Structural DNA Nanotechnology: From Design to Applications

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Abstract:
Structural DNA Nanotechnology applies modified DNA strands to come up with various shapes and order of arrangements of DNA molecules as desired. This DNA specimen is produced by exchange of DNA backbones in a reciprocal fashion resulting in systems of branched strands with many helical domains. The DNA strands are joined by cohesion forces at the ends as a result from hydrogen bonds or covalent bonding. They can also be joined paranemically or by sharing the same edges. The process utilizes the ability of nucleic acids to combine only with specific complements hence a DNA sequence can be designed to favor the formation of a particular strand. The difference between naturally occurring DNA structures and artificial DNA is that the junction is artificially fixed at certain point to favor a particular rigid pattern and stability as desired. Structural nanotechnology is based on four basic concepts mentioned below. First, tile based structures; this was the most dominant method of DNA design between 1990s and 2000 and was replaced by DNA origami. In this approach, the targeted structure is broken into smaller sub-units with strong bonding between two strands forming a particular unit while having weak connections between the units. The approach is usually used in making periodic lattice and implementing self-assembly applied in DNA computing. Second, folding structures (DNA origami); it involves making the DNA nanostructure from one long strand of DNA, nucleic acid sequence in this long strand can be designed such that it folds by itself or the folding can be done manually by use a staple strand. The latter method is what is known as DNA origami, which permit creation of 2D and 3D shapes nanoscales. Third, dynamic assembly; in this approach, the intermediate and final product of DNA assembly are controlled all through, the starting materials are made to form a hairpin structure which then assemble in a specific order. The process is isothermal and does not require thermal annealing to trigger the assembly in desired conformation. Fourth, sequence design; this is the final stage done after any of the above approaches have been used, it is done to dedicate a certain nucleic acid base to a particular constituent in the strand so that they assembly in a certain predetermined order. The desired sequence is separated from the undesired by either symmetry minimization or thermally.

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