- **A vaccine** is a medical preparation given to provide immunity from a disease.
- Vaccines use a variety of different substances ranging from dead microorganisms to genetically engineered antigens to defend the body against potentially harmful microorganisms.
- Effective vaccines change the immune system by promoting the development of antibodies that can quickly and effectively attack disease-causing microorganisms when it enters the body, preventing disease development.
- A vaccine may contain live-attenuated or killed microorganisms or parts or products from them capable of stimulating a specific immune response comprised of protective antibodies and T cell immunity.
- A vaccine should stimulate a sufficient number of memory T and B lymphocytes to yield effector T cells and antibody-producing B cells from memory cells.
- The viral vaccines should also be able to stimulate high titers of neutralizing antibodies.
- Injection of a vaccine into a nonimmune subject induces active immunity against the modified pathogens.
- **Vaccination** is immunization against infectious disease through the administration of vaccines for the production of active (protective) immunity in humans or other animals.

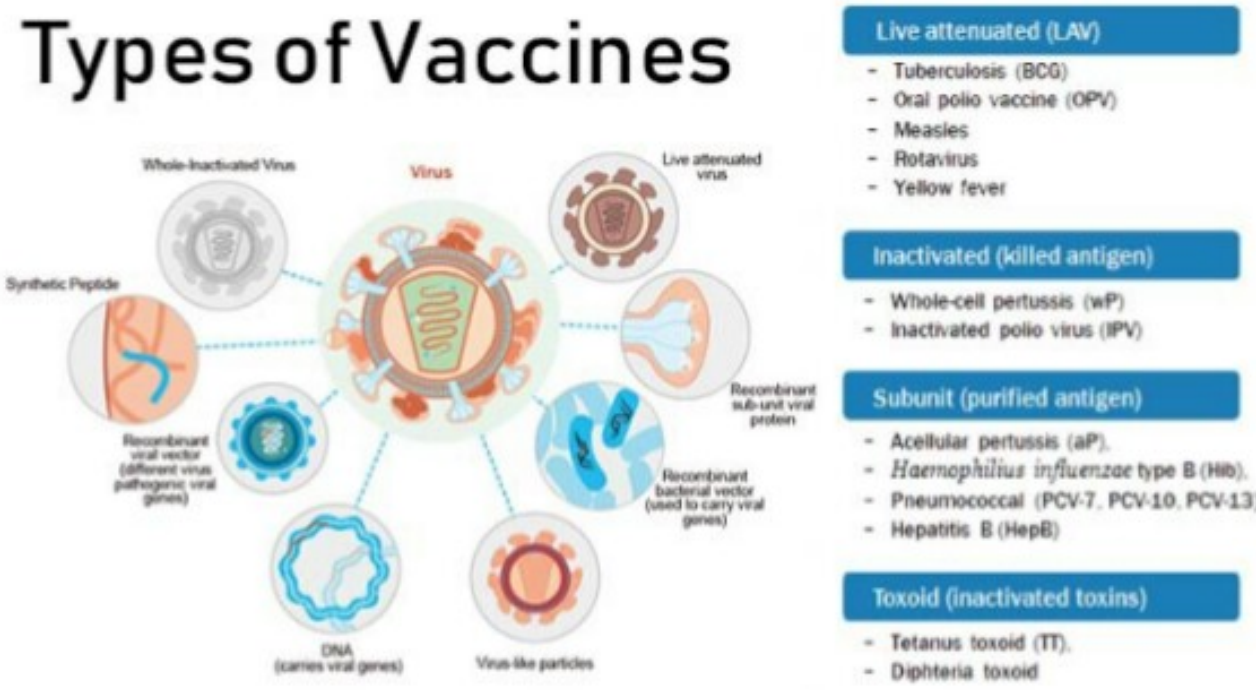

Figure: Types of Vaccines. Image Source: GenScript

There are 4 main types of vaccines:

