Twist Bioscience and Collaborators Microsoft, University of Washington Preserve Archive-Quality Audio Recordings for Memory of the World

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-- Iconic Performances of Deep Purple's "Smoke on the Water"and Miles Davis' "Tutu" Performed at the Montreux Jazz Festival Stored on DNA for the First Time --

San Francisco, CA – September 29, 2017 – Twist Bioscience, a company accelerating science and innovation through rapid, high-quality DNA synthesis, today announced that, working with Microsoft and University of Washington researchers, they have successfully stored archival-quality audio recordings of two important music performances from the archives of the world-renowned Montreux Jazz Festival.

These selections are encoded and stored in nature's preferred storage medium, DNA, for the first time. These tiny specks of DNA will preserve a part of UNESCO's Memory of the World Archive, where valuable cultural heritage collections are recorded. This is the first time DNA has been used as a long-term archival-quality storage medium.

Quincy Jones, world-renowned Entertainment Executive, Music Composer and Arranger, Musician and Music Producer said, "With advancements in nanotechnology, I believe we can expect to see people living prolonged lives, and with that, we can also expect to see more developments in the enhancement of how we live. For me, life is all about learning where you came from in order to get where you want to go, but in order to do so, you need access to history! And with the unreliability of how archives are often stored, I sometimes worry that our future generations will be left without such access...So, it absolutely makes my soul smile to know that EPFL, Twist Bioscience and others are coming together to preserve the beauty and history of the Montreux Jazz Festival for our future generations, on DNA!...I've been a part of this festival for decades and it truly is a magnificent representation of what happens when different cultures unite for the sake of music. Absolute magic. And I'm proud to know that the memory of this special place will never be lost."

"Our partnership with EPFL in digitizing our archives aims not only at their positive exploration, but also at their preservation for the next generations," says Thierry Amsallem, president of the Claude Nobs Foundation. "By taking part in this pioneering experiment which writes the songs into DNA strands, we can be certain that they will be saved on a medium that will never become obsolete!"

The Montreux Jazz Digital Project is a collaboration between the Claude Nobs Foundation, curator of the Montreux Jazz Festival audio-visual collection and the École Polytechnique Fédérale de Lausanne (EPFL) to digitize, enrich, store, show, and preserve this notable legacy created by Claude Nobs, the Festival's founder.

In this proof-of-principle project, two quintessential music performances from the Montreux Jazz Festival – *Smoke on the Water*, performed by Deep Purple and *Tutu*, performed by Miles Davis – have been encoded onto DNA and read back with 100 percent accuracy. After being decoded, the songs were played on September 29th at the ArtTech Forum (see below) in Lausanne, Switzerland. *Smoke on the Water*was selected as a tribute to Claude Nobs, the Montreux Jazz Festival's founder. The song memorializes a fire and *Funky Claude's* rescue efforts at the Casino Barrière de Montreuxduring a Frank Zappa concert promoted by Claude Nobs. Miles Davis' *Tutu* was selected for the role he played in music history and the Montreux Jazz Festival's success. Miles Davis died in 1991.

"We archived two magical musical pieces on DNA of this historic collection, equating to 140MB of stored data in DNA," said Karin Strauss, Ph.D., a Senior Researcher at Microsoft, and one of the project's leaders. "The amount of DNA used to store these songs is much smaller than one grain of sand. Amazingly, storing the entire six petabyte Montreux Jazz Festival's collection would result in DNA smaller than one grain of rice."

Luis Ceze, Ph.D., a professor in the Paul G. Allen School of Computer Science & Engineering at the University of Washington, said, "DNA, nature's preferred information storage medium, is an ideal fit for digital archives because of its durability, density and eternal relevance. Storing items from the Montreux Jazz Festival is a perfect way to show how fast DNA digital data storage is becoming real."

Nature's Preferred Storage Medium

Nature selected DNA as its hard drive billions of years ago to encode all the genetic instructions necessary for life. These instructions include all the information necessary for survival. DNA molecules encode information with sequences of discrete units. In computers, these discrete units are the 0s and 1s of "binary code," whereas in DNA molecules, the units are the four distinct nucleotide bases: adenine (A), cytosine (C), guanine (G) and thymine (T).

"DNA is a remarkably efficient molecule that can remain stable for millennia," said Bill Peck, Ph.D., chief technology officer of Twist Bioscience. "This is a very exciting project: we are now in an age where we can use the remarkable efficiencies of nature to archive master copies of our cultural heritage in DNA. As we develop the economies of this process new performances can be added any time. Unlike current storage technologies, nature's media will not change and will remain readable through time. There will be no new technology to replace DNA, nature has already optimized the format."

