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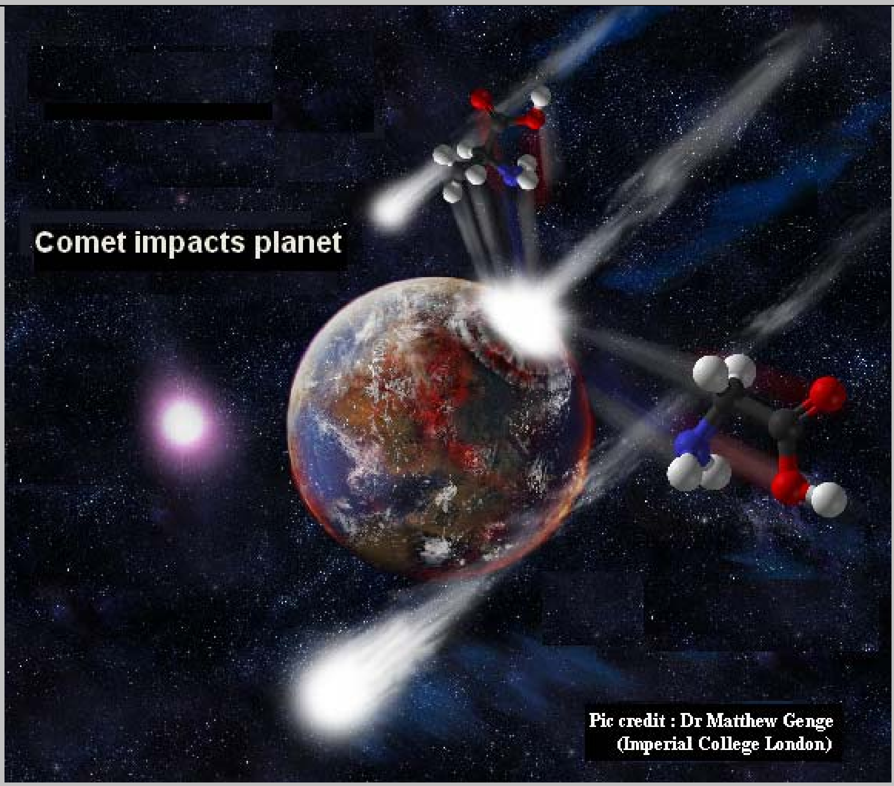


Seeds of life in comet impact

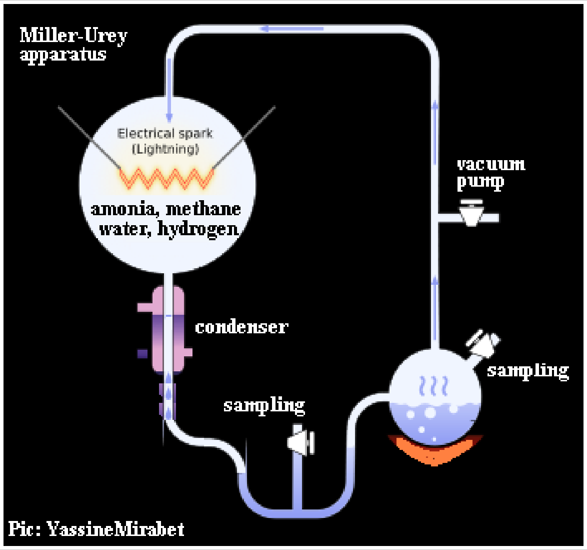
Another route to generating components of life has been discovered, says S.Ananthanarayanan.

The ***Miller-Urey*** experiment of 1953 had shown that ***amino acids***, of which proteins are made up, are generated when a mixture of gases, like what may have existed in the primitive earth, is exposed to electric discharge, to simulate lightning. Other experiments have shown that these components could later assemble to form cell-like and primitive forms of self-replicating structures.

Zita Martins, Mark C. Price, Nir Goldman, Mark A. Sephton and Mark J. Burchell from London, Canterbury and California report in the journal, ***Nature***, that impact of rocky bodies into the icy surfaces of comets could also generate complex organic molecules, like amino acids. The discovery is significant in the context of NASA's ***Stardust*** spacecraft having found the simple amino acid, ***glycine***, in the gas surrounding the comet, 81P/***Wild 2***.

Abiogenesis

The Miller-Urey experiment demonstrated how organic molecules could arise from inorganic components. Water vapour, ammonia, methane and hydrogen were cycled through a flask in which electric sparks were fired. After passing through the flask where the mixture was sparked, the vapour was condensed, to be collected and heated again, and so on. Within a day, the mixture had turned pink in colour, and at the end of two weeks 10 to15% of the carbon in the system had turned to organic compounds. Two percent of the carbon had formed amino acids, with glycine as the most abundant. 18% of the methane-molecules became bio-molecules. The rest turned into hydrocarbons like bitumen. In an interview, Stanley Miller said: "Just turning on the spark in a basic pre-biotic experiment will yield 11 out of 20 amino acids."



