# Could we ever know whether life on Mars represents a second genesis?


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If we are ever successful in finding life on Mars, one of the key questions we would want to answer is whether life on Mars formed independently or shared a common origin with life on Earth. The issue arises because we know that it is possible for material to be transferred between the two planets. We know of more than 20 meteorites that originated from Mars. Indeed, it was suggested in 1996 that there was evidence for fossil life in the Martian meteorite ALH84001 [1]. While the evidence for life in ALH84001 has not been generally accepted, studies of the meteorite have shown that it travelled from Mars to Earth without its interior being heated to more than 40˚C [2]. It has also been demonstrated that bacterial spores can survive in space for more than 5 years [3,4].

The transfer of microbial life from Mars to Earth must therefore be considered a definite possibility, and transfer of life from Earth to Mars, though more difficult, may also be possible [5].

With life on Earth as our only example, we don't know whether life is the result of some unlikely chance event or something that is inevitable, given a planet with the right conditions. If we found that life had originated independently on two planets in the same solar system, it would be a very strong indication that life arises easily and that we must live in a universe that is teeming with life. But we can only reach this conclusion if we can demonstrate that Martian life has an independent origin.

On the other hand, a common origin for life on Earth and Mars would indicate that life can travel between planets, but would leave open the question of how easily life arises and tell us nothing about the likelihood of life beyond our solar system. Can we distinguish these two cases?

In the case of Earth we can say with some degree of confidence that all life has a common origin. This follows from the fact that all life is based on a common set of fundamental chemical processes. All life uses DNA as its basic genetic material. The DNA message is read by copying it onto RNA (transcription) and this RNA message is used to synthesise proteins (translation) by means of an RNA/protein complex called the ribosome. The resulting proteins are most frequently used as catalysts (enzymes) to drive the many chemical processes in the cell. The genetic code – which translates three 'letter' sequences of the four DNA bases (A, C, G, T) to the corresponding amino acid to be added into a protein – is almost universal (with a few minor variations as we shall see below). We thus believe that all life inherited these common properties from a universal ancestor, sometimes known as LUCA (Last Universal Common Ancestor). Moreover, by comparing the sequences of genes involved in these fundamental processes common to all life we can construct the 'tree of life' showing the relatedness of all groups of life.

If we can do this for life on Earth, then surely we can apply the same argument to any life we might find on Mars. If Martian life is found to share the same chemical processes as life on Earth, this would indicate a common origin, whereas if we find some fundamental differences in the chemistry, this would indicate an independent origin. While the first conclusion is probably valid, the second is not. A different chemical basis for life

