



MECHANISMS OF VACCINATION AGAINST VIRUSES AND FUTURE TECHNOLOGIES

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Abstract: Vaccination against viruses is a key component of public health policy to protect human and animal populations. Vaccines can be produced in many forms, including inactivated (killed), toxoid, virus-like particles, synthetic peptides, polysaccharides, viral vector-based, nucleic acid (DNA and mRNA), and bacterial cell-based vaccines. Various processes are employed in vaccine production, and recent advancements in medicine, biomedical engineering, biology, immunology, and vaccinology have led to the emergence of new nucleic acid-based vaccines in addition to traditional and subunit vaccines

Keywords: vaccine, types of vaccines, vaccine platforms, inactivated vaccine, live attenuated vaccine, virus-like particles, toxoid vaccine, polysaccharide vaccine, next-generation vaccines, viral vector vaccine, DNA vaccine, mRNA vaccine.

Relevance of the topic: Viruses are a biological factor that has a tragic effect on our life. Viruses can pose serious threats to the human body because they cause various diseases, including dangerous diseases such as influenza, hepatitis, HIV, and COVID-19. Thus, the development of effective vaccines against viruses and their widespread distribution around the world are important for maintaining health and preventing epidemics. Current vaccination technologies are an important tool in the fight against viruses, but the possibility of the emergence of new viruses and



pandemics requires constant attention to the effectiveness and development of vaccines. Therefore, we consider this as an urgent topic of today and a lot of research is needed in this regard.

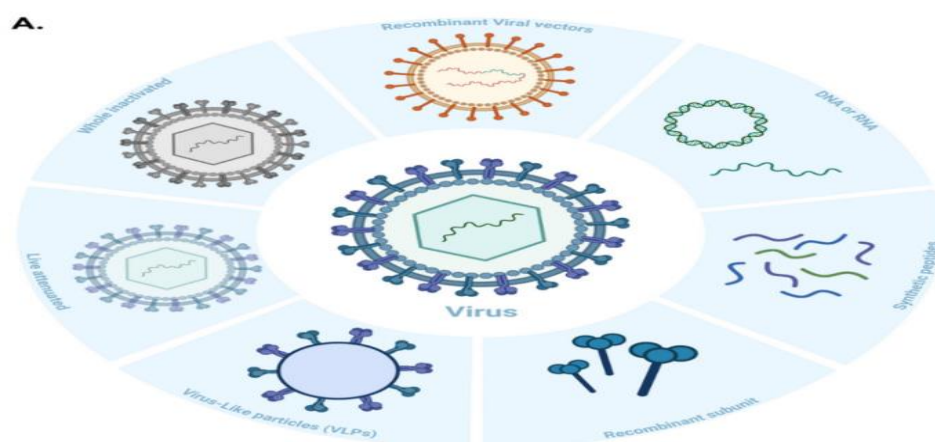
The main part. Vaccination, also known as vaccination, is one of the most effective ways to prevent and control serious and sometimes fatal infectious diseases. Surveillance, public and mass vaccination campaigns have helped eradicate diseases such as smallpox and significantly reduce morbidity and mortality caused by several pathogens, including SARS-CoV-2. In the United States and other high-income countries, vaccines have proven essential in eliminating debilitating diseases such as poliomyelitis, Haemophilus influenzae b (Hib), rotaviral enteritis, hepatitis, mumps, whooping cough, chicken pox, tetanus, measles, and others. According to the World Health Organization (WHO), vaccines prevent 2-3 million deaths each year, despite significant disparities in vaccine uptake, particularly in low- and middle-income countries. Vaccines are biological compositions designed to stimulate and prepare the immune system against infection or disease. They take advantage of the highly developed mammalian immune system's ability to recognize, respond to, and remember pathogens. The main component of vaccines are antigens derived from or biologically produced by the pathogen of interest. Additional components may contain preservatives, stabilizers, auxiliary substances and traces of products carried out during the production process. Mechanisms of Vaccination Against Viruses. The mechanism of vaccination is the process of preparing the immune system by introducing a virus or its part into the body. Various vaccines are available in the following forms:

Social immunization (Live attenuated vaccines): Developed using attenuated forms of the virus. When they enter the body, they form an immune response without causing an actual disease. Example: measles, poliomyelitis. **Inactivated vaccines:** A form of the virus that has been inactivated by death or other chemical methods is used. Example: hepatitis A **Recombinant vaccines:** These vaccines are



developed using only a part of the virus or its genetic material. Example: hepatitis B. mRNA vaccines: mRNA vaccines are new technology in recent years, such as the Pfizer-BioNTech and Moderna vaccines against COVID-19. These vaccines can be developed quickly and efficiently. Future Technologies: New anti-virus technologies will help develop more effective and faster vaccinations in the future: Nanotechnology: Nanoparticulate technologies will increase the effectiveness of vaccines and speed up absorption. Artificial Intelligence (AI) and Data Analysis: Artificial intelligence will help to analyze the genetic structure of viruses and speed up the development of new vaccines. CRISPR technology: Using genetic editing, new vaccines against viruses can be created, this technology has high efficiency. Universal vaccines: In the future, it is expected that "universal vaccines" will be developed that are effective against various viruses.

Discussion and Results: Although current vaccination mechanisms are effective against viruses, they have limitations. For example, vaccines against some viruses may not be developed for a long time, or existing vaccines may not be effective when new viruses appear. Therefore, future technologies, especially approaches such as mRNA and genetic editing, will further advance the field of vaccination. The introduction of artificial intelligence and nanotechnologies will help to speed up the vaccination process and create new and effective vaccines. Also, with the development of universal vaccines, new opportunities will open up to improve global health.





Schematic representation of different vaccine platforms for infectious diseases, showing different vaccine technologies against viral pathogens.

Conclusion. New-generation platforms such as mRNA- and DNA-derived vaccines offer an interesting and promising avenue for vaccine development due to their low cost, safety, high potency, and mass distribution. These platforms are particularly relevant for complex pathogens with immune evasion potential. Moreover, unlike conventionally derived vaccines, these platforms can offer successful solutions for non-communicable diseases such as cancer. Prototyping a pathogen can significantly improve response time in a pandemic situation. Clearly, future funding and effective monitoring of new data will help usher in a new era of vaccinology and vaccination that will mitigate current and emerging public health threats. Antiviral vaccination mechanisms and future technologies will allow significant advances in medicine. New technologies such as mRNA vaccines and nanotechnology can increase the effectiveness of vaccines, shorten their development time and speed up their distribution worldwide. In the future, the development of universal vaccines, artificial intelligence and CRISPR technologies will create new opportunities in the fight against viruses. However, the introduction of these technologies will require a careful approach and ensure security.

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