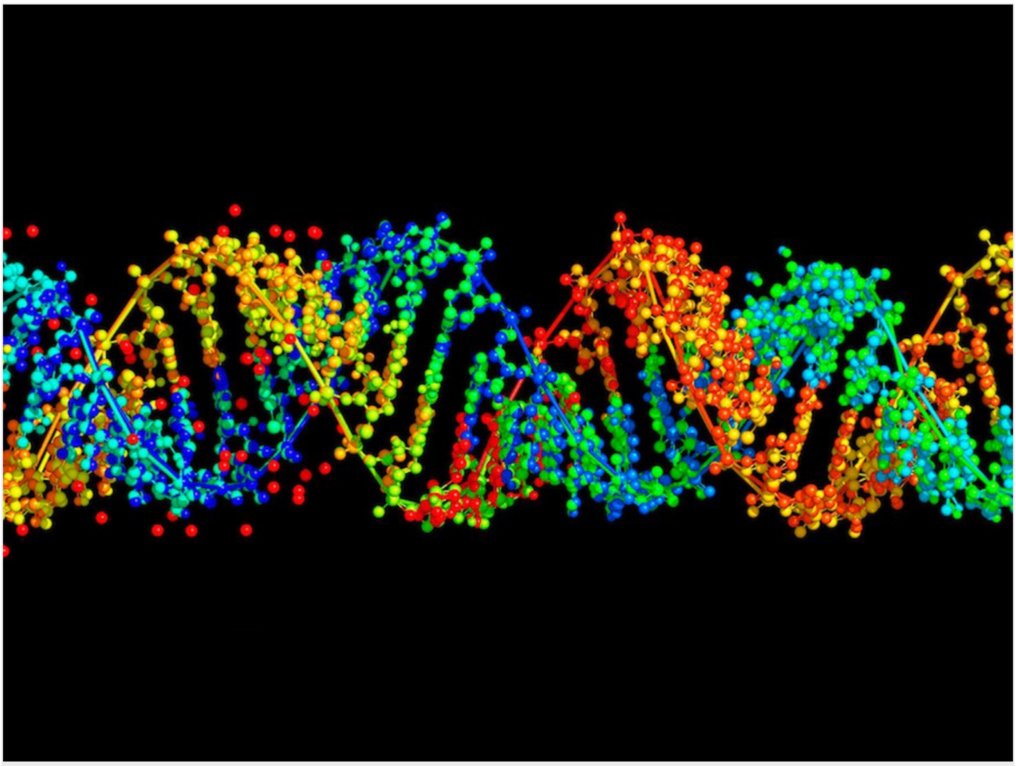
NATURE | NEWS

Building blocks for 'RNA world' made from simple ingredients

Chemical assembly bolsters theory that life might have begun with RNA.

Davide Castelvecchi

12 May 2016



Laguna Design/Science Photo Library

Some chemists argue that the emergence of the RNA molecule (here shown in double-stranded form) might have marked the origins of life on Earth.

If life began with RNA — as one theory posits — then the first RNA molecules would have emerged from simple ingredients on early Earth. In a step towards supporting this 'RNA world' theory, biochemists have now shown that all four of RNA’s major components can be assembled efficiently from simple chemicals in conditions that, they argue, might have been present billions of years ago on our planet.

A study published in 2009 described an easy way to create two of RNA’s building blocks, called ribonucleotides[1]. And in a paper published in *Science* on 12 May, scientists now demonstrate a straightforward chemical pathway to the formation of the other two[2].

“It is a very nice piece of work and certainly comparable in significance to the 2009 paper,” says Gerald Joyce, an origins-of-life researcher at the Scripps Research Institute in La Jolla, California. But objectors who favour other explanations of life’s origins are not swayed. While chemists have sought ways to create RNA out of pools of simple chemicals in warm water, these might not be the most plausible conditions for the beginnngs of life on Earth, they argue.

RNA from scratch

RNA, a complex polymer related to DNA, can catalyse chemical reactions and even duplicate itself — leading some to suggest that its creation might have jump-started life. But in modern cells, it takes a menagerie of enzymes that would not have been present on primordial Earth to make an RNA strand. So chemists have tried to find simpler ways to do it.

The molecule’s ribonucleotide building blocks are themselves made up of three parts: a sugar molecule, a phosphate group and one of the four bases that form the alphabet of RNA's genetic code — adenine, uracil, cytosine and guanine. In the 2009 paper, John Sutherland, a biochemist now at the University of Cambridge, UK, and his collaborators found a way to synthesize uracil and cytosine from simple ingredients.

Now, organic chemist Thomas Carell of Ludwig Maximilian University in Munich, Germany, and his team have shown how the other two bases, guanine and adenine, can form from simpler molecules and spontaneously link up with the sugar molecule, creating a precursor to the full ribonucleotide called a nucleoside. They have not yet demonstrated how to complete the process by adding a phosphate group. The starting ingredients in their research include aminopyrimidines, which in turn can assemble from molecules that the European Space Agency's Rosetta probe has detected on the comet 67P/Churyumov-Gerasimenko.

Deep-sea rival

"It's very fine chemistry," says Bill Martin, a microbiologist at Heinrich Heine University of Düsseldorf in Germany. But he and others don't hold with the RNA-world hypothesis. Martin is a proponent of an opposing view that life is likely to have emerged in alkaline conditions in hot deep-sea vents. There, the argument runs, geological conditions could have set up gradients in the concentration of protons across pores in rocks — a very simple version of the flow of protons across membranes that every living cell today uses to generate chemical energy. Once the energetic flows necessary for life to persist arose, they could have led to the creation of simple organic molecules and cells.

On this view, RNA-from-scratch chemistry is not relevant to the emergence of the earliest life. "I remain sceptical that it is reflecting any process that were involved in how we — our ancestors — arose," Martin says.

Nature | doi:10.1038/nature.2016.19901

References

1. Powner, M. W., Gerland, B. & Sutherland, J. D. *Nature* **459**, 239–242 (2009).
2. Becker, S. *et al*. *Science* **352**, 833–836 (2016).