Vaccines can be classified based on their composition, method of preparation, and purpose. Below are the main classifications:

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1. Based on Composition:

a. Live-Attenuated Vaccines

- Contain weakened versions of the virus or bacteria.
- Elicit a strong and lasting immune response.
- Examples: Measles, Mumps, and Rubella (MMR), Varicella (chickenpox), Oral Polio Vaccine (OPV).

b. Inactivated Vaccines

- Contain killed or inactivated pathogens.
- Require multiple doses to maintain immunity.
- Examples: Inactivated Polio Vaccine (IPV), Hepatitis A vaccine.

c. Subunit, Recombinant, Polysaccharide, and Conjugate Vaccines

- Contain specific pieces (antigens) of the pathogen, like proteins or sugar.
- Safer for people with weakened immune systems.
- Examples: Hepatitis B, Human Papillomavirus (HPV), Pneumococcal vaccine.

d. Toxoid Vaccines

- Use inactivated toxins (toxoids) produced by bacteria.
- Target toxins rather than the bacteria itself.
- Examples: Diphtheria, Tetanus.

e. mRNA Vaccines

- Use messenger RNA to instruct cells to produce a harmless protein from the pathogen.
- Induces an immune response.
- Examples: COVID-19 vaccines (Pfizer-BioNTech, Moderna).

f. Viral Vector Vaccines

- Use a harmless virus (vector) to deliver genetic material from the pathogen.
- Stimulate immunity without causing disease.
- Examples: COVID-19 vaccines (AstraZeneca, Johnson & Johnson).

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2. Based on Purpose:

a. Prophylactic Vaccines

- Prevent diseases before exposure to the pathogen.
- Examples: Polio, Influenza, HPV vaccines.

b. Therapeutic Vaccines

- Treat existing diseases or conditions.
- Examples: Cancer vaccines (e.g., Sipuleucel-T for prostate cancer).

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3. Based on Targeted Disease:

- **Viral vaccines:** Protect against viral infections (e.g., Influenza, Hepatitis B).
- **Bacterial vaccines:** Protect against bacterial infections (e.g., Tuberculosis, Pneumococcus).

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4. Based on Development Technique:

a. First-generation Vaccines

- Include live-attenuated and inactivated vaccines.

b. Second-generation Vaccines

- Include subunit and toxoid vaccines.

c. Third-generation Vaccines

- Include mRNA and DNA vaccines.

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5. Based on Route of Administration:

- **Oral vaccines** (e.g., Oral Polio Vaccine).
- **Injectable vaccines** (e.g., COVID-19 vaccines).
- **Intranasal vaccines** (e.g., FluMist).

This classification helps in understanding the diverse approaches in vaccine development and their suitability for different populations.

Acellular Vaccines

Acellular vaccines do not contain entire cells of bacteria or viruses. Instead, they include only specific components, such as proteins or polysaccharides, that trigger an immune response. These vaccines can be classified into the following types:

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1. Subunit Vaccines

- Contain purified proteins or antigens from the pathogen's surface, such as viral or bacterial proteins.
- Stimulate a targeted immune response by focusing on the most immunogenic components.
- Safer for immunocompromised individuals as they do not contain live pathogens.

- May require adjuvants to enhance the immune response.
- Examples: Hepatitis B vaccine, Human Papillomavirus (HPV) vaccine.

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2. Recombinant Vaccines

- Produced using genetic engineering techniques to manufacture specific proteins from the pathogen.
- Highly precise, eliminating unnecessary or harmful components of the pathogen.
- Do not require growing the actual virus or bacteria, reducing production risks.
- Can be designed for large-scale production using yeast, bacteria, or mammalian cells.
- Examples: Hepatitis B vaccine, Recombinant Influenza vaccine.

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3. Polysaccharide Vaccines

- Contain polysaccharides (sugar molecules) from the outer coating of bacteria.
- Elicit a T-cell independent immune response, which can be less effective in young children.
- Provide immunity against bacteria with polysaccharide capsules.
- Do not always induce long-term immunity or immunological memory.
- Examples: Pneumococcal vaccine (PPSV23), Meningococcal vaccine.

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4. Conjugate Vaccines

- Combine polysaccharides with a protein carrier to improve immunogenicity.
- Induce a strong T-cell dependent immune response, effective even in young children.
- Provide long-lasting immunity and immunological memory.
- Effective against bacteria with polysaccharide capsules, reducing infection rates significantly.
- Examples: Haemophilus influenzae type b (Hib) vaccine, Pneumococcal Conjugate Vaccine (PCV), Meningococcal Conjugate Vaccine.

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5. Toxoid-Based Acellular Vaccines

- Contain inactivated bacterial toxins (toxoids) that trigger immunity against toxin-mediated diseases.
- Focus on neutralizing the toxin rather than the bacterial pathogen itself.
- Safe and stable, with minimal risk of causing disease.
- Often require booster doses for sustained immunity.
- Examples: Tetanus toxoid vaccine, Diphtheria toxoid vaccine.