1. Live Attenuated vaccines (LAV)
2. Inactivated vaccines (Killed Antigen)
3. Subunit and Conjugate Vaccines (Purified Antigen)
4. Toxoid vaccines (Inactivated Toxins)

A. Live Attenuated Vaccines

- In some cases, microorganisms can be attenuated or disabled so that they lose their ability to cause significant disease (pathogenicity) but retain their capacity for transient growth within an inoculated host.
- Some agents are naturally attenuated by virtue of their inability to cause disease in a given host, although they can immunize these individuals.
- The first vaccine used by Jenner is of this type: vaccinia virus (cowpox) inoculation of humans confers immunity to smallpox but does not cause smallpox.
- Attenuation can often be achieved by growing a pathogenic bacterium or virus for prolonged periods under abnormal culture conditions.
- This selects mutants that are better suited for growth in the abnormal culture conditions than in the natural host.
- For example, an attenuated strain of *Mycobacterium bovis* called **Bacillus Calmette-Guerin (BCG) Vaccine** was developed by growing *M. bovis* on a medium containing increasing concentrations of bile.
- After 13 years, this strain had adapted to growth in strong bile and had become sufficiently attenuated that it was suitable as a vaccine for tuberculosis.
- Due to variable effectiveness and difficulties in follow-up monitoring, BCG is not used in the United States.
- The Sabin form of the polio vaccine and the measles vaccine both consist of attenuated viral strains.

Examples:

- Vaccinia (smallpox)
- Measles, mumps, rubella (MMR combined vaccine)
- Varicella (chickenpox)
- Influenza (nasal spray)
- Rotavirus
- Zoster (shingles)
- Yellow fever

B. Inactivated vaccines (Killed Antigen)

- Another common means to make a pathogen safe for use in a vaccine is by treatment with heat or chemicals.
- This kills the pathogen, making it incapable of replication, but still allows it to induce an immune response to at least some of the antigens contained within the organism.
- It is critically important to maintain the structure of epitopes on surface antigens during inactivation.
- Heat inactivation is often unsatisfactory because it causes extensive denaturation of proteins; thus, any epitopes that depend on higher orders of protein structure are likely to be altered significantly.
- Chemical inactivation with formaldehyde or various alkylating agents has been successful.
- **The Salk polio vaccine** is produced by formaldehyde inactivation of the poliovirus.

Examples:

- Polio (IPV)

- Hepatitis A
- Rabies

C. Subunit and Conjugate Vaccines (Purified Antigen)

- These subunit vaccines are composed of antigens purified from microbes which are usually administered with an adjuvant.
- Vaccines composed of bacterial polysaccharide antigens are used against pneumococcus and *Haemophilus influenzae*.
- Because polysaccharides are T-independent antigens, they tend to elicit low-affinity antibody responses and are poorly immunogenic in infants (who do not mount strong T cell-independent antibody responses).
- High affinity antibody responses may be generated against polysaccharide antigens even in infants by coupling the polysaccharides to proteins to form conjugate vaccines.
- These vaccines elicit helper T cells to simulate germinal center reactions, which would not occur with simple polysaccharide vaccines.
- Such vaccines work like hapten-carrier conjugates and are a practical application of the principle of T-B cell cooperation.

Examples:

- Hepatitis B
- Influenza (injection)
- Haemophilus influenzae type b (Hib)
- Pertussis (part of DTaP combined immunization)
- Pneumococcal
- Meningococcal
- Human papillomavirus (HPV)

D. Toxoid vaccines (Inactivated Toxins)

- Toxoid vaccines use a toxin (harmful product) made by the germ that causes a disease.
- They create immunity to the parts of the germ that cause a disease instead of the germ itself.
- That means the immune response is targeted to the toxin instead of the whole germ.
- Like some other types of vaccines, you may need booster shots to get ongoing protection against diseases.

Examples:

- Diphtheria, tetanus (part of DTaP combined immunization)