

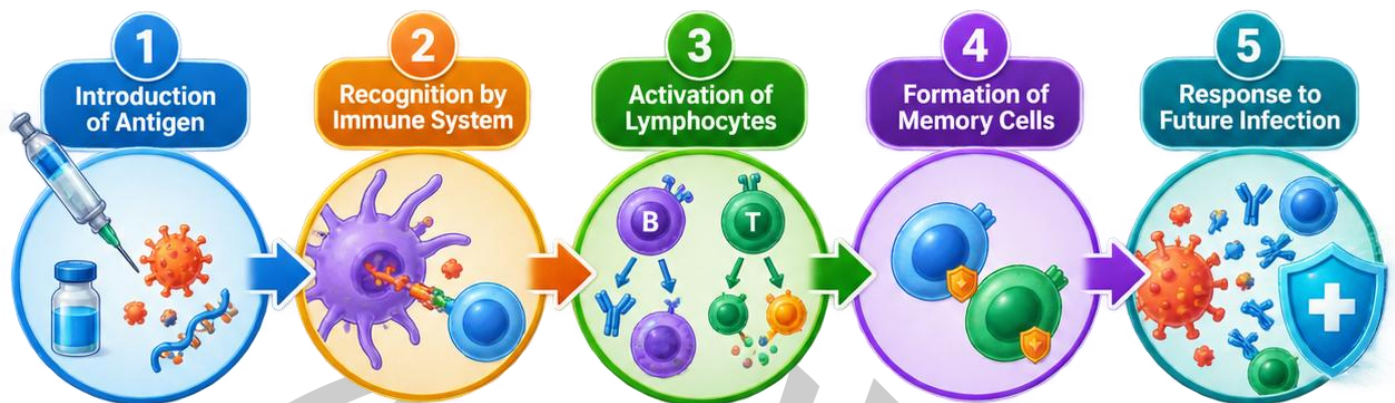
Vaccine Technology

Vaccines and Their Types

Definition of Vaccines

- Vaccines are **biological preparations** that provide immunity against specific diseases.
- They contain antigens (weakened, killed, or parts of pathogens) that stimulate the immune system without causing disease.

Basic Principle of Vaccination



1. Introduction of Antigen

- A vaccine introduces a safe form of an antigen, or information for producing that antigen, into the body.

2. Recognition by the Immune System

- Antigen-presenting cells recognize and process the antigen.
- The antigen is presented to appropriate lymphocytes.

3. Activation of Lymphocytes

- Specific B lymphocytes and T lymphocytes become activated.
- B cells can differentiate into plasma cells that produce antibodies.
- T cells can provide helper functions or develop other appropriate immune activities.

4. Formation of Memory Cells

- Some activated B cells and T cells develop into memory cells.
- These cells can remain in the body for a long period.

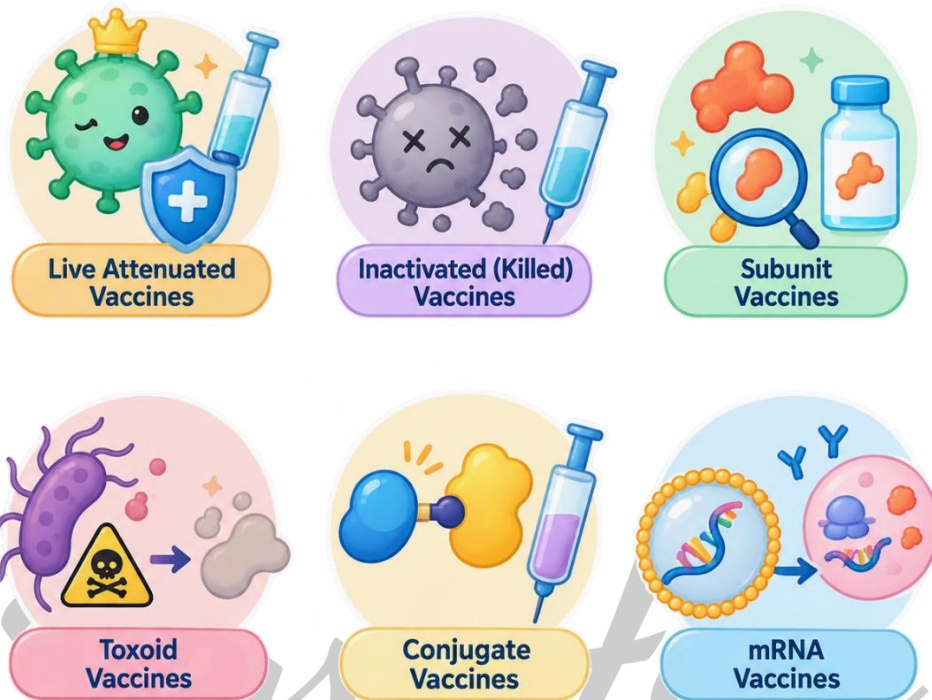
5. Response to Future Infection

- When the actual infectious agent enters the body later, memory cells recognize its antigens.
- The immune system can then produce a faster and stronger response.

