Understanding Vaccine Technologies: From Early Methods to mRNA Innovation

CVEEP
Fighting Infectious Respiratory Disease

Vaccines have transformed human health by preventing or reducing the severity of diseases that once claimed millions of lives.[1] The progress from early vaccine developments to today's mRNA technology reflects decades of innovation, collaboration, and scientific advancement.

Over time, scientists have developed different types of vaccines, each suited to work well against specific viruses or for particular populations. For example:

Live Vaccines

Live vaccines mimic natural infections that have been weakened and work well against viruses that require a strong and broad immune response.[2]

Subunit and Toxoid Vaccines

Subunit and toxoid vaccines are safer for people who are immunocompromised because they use only specific pieces of a virus or bacteria – like a protein or inactivated toxin – instead of the whole germ.[3]

mRNA Vaccines

mRNA vaccines offer faster and more flexible antibody production, which make them especially useful for keeping up with viruses that change quickly.[4] Although mRNA vaccines were first widely used during the COVID-19 pandemic, research on the platform began decades earlier. Scientists have been studying mRNA technology in vaccines since the 1990s, with major breakthroughs in stability, delivery methods, and large-scale manufacturing occurring in the 2000s and 2010s.[10] These foundational advancements made it possible to deploy mRNA vaccines rapidly when COVID-19 emerged.

Having multiple vaccine platforms gives scientists and public health systems a wider set of tools to work with, allowing faster, more targeted responses to different kinds of health threats. Each platform has its own strengths and having access to a range of technologies helps ensure we're best prepared for current and future public health challenges.

The chart below shows the main types of vaccines, when they were first introduced, how they work, and examples of diseases they help prevent. Understanding these vaccine platforms helps explain how immunizations have been able to protect people from serious illness for more than a century – and how we can prepare for future threats.

VACCINE TYPE	YEAR INTRODUCED	HOW IT WORKS
Live Attenuated	1884[5]	Uses a weakened (attenuated) version of the virus or bacteria to trigger an immune response without making you sick. This helps your body recognize and fight the real infection in the future. **An example of a live attenuated vaccine we use today is the MMR (Measles, Mumps, and Rubella) vaccine.**
Inactivated	1885[6]	Uses the killed (inactivated) version of the virus or bacterium. Your immune system learns to recognize these germs and protect you from future infection. **An example of an inactivated vaccines we use today is the flu vaccine.**
Toxoid	1920s[7]	Uses a harmless form of a toxin (a harmful substance) made by the germ that causes a disease. This helps your body build targeted protection against the parts of the germ that cause a disease. **An example of a toxoid vaccine we use today is the tetanus vaccine.**
Viral Vector	1970s[8]	Uses a modified version of a different virus to carry genetic instructions that teach your cells to make a piece of the virus, so your immune system can learn to defend against it. This technology is not currently used for any routinely recommended vaccines in the U.S.
Subunit / Recombinant / Conjugate	1980s[9]	Uses only specific pieces of the germ, like proteins or sugars, instead of the whole virus or bacteria. These pieces are enough to help your immune system recognize and respond to the threat safely. **Examples of conjugate vaccines we use today include shingles, pneumococcal, pertussis (whooping cough), and RSV vaccines.**
mRNA	2020[10]	Provides your cells with genetic instructions to make a small, harmless part of the virus. This part teaches your immune system how to fight the real virus if it ever enters your body. **Two of the three COVID-19 vaccines (Pfizer-BioNTech and Moderna) available in the U.S. use an mRNA platform.**

The Benefits of mRNA Vaccines

- **Speed & Flexibility:** mRNA vaccines can be developed, updated, and produced rapidly, allowing swift responses to emerging outbreaks.[11]
- **Proven Science:** Just like other vaccine types, mRNA technology is backed by decades of research, providing a strong foundation for its safety and effectiveness across a range of diseases.[12]
- **Platform for the Future:** mRNA is more than just a tool for fighting infections. It's a flexible platform with wide-ranging potential, including treating conditions like cancer.

1 https://pmc.ncbi.nlm.nih.gov/articles/PMC7371956/
2 https://www.immunize.org/vaccines/vaccine-timeline/
3 https://pmc.ncbi.nlm.nih.gov/articles/PMC4494222/
4 https://www.britannica.com/science/mRNA-vaccine
5 https://www.immunize.org/vaccines/vaccine-timeline/
6 https://www.passporthealthusa.com/2024/06/the-history-of-the-cholera-vaccine/
7 https://historyofvaccines.org/history/vaccine-timeline/overview
8 https://pmc.ncbi.nlm.nih.gov/articles/PMC4494222/
9 https://pmc.ncbi.nlm.nih.gov/articles/PMC4494222/
10 https://www.britannica.com/science/mRNA-vaccine
11 https://www.britannica.com/science/mRNA-vaccine
12 https://pmc.ncbi.nlm.nih.gov/articles/PMC8502079/