Bacteria recycle broken DNA

November 18 2013

Bacteria recycle broken DNA that bacteria can take up small as well as large pieces of old DNA from this scrapheap and include it in their own genome. This discovery may have major consequences – both in connection with resistance to antibiotics in hospitals and in our perception of the evolution of life itself.

Our surroundings contain large amounts of strongly fragmented and damaged DNA, which is being degraded. Some of it may be thousands of years old. Laboratory experiments with microbes and various kinds of DNA have shown that bacteria take up very short and damaged DNA from the environment and passively integrate it in their own genome. Furthermore this mechanism has also been shown to work with a modern bacteria's uptake of 43.000 years old mammoth DNA. The results are published now in the scientific journal *Proceedings of the National Academy of Sciences* (*PNAS*). The discovery of this second-hand use of old or fragmented DNA may have major future consequences. Postdoc Søren Overballe-Petersen from the Centre for GeoGenetics at the Natural History Museum of Denmark is first author on the paper and he says about the findings:

It is well-known that bacteria can take up long intact pieces of DNA but so far the assumption has been that short DNA fragments were biologically inactive. Now we have shown that this assumption was wrong. As long as you have just a tiny amount of DNA left over there is a possibility that bacteria can re-use the DNA. One consequence of this is in hospitals that have persistent problems with antibiotic resistance. In some cases they will have to start considering how to eliminate DNA remnants. So far focus has been on killing living pathogen bacteria but this is no longer enough in the cases where other bacteria afterwards can use the DNA fragments which contain the antibiotic resistance.

The research group's results reveal that the large reservoir of fragments and damaged DNA in the surroundings preserve the potential to change the bacteria's genomes even after thousands of years. This is the first time a process has been described which allows cells to acquire genetic sequences from a long gone past. We call this phenomenon Anachronistic Evolution – or Second-hand Evolution. Professor Eske Willerslev from the Centre for GeoGenetics at the Natural History Museum of Denmark is the leader of the project. He says:

That DNA from dead organisms drives the evolution of living cells is in contradiction with common belief of what drives the evolution of life itself.

Furthermore old DNA is not limited to only returning microbes to earlier states. Damaged DNA can also create new combinations of already functional sequences. You can compare it to a bunch of bacteria which poke around a trash pile looking for fragments they can use. Occasionally they hit some 'second-hand gold', which they can use right away. At other times they run the risk of cutting themselves up. It goes both ways. This discovery has a number of consequences partially because there is a potential risk for people when pathogen bacteria or multi-resistant bacteria exchange small fragments of 'dangerous' DNA e.g. at hospitals, in biological waste and in waste water.

In the grand perspective the bacteria's uptake of short DNA represents a fundamental evolutionary process that only needs a growing cell consuming DNA pieces. A process that possibly is a kind of original type of gene-transfer or DNA-sharing between bacteria. The results show how genetic evolution can happen in jerks in small units. The meaning of this is great for our understanding of how microorganisms have exchanged genes through the history of life. The new results also support the theories about gene-transfer as a decisive factor in life's early evolution. Søren Overballe-Petersen explains:

This is one of the most exciting perspectives of our discovery. Computer simulations have shown that even early bacteria on Earth had the ability to share DNA – but it was hard to see how it could happen. Now we suggest how the first bacteria exchanged DNA. It is not even a mechanism developed to this specific purpose but rather as a common process, which is a consequence of living and dying.

More information: The scientific article 'Bacterial natural transformation by highly fragmented and damaged DNA' is published in *Proceedings of the National Academy of Sciences* on November 18, 2013.

Provided by University of Copenhagen