Purpose of Vaccination

- To induce **protective immunity**
- To generate **immunological memory**
- To prevent infectious diseases

Types of Vaccines



1. Live Attenuated Vaccines

- Contain weakened (attenuated) forms of pathogens
- Can replicate in the host but do not cause disease in healthy individuals
- Produce strong and long-lasting immunity
- **Examples:**
 - Measles, Mumps, Rubella (MMR)
 - BCG vaccine

2. Inactivated (Killed) Vaccines

- Contain killed pathogens
- Cannot replicate
- Safer but produce weaker immune response
- **Examples:**
 - Polio (IPV)
 - Rabies vaccine

3. Subunit Vaccines

- Contain only specific parts of the pathogen (antigens)
- Reduce side effects
- **Examples:**
 - Hepatitis B vaccine
 - HPV vaccine

4. Toxoid Vaccines

- Contain inactivated toxins produced by bacteria
- Provide immunity against toxin effects
- **Examples:**
 - Tetanus toxoid
 - Diphtheria toxoid

5. Conjugate Vaccines

- Combine weak antigen with a strong carrier protein
- Enhance immune response, especially in children
- **Examples:**
 - Haemophilus influenzae type b (Hib) vaccine

6. mRNA Vaccines

- Contain messenger RNA encoding antigen
- Host cells produce antigen → immune response
- **Examples:**
 - COVID-19 mRNA vaccines

Importance in Immunotechnology

- Basis for disease prevention programs
- Important in controlling epidemics and pandemics
- Platform for modern vaccine design

Conventional Vaccines

Definition

- Conventional vaccines are traditional vaccines developed using **whole organisms or their components** without advanced genetic engineering.

Types of Conventional Vaccines

1. Live Attenuated Vaccines

- Produced by weakening pathogen through repeated culture
- Provide strong immunity

2. Killed (Inactivated) Vaccines

- Pathogens are killed using heat or chemicals
- Cannot cause disease

3. Toxoid Vaccines

- Based on inactivated bacterial toxins

Methods of Preparation

A. Attenuation

- Pathogen is weakened by growing under unfavorable conditions

B. Inactivation

- Use of heat, radiation, or chemicals (e.g., formaldehyde)

C. Purification

- Isolation of antigenic components

Advantages

- Well-established and widely used
- Proven safety and efficacy

Limitations

- May require booster doses
- Risk of reversion (in live vaccines)
- Less targeted compared to modern vaccines

Applications

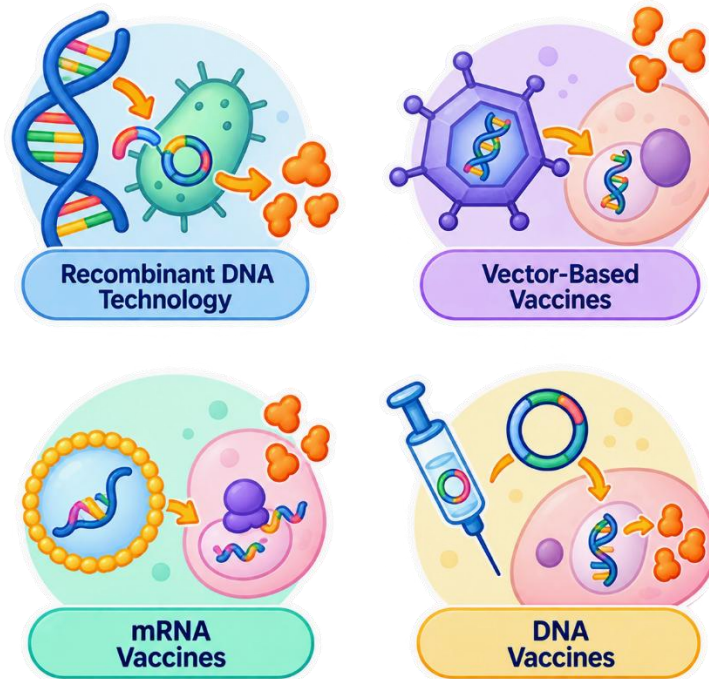
- Used in national immunization programs
- Protection against common infectious diseases

Novel Methods for Vaccine Production

Definition of Novel Vaccine Methods

- Modern approaches using **biotechnology and genetic engineering**.
- Aim to improve **safety, specificity, and efficiency**.

Types of Novel Vaccine Production Methods



1. Recombinant DNA Technology

- Genes encoding antigen are inserted into host cells (bacteria, yeast)
- Host produces antigen protein

2. Vector-Based Vaccines

- Use harmless viruses or bacteria to deliver antigen genes
- Example: adenovirus-based vaccines

3. mRNA Vaccines

- Synthetic mRNA is introduced into host cells
- Cells produce antigen internally

4. DNA Vaccines

- Plasmid DNA encoding antigen is injected
- Host cells express antigen

Advantages

- High safety (no live pathogen)
- Specific and targeted response
- Faster production

Challenges

- Stability issues (e.g., mRNA vaccines)
- Storage and transport requirements



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