VACCINES

1. Introduction

- **Vaccine**: A **biological preparation** that provides **active acquired immunity** to a particular infectious disease.
- It stimulates the body's **immune system** to recognize, fight, and "remember" specific pathogens (viruses or bacteria) **without causing disease**.
- **Immunization** is the process of making an individual immune to an infection, usually by vaccination.

2. History

- **1796 – Edward Jenner**: Developed the first vaccine (smallpox) using cowpox virus.
- **1885 – Louis Pasteur**: Developed rabies vaccine.
- Since then, vaccines have eradicated or controlled many deadly diseases (e.g., smallpox eradicated in 1980).

3. Principle of Vaccination

- Based on the concept of **immune memory**.
- When a vaccine (antigen) is introduced:
  - The immune system produces **specific antibodies** and **memory B and T cells**.
  - On future exposure to the pathogen, the immune response is **faster and stronger**, preventing disease.

4. Types of Immunity

Type	Definition	Example
Active immunity	Body produces its own antibodies after exposure to antigen	Natural infection or vaccination
Passive immunity	Ready-made antibodies are transferred	Maternal antibodies, immunoglobulin injection
Artificial active immunity	Through vaccines	Measles, polio vaccine
Artificial passive immunity	Through injected antibodies	Anti-rabies serum, antitoxin

5. Types of Vaccines

- Vaccines can be classified by how they are made and what they contain.

A. Live Attenuated Vaccines

- Contain **weakened (attenuated)** form of the pathogen.
- Closely mimic natural infection → strong, long-lasting immunity.
- Usually need **only one or two doses**.

Examples:

- BCG (tuberculosis)
- OPV (oral polio vaccine, Sabin)
- MMR (measles, mumps, rubella)
- Varicella (chickenpox)
- Yellow fever vaccine

Advantages:

- Strong cellular and humoral response
- Long-lasting immunity

Disadvantages:

- Can revert to virulence (rare)
- Not safe for immunocompromised or pregnant individuals

B. Inactivated (Killed) Vaccines

- Contain **killed or inactivated pathogens**.
- Safe, but induce weaker immunity — require **booster doses**.

Examples:

- IPV (inactivated polio vaccine, Salk)
- Rabies vaccine
- Hepatitis A vaccine
- Cholera vaccine
- Influenza (inactivated) vaccine

C. Subunit / Acellular Vaccines

- Contain only specific **antigenic parts** of the pathogen (proteins, polysaccharides).
- Cannot cause disease.

Examples:

- Hepatitis B (recombinant surface antigen)
- HPV (human papillomavirus)
- Pertussis (acellular)
- Pneumococcal polysaccharide vaccine

D. Toxoid Vaccines

- Contain **inactivated bacterial toxins (toxoids)**.
- Stimulate immunity against the toxin, not the pathogen.

Examples:

- Diphtheria toxoid
- Tetanus toxoid

E. Conjugate Vaccines

- Link a **polysaccharide antigen** to a **protein carrier** to enhance immune response (especially in infants).

Examples:

- Haemophilus influenzae type b (Hib)
- Meningococcal conjugate vaccine
- Pneumococcal conjugate vaccine

F. Recombinant / Genetic Vaccines

- Use **genetic engineering** to produce antigens or viral components.

Examples:

- Hepatitis B (recombinant DNA)
- HPV (virus-like particles)

G. mRNA and Vector-Based Vaccines (Newer Technologies)

- **mRNA vaccines:** Deliver genetic code for antigen (e.g., COVID-19 spike protein).
    - Examples: Pfizer-BioNTech, Moderna (COVID-19)
- **Viral vector vaccines:** Use harmless virus to deliver antigen genes.
    - Examples: Oxford–AstraZeneca (Covishield), Johnson & Johnson (COVID-19)

6. Components of a Vaccine

Component	Function
Antigen	Stimulates immune response
Adjuvant	Enhances immune response (e.g., aluminum salts)
Stabilizer	Maintains vaccine potency during storage (e.g., sugars, gelatin)
Preservative	Prevents contamination (e.g., thiomersal)
Diluent	Used for reconstitution of freeze-dried vaccines

7. Routes of Vaccine Administration

Route	Example
Intramuscular (IM)	DTP, Hepatitis B, Influenza
Subcutaneous (SC)	Measles, MMR, Yellow fever
Intradermal (ID)	BCG
Oral	OPV, Rotavirus, Typhoid (oral)
Nasal	Live attenuated influenza vaccine (FluMist)

8. Vaccine Schedule (Example: India's Universal Immunization Programme)

Age	Vaccine(s)
At birth	BCG, OPV (0 dose), Hepatitis B
6 weeks	DTP-1, OPV-1, Hepatitis B-2, Hib-1
10 weeks	DTP-2, OPV-2, Hib-2
14 weeks	DTP-3, OPV-3, Hepatitis B-3, Hib-3
9–12 months	Measles / MR vaccine
16–24 months	DTP booster, OPV booster, MMR-2
5 years	DTP booster-2, OPV booster
10 & 16 years	Tetanus, Diphtheria booster (Td)

(Schedules may vary by country.)

9. Combination Vaccines

- Contain antigens from multiple diseases in one injection → reduces number of shots.

  Examples:
- DTP (Diphtheria, Tetanus, Pertussis)
- Pentavalent (DTP + Hepatitis B + Hib)
- MMR (Measles, Mumps, Rubella)

10. Cold Chain System

- Vaccines must be kept within a specific **temperature range (usually 2–8°C)** to maintain potency.
- **Cold chain** includes all equipment and procedures for safe storage and transport.

Components:

- Cold rooms, refrigerators, vaccine carriers, ice packs, cold boxes.
- **Never freeze:** Hepatitis B, DTP, Tetanus toxoid (damage risk).

11. Adverse Effects of Vaccination

Most vaccines are safe, but some side effects can occur:

Reaction	Example / Description
Local	Pain, redness, swelling at injection site
Systemic	Mild fever, malaise
Allergic	Rash, urticaria, anaphylaxis (rare)
Vaccine-derived infections	Rare (e.g., OPV reversion → vaccine-derived polio virus)

12. Contraindications

Type	Examples
Absolute	Severe allergic reaction to previous dose, anaphylaxis
Temporary	Moderate/severe acute illness, fever, pregnancy (for live vaccines)
Relative	Immunodeficiency (avoid live vaccines)

14. Challenges in Vaccination

- Vaccine hesitancy and misinformation
- Cold chain maintenance issues
- Limited access in developing countries
- Mutation of pathogens (e.g., influenza variants)
- Adverse event fears

15. New and Emerging Vaccines

Vaccine	Target Disease
mRNA vaccines	COVID-19, Influenza (in development)
Dengue vaccine (CYD-TDV)	Dengue fever
Malaria vaccine (RTS,S/AS01 – Mosquirix)	Plasmodium falciparum
RSV vaccine	Respiratory syncytial virus
Ebola vaccine (rVSV-ZEBOV)	Ebola virus