Precision targeting and enhanced therapeutic delivery using DNA nanorobots

Mahboubeh Ebrahimian[1], Jorge Eduardo Guerrero[1], Micheal Brandon Reed[1], Reza Zadegan[1]*

[1]Department of Nanoengineering, Joint School of Nanoscience and Nanoengineering, NC A&T State University, Greensboro, NC, USA

Delivering therapeutic agents directly to specific cellular compartments significantly boosts treatment efficacy and precision by limiting off-target effects and potential side effects. This approach improves overall therapeutic outcomes. The use of self-assembled nucleic acids is especially valuable, as it enables precise DNA folding into intricate structures ideal for targeted nanotechnology applications. These designed structures provide a safer option compared to standard viral and bacterial vectors, allowing non-integrating gene manipulation techniques, which is essential for efficient gene delivery.

The introduction of functional nanostructures into cellular settings is crucial for numerous applications, necessitating careful control over their shape and structure. This precision is attained by DNA origami, a self-assembly process based on structural DNA nanotechnology. The Model ENfolded DNA Editing Library (MENDEL) software plays a key role in creating complex 3D DNA origami structures, offering a script-based interface to simplify the initial design process. Built-in Python, MENDEL enables detailed parametric designs, automates staple calculation, and generates Cadnano-compatible files. It is additionally compatible with Blender for real-time visualization, improving the design process. MENDEL greatly simplifies the creation of intricate DNA nanostructures, making the process faster and more efficient.

By streamlining the design process, MENDEL makes complex DNA origami structures more accessible to researchers. Once built, these structures can be thoroughly examined by Atomic Force Microscopy (AFM) to determine their size, shape, and structural integrity. After evaluation and any necessary surface modifications or adjustments to targeting mechanisms, the DNA origami structures are delivered into cells with precision. This targeted delivery ensures that the nanostructures reach their intended cellular locations, maximizing their functional impact and enhancing the potential of targeted gene therapy.