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Types of Vaccines

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Vaccine

- A preparation that is used to stimulate the body's immune response against diseases. Vaccines are usually administered through needle injections, but some can be administered by mouth or sprayed into the nose.

Historical Note

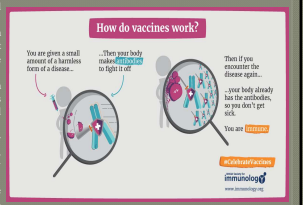
- Two scientists who discovered key functions of the immune system, Louis Pasteur (image at R) and Robert Koch, should have been able to see their work as complementary, but they wound up rivals.
- Pasteur, (born December 27, 1822, Dole, France - died September 28, 1895, Saint-Cloud), French chemist and microbiologist who was one of the most important founders of medical microbiology.
- Koch, (born Dec. 11, 1843 - died May 27, 1910, Baden-Baden, Ger.), German physician and one of the founders of bacteriology. He discovered the anthrax disease cycle (1876) and the bacteria responsible for tuberculosis (1882) and cholera (1883).
- Both helped establish the germ theory of disease.

TYPES OF IMMUNIZATION

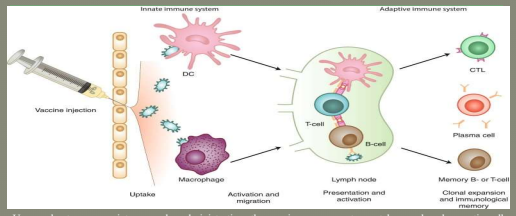
- Immunization can be derived from either passive or active means. These means can be from either natural or artificial sources. Natural sources are due to exposure to the environment, humans, and animals. In contrast, artificial sources are due to medical interventions.
- Passive immunization occurs with the transfer to preformed antibodies to an unimmunized individual. This individual would then develop a temporary immunity to a particular organism or toxin due to the presence of these preformed antibodies. Once these preformed antibodies have been destroyed, the individual would no longer have immunity to this microorganism or toxin.
- Passive immunization can occur either naturally or artificially. Excellent examples of natural passive immunization are the passage of maternal antibodies through the placenta to the fetus and the passage of these maternal antibodies to the infant through the colostrum and milk.
- Excellent examples of artificial passive immunization include the administration of pooled human immune gamma globulin and antivenin. These gamma globulins and antivenins provide temporary immunity to either a particular illness or venom. Concurrent with these effects of this temporary immunity from the preformed antibodies, the individual's own body is likely to be in the early stages of developing its own active immune response.
- Active immunization occurs with the exposure of an unimmunized individual to a pathogenic agent. The immune system of this individual then begins the process of developing immunity to this agent. In contrast to passive immunization, active immunization typically produces long-term immunity due to the stimulation of the individual's immune system. The process of stimulating the immune system against a pathogenic agent will be further discussed in this article.
- Active immunization can occur either naturally or artificially. An excellent example of natural active immunization is exposure to influenza. The body then begins the process of developing long-term immunity to the influenza virus.
- Excellent examples of artificial active immunization include the different types of immunizations that will be discussed in this article. These immunizations mimic the stimulation necessary for immune development yet do not produce active disease

How Vaccines Work

- Vaccines prevent diseases that can be dangerous, or even deadly. Vaccines greatly reduce the risk of infection by working with the body's natural defenses to safely develop immunity to disease.
- Vaccines help develop immunity by imitating an infection. This type of infection, however, almost never causes illness, but it does cause the immune system to produce T-lymphocytes and antibodies.
- Sometimes, after getting a vaccine, the imitation infection can cause minor symptoms, such as fever. Such minor symptoms are normal and should be expected as the body builds immunity.
- Once the imitation infection goes away, the body is left with a supply of "memory" T-lymphocytes, as well as B-lymphocytes that will remember how to fight that disease in the future.
- However, it typically takes a few weeks for the body to produce T-lymphocytes and B-lymphocytes after vaccination. Therefore, it is possible that a person infected with a disease just before or just after vaccination could develop symptoms and get a disease, because the vaccine has not had enough time to provide protection.



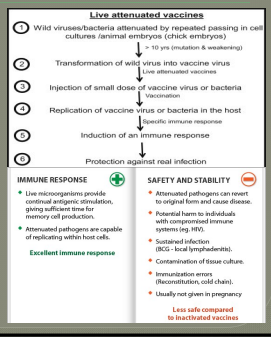
Overview of the steps leading to immunity after administration of a vaccine.



Upon subcutaneous or intramuscular administration, the vaccine components are taken up by phagocytic cells such as macrophages and dendritic cells (DCs) that reside in the peripheral tissue and express pattern recognition receptors (PRRs) that recognize pathogen-associated molecular patterns (PAMPs). Professional antigen-presenting cells (APCs) that have taken up antigens become activated and start migrating towards nearby lymph nodes. Inside the lymph nodes, the antigen processed by the APCs is presented to lymphocytes, which, when recognizing the antigen and receiving the appropriate co-stimulatory signals, become activated. These antigen-specific B- and T-cells clonally expand to produce multiple progenitors recognizing the same antigen. In addition, memory B- and T-cells are formed that provide long-term (sometimes lifelong) protection against infection with the pathogen.

Live Attenuated Vaccines (LAVs)

- **Live attenuated vaccines** fight viruses and bacteria. These vaccines contain a version of the living virus or bacteria that has been weakened so that it does not cause serious disease in people with healthy immune systems.
- Because live, attenuated vaccines are the closest thing to a natural infection, they are good teachers for the immune system.
- Examples of live, attenuated vaccines include measles, mumps, and rubella vaccine (MMR) and varicella (chickenpox) vaccine. Even though they are very effective, not everyone can receive these vaccines.
- Children with weakened immune systems—for example, those who are undergoing chemotherapy—cannot get live vaccines.

