'Synthetic fossils' could make it possible to store data on DNA for millions of years

Researchers in Switzerland have taken inspiration from fossils to discover how DNA could be used to reliably store data for over two million years. They stored 83 kilobytes of data — containing the text from the Swiss Federal Charter of 1291 and the English translation of the Method of Archimedes — on DNA, which was subsequently encapsulated in silica to mimic the protective shell provided by fossilized bone.

DNA has huge potential as a data storage medium, with just one gram able to hold nearly half a zettabyte (almost 500 billion gigabytes) of data. Given that DNA fragments recovered from fossilized bones have been used to reconstruct the

Posted on MAR 11 2015 7:44AM

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genome of animals that died hundreds of thousands of years ago, the molecule also shows promise for long-term data archiving. By contrast, traditional optical and magnetic storage devices are generally only reliable for storing data up to around half a century.

Despite this promise, there are still drawbacks to using DNA as a long-term storage medium. DNA decays over time, with DNA in bone having a typical half-life of around 500 years. However, this is strongly affected by factors such as temperature and moisture, as well as exposure to light and oxygen.

Now, researchers in Switzerland have taken inspiration from fossils to discover how DNA could be used to reliably store data for over two million years. They stored 83 kilobytes of data - containing the text from the Swiss Federal Charter of 1291 and the English translation of the Method of Archimedes - on DNA, which was subsequently

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encapsulated in silica to mimic the protective shell provided by fossilized bone.

The data was successfully resequenced after the silica-encapsulated DNA had been stored at 70 °C (158 °F) for one week. The researchers calculated that the DNA had degraded by four half-lives. This is equivalent to storing data on silica-encapsulated DNA at a temperature of around 9 °C (48 °F) for 2,000 years. Equally, this means that data could successfully be recovered from DNA encapsulated in silica and stored at the Svalbard Global Seed Vault, where the temperature is -18 °C (0 °F), after more than two million years.

"We have implemented a forward-error correction scheme into the data we store," explains lead researcher Robert Grass from the Swiss Federal Institute of Technology in Zurich, Switzerland. "With this we can cope with errors occurring during decay of the DNA molecules... we have a distinct edge over natural DNA when it comes to reconstructing the original data without error".

While Grass believes that storing the DNA at even cooler temperatures could lead to further increased longevity, he says that future work will focus on increasing the stability of DNA at temperatures between 0-10°C (32-50 °F), as this is a more practical value for long-term storage. Longevity could also be increased by adding additional redundancy to the data, but this would mean that more DNA is required per bit stored.

"This is very interesting work," says Nick Goldman of the European Bioinformatics Institute (EMBL-EBI), who was not involved in the research. "There are lots of reasons why we might want to preserve DNA better: biobanking for medical reasons, preserving biodiversity, and storing digital information safely are just three examples."

The research is published in the journal Angewandte Chemie.

- Andrew Purcell

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