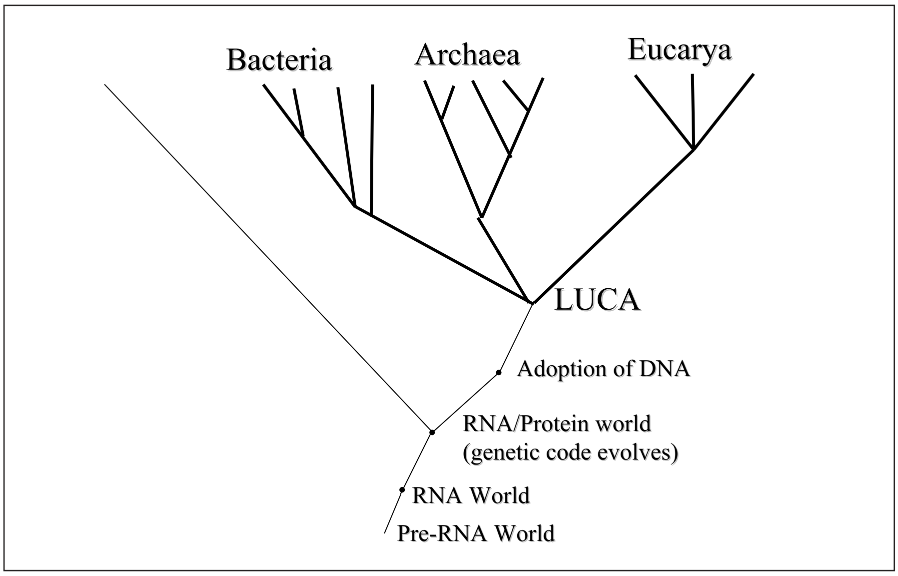


Figure 1. A possible scenario by which Martian life might have a different genetic code from that on Earth while still sharing a common origin. The evolutionary split between Mars and Earth life occurs during the stage at which the genetic code is still evolving, and thus life on Mars would end up with a different code from that used in LUCA and its descendants (the three domains of life in Earth, the Bacteria, Archaea and Eucarya).

might not necessarily indicate an independent origin.

To understand this we need to realise that LUCA is the last common ancestor of all life living today, not of all life that ever lived on Earth. While all life living today may have a common chemical basis, the same is not true of all life that ever lived. The common chemical processes which have been inherited from LUCA, are themselves the result of evolution that occurred prior to LUCA.

The evolution of life before LUCA is poorly understood, as we have no direct fossil record of what occurred. However, it is generally thought that the current DNA/RNA/protein basis for life was preceded by a stage known as the 'RNA World' in which RNA provided the information storage and catalytic roles, which were later taken over by DNA and proteins[6]. This RNA world was probably itself preceded by a pre-RNA world based on some other genetic material. If life originated on Mars, and was transferred to Earth, the evolutionary split must have occurred before LUCA, in a stage in which the chemical basis for life could be very different from that we know today.

To examine a specific scenario, let us look at the case of the genetic code. One of the differences we could look for in Martian life is a different genetic code from the 'Universal Genetic Code' used by life on Earth. Would this be evidence for an independent origin for life on Mars? Almost all life on Earth uses the same standard genetic code, and while there are cases of variant codes in some groups of organisms, these are relatively minor variations (usually reassignment of one of the three stop codons to an amino acid). It seems that the standard code must have been the one inherited from LUCA and it has changed little or not at all in subsequent evolution, presumably because any substantial changes would make all genes produce the wrong protein sequence and be lethal to the organism.

Nevertheless, there is strong evidence that the genetic code hasn't always been the same. Simulations using different possible codes have shown that the standard code is among the best possible ("one in a million" according to one study[7]) in the sense that it minimises the effect of errors in the DNA sequence. Most simple errors either lead to the same amino acid or to one with similar chemical properties. This strongly suggests that the code itself has evolved by natural selection to be one of the best possible, and is not a "frozen accident" as once suggested[8]. Hence, if Mars and Earth life diverged before LUCA, they may have done so at a time when the genetic code was still in the process of evolving to its current form. If that is the case, a different genetic code is perfectly compatible with a common origin for life on Earth and Mars.

Similar arguments can be applied to other possible differences we might find in the chemistry of Martian life, such as a different set of amino acids or the use of something other than DNA as the genetic material. Thus, even if we are successful in finding life on Mars (and we need living organisms, not fossils to even begin such an analysis), it will not be easy to find proof that Martian life had an independent origin.

## References


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## ASM 2004 Educators' Workshop

In 2004 the Annual Scientific Meeting of ASM is in Sydney and EDSIG, through Julian Cox, Kathy Takayama and others, is planning a pre-conference Educators' Workshop. This is an experiment to see if we can attract more people to participate in our group and talk teaching, by taking away the need to choose between our sessions and sessions they feel they need to attend to update their teaching.

The workshop will be on the Sunday before the conference begins and there will only be a minimal charge to cover catering costs. Something to keep in mind.

If you have any ideas at all about what you'd like to hear, see or even do at the workshop, please contact Julian Cox (julian.cox@unsw.edu.au) or register for AMEN and give your opinion there. Details will appear in AMEN and on the EDSIG website (http://www.foodscience.unsw.edu.au/edsig/index.html) as they come to hand.