Summary

- Acellular vaccines are a safer alternative to whole-cell vaccines.

- Subtypes like subunit, recombinant, polysaccharide, conjugate, and toxoid-based vaccines focus on specific components, enhancing safety and effectiveness.
- Their selection depends on the pathogen and the targeted immune response required for protection.

2. Based on Purpose:

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a. Prophylactic Vaccines

Prophylactic vaccines are designed to prevent diseases before exposure to the pathogen, thereby providing immunity against specific infections. These vaccines are the most commonly used and are given to healthy individuals to protect them from acquiring infectious diseases. Prophylactic vaccines can provide long-lasting protection and often require booster doses to maintain immunity. They work by training the immune system to recognize and respond to pathogens such as viruses and bacteria, without causing illness. These vaccines are generally administered in childhood or during vaccination campaigns, but can also be given to adults depending on the disease.

- **Stimulate long-lasting immunity** through the production of antibodies and memory cells.
- **Examples**:
  - **Polio Vaccine**: Prevents poliovirus infection, which can lead to paralysis.
  - **Influenza Vaccine**: Provides protection against seasonal flu strains and helps reduce the severity of illness.
  - **HPV Vaccine**: Protects against the human papillomavirus, which is linked to cervical and other cancers.
  - **Measles, Mumps, Rubella (MMR) Vaccine**: Provides protection against three viral infections with long-term immunity.

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b. Therapeutic Vaccines

Therapeutic vaccines are intended to treat existing diseases or conditions, rather than prevent them. These vaccines work by stimulating the immune system to fight off the disease once it has developed. Unlike prophylactic vaccines, therapeutic vaccines aim to enhance or trigger an immune response against an already established infection or condition, such as cancer or chronic infections. They can be used alongside other treatments to improve outcomes, such as in cancer immunotherapy. Therapeutic vaccines are still being studied and developed, but some have already shown promise in clinical use.

- **Target specific disease cells** (such as cancer cells) to enhance the immune system's ability to identify and destroy them.
- **Not designed for prevention** but for treating an ongoing disease or condition.
- **Examples**:
  - **Sipuleucel-T** (Provenge): A cancer vaccine for prostate cancer that stimulates the immune system to target and fight prostate cancer cells.
  - **Therapeutic cancer vaccines**: These vaccines are designed to treat cancers such as melanoma or breast cancer by enhancing the body's immune response against tumor cells.

- **Therapeutic vaccines for chronic infections** (e.g., HIV or hepatitis B): Work to strengthen the immune response against ongoing viral infections.

In summary, **prophylactic vaccines** prevent infections before exposure, while **therapeutic vaccines** aim to treat or manage existing diseases, often by enhancing the body's immune system to target specific disease-causing agents. Both types play critical roles in modern medicine and disease control, but they differ significantly in their purpose and application.

On The Basis Of Development

1st, 2nd and 3rd Generation Vaccines
Vaccines are one of the most important medical interventions for the prevention of infectious diseases. Over the years, vaccines have evolved from first-generation to second-generation and now to third-generation vaccines. Each generation of vaccines has its unique features, advantages, and limitations.
1st Generation Vaccines
First-generation vaccines were developed in the late 18th and early 19th centuries.
They were based on live, attenuated or killed pathogens that were used to stimulate the immune system.
Examples of first-generation vaccines include the smallpox vaccine, the rabies vaccine, and the polio vaccine.
These vaccines were effective in controlling the spread of infectious diseases, but they had some limitations.
Live vaccines could cause severe side effects in some individuals, and killed vaccines did not provide long-lasting immunity.
2nd Generation Vaccines
Second-generation vaccines were developed in the 20th century.
They were based on purified subunits of the pathogens or recombinant proteins that could stimulate the immune system. Examples of second-generation vaccines include the hepatitis B vaccine, the HPV vaccine, and the meningococcal vaccine. These vaccines were safer and more effective than first-generation vaccines. They could provide long-lasting immunity and had fewer side effects. However, they required more sophisticated manufacturing processes and were more expensive to produce. 3rd Generation Vaccines Third-generation vaccines are still under development. They are based on new technologies that allow for the production of vaccines that are more effective and safer than previous generations. Examples of third-generation vaccines include mRNA vaccines and DNA vaccines. These vaccines use genetic material to stimulate the immune system, rather than using whole pathogens or their subunits. They have the potential to provide long-lasting immunity with fewer side effects. However, these vaccines are still in the early stages of development, and more research is needed to determine their safety and efficacy.

Read more at: https://edurev.in/question/419281/What-are-1st-2nd-and-3rd-generation-vaccines-

Refrence Link:
https://www.indiascienceandtechnology.gov.in/covid-19-vaccine/types-vaccine