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What is a vaccine?[1]

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Why are vaccines used?

The purpose of a vaccine is to expose an individual to a weakened pathogen, or part of a pathogen, to train the immune system to protect that individual from serious illnesses caused by infection from that virus or bacteria. Inoculation has been used for centuries in prevention of infectious diseases such as smallpox. A vaccine works by teaching the immune system to recognize and produce a response against the harmful microorganism so that disease is significantly reduced or does not develop at all. The major advantage is that the immune system receives training without the individual becoming sick or exposed to the active pathogen.

Most vaccines are given before an individual has been exposed to the harmful organism so protective immunity can develop. These vaccines are called prophylactic or preventative vaccines; the vast majority of vaccines fall into this category. There are also therapeutic vaccines, which are given to patients at the time of illness to enhance the immune system's response.

When discussing vaccines, there are a few important terms to know.

- **Antigen:** The part of the microorganism (specifically recognized by the body) that triggers the development of a protective immune response.
- **Antibody:** The defense protein (made by the body) that recognizes the antigen and triggers killing of the harmful microbe.
- **Adjuvants:** Substances that activate the immune system and are added to vaccines to enhance the immune response to the antigen.

Sometimes, protective immunity lasts for a person's entire life, but in other cases, immunity diminishes over time. In the latter case, a **vaccine booster** is given. This **booster dose** exposes the immune system to the antigen an additional time to increase immunity to protective levels again.

Vaccines are given before a person has been exposed to the harmful microorganism. This is part of the reason that vaccinations are given to children. Vaccines are also given at different stages of childhood development (often referred to as a vaccination schedule) to produce optimal protective immunity. This is why some vaccines are given to babies, while others are given to children and teens and some are given only to adults. Vaccines are one of the most effective tools in preventative health care. They protect millions of people from preventable diseases each year and are estimated to save $70 billion in societal costs in the US alone. For these reasons, some vaccines (such as those against measles) are required for children to attend school. Others are highly recommended, but not required, such as the annual flu vaccine. Table 1 describes the six types of vaccines currently available.

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Table 1. Common types and features of vaccines.

Type	Description	Other Characteristics	Examples
Inactivated/Killed	Made by inactivating the whole pathogen by heat or chemicals (e.g., formaldehyde).	Easy to generate New formulations are easily made Safe because there is no risk of the dead microbe causing infection	Polio Hepatitis A Rabies
Toxoid	A toxin is inactivated by heat or chemical (e.g., formalin) and used to stimulate the immune response.	Often require booster immunizations to maintain the protective immune response	Tetanus Diphtheria
Subunit	Made by isolating a specific component of a pathogen that can generate a protective immune response and only administering that component rather than the entire microbe.	Commonly mixed with an adjuvant to help increase the immune response	Hepatitis B HPV Pertussis Flu shot (not FluMist)
Conjugate	Mostly carbohydrate-based and designed to elicit an immune response against microbes with thick carbohydrate coats. Conjugated with a protein carrier/antigen.	Some individuals (often infants) do not generate strong immune responses Often bound to a toxoid protein to enhance the immune response	*Haemophilus influenzae* Pneumococcal Meningococcal
Live/Attenuated	Contains live microorganisms that have a decreased ability to replicate and cause disease, but do produce an immune response.	If a person has a compromised immune system, the attenuated microbes may cause disease	MMR Chickenpox Rotavirus FluMist
DNA/mRNA	Genetic material that encodes part of the virus (e.g., spike protein gene of SARS-CoV-2) is introduced to the body via small particles or viral vectors. The body's cells then use the genetic material to produce antigens that produce an immune response.	Produce broad immune response Easy to produce and manufacture Stable	SARS-CoV-2 (Pfizer-BioNTech) SARS-CoV-2 (Moderna)