

Vaccine delivery systems

Vaccines

What a Vaccine Is

- A vaccine is a biological preparation that trains the immune system to recognize and fight a specific pathogen such as a virus or bacterium.



- Instead of causing the disease, the vaccine introduces harmless components of the pathogen so the body learns how to defend itself.

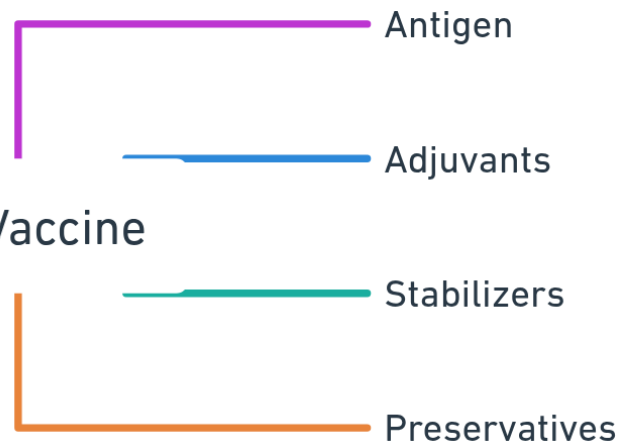
The immune system has two major parts

- **Innate Immunity** – the immediate, non-specific defense system
 - Skin
 - Macrophages
 - Neutrophils
- **Adaptive Immunity** – a specific defense system that develops memory against pathogens
- Vaccines mainly stimulate the adaptive immune system.
- **When a vaccine enters the body:**
 - The immune system identifies the vaccine components as foreign.
 - Immune cells process these components.
 - The body produces antibodies and memory cells.
 - If the real pathogen enters later, the immune system recognizes it quickly and destroys it.

Main Components of a Vaccine

A vaccine usually contains the following components:

Main Components of a Vaccine



A. Antigen

- The antigen is the substance that stimulates the immune response.
- **It may be:**
 - Whole pathogen (weakened or killed)
 - A protein from the pathogen
 - A piece of genetic material encoding the antigen
- **Examples include:**
 - Spike protein in mRNA COVID vaccines
 - Toxoid in tetanus vaccine

B. Adjuvants

- Adjuvants are substances added to enhance immune response. They help the immune system recognize the antigen more effectively.
- Common adjuvants include:
 - Aluminum salts (alum)
 - Oil emulsions
 - Toll-like receptor agonists

C. Stabilizers

- These substances keep the vaccine stable during storage and transportation.
- Examples:
 - Sugars
 - Gelatin
 - Proteins

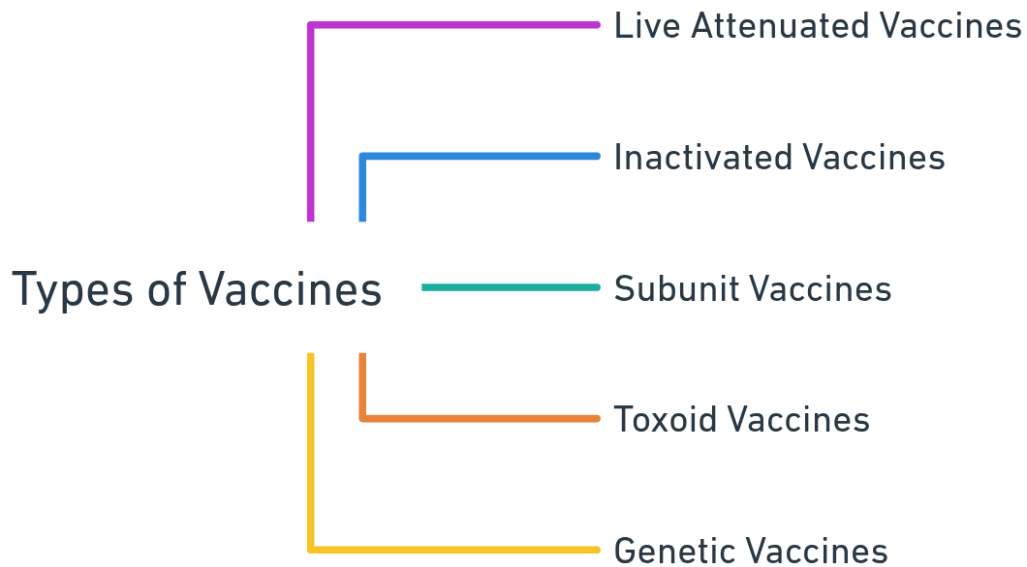
D. Preservatives

- Preservatives prevent contamination by bacteria or fungi.

- Example:
 - Thiomersal (used in some vaccines)

Types of Vaccines

Vaccines can be classified based on how the antigen is prepared.