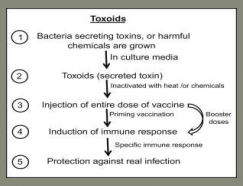


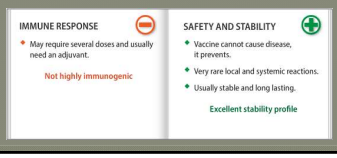
Inactivated Vaccines

- These vaccines are made by inactivating, or killing, the germ during the process of making the vaccine. The inactivated polio vaccine is an example of this type of vaccine.
- Inactivated vaccines produce immune responses in different ways than live, attenuated vaccines.
- Often, multiple doses are necessary to build up and/or maintain immunity.

Toxoid vaccines

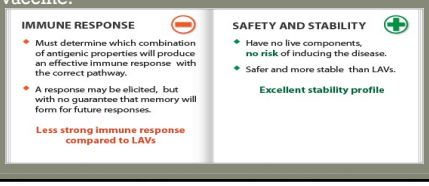
- **Toxoid vaccines** prevent diseases caused by bacteria that produce toxins (poisons) in the body. In the process of making these vaccines, the toxins are weakened so they cannot cause illness. Weakened toxins are called toxoids. When the immune system receives a vaccine containing a toxoid, it learns how to fight off the natural toxin. The DTaP vaccine contains diphtheria and tetanus toxoids.





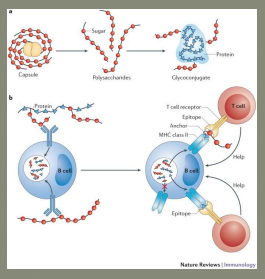
Subunit vaccines

- These include only parts of the virus or bacteria, or subunits, instead of the entire germ. Because these vaccines contain only the essential antigens and not all the other molecules that make up the germ, side effects are less common. The pertussis (whooping cough) component of the DTaP vaccine is an example of a subunit vaccine.



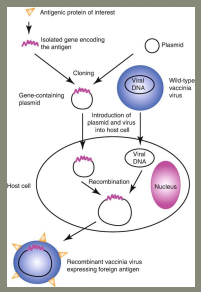
Conjugate vaccines

- Target bacteria have antigens with an outer coating of sugar-like substances called polysaccharides. This type of coating disguises the antigen, making it hard for a young child's immature immune system to recognize it and respond to it. Conjugate vaccines are effective for these types of bacteria because they connect (or conjugate) the polysaccharides to antigens that the immune system responds to very well. This linkage helps the immature immune system react to the coating and develop an immune response. An example of this type of vaccine is the *Haemophilus influenzae* type B (Hib) vaccine.

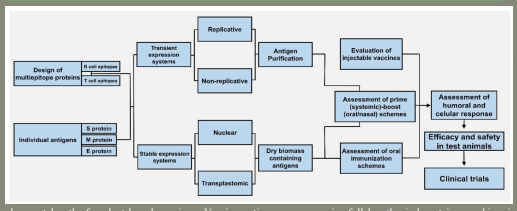


Recombinant Vaccines

- Recombinant vaccines are made using bacterial or yeast cells to manufacture the vaccine.
- A small piece of DNA is taken from the virus or bacterium against which we want to protect and inserted into the manufacturing cells.
- For example, to make the hepatitis B vaccine, part of the DNA from the hepatitis B virus is inserted into the DNA of yeast cells.
- These yeast cells are then able to produce one of the surface proteins from the hepatitis B virus, and this is purified and used as the active ingredient in the vaccine.

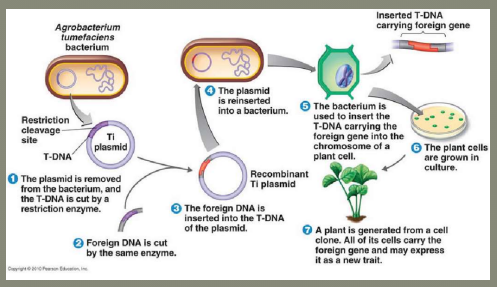


Plant Based Vaccines



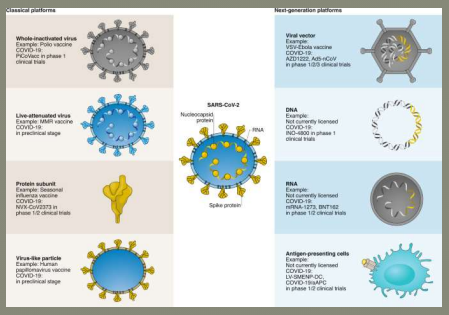
Developmental paths for plant-based vaccines- Vaccine antigens can comprise full length viral proteins or chimeric proteins rationally designed to serve as multiepitopic vaccines. This is based on the selection of T cell and B cell epitopes with the aid of immune bioinformatics tools and experimental data of their protective capacity. Current genetic engineering technologies allow expressing target antigens either stably or transiently, which allow exploring distinct immunization approaches. Transient expression typically requires purification of the antigen—which is useful for the formulation of injectable vaccines—whereas stable transformation, especially in edible crops, allows implementing oral immunization schemes without purification. Combined schemes, using pure antigens for priming by parenteral administration and plant biomass containing the antigen for oral boosting, are likely ideal approaches capable of inducing long-term protection in several compartments, especially in mucous membranes.

Plant Based Vaccines (Example)



Stable plastid transformation using Agro-bacterium.

An overview of the different vaccine platforms in development



References and Further Readings

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- *@inproceedings{Girma2019VaccinePl, title={Vaccine Production in Transgenic Plants for Animal and Human Diseases}, author={Birtukan Girma and Dereje Shegu and Ayelech Muluneh and Fanos Tadesse Woldemariyam}, year={2019}}*