EDITORIAL

XNA

HB Asad, S Akhter

Dept of Laboratory Services, National Institute of ENT, Dhaka

The common genetic language-DNA is present in almost all organisms. But now scientists demonstrated that laboratory made variants of DNA can store and transmit genetic information[1]. These are XNAs. The 'X' in XNA stands for 'xeno'. So XNA is xenonucleic acid.

Scientists use the xeno prefix to indicate that one of the ingredients typically found in the building blocks of RNA and DNA has been replaced by something different from what we find in nature - something 'alien'. The researchers, led by Philipp Holliger and Vitor Pinheiro, synthetic biologists at the Medical Research Council Laboratory of Molecular Biology in Cambridge, UK has shown that artificial nucleic acids - called Xeno (non-natural) Nucleic Acids 'XNAs' - can replicate and evolve, just like DNA and RNA.

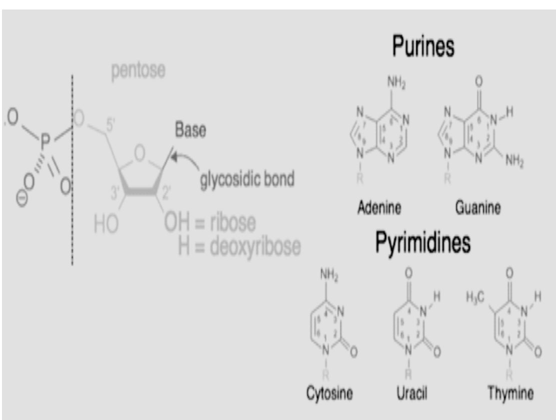

Fig. 1: Natural DNA & RNA

The molecules that piece together to form the six XNAs investigated by Pinheiro and his colleagues are almost identical to those of DNA and RNA. A nucleotide contains a nucleobase (A, C, T or G), a sugar group and a phosphate[2]. XNA has been created by replacing the sugar group. That means they have only one exception: in XNA nucleotides. The deoxyribose and ribose sugar groups of DNA and RNA have been replaced. Some of these replacement molecules contain four carbon atoms instead of the standard five. Others contain as many as seven carbons. The name of the backbone is then reflected in the name of the nucleic acid. Such synthetic 'XNA' created so far include HNA (1,5-anhydrohexitol nucleic acid), CeNA (cyclohexenyl nucleic acid), TNA (threose nucleic acid), ANA (arabino nucleic acid), FANA (2' Fluro-arabino nucleic acid), LNA (locked nucleic acid), GNA (glycol nucleic acid) and PNA (peptide nucleic acid)[3].

These substitutions make XNAs functionally and structurally analogous to DNA and RNA.

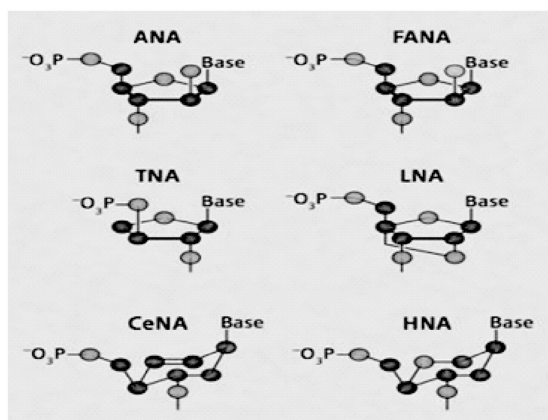

Fig 2 : XNA

Most XNAs still use the same bases found in DNA: adenine (A), thymine (T), guanine (G), and cytosine (C). The pairing is also the same: A-T and G-C. A few of these XNAs, such as HNA(1,5-anhydrohexitol nucleic acid), glycol nucleic acid (GNA), and threose nucleic acid (TNA), even form the same double helix structure familiar to DNA.

The latest research by synthetic biologists in Cambridge shows that this synthetic genetic material is also capable of performing another crucial biological role. That is they can catalyze biochemical reactions that are essential for life. The team were able to create synthetic enzymes using their lab-made XNAs as building blocks. These are named as 'XNAzymes'. They could cut up and stitch together small chunks of genetic material like naturally occurring enzymes. One of the XNAzymes was also able to join XNA strands together to form longer molecules. This is a key step towards creating a living system that can replicate itself. Although it will still be some time before these can be used to create living synthetic organisms, Dr. Holliger believes that XNAzymes could also be useful for developing new therapies for a range of diseases including cancers and some viral infections.

Some of the XNAs are used as anti-viral and anti-cancer agents. They are administered as nucleosides (base+sugar) since charged nucleotides can not easily cross cell membranes. These compounds are activated in the cells by being converted into nucleotides (base + sugar+phosphate).

XNAs are now being used in molecular biology for several purposes:

- Investigation of possible scenarios of the origin of life: By testing different analogs, researchers try to answer the question of whether life's use of DNA and RNA was selected over time due to its advantages or if they were chosen by arbitrary chance.
- As a tool to detect particular sequences: XNA can be used to tag and identify a wide range of DNA and RNA components with high specificity and accuracy.
- As an enzyme acting on DNA, RNA and XNA substrates: XNA has been shown to have the ability to cleave and ligate DNA, RNA and other XNA molecules similar to the actions of RNA ribozymes.
- As a tool with resistance to RNA hydrolysis.
- Investigation of the mechanisms used by enzyme.
- Investigation of the structural features of nucleic acids.

References

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3. Robbie Gonzalez. XNA is synthetic DNA that's stronger than the real thing. 2012.