1. Live Attenuated Vaccines

- These contain weakened forms of pathogens that cannot cause disease in healthy people.
- Examples:
 - Measles vaccine
 - BCG vaccine
- **Advantages**
 - Strong immune response
 - Long lasting immunity
- **Disadvantages**
 - Not suitable for immunocompromised individuals

2. Inactivated Vaccines

- These contain killed pathogens.
- Examples:
 - Polio (IPV)
 - Rabies vaccine
- **Advantages**
 - Safer than live vaccines
- **Disadvantages**

- Weaker immune response
- Booster doses required

3. Subunit Vaccines

- Only **specific parts of the pathogen** are used.
- Examples:
 - Hepatitis B vaccine
 - HPV vaccine
- **Advantages**
 - Safe and specific
- **Disadvantages**
 - May require **adjuvants**

4. Toxoid Vaccines

- These vaccines use inactivated toxins produced by bacteria.
- Examples:
 - **Tetanus**
 - **Diphtheria**

5. Genetic Vaccines

- These vaccines use genetic material that instructs cells to produce antigens.
- **Types**
 - mRNA vaccines
 - DNA vaccines
 - Viral vector vaccines
- **Example:**
 - COVID-19 mRNA vaccines

Vaccine Delivery Systems

- A **vaccine delivery system** is the method or technology used to transport the antigen into the body so that it can stimulate an immune response.
- The delivery system influences how efficiently the antigen reaches immune cells.
- **An ideal vaccine delivery system should:**

- Protect the antigen from degradation
 - Deliver the antigen to immune cells
 - Produce strong and long-lasting immunity
 - Require fewer doses
 - Be safe and easy to administer
- Traditional vaccines are usually delivered through **injection**, but modern delivery systems include many advanced technologies.



Syringes & Needles



Nasal Sprays



Microneedle Patches

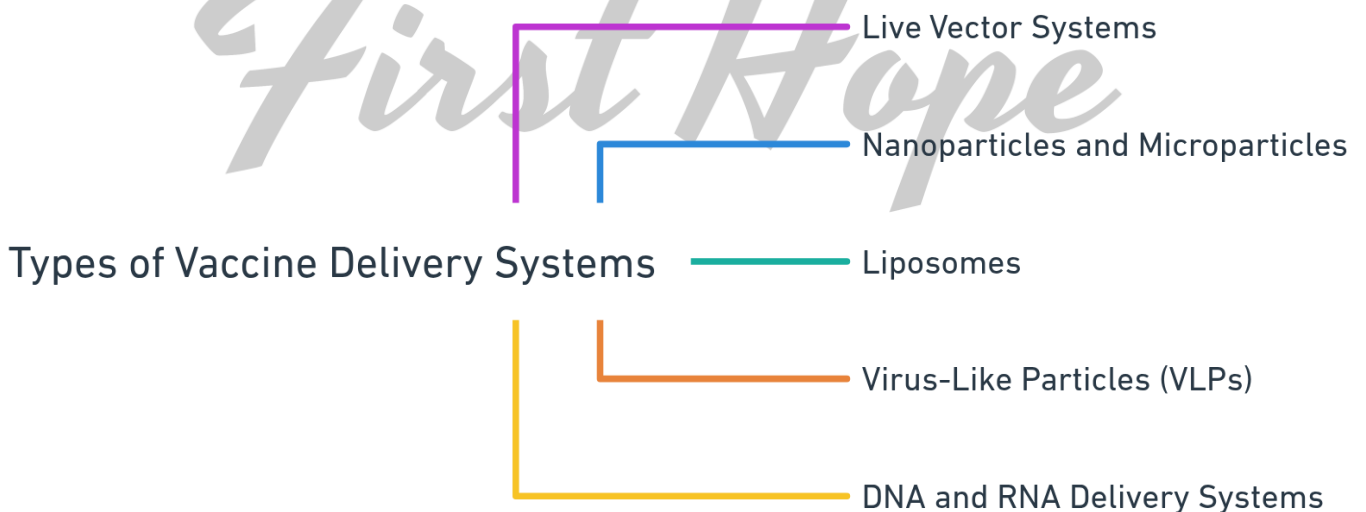


Jet Injectors



Oral Vaccine

Types of Vaccine Delivery Systems



1. Live Vector Systems

- In this system, a harmless virus or bacterium is used as a **carrier (vector)** to deliver the antigen gene into the body.
 - The vector infects host cells.
 - It produces the antigen inside the body.
 - This stimulates immune responses.
- **Example:**
 - Adenovirus vectors used in some **COVID-19 vaccines**

2. Nanoparticles and Microparticles

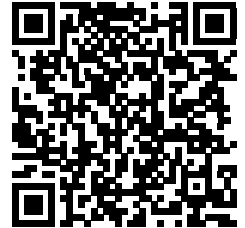


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