

## DNA-templated conjugation and assembly of molecular components

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Nature displays exquisite control in organizing and assembling molecules into complex, functional nanostructures. In building synthetic molecular complexes with specialized functions we are challenged to achieve similar control over fabrication including the integration of heterogeneous components and their positioning with near-atomic precision.

We present a DNA templating technique<sup>1</sup> for the selective attachment of two different oligonucleotides to a homobifunctional organic molecule, enabling its controlled and programmable placement within a DNA nanostructure. We demonstrate its application to a wide range of organic molecules with different conjugation chemistries and water solubilities. We show that the two oligonucleotide adapters can be used to integrate a bifunctional cyanine dye into a self-assembled 3D-DNA origami nanostructure, giving control of both position and orientation. We also demonstrate the use of both adapters to exert dynamic control over the environment of the target molecule by means of a series of strand-displacement reactions. We discuss the application of our technique in the assembly of molecular electronic devices.

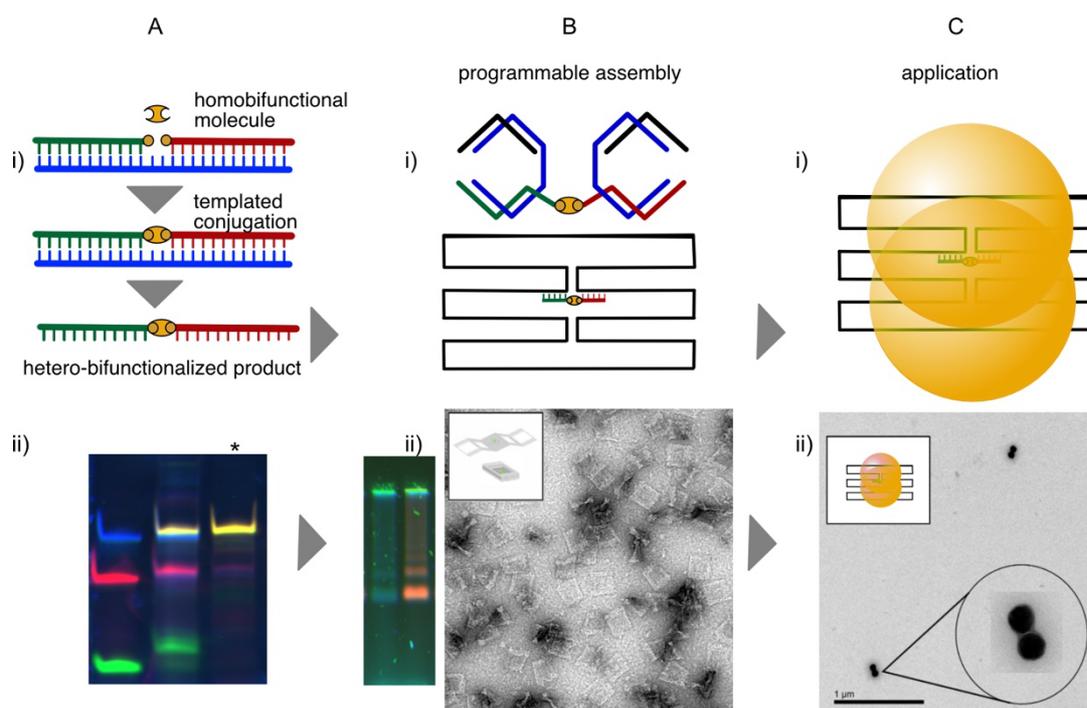


Fig. 1. A. Templated conjugation. i) The template (blue) colocalizes two distinct oligonucleotide adapters (red and green), creating a short gap that accommodates the homobifunctional molecule to be conjugated. ii) Merged colour image of 20% denaturing PAGE gel showing reactants, products of templated conjugation reaction and HPLC-purified heterofunctionalized product (\*). B. Integration of a heterofunctionalized molecule in a DNA origami breadboard through hybridization of adapters to the scaffold: i) schematic; ii) 1% agarose gel of the DNA nanostructure without (L) and with (R) the bifunctional fluorophore; TEM image. C. Use of an origami breadboard to incorporate a conducting molecule in an electrical circuit: i) schematic; ii) TEM.

[1] S. Helmi, and A. J. Turberfield, "Template-directed conjugation of heterogeneous oligonucleotides to a homobifunctional molecule for programmable supramolecular assembly", *accepted for publication*.