf (HHU) have reconstructed the metabolism of the last universal common ancestor, LUCA. They discovered that almost all of the chemical steps used by primordial life to rebuild the molecular building blocks of cells are energy-releasing reactions. This identified the long-sought source of energy needed to advance these reactions, which was hidden in plain sight. The energy required to synthesize the building blocks of life comes from the metabolism itself, as long as an essential starting compound is included. The secret ingredient that releases energy from within at the origin of life is the cleanest, greenest, newest, and oldest of all energy carriers: hydrogen gas, H_2.

The team of Prof. Dr. William Martin of the Institute for Molecular Evolution at HHU studies how and where life appeared on early Earth. Their approach is experimental and computational. In the laboratory, they conduct chemical experiments to study the reactions between hydrogen and carbon dioxide, CO_2, using catalysts and conditions found in underwater hydrothermal vents. On the computer, they have developed a form of molecular archeology that allows them to discover the many different traces of primordial life that are preserved in the proteins, DNA and chemical reactions of modern cells.

In their latest work, they investigated the question of what type of chemical environment favored the chemical reactions that gave rise to metabolism, and later to LUCA itself, and where the energy to make it came from came from. advance these reactions. To do this, they did not examine the genes, but the information contained in the chemical reactions of life themselves. They identified 402 metabolic reactions that have remained virtually unchanged since the origin of life around 4 billion years ago. Because these reactions are common to all cells, they were also present in LUCA. They shed light on how primordial life processes energy in the metabolism and where it obtains the energy necessary to advance the chemical reactions of life.

Jessica Wimmer, doctoral student at the institute and lead author of the new article, was particularly interested in the energy balance of LUCA’s metabolic reactions, because all life requires energy. For this, she has compiled a catalog of 402 reactions that simple and ancient cells of modern cells – bacteria and archaea – use to build the building blocks of life: the 20 amino acids, the bases of DNA and RNA, and the 18 vitamins (cofactors) which are essential for metabolism. In the most primitive of modern cells, and in Wimmer’s computer analyzes, these compounds are synthesized from simple molecules that are present in the modern environment and which were also present in the hydrothermal vents of the early Earth: hydrogen (H_2), carbon dioxide (CO_2) and ammonia (NH_3). The result was the LUCA metabolic network.

Asked about the motivation behind the central question of the new study, Jessica Wimmer said: “We wanted to know where the energy came from that pushed the primordial metabolism forward. At the very beginning of metabolic reactions about 4 billion years ago, there were no proteins or enzymes to catalyze reactions because they had not yet evolved. Metabolism was to come from reactions that could take place in the environment, possibly with the help of inorganic catalysts. But catalysts or not, to move forward, reactions must release energy. Where does this energy come from? There have been many suggestions for possible sources of metabolic energy in the literature. But no one has ever looked at the reactions of the metabolism itself. To find sources of energy in metabolic reactions, the team calculated the amount of free energy, also known as Gibbs energy, that is released or consumed in each reaction.

The result: LUCA’s metabolism did not require any external energy source such as UV light, meteor impacts, volcanic eruptions, or radioactivity. On the contrary, in an environment typical of many modern underwater hydrothermal vents, the energy required for metabolic reactions to take place comes from within the metabolism itself. In other words, almost all of LUCA’s metabolic reactions release energy on their own: life energy comes from life itself. Martin, lead author of the study, says: “It’s exciting, because the 400 interconnected reactions of the central metabolism, which seem so hopelessly complex on first encounter, suddenly reveal a natural tendency to unfold on their own under the right conditions. . ”

To reach this conclusion, the team had to first study the energetics of the 402 reactions using computer programs that simulate different environmental conditions, in order to distinguish the energetically favorable combinations from the unfavorable ones. This is important because whether or not a reaction releases energy often depends on environmental conditions. They studied conditions ranging from pH 1 (acidic) to pH 14 (alkaline), temperatures from 25 to 100 ° C and different relative amounts of reactants to products. They looked with particular attention to the energetic role of hydrogen. Wimmer: “Without hydrogen, nothing happens, because hydrogen is needed to get carbon from CO_2 incorporated into the metabolism in the first place. ”

The energetically optimal conditions are in an alkaline pH range around pH 9 and a temperature around 80 ° C, with hydrogen required for CO_2 fixation. Putting this result into context, Martin explains, “This is almost exactly what we see in Lost City, an H_2-production of a hydrothermal field in the central Atlantic. In such an environment, about 95-97% of LUCA’s metabolic reactions could take place spontaneously, that is, without the need for any other source of energy. In the abyssal darkness of hydrothermal systems, H_2 is chemical sunlight. Modern energy research exploits the exact same properties of hydrogen as life. It’s just that life has four billion years of experience with hydrogen technology, and we’re just getting started. ”

Jessica Wimmer adds: “Regarding the energy at the origin of life, we can say that pure chemical energy is sufficient.$_2$ and co$_2$, plus ammonia and salts. Due to the extremely conserved nature of chemical reactions in our biosynthetic network, we can get some interesting information about the reactions that gave rise to LUCA, even though it lived four billion years ago.

Publication

Jessica LE Wimmer, Joana C. Xavier, Andrey d. N. Vieira, Delfina PH Pereira, Jacqueline Leidner, Filipa L. Sousa, Karl Kleinermanns, Martina Preiner, William F. Martin, Energy at origins: Favorable thermodynamics of biosynthetic reaction in the last universal common ancêtre (LUCA), *Frontiers in microbiology* (2021).

DOI: 10.3389 / fmicb.2021.793664

Journal

Frontiers in microbiology

The title of the article

Energy at the origins: favorable thermodynamics of biosynthetic reactions in the last universal common ancestor (LUCA)

Publication date of the article

13-Dec-2021

« PREV
The next generation of exoplanet astronomy -.

NEXT »
Five strange events that occur in space, according to NASA -.

RELATED POSTS