

PRESS RELEASE

Source: University of Electro-communications, Center for Public Affairs and Communications

For immediate release: 6 July 2016

University of Electro-communications research: Mathematical model gives insights into cotranscriptional folding of RNA

(Tokyo, 6 July) Researchers propose “Oritatami” as a mathematical model of the cotranscriptional folding of RNA in order to widen applications of RNA origami—one of the most significant experimental breakthroughs in molecular self-assembly.

RNA origami by Geary, Rothemund, and Andersen is an experimental architecture of nanoscale rectangular tiles that self-assemble from an RNA sequence being folded cotranscriptionally, as shown in Figure 1. Theoretical models for programming this kind of molecular self-assembly are needed, as Winfree’s abstract tile assembly model (aTAM) has yielded tremendous successes in experimental DNA tile self-assembly, which self-assemble a structure by letting unit DNA tiles attach to each other in some pre-programmed manner.

With Geary, now Shinnosuke Seki at the University of Electro-communications and his colleagues Pierre-Etienne Meunier and Nicolas Schabanel in Finland and France have proposed Oritatami to help understand the nature of cotranscriptional folding, the way that cells control RNA folding *in vivo*.

With this work, rather than simply predicting most likely conformations of RNA, they can implement computational devices out of RNA that take advantage of sequential folding to do something practical, such as count. The binary counter proof implements one of the most important types of device used in technology as a molecular self-assembly. The authors design an oritatami binary counter (see Figure 2), which suggests a way to use cotranscriptional folding for biomolecules to count *in vivo*. They also propose a fixed-parameter-tractable (FPT) algorithm to facilitate the design process of oritatami.

Background

Transcription

Transcription is the first step of gene expression, in which a DNA template sequence, over A, C, G, T, is copied to an RNA transcript sequence, over A, C, G, U, called a messenger RNA (mRNA). An enzyme called RNA polymerase scans the DNA template and copies it letter by letter as A → U, C → G, G → C, and T → A.

Cotranscriptional folding

An RNA sequence tends to fold rapidly upon itself to take the most stable conformation, and hence, the RNA transcript already begins to fold while it is still being produced. What

characterizes the folding of RNA transcripts is that transcripts fold in a continuous process while being transcribed. This means that the folding is controlled by the rate of strand production. This way of folding is hence called cotranscriptional or kinetic folding. In this way of folding, locally-stable structures of RNA will be preferred over some folds with better stability because they would require first unfolding parts of the strand in order to form.

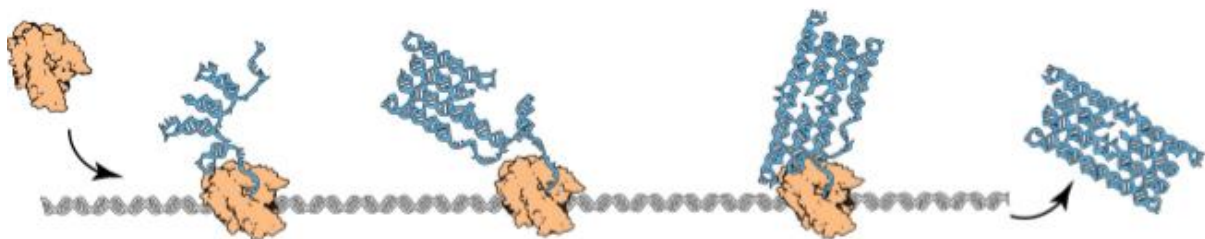
Reference

Cody Geary¹, Pierre-Étienne Meunier², Nicolas Schabanel³, and Shinnosuke Seki⁴, Programming biomolecules that fold greedily during transcription, *Leibniz International Proceedings in Informatics Schloss Dagstuhl – Leibniz-Zentrum für Informatik*, (2016).

