Flipons within Junk DNA Enhance Biological Computations by Exchanging Energy for Information

Junk DNA enhances evolution by changing how information is read out from the genome

CHARLESTOWN, MA, UNITED STATES, November 20, 2023 /EINPresswire.com/ -- Dr. Alan Herbert from InsideOutBio describes how biological systems compute differently from our current generation of machines in a published online today by The International Journal of Molecular Science. The study focuses on the intransitive logic of biological systems that is enhanced by a genome full of junk DNA. Previously junk DNA was considered as an accumulation of genomic errors. Instead, the junk adds a level of programmability to the genome that was not previously appreciated. The junk DNA increases the complexity of programs stored in the genome by incorporating repeat elements, called flipons, that change shape to to alter the readout of genetic information (Figure 1).

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> *Alan Herbert*

Flipons enable the exchange of metabolic energy for information. The process increases the informational entropy available for natural selection to act upon while diminishing the energy loss through thermodynamic entropy. The design is based on intransitive logic rather than the transitive logic of current day computers.

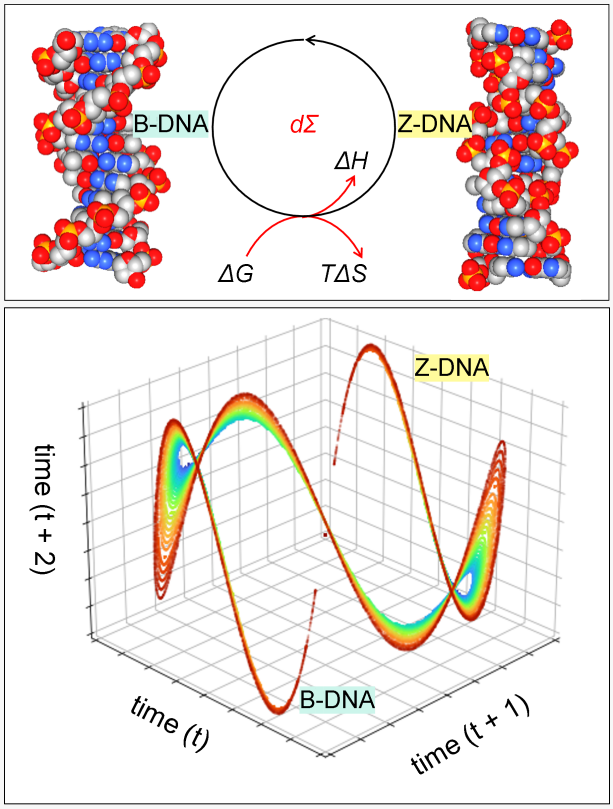
Intransitive logic is found in games like rock, paper, scissors where each choice can either win of lose the game depending on the other players' response. Here the rules are fixed, but the outcome is determined by the flow of the information. The rules establish when one play beats another. They are best described using a directed cycle (DC) (Figure 1). Of course, the game uses energy to power the play and involves losses through entropy.

Biological systems follow the same logic. The directed cycles ensure that the system regenerates itself. The different paths followed allows the cycle to drive different biochemical pathways. Those outcomes can be determined by natural selection that acts also to minimize energy losses through entropy. Unlike computational devices based on Turing machines, biological systems are not designed to arrive at an answer, then halt.

Through their intransitive nature, DCs enable a cell to do a number of things current computational devices cannot do: regenerate, recalibrate, reset, repair, rewrite, and reproduce themselves into the next generation.

The intransitive logic of directed cycles is also embedded in the genome through what has previously be called junk DNA. The name junk was given because these sequences are of low complexity and do not code for protein.

They take up over 50% of the genome and are considered by many as evolutionary fluff. However, these repeat sequences have informational value because that act as flipons, adopting alternative conformations that localize cellular machinery to a genomic region. The response depends on whether flipons are in the right-handed Watson-Crick B-DNA conformation or are in an alternative structure like left-handed Z-DNA. By cycling between conformations, they act as binary switches, enabling different outcomes to be associated with each state. The repeat elements therefore increase the complexity of the genome and alter the readout of genetic information. The increased diversity they generate is subject to natural selection and provides an evolutionary advantage to individuals of a species.



Repeat DNA Adopts Different Conformations. By cycling between different states, DNA can change the readout of information from the genome. The process exchanges metabolic energy for information. Sequences that change shape under physiological conditions

The complexity of a genome can also be viewed from a programming perspective. The most complex program a genome can generate is equivalent to the complexity of the genome itself, an example of the theorem proposed by Andrey Kolmogorov. From this perspective, junk DNA is advantageous. Even though the junk sequences are simple and repetitive, they enable simple rules that, like the Conway Game of Life, can generate unexpected and diverse outcomes, some of which cycle between states.

The implications for the design of novel therapeutics and new bioprocesses are discussed in the paper. Many of these technologies can be developed by cell selection and then implemented with more conventional approaches.

The paper explores in depth both thermodynamic and informational entropies and provides examples of both, concluding by stating: “DCs offer the best way to survive in the midst of chaos,

but they do not guarantee eternal life. DCs embrace intransitivity. They maximize informational entropy while avoiding thermodynamic equilibrium. DCs are not just the cycles of life, but they also embed the logic of life."

The paper is entitled "The Intransitive Logic of Directed Cycles and Flipons Enhances the Evolution of Molecular Computers by Augmenting the Kolmogorov Complexity of Genomes"

About InsideOutBio: InsideOutBio is a start-up focused on developing a novel class of proprietary therapeutics to 'light' up tumors for the immune system to kill by reprogramming self/nonself pathways within cancer cells. Dr. Herbert leads discovery at InsideOutBio. His work on Z-DNA was foundational to the discovery of flipons. These statements about InsideOutBio comply with Safe-Harbor laws. They are forward-looking and involve known and unknown risks and uncertainties. They are not guarantees of future performance and undue reliance should not be placed on them.

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