

Mains Practice Question

Q.How does mRNA technology differ from traditional vaccine approaches? Discuss its advantages and limitations in the context of emerging global health challenges. **(150 words)**

06 Nov, 2024 GS Paper 3 Science & Technology

Approach

- Introduce mRNA technology and its role in global health, particularly post-Covid-19.
- Compare mRNA vaccines with traditional vaccines in terms of mechanism and production.
- Highlight the key benefits of mRNA technology
- Discuss challenges like storage, cost, and long-term immunity.
- Conclude by stressing mRNA's potential while acknowledging current limitations.

Introduction

Messenger RNA (mRNA) vaccine technology has been spotlighted by the success of Covid-19 vaccines like Pfizer-BioNTech and Moderna.

 Unlike traditional vaccines, which use weakened or inactivated forms of pathogens, mRNA vaccines deliver synthetic genetic material that instructs cells to produce specific antigens, triggering an immune response.

Body

Differences Between mRNA Technology and Traditional Vaccines:

- Mechanism of Action:
 - Traditional Vaccines: Generally use attenuated (weakened) or inactivated viruses or protein subunits to stimulate an immune response. Examples include the inactivated polio vaccine and the measles-mumps-rubella (MMR) vaccine.
 - mRNA Vaccines: Contain mRNA encoding specific antigens (e.g., spike proteins for Covid-19) which the body's cells use to produce these proteins, leading to an immune response without using the actual pathogen.
- Production Time:
 - Traditional vaccines require lengthy processes, including **virus culturing and protein purification**, often taking years to develop.
 - mRNA vaccines can be designed and manufactured in a matter of weeks, as demonstrated during the Covid-19 pandemic.

Advantages of mRNA Technology in Addressing Global Health Challenges

- **High Efficacy and Flexibility:** mRNA vaccines have shown high efficacy, with **Pfizer-BioNTech** initially reporting over 90% effectiveness against Covid-19.
 - Additionally, mRNA platforms can be swiftly adapted for different pathogens by altering the mRNA sequence.

- Scalable Manufacturing: Production of mRNA vaccines does not require pathogen culture facilities, simplifying scaling up and reducing the costs of bioreactors and other complex infrastructure.
- Targeting Difficult-to-Treat Diseases: Researchers are exploring mRNA vaccines for diseases like HIV, malaria, and certain cancers, where traditional approaches have faced limitations.

Limitations of mRNA Technology in Global Health:

- Storage and Distribution Challenges: mRNA vaccines are sensitive to temperature and require ultra-cold storage (-70 to -80°C for Pfizer), making distribution difficult in low-resource settings lacking cold-chain infrastructure.
 - Many **low- and middle-income countries** faced delays and logistical barriers in receiving mRNA vaccines due to these requirements.
- Short-Term Immunity and Need for Boosters: Unlike some traditional vaccines that provide long-lasting immunity (e.g., Measles, Mumps, and Rubella (MMR) Vaccination), current mRNA vaccines for Covid-19 have shown waning immunity over months, necessitating booster doses.
 - This may raise concerns for long-term sustainability and public compliance.
- High Costs and Intellectual Property Issues: Initial costs for mRNA vaccines were significantly higher than traditional options, impacting affordability in Iow-income regions.
 Intellectual property (IP) barriers have also restricted local production.
- Adverse Events and Public Perception: Though rare, there have been instances of adverse events (e.g., myocarditis in young males post mRNA Covid-19 vaccination), which can affect public perception and vaccine uptake, especially with misinformation circulating on social media.

Conclusion

mRNA technology stands at the **forefront of modern vaccine innovation**, offering remarkable advantages in **speed**, **adaptability**, **and potential scope for various diseases**. With further advances, especially in **storage solutions and cost reductions**, mRNA vaccines could reshape global health responses, **not only against infectious diseases but also in areas such as cancer and antimicrobial resistance**.

PDF Refernece URL: https://www.drishtiias.com/mains-practice-question/question-8532/pnt