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Expression Systems Based on Prokaryotes and Eukaryotes: Progress in Post-pandemic Viral Antigen Generation for Vaccines

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Introduction

The COVID-19 pandemic has accelerated the development of innovative technologies and platforms for vaccine production, with a focus on scalability, efficiency, and safety. Viral antigens are critical components of many vaccines, acting as the primary agents that stimulate the immune system to produce a protective response. The rapid development of vaccines during the pandemic underscored the importance of diverse expression systems for the production of viral antigens. Prokaryotic and eukaryotic expression systems have each played significant roles in this endeavor, offering unique advantages and limitations depending on the specific requirements of the vaccine.This article explores recent advancements in prokaryotic and eukaryotic expression systems used for viral antigen production, emphasizing their roles in post-pandemic vaccine development. It examines the strengths and limitations of each system, their applications in vaccine platforms, and how the lessons learned during the pandemic have shaped the future of antigen generation for vaccines.

Description

Prokaryotic systems have been successfully used to produce antigens for several viral vaccines, including hepatitis B, influenza, and COVID-19. For example, the receptor-binding domain (RBD) of the SARS-CoV-2 spike protein has been expressed in E. coli for preclinical studies. Advances in protein engineering and fusion tags have improved the solubility and immunogenicity of antigens expressed in prokaryotes. Eukaryotic systems, including yeast, insect, and mammalian cells, are indispensable for the production of complex proteins that require post-translational modifications. Yeast systems, such as Saccharomyces cerevisiae and Pichia pastoris, are popular for their robustness and ability to perform certain post-translational modifications. Yeast cells grow quickly, can be cultured in simple media, and are capable of glycosylation, albeit with differences from human glycosylation. Hyperglycosylation in yeast can affect antigenicity, and some proteins may misfold due to differences in the cellular machinery. Hepatitis B surface antigen (HBsAg) and the quadrivalent HPV vaccine (Gardasil) are examples of yeast-based vaccines.

Insect cell systems, particularly those using the baculovirus expression vector system (BEVS), are highly versatile and capable of producing complex proteins. Insect cells can perform many post-translational modifications and are scalable for industrial production. Differences in glycosylation patterns compared to mammalian cells can impact protein function. Insect cells have been used to produce antigens for influenza vaccines (e.g., Flublok) and SARS-CoV-2 vaccines. Mammalian cells, such as Chinese hamster ovary (CHO) cells and human embryonic kidney (HEK) cells, are the gold standard for producing biologics that require human-like post-translational modifications. Mammalian cells are capable of human-like glycosylation, proper folding, and assembly of complex proteins. These systems are expensive, have slower growth rates, and require sophisticated infrastructure. Mammalian cells are widely used for monoclonal antibodies, subunit vaccines, and viral vectors. The production of the spike protein for the Pfizer-BioNTech and Moderna COVID-19 vaccines relies on mammalian cell systems [1,2].

Conclusion

Expression systems based on prokaryotes and eukaryotes have been instrumental in the rapid development of vaccines during and after the COVID-19 pandemic. Prokaryotic systems offer simplicity and cost-effectiveness, while eukaryotic systems provide the capacity for producing complex, high-quality antigens. The integration of advanced technologies, including mRNA platforms and synthetic biology, has further revolutionized the field.As the world prepares for future pandemics and addresses ongoing challenges such as emerging variants and global vaccine equity, the continued optimization of expression systems will be essential. Collaboration among researchers, industry stakeholders, and policymakers will ensure the development of efficient, scalable, and accessible antigen production platforms, safeguarding global health in the post-pandemic era.

References

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