The Torch
Vol. 4 (36)

Implications of DNA Origami

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DNA origami is one of the latest techniques where short fragments of DNA strands, called staples, bind to their complementary region on a longer piece of single-stranded DNA, called a scaffold. The strand is then forced to fold around it, and if the process is repeated in many places along the DNA strand, complicated folded shapes are generated. With careful design, we can actually manipulate the single-stranded DNA to fold into any shape we want. Such shapes have numerous medical applications, a few of which are: (a) boxes that deliver drugs directly to cancer cells, (b) nanorobots that navigate to a certain part of the body when injected, and (c) a DNA alien, which is a bacterial killer that can replace antibiotics. Thus, DNA origami is the nanoscale folding of DNA to create arbitrary two- and three-dimensional shapes at the nanoscale.   The most prominent parameters for this folding are the specificity of the interactions between complementary base pairs, as well as the suitability of DNA to create scaffolds for holding other molecules in place. Self-assembly is facilitated by a combined effect of heat and chemical denaturation of double-stranded DNA scaffold strands in the proximity of staple strands, accompanied by a rapid drop in temperature and sequential dialysis to eliminate chemical denaturant. Drug delivery vessels were designed using this technique, in which a DNA nanorobot consisting of an open DNA tube filled with drugs is held shut by a DNA aptamer.   On the introduction of the origami nanorobots into the patient, they travel to the infected cells where the aptamer identifies and detects the disease-related protein and breaks apart, thus releasing the drug. The first disease model created was against leukaemia and lymphoma. Structures with triangular shapes hybridised with gold nanorods prove highly efficient against cancer cells. This hybrid product serves as both a medical imaging agent and a photothermal therapy agent. Furthermore, to replicate the envelope of a virus, DNA is folded into an octahedral shape and covered with a single bilayer of phospholipid. After being injected into mice, the DNA nanoparticles persist in the circulation for hours. It also stimulates a weaker immune response than the particles that are not covered. Therefore, it has immense potential to be used in drug delivery.

Keywords: DNA origami, Nanorobots, Aptamer, Self-assembly, Scaffolds, Drug delivery vessels

Citation:
Poojhaa S. Implications of DNA Origami. The Torch. 2023. 4(36). Available from:
https://www.styvalley.com/pub/magazines/torch/read/implications-of-dna-origami.