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Introduction to emerging concepts in nucleic acids: structures, functions and applications

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An introduction to the *Nanoscale, Nanoscale Advances* and *Physical Chemistry Chemical Physics (PCCP)* themed collection on DNA and RNA nanotechnology, featuring a selection of excellent articles that highlight the potential of nucleic acids for various applications.

Nucleic acids are known to play a significant "traditional" role in biology and are also useful as materials for nanotechnology. Recent research across different disciplines has focused on the basic properties of nucleic acids, including DNA, RNA, and their variations, such as xeno nucleic acids, modified nucleic acids and peptide nucleic acids. These molecules also hold promise for several applications across disciplines from molecular biology and medicine to nanotechnology and materials science. With these ideas in focus, this combined themed collection from the journals *Nanoscale*, *Nanoscale Advances*, and *Physical Chemistry Chemical Physics* (*PCCP*) aims to cover the most recent progress in the structure, function, and applications of DNA and DNA-based materials.

This themed issue covers new research in emerging areas of nucleic acids, including biosensing, drug delivery, nanostructure assembly, new imaging techniques and materials science. In biosensing, these papers discuss methods for detection of microRNAs, viral RNAs, single nucleotide polymorphisms, and small molecules involved in neurodegenerative diseases. New topics on drug delivery cover

Dhiraj Bhatia

Dr Dhiraj Bhatia obtained his PhD from NCBS-TIFR in Bangalore, India, in DNA nanotechnology. Post PhD he went to the Curie Institute in Paris initially as a Curie fellow and later as an HFSP long-term fellow where he learnt the cellular and biological applications of DNA nanodevices. In 2018, he moved to India to start his own laboratory at the Indian Institute of Technology Gandhinagar where he is an Assistant Professor and Ramanujan fellow. His lab focusses on translational aspects of DNA nanotechnology to develop tools to program biological systems for biomedical applications. He is currently a member of INYAS-INSA and also scientific advisor for the startup company Q-Nano-Sol Biotech.

Prabal K. Maiti

Prabal K. Maiti is Professor and currently the chair in the Department of Physics, Indian Institute of Science, Bangalore. He works in Multiscale Modelling of Soft and Bio-materials. Prof. Maiti received his MSc and PhD degrees in Physics from IIT, Kanpur, India followed by postdoctoral stays at MPIP, Mainz, the University of Colorado at Boulder, and Caltech, USA. He is a fellow of the Indian Academy of Science (IASc), Indian National Science Academy (INSA) and Royal Society of Chemistry (FRSC). Currently, he is an associate editor of PCCP *published by the Royal Society of Chemistry (RSC).*

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aspects of drug transport across membranes, immune response control, and the assembly of rigid DNA nanostructures. For example, Bhatia and colleagues show how the *in vivo* stability and uptake of DNA nanocages can be improved by shielding their backbones with positively charged lipids (**https://doi.org/10.1039/D2NA00905F**).

Progress has also been presented on new analysis of DNA structures and their interactions with other materials such as peptides, lipids and graphene. For example, Sathyamoorthy and co-workers investigate structural differences in DNA structures involving C, ^{5m}C, and their oxidized (^{5hm}C/^{5f}C) counterparts using NMR spectroscopy (**https://doi.org/10.1039/D2CP04837J**). Such structural analysis leads to more insight into how such nucleotide modifications can alter the physical properties of duplex DNA and the role of epigenetic modifications in the biological function of nucleic acids.

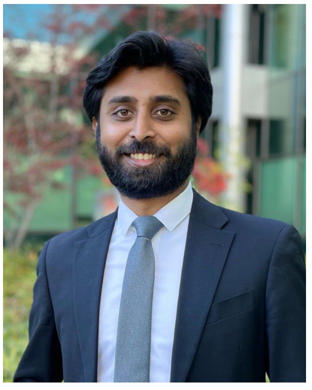
The issue also includes articles that discuss developments in new simulation and experimental methods. Šulc and co-workers use molecular dynamics simulations of DNA origami designs as a promising candidate for experimental realization of cubic diamond lattices (**https://doi.org/10.1039/D2NR03533B**). Zheng and colleagues use surface-enhanced Raman spectroscopy (SERS) and molecular dynamics simulations to analyze interactions between DNA and small molecules, with potential use in drug screening and targeted drug design (**https://doi.org/10.1039/D2CP04566D**).

Rounding out the issue are review articles on a variety of topics related to nucleic acids, including those on DNA computing, peptides in nucleic acid nanotechnology, DNA hydrogels, and opinion pieces on how DNA nanotechnology can bridge the gap between biochemistry and the core nanotechnology fields. Some examples include the review by Ganji and colleagues on labeling approaches for DNA-PAINT super-resolution imaging (**https://doi.org/10.1039/D2NR06541J**) and by Mathur *et al.* on the uptake and stability of DNA nanostructures in cells (**https://doi.org/10.1039/D2NR05868E**).

This themed issue provides a glimpse of nucleic acid research in different disciplines as well as interdisciplinary work using nucleic acids. Combined with the basic understanding of the structure and function of nucleic acids, one can only expect more new concepts to emerge in the future for nucleic acid-based materials.

Xiaogang Liu

Xiaogang Liu earned his doctorate in inorganic chemistry from Northwestern University in 2004. Following this, he spent two years as a postdoctoral researcher at Massachusetts Institute of Technology. Currently, he holds a position at the National University of Singapore. He is an associate editor of Nanoscale *and* BMEMat, *in addition to serving on the editorial boards of several scientific journals. Among his research interests are the study of energy transfer in lanthanide-doped nanomaterials, the application of optical nanomaterials for neuromodulation, the development of advanced X-ray imaging scintillators, and the prototyping of electronic tools for assistive technologies.*



Arun Richard Chandrasekaran

Arun Richard Chandrasekaran received his PhD from New York University, working with Nadrian Seeman for his doctoral thesis. He then worked as a postdoctoral associate with Ken Halvorsen at the University at Albany, State University of New York (SUNY). Currently, Arun is a Senior Research Scientist at The RNA Institute at SUNY Albany. His research group focusses on the design, functionalization and applications of DNA nanostructures.