The experiment verified an earlier hypothesis, of ***Alexander Oparin*** and ***JBS Haldane***, that the oxygen-free conditions of the very early earth, would have favoured synthesis of organic molecules, using the energy of sunlight or lightning flashes. There are then different mechanisms suggested for explaining the appearance of the complexity of life, from high temperatures and a reducing (as opposed to oxidizing) environment to freezing conditions. In extreme cold, water freezes, leaving dissolved components of organic molecules in higher concentration and under pressure. Freezing conditions thus favour formation of two of the four bases of the DNA molecule, while the other two need boiling conditions.

At the time of the Miller-Urey experiment, there was consensus that the early earth had a strongly reducing, or hydrogen-rich and oxygen-free, environment. The evidence hence appeared to be that the origin of life on earth was by synthesis driven by impacts, sunlight or electrical discharge. But there is now ground to hold that the early atmosphere on the earth was either weakly reducing or neutral. Such conditions affect the extent and composition of amino acids that could be synthesised and suggest looking for other mechanism for the appearance of life.

Extra-terrestrial

The alternate mechanism is that the precursors of life originated in outer space and were brought to the earth through comets or meteorites or were acquired through gravitation. The discovery of the amino acid ***glycine*** in the clouds that surround the comet, ***81P/Wild 2***, strongly suggested that this was in fact the route that was followed.

In 1999, NASA sent out a 300 kg robotic space probe, ***Stardust***, with the primary mission of collecting dust samples from the coma, or the atmosphere of the comet Wild 2 (pronounced 'Vilt 2'). ***Stardust*** flew through the dense gas and dust close to the icy comet in Jan 2004. A special grid, filled with a sponge-like 'aerogel' material collected gas and dust and was stored in a capsule, to be parachuted down to earth when the craft returned in 2006. Since then, the samples of comet dust in the aerogel, and also on the aluminium foil used in the grid have been analysed, with better and better equipment, to deal with the exceedingly sparse sample material.

The first analyses showed traces of the amino acid, glycine, both in the aerogel and on the foil. But as glycine is used by life forms on the earth, it was possible that this was just contamination. To check on this possibility, isotope analysis of the carbon atoms in the glycine was carried out. The carbon atom can be of two kinds, the regular kind, with 12 particles in the nucleus or the radioactive kind, which has 13. The processes that give rise to molecules, including glycine, on the earth, have reached a balance with a certain proportion of C_{12} to C_{13}. But samples of glycine that have come from space would have a slightly higher C_{13} content. Analysis has shown that the glycine in the ***Stardust*** capsule had the higher percentage, which indicates that the glycine did come from the gas cloud around the comet.

Finding amino acids out in space puts a whole new spin on the question of where the molecules of life on the earth came from."If you're seeing amino acids in comets, then that really gives credence to the idea that the basic components of life are going to be widespread throughout the universe," planetary biologist Max Bernstein of the NASA Astrobiology Institute said.

How did they get there?

The sources of complex organic molecules in space are considered to be impacts of icy bodies, like comets, on rocky surfaces or the impact of hard projectiles on icy surfaces, like the satellites of Jupiter or Saturn. There is ample evidence that these satellites contain ammonia, carbon dioxide and methane. As there are so many Solar System objects that have the necessary starting components, the authors of the paper published in ***Nature*** undertook to test out whether impacts on icy objects could create organic molecules.

The main target samples were ice formed of ammonia dissolved in water, carbon dioxide and methanol, in the ratio 9.1:8:1, frozen to minus 160˚C. The targets were divided into 2 samples, one was impacted and the other was placed below the first, so that it experienced the same conditions, but was not impacted. The impact was by high speed steel projectiles, impelled to about 7 km/sec by a gas gun, specially designed with a light gas, like helium or hydrogen. After impacting, the samples were heated to over 90˚C, so that the ice mixtures evaporated and left a residue, which was examined for traces of organic molecules, using chemical and spectroscopic methods.

Analysis showed that high speed impact of typical comet ice mixtures resulted in a number or amino acids. All containers and implements had been sterilized by baking at 500˚C for six hours. The methods of analyses were the same as used with the samples that had come from space. The control, un-impacted, ice as well as the containers and implements were also analysed, to be sure that what was detected was from impacting ice. The experiment thus shows that impaction is a reliable mechanism to account for extraterrestrial amino acids and analysis of the results of different speeds of impacts has yielded some ideas about the pathway of synthesis.

"These results present a significant step forward in our understanding of the origin of the building blocks of life," say the authors in the paper. The results will guide the selection of instruments to accompany the future, life detection missions that are planned to the icy moons of Jupiter and Saturn.