

## Vaccine functions and types

When bacteria, viruses, or other pathogens enter our body and then reproduce in us, we refer to this as an infection. Many infections run their course unnoticed because they do not make us sick. However, if an infection causes illness, we call this an infectious disease. Vaccines are used to vaccinate people and animals to protect them from infectious diseases preventively, especially from those diseases that are very dangerous or particularly contagious. Vaccines simulate an infection, but they do not trigger the disease. The immune system is activated. The body produces antibodies and memory cells, which can respond quickly if the body subsequently encounters the actual pathogen. Now the body can defend itself against the pathogen. It is immune to the pathogen. For this reason, we also refer to vaccination as immunization.

### Passive and active vaccination

In passive vaccination, antibodies to the pathogen are injected. Protection is immediate, but it does not last long. Because the immune system is not activated, the body does not produce antibodies and memory cells and it does not become immune to the pathogen. Passive vaccination is therefore not immunization. This method is used when a person or animal has already become infected but does not have sufficient immune protection – thus when it is too late for immunization.

In active vaccination, the immune system is stimulated by the vaccine to produce antibodies and memory cells. The body builds its own immune protection. There are various methods and vaccines for active vaccination.

### Vaccine types and their mode of action

#### Live-attenuated vaccines

Live-attenuated vaccines contain live pathogens capable of reproducing, but they have been changed (weakened) so that they do not cause disease. In rare cases, live-attenuated vaccines may lead to a vaccine-induced disease. The person develops symptoms similar to becoming sick with the actual pathogen, but normally only very mildly. Vaccine-induced diseases are not contagious.

Because the live-attenuated vaccines are very similar to the actual pathogen, they trigger a similarly strong immune response. The body must deal very intensively with the pathogen. For this reason, live-attenuated vaccines are the only vaccines that can provide live-long immunity.

- Examples: vaccines for measles, mumps, rubella, and chicken pox

#### Inactivated vaccines

Inactivated vaccines contain killed pathogens or only parts thereof. They can no longer reproduce and therefore also cannot cause an infection and make the person sick. The immune response is not as strong as with live-attenuated vaccines, and immunity is not life-long.

- Examples: vaccines for polio, whooping cough, meningococcus, rabies, and tetanus

#### mRNA vaccines

As the name indicates, mRNA vaccines consist of mRNA (messenger ribonucleic acid). The nucleus of each cell contains the blueprint for each of its proteins: the DNA (deoxyribonucleic acid). For a protein to be produced, a copy of its blueprint must be moved from the cell nucleus to the

cytoplasm (that is, into the part of the cell surrounding the cell nucleus), where protein production takes place. This DNA copy is the mRNA – the “m” stands for messenger. The mRNA leaves the cell nucleus and carries the blueprint for “cell machinery” to the cytoplasm, which then translates the mRNA blueprint into the protein.

An mRNA vaccine consists of artificially produced mRNA that contains the blueprint for a harmless viral protein, meaning it doesn't cause disease. This mRNA is packed in a layer of lipids (fat) and enters the body cells after vaccination. The body cells then produce the viral protein – thus a part of the pathogen – themselves. Since the viral protein is foreign to the host cells, these cells bind the protein to their surface and transport it to the T cells in the lymph nodes. The adaptive immune response is triggered. Antibodies and memory cells are produced.

After a while, the viral mRNA is broken down. No further viral protein is produced, and the immune reaction is stopped.

- Examples: So far, mRNA vaccines have been developed only for the SARS-CoV-2 coronavirus.

### **Viral vector vaccines**

Viral vector vaccines work in a similar way to mRNA vaccines. They also contain the blueprint for a viral protein. For viral vector vaccines, however, this blueprint consists of artificially produced DNA that is packed in harmless viruses. Referred to as vectors, these viruses transport the DNA into the nuclei of the body's cells. Once there, the DNA must first be copied. The copy (mRNA) is translated into the protein in the cytoplasm. The protein is likewise bound to the surfaces of the body cells and transported to the lymph nodes; the immune reaction is activated.

- Examples: vaccines for Ebola, dengue fever, and SARS-CoV-2

### **Booster vaccinations and primary immunization**

Generally, a single vaccination is insufficient to build up stable, long-lasting immunity. Therefore, it is necessary to repeat the vaccination. When vaccination is repeated two or three times at roughly four-week intervals, it is called primary immunization. Starting from the second vaccination, the immune response and immunity improve more and more. The number of memory cells increases. The antibodies learn to recognize the pathogen even faster and better, and more and more antibodies are produced.

After a person has received primary immunization, booster vaccinations are necessary at longer intervals (of up to ten years, depending on the infectious disease) to preserve immunity.