Rapid Technology Assessment: Nucleic Acid Technologies

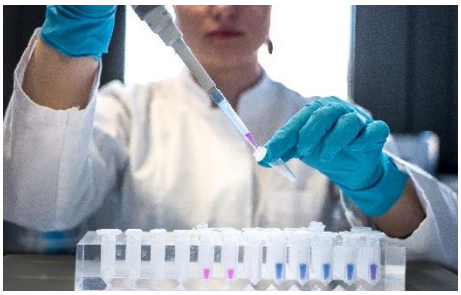
COVID-19 vaccines have brought nucleic acid technologies to the fore and demonstrated large-scale feasibility. New therapeutics, vaccines, and gene therapies building on our increased understanding of the effective design, synthesis, and delivery of nucleic acids could be transformative to a range of areas in human and non-human health.

Introduction

- **Nucleic acids are the building blocks of our genetic code and are essential for an array of cellular processes.** DNA encodes our genome, with RNA essential for translating this code into functional proteins and regulating the levels of different proteins.
- **Synthetic nucleic acids use this control of protein production to influence specific biological processes** through inducing protein production and a subsequent immune response (vaccines), delivering healthy versions of genes or regulating gene expression (gene therapy), and blocking production of disease-related proteins.
- **Nucleic acid technology can enable increased therapeutic precision at the sub-cellular level** and combined with advances in our understanding of genetic disease factors bring us closer to true "personalised medicine"**.** Beyond health there are applications in agriculture (e.g. enhancing yield, reducing waste) and industry (see our RTA on *Synthetic Genomics*).

Recent Developments

- **Nucleic acid therapeutics, vaccines, and gene therapies have seen increasing regulatory approval and use.** mRNA vaccines for COVID-19 have demonstrated the effectiveness of RNA vaccine technology. Gene therapies and nucleic acid therapeutics have been approved for conditions including retinal disease, spinal muscular atrophy, and high cholesterol.
- **Innovative delivery systems and advances in nucleic acid design and synthesis have advanced the application of nucleic acid technology.** Delivery systems include lipid nanoparticles (e.g. Pfizer-BioNTech COVID-19 vaccine) and viral vectors (e.g. AstraZeneca-Oxford COVID-19 vaccine). RNA therapeutics can be targeted to specific tissues by combination with a molecule that binds a receptor on the target (bioconjugation, e.g. Inclisiran).
- **The USA dominates the investment landscape but research activity is growing internationally**, particularly in China and India. In most countries, growth in research output is outpacing patent applications.



UK Position

- **The UK has a strong research base,** ranking 1st for research impact with other countries close behind, and ranking 3rd for total publication number (2011-2020).
- Although the UK ranks 7th globally for patent applications, these have grown at an annual growth rate of 4% from 2011-2020, the highest in Europe.

Opportunities

- **Treating previously 'undruggable' diseases**. Nucleic acid technologies could provide new treatments to a range of complex conditions where current options are limited to managing symptoms rather than curing the disease, e.g. Crohn's disease, and Alzheimer's.
- **Time efficient novel vaccine design and production.** mRNA vaccines can be developed quickly by using the genomic sequence of a new pathogen. The same principle allows for rapid adaption of vaccines that target emerging variants. The speed and availability of the required technology also enables start-ups and researchers to rapidly develop innovative therapies.
- **Nucleic acid therapeutics could offer advantages over current treatments** including less frequent and lower doses, potentially improved safety profiles due to the highly specific mechanism of action, and multiple routes of administration.

Challenges & Risks

- **Research challenges remain which will require interdisciplinary collaboration** between academia and industry**.** For example, improving precise tissue targeting, limiting instability and cold storage requirements, and improving delivery methods.
- **Improving our understanding of the molecular basis of different diseases** is needed to develop new nucleic acid therapeutics. Continued rigorous clinical trials are essential for understanding potential side effects and risks of new therapeutics.
- **Translating the UK's strong research base into commercial success**. The UK has fostered commercial growth in this technology but experts highlighted challenges in scaling and commercialising research findings, including funding for applied research (particularly for early career researchers), SME access to investment, and domestic manufacturing and supply chain capabilities.

*This is a summary of a report completed in October 2021. There may have been developments and additional data since then that are not captured in this summary. Patent and research publication data was sourced from **Dimensions Analytics**. Search terms available on request. We would like to thank the following for their contribution and expert review: BEIS, DSTL, FSA, OLS, DHSC, MHRA, Innovate UK, MRC, CSI Seqirus, Touchlight, Cell and Gene Therapy Catapult, Prof. Robin Shattock and Prof. Mimoun Azzouz.*