

# IMMUNISATION TECHNOLOGIES

Immunisation, once reliant on a limited set of technologies, has significantly evolved to incorporate scientific and technological advancements. **Today, a broad spectrum of vaccine platforms exists, enabling protection against a wider range of pathogens and infectious diseases and allowing for more targeted approaches tailored to different population needs.** This diversity supports flexible immunisation strategies that consider factors such as age, underlying health conditions, cultural beliefs, geographic location, and socio-economic status, helping to improve vaccine acceptance and accessibility.

Crucially, **the availability of multiple vaccine technologies boosts global preparedness and response capabilities,** increasing the likelihood of rapid and successful vaccine development in the face of emerging health threats.



## SUBUNIT VACCINES



### PROTEIN VACCINES

Protein vaccines contain fragments of proteins naturally found in the pathogens rather than the entire pathogen. These proteins are recognised by the immune system that produces antibodies and immune cells to attack them<sup>1</sup>.

There are several types of protein vaccines:

- **Purified antigenic proteins:** extracted and purified from the whole pathogen<sup>2</sup>;
- **Recombinant protein vaccines:** produced through genetic engineering in host cells<sup>2</sup>;
- **Protein nanoparticles:** the proteins are delivered through nano-sized carriers<sup>3</sup>.



### TOXOID VACCINES

Toxoids are toxins secreted by bacteria, that have been inactivated using heat and/ or chemicals. These toxoids are no longer pathogenic, by they can induce an immune response in the organism<sup>2</sup>.



### VIRUS-LIKE PARTICLES (VLP)

VLPs are large molecular structures made to resemble real viruses in their size, shape, and surface characteristics. These particles cannot replicate because they lack the viral genome, but they can elicit an immune response in the organism<sup>2,4</sup>.



### POLYSACCHARIDE VACCINES

Polysaccharides are substances that can be found in the protective capsules of several bacteria, aiding their survival during infection. Vaccines against these bacteria use purified capsular polysaccharides from the whole pathogens<sup>2</sup>.



### POLYSACCHARIDE CONJUGATE VACCINES (GLYCOCONJUGATE VACCINES)

Polysaccharide conjugate vaccines combine polysaccharide of certain bacteria with a carrier protein. This combination has been shown to enhance antibody production and immune memory<sup>2</sup>.



### OUTER MEMBRANE VESICLES (OMVs)

OMVs are spherical particles that are naturally released from the outer membrane of Gram-negative bacteria. These vesicles contain various components from the bacteria, such as proteins, lipopolysaccharides and other molecules that can induce a robust immune response<sup>5</sup>.



### GENERALISED MODULES FOR MEMBRANE ANTIGENS (GMMA)

GMMA are outer membrane vesicles (OMVs) produced by genetically modifying the bacteria to increase the yield of vesicle production, reduce toxicity (by altering or removing harmful components like certain lipopolysaccharides), and enhance the expression of specific antigens<sup>5</sup>.



### MULTIPLE ANTIGEN PRESENTING SYSTEMS (MAPS)

MAPS is a vaccine platform designed to present multiple antigens to the immune system simultaneously. This approach allows for the combination of various antigens from one or more pathogens in a single vaccine. By displaying multiple antigens, MAPS aims to generate a stronger and more comprehensive immune response compared to vaccines that target only one antigen<sup>6</sup>.



## LIVE-ATTENUATED VACCINES

Vaccines containing pathogens that have been weakened, altered or selected to be less virulent. In this state, the pathogens mimic a natural infection but do not cause the actual disease or only induce a mild form of it. In general, live-attenuated vaccines are produced from viruses rather than bacteria due to their genetic characteristics<sup>2</sup>.

## WHOLE-INACTIVATED VACCINES

Vaccines produced by inactivating preparations of whole pathogens using heat, radiation or chemicals. The pathogen's capacity to replicate and cause the disease is therefore reduced, but the immune system can still recognise it<sup>2</sup>.



## VIRAL VECTOR

Viral vector vaccines use a modified virus like adenovirus, influenza, or measles to carry genetic material that stimulates an immune response against specific pathogens. These vaccines can mimic natural infections without causing illness<sup>7,8</sup>.

## NUCLEIC ACID



### DNA

DNA vaccines use a small piece of circular DNA to instruct our cells to produce a protein from a pathogen. This protein then triggers the immune system to create a defence against the real pathogen<sup>4</sup>.



### RNA

RNA vaccines utilise a molecule called RNA (ribonucleic acid) to instruct our cells to make a protein that triggers an immune response.

There are 3 types of RNA vaccines:

- conventional mRNA
- self-amplifying mRNA (SAM)
- circular RNA (circRNA)<sup>4</sup>.



## MONOCLONAL ANTIBODIES (MABS) FOR PREVENTATIVE USE

Monoclonal antibodies (mAbs) for prophylactic use work by binding to the surface of a specific pathogen, thereby preventing it from entering human cells and replicating<sup>9,10</sup>.

<sup>1</sup> Council of the European Union. How protein-based vaccines work against COVID-19. [Online]; 2021 [cited April 2026]. Available from: <https://www.consilium.europa.eu/en/infographics/covid-19-protein-based-vaccine/>.

<sup>2</sup> Vetter V, Denizer G, Friedland LR, Krishnan J, Sha. Understanding modern-day vaccines: what you need to know. *Annals of medicine*. 2018; 50(2): 110-20.

<sup>3</sup> Nguyen B, Tolia NH. Protein-based antigen presentation platforms for nanoparticle vaccines. *npj Vaccines*. 2021; 6(1): 70.

<sup>4</sup> Ghattas M, Dwivedi G, Lavertu M, Alameh MG. Vaccine technologies and platforms for infectious diseases: Current progress, challenges, and opportunities.. *Vaccines*. 2021; 9(12): 1490.

<sup>5</sup> Mancini F, Micoli F, Necchi F, Pizzo M, Berlanda S. GMMMA-based vaccines: the known and the unknown. *Frontiers in Immunology*. 2021.

<sup>6</sup> Malley R, Lu YJ, Sebastian S, Zhang F, Willer DO. Multiple antigen presenting system (MAPS): State of the art and potential applications. *Expert Review of Vaccines*. 2024; 23(1): 196-204.

<sup>7</sup> HHS. Vaccine Types. [Online]; 2022 [cited 2025 August]. Available from: <https://www.hhs.gov/immunization/basics/types/index.html>.

<sup>8</sup> Mathew S, Faheem M, Hassain NA, Benslimane FM, Al. Platforms exploited for SARS-CoV-2 vaccine development. *Vaccines*. 2020; 9(1): 11.

<sup>9</sup> Cowan J, Amson A, Christofides A, Chagla Z. Monoclonal antibodies as COVID-19 prophylaxis therapy in immunocompromised patient populations. *Monoclonal antibodies as COVID-19 prophylaxis therapy in immunocompromised patient populations*. 2023.

<sup>10</sup> Stadler E, Burgess MT, Schlub TE, Khan SR, Chai KL. Monoclonal antibody levels and protection from COVID-19. *Nature Communications*. 2023; 14(1): 4545.