Journal website: <https://www.dagstuhl.de/en/publications/lipics>

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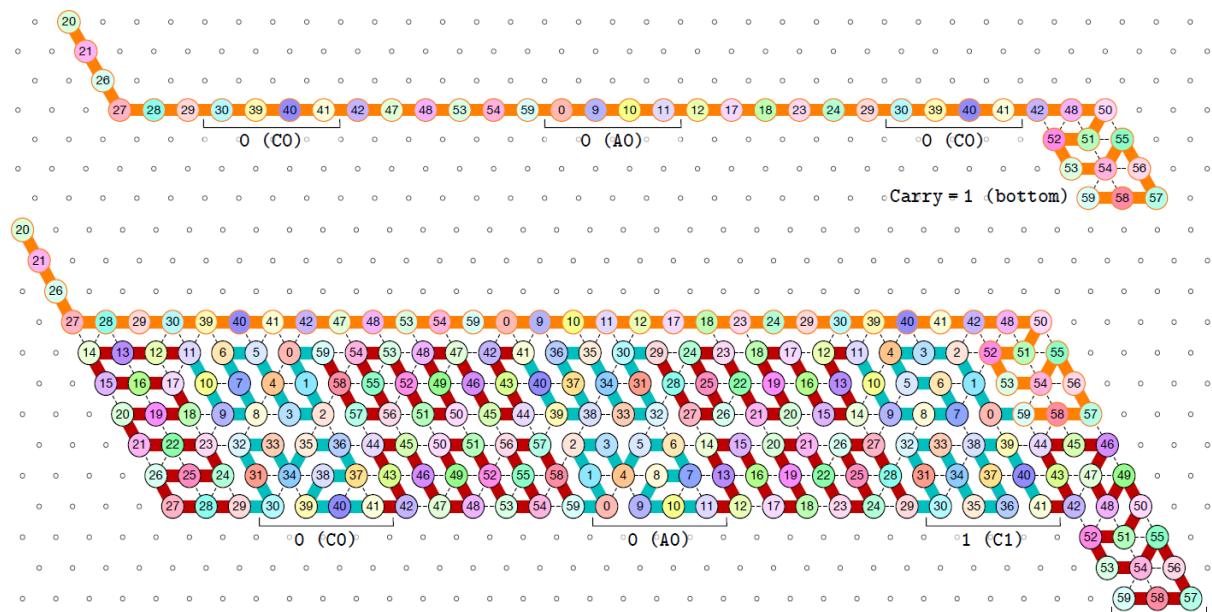
Fig. 1



Caption

RNA origami: An RNA molecule folding over itself while being transcribed, as in the experiments described in previous work: Cody Geary, Paul W. K. Rothemund, and Ebbe S. Andersen A single-stranded architecture for cotranscriptional folding of RNA nanostructures (2014) *Science* **345**, 799–804.

Fig.2



Caption

Oritatami binary counter: It cotranscriptionally folds a periodic sequence 0-1-2- ... - 59-0-1-2- ... of 60 abstract molecule (bead) types. (Top) The initial count 000 is encoded as a sequence of four bead types. (Bottom) One zig-zag amounts to increment by 1, exposing different bead types below, encoding 001. After one more zig-zag, other bead types encoding 010 would be exposed below, and so on.

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About The University of Electro-Communications

The University of Electro-Communications (UEC) in Tokyo is a small, luminous university at the forefront of applied sciences, engineering, and technology research. Its roots go back to the Technical Institute for Wireless Communications, which was established in 1918 by the Wireless Association to train so-called wireless engineers in maritime communications in response to the Titanic disaster in 1912. In 1949, the UEC was established as a national university by the Japanese Ministry of Education, and moved in 1957 from Meguro to its current Chofu campus Tokyo.

With approximately 4,000 students and 350 faculty, UEC is regarded as a small university, but with particular expertise in wireless communications, laser science, robotics, informatics, and material science, to name just a few areas of research.

The UEC was selected for the Ministry of Education, Culture, Sports, Science and Technology (MEXT) Program for Promoting the Enhancement of Research Universities as a result of its strengths in three main areas: optics and photonics research, where we are number one for the number of joint publications with foreign researchers; wireless communications, which reflects our roots; and materials-based research, particularly on fuel cells.

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