Introduction to Nucleic Acid-Based Vaccines

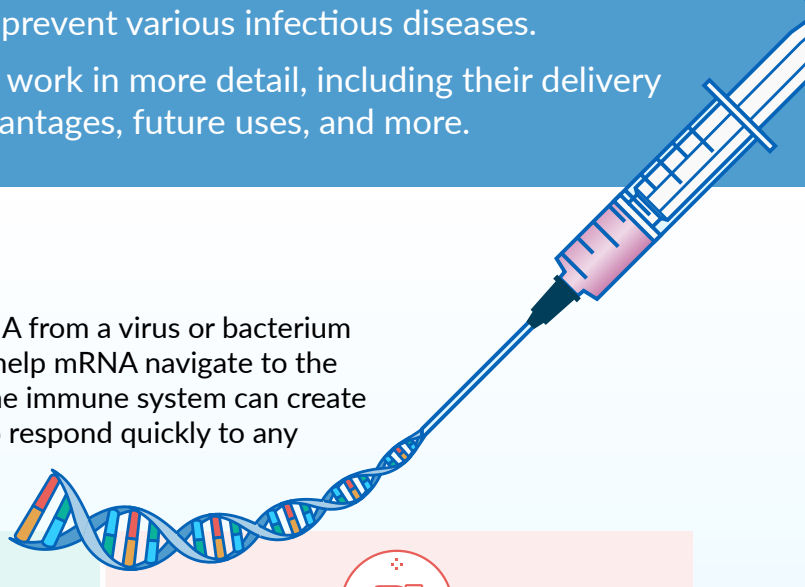
Nucleic acid-based vaccines, which use DNA or RNA to stimulate an immune response, are a relatively new approach to vaccination. Research on intracellular mRNA delivery first began in the **1970s**, and several groups pioneered DNA vaccines in the early **1990s**.

However, these vaccines did not gain widespread attention until the COVID-19 pandemic, when several companies developed and successfully deployed mRNA vaccines against SARS-CoV-2 in a matter of months. The success of these vaccines has led to increased interest and research on utilizing them to prevent various infectious diseases.

This infographic explores how these vaccines work in more detail, including their delivery methods, advantages and disadvantages, future uses, and more.

How do Nucleic Acid Vaccines Work?

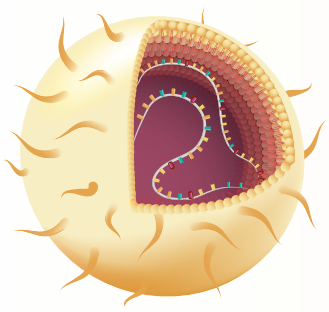
Nucleic acid-based vaccines utilize modified DNA or RNA from a virus or bacterium to stimulate an immune response. These modifications help mRNA navigate to the proper ribosome for protein synthesis. Upon delivery, the immune system can create antibodies to destroy future viral antigens, allowing it to respond quickly to any additional viral exposure.



	Advantages	Disadvantages
DNA Vaccines	• Stability and ease of storage at room temperature. • Relatively easy to manufacture. • Long-lasting immunity, as plasmids can persist in the body for weeks/months post-immunization.	• Additional injections may be required to achieve a sufficient immune response. • Considered less effective in inducing immune responses in certain populations (e.g., elderly adults, immunocompromised individuals).
RNA Vaccines	• Rapid development time, similar to DNA vaccines. • Does not require live viruses or pathogens, which can reduce side effects. • Can be designed to produce a specific immune response, like neutralizing antibodies.	• Relatively unstable compared to DNA, requires low-temperature storage. • May require higher doses or more frequent booster shots to maintain immunity. • Long-term safety is not yet fully understood (not yet widely used in humans).

Current Uses

Nucleic acid-based vaccines have emerged as a promising tool in the fight against various diseases. The most prominent use of these vaccines is against COVID-19, with both Pfizer-BioNTech and Moderna vaccines using mRNA technology to trigger an immune response against the virus. These vaccines are also being developed as an alternative to traditional influenza vaccines, with the potential for faster protection against seasonal flu strains. Research has also focused on nucleic acid-based vaccines as potential candidates for immunizing against Zika virus, African swine fever, and avian influenza, offering new avenues for disease control and prevention.



Present (and Future) Delivery Methods

Nucleic acid-based vaccines are typically delivered through lipid nanoparticles (LNPs), like the Pfizer-BioNTech and Moderna COVID-19 vaccines. Electroporation is another method that uses electrical pulses to create tiny pores in cell membranes. Future methods include using nanoparticles to target specific cells or tissues, adenoviral vectors (like that seen with the AstraZeneca COVID-19 vaccine), and self-amplifying RNA (saRNA), replicating itself within a cell to increase potency and durability.

Future Applications

Nucleic acid-based vaccines are not only helpful in preventing infectious diseases but also have promising applications for various illnesses. These vaccines have been shown to target tumor-specific antigens for cancer treatment to stimulate an immune response while sparing healthy cells. Nucleic acid-based vaccines are also being studied for autoimmune diseases, allergies, and inherited disorders caused by genetic mutations. For example, RNA-based therapies are being developed for cystic fibrosis and Duchenne muscular dystrophy.