DNA: Far More Efficient Than a Computer

Each cell within the human body contains approximately three billion base pairs of DNA. With 75 trillion cells in the human body, this equates to the

storage of 150 zettabytes (1021) of information within each body. By comparison, the largest data centers can be hundreds of thousands to even millions of square feet to hold a comparable amount of stored data.

The Elegance of DNA as a Storage Medium

Like music, which can be widely varied with a finite number of notes, DNA encodes individuality with only four different letters in varied combinations. When using DNA as a storage medium, there are several advantages in addition to the universality of the format and incredible storage density. DNA can be stable for thousands of years when stored in a cool dry place and is easy to copy using polymerase chain reaction to create back-up copies of archived material. In addition, because of PCR, small data sets can be targeted and recovered quickly from a large dataset without needing to read the entire file.

How to Store Digital Data in DNA

To encode the music performances into archival storage copies in DNA, Twist Bioscience worked with Microsoft and University of Washington researchers to complete four steps: Coding, synthesis/storage, retrieval and decoding. First, the digital files were converted from the binary code using 0s and 1s into sequences of A, C, T and G. For purposes of the example, 00 represents A, 10 represents C, 01 represents G and 11 represents T. Twist Bioscience then synthesizes the DNA in short segments in the sequence order provided. The short DNA segments each contain about 12 bytes of data as well as a sequence number to indicate their place within the overall sequence. This is the process of storage. And finally, to ensure that the file is stored accurately, the sequence is read back to ensure 100 percent accuracy, and then decoded from A, C, T or G into a two-digit binary representation.

Importantly, to encapsulate and preserve encoded DNA, the collaborators are working with Professor Dr. Robert Grass of ETH Zurich. Grass has developed an innovative technology inspired by preservation of DNA within prehistoric fossils. With this technology, digital data encoded in DNA remains preserved for millennia.

About UNESCO's Memory of the World Register

UNESCO established the Memory of the World Register in 1992 in response to a growing awareness of the perilous state of preservation of, and access to, documentary heritage in various parts of the world. Through its National Commissions, UNESCO prepared a list of endangered library and archive holdings and a world list of national cinematic heritage.

A range of pilot projects employing contemporary technology to reproduce original documentary heritage on other media began. These included, for example, a CD-ROM of the 13th Century Radzivill Chronicle, tracing the origins of the peoples of Europe, and Memoria de Iberoamerica, a joint newspaper microfilming project involving seven Latin American countries. These projects enhanced access to this documentary heritage and contributed to its preservation.

"We are incredibly proud to be a part of this momentous event, with the first archived songs placed into the UNESCO Memory of the World Register," said Emily Leproust, Ph.D., CEO of Twist Bioscience.

About ArtTech

The ArtTech Foundation, created by renowned scientists and dignitaries from Crans-Montana, Switzerland, wishes to stimulate reflection and support pioneering and innovative projects beyond the known boundaries of culture and science.

Benefitting from the establishment of a favorable environment for the creation of technology companies, the Foundation aims to position itself as key promoter of ideas and innovative endeavors within a landscape of "Culture and Science" that is still being shaped.

Several initiatives, including our annual global platform launched in the spring of 2017, are helping to create a community that brings together researchers, celebrities in the world of culture and the arts, as well as investors and entrepreneurs from Switzerland and across the globe.

About EPFL

EPFL, one of the two Swiss Federal Institutes of Technology, based in Lausanne, is Europe's most cosmopolitan technical university with students, professors and staff from over 120 nations. A dynamic environment, open to Switzerland and the world, EPFL is centered on its three missions: teaching, research and technology transfer. EPFL works together with an extensive network of partners including other universities and institutes of technology, developing and emerging countries, secondary schools and colleges, industry and economy, political circles and the general public, to bring about real impact for society.

About Twist Bioscience

At Twist Bioscience, our expertise is accelerating science and innovation by leveraging the power of scale. We have developed a proprietary semiconductor-based synthetic DNA manufacturing process featuring a high throughput silicon platform capable of producing synthetic biology tools, including genes, oligonucleotide pools and variant libraries. By synthesizing DNA on silicon instead of on traditional 96-well plastic plates, our platform overcomes the current inefficiencies of synthetic DNA production, and enables cost-effective, rapid, high-quality and high throughput synthetic gene production, which in turn, expedites the design, build and test cycle to enable personalized medicines, pharmaceuticals, sustainable chemical production, improved agriculture production, diagnostics and biodetection. We are also developing new technologies to address large scale data storage. For more information, please visit www.twistbioscience.com. Twist Bioscience is on Twitter. Sign up to follow our Twitter feed @TwistBioscience at https://twitter.com/TwistBioscience.

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