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Introduction to the DNA nanotechnology themed collection

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DNA nanotechnology has transformed nucleic acids from simple genetic information carriers to programmable building blocks capable of manipulating matter at molecular-, nano-, and micro-scales. By harnessing Watson–Crick base pairing, researchers have created unprecedented architectures and devices, ranging from DNA origami and plasmonic nanoassemblies to molecular robots, computational science, biosensors, and therapeutic systems. This themed collection showcases state-of-the-art advances that exploit the sequence-encoded addressability of DNA to achieve precise structural control and functional integration, while revealing emerging opportunities across a wide range of disciplines.

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Leveraging DNA programmability, this collection features precision DNA origami, amplification techniques, computational modeling approaches, and clinical translation. Within this landscape, Arya's group reviewed the convergence of dynamic DNA mechanisms and hierarchical assembly, highlighting emergent superstructures with potential applications in optoelectronics, biomedicine, and synthetic biology (**https://doi.org/10.1039/D5NH00436E**). Consistent with the potential for biomedical applications, Bastings' group explored new directions for next-generation immunotherapies by using DNA origami to organize pMHC-I ligands. Their study revealed that nanoscale spacing, symmetry, and rigidity govern T-cell activation (**https://doi.org/10.1039/D5NH00412H**).

Rolling circle amplification (RCA), an emerging amplification method, has

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Chunhai Fan

Chunhai Fan is a K. C. Wong Chair Professor at Shanghai Jiao Tong University (SJTU), New Cornerstone Investigator (NCSI), Dean of the School of Chemistry and Chemical Engineering, and Executive Director of the National Center for Translational Medicine. He is a member of the Chinese Academy of Sciences, the World Academy of Sciences (TWAS) and the Chinese Academy of Medical Sciences. He is an Associate Editor of JACS-Au, and an editorial board member of over 10 international journals. His research interests include nucleic-acid chemistry, DNA nanotechnology, biosensors and biophotonics.

gained attention as a versatile technique for synthesizing tandem repeats of precisely designed nucleic acid nanostructures. A comprehensive review by Guo, Yao, Yang *et al.* summarized RCA-based nanotechnology as a versatile platform for nucleic acid drug delivery, emphasizing design strategies, targeting modalities, and therapeutic applications (**https://doi.org/10.1039/D5NH00364D**). Extending this concept, Lee, Kim *et al.* introduced an RCA-enabled approach to efficiently produce DNA origami staples while maintaining folding efficiency and fidelity (**https://doi.org/10.1039/D5NH00357A**).

Similarly, Wang's group demonstrated the use of DNA nanostructures as enzyme inhibitors to control the gelation of a DNA-triggered blood-contacting injectable hydrogel, suggesting the potential applications of injectable *in situ* hydrogels in vascular embolization and hemostasis (**https://doi.org/10.1039/D5NH00314H**).

Further efforts are aimed at establishing the clinical efficacy and translational potential of DNA nanostructures. Focusing on nucleic acid chirality, Li, Ding *et al.* reviewed design strategies for chiral nanostructures and programmable architectures, suggesting that such chirality could reveal unexplored applications in drug delivery, biocomputing, and clinical translation (**https://doi.org/10.1039/D5NH00140D**). Complementing this, Wang, Song *et al.* established a robust nanoscale quality control framework for evaluating DNA integrity in preserved tissue samples, providing a standardized approach for precision genomics in a clinical context (**https://doi.org/10.1039/D5NH00176E**).

With the increasing integration of computational science into biotechnology, Mao's group evaluated the latest AlphaFold algorithm for the structural

Na Liu

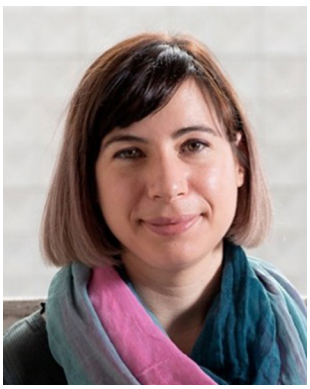
Na Liu received her PhD in Physics from the University of Stuttgart, Germany. She then worked as a postdoctoral fellow at the University of California, Berkeley, and later as a Texas Instruments Visiting Professor at Rice University. Prior to her appointment as a Full Professor at the Kirchhoff Institute for Physics at the University of Heidelberg in 2015, she worked as an independent group leader at the Max Planck Institute for Intelligent Systems. In 2020, she joined the University of Stuttgart, where she became the Director of the 2nd Physics Institute.

Chengde Mao

Chengde Mao is a professor of Chemistry at Purdue University. He received his B.S. degree from Beijing University in 1986 and his PhD degree from New York University in 1999. After completing postdoctoral training at Harvard University, he joined the faculty of the Department of Chemistry at Purdue University in 2002. He is interested in programmed self-assembly of nucleic acids (DNA and RNA), aka DNA nanotechnology. In particular, he focuses on developing strategies to robustly assemble moderately complicated DNA nanostructures with minimal components.

Young Hoon Roh

Young Hoon Roh completed his PhD in the Department of Biological and Environmental Engineering under Professor Dan Luo at Cornell University and his postdoctoral associate research in the Department of Chemical Engineering and Koch Institute for Integrative Cancer Research under Institute Professor Paula T. Hammond at MIT. Currently, he is a professor at the Department of Biotechnology in Yonsei University. His research includes nucleic acid nanotechnology, biopolymers, and hydrogels for biomedical applications such as drug delivery, tissue engineering, and biosensing.



Shelley Wickham

Shelley Wickham is an Associate Professor in the Schools of Chemistry and Physics at the University of Sydney and group leader of the DNA nanotechnology group. She received her PhD in Condensed Matter Physics from the University of Oxford, UK, then moved to a postdoctoral fellow position at Harvard Medical School, USA, based in the Dana-Farber Cancer Institute, and the Wyss Institute for Biologically Inspired Engineering. She has research interests in self-assembling nanotechnology and molecular robotics, in particular, in the design and assembly of programmable nanostructures out of DNA, with applications in cell biology, materials science and nanomedicine.

prediction and design of biomolecules. Their findings offer guidelines for assessing symmetric DNA motifs and highlight the potential and limitations of the algorithm (**https://doi.org/10.1039/D5NH00059A**). Choi's group employed computer simulations of molecular dynamics to examine how motif design and ligation patterns influence the mechanical deformation of DNA, providing insights for designing robust and tunable DNA nanostructures (**https://doi.org/10.1039/D5NH00524H**).

The contributions gathered here offer a concise glimpse into the creativity and momentum currently shaping DNA nanotechnology. We invite readers to explore the full collection and engage with the questions it raises regarding the next generation of programmable nanosystems. We extend our sincere thanks to all contributing authors and reviewers for their insightful efforts and to the Royal Society of Chemistry editorial team for their invaluable support in bringing this collection to fruition.