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Q16

What is the basic principle behind vaccine development? How do vaccines work? What approaches were adopted by the Indian vaccine manufacturers to produce COVID-19 vaccines ?

UPSC Civil Services Mains 2022 · GS III · 15 marks · Indian Economy

Indian Economy and issues relating to planning, mobilization of resources, growth, development and employment.

Core demand of the question

- State the basic principle of vaccine development
- Explain how vaccines work in the body
- Describe Indian approaches to COVID-19 vaccines

Revision summary

Vaccines present a safe antigen so the immune system forms memory without the full disease.

Platforms include inactivated, live attenuated, subunit, viral vector and nucleic acid.

Antibodies and memory T/B cells then respond faster on real exposure.

Covishield is an adenovirus vector made by SII; **Covaxin** is an inactivated whole-virion vaccine from Bharat Biotech with ICMR-NIV.

India also authorised a DNA vaccine and protein-subunit products; protection against severe disease was the public-health aim as variants evolved.

Introduction

A **vaccine** teaches the immune system to recognise a pathogen **before a dangerous infection. Development is the craft of showing that teacher safely: an antigen, a delivery method, and trials that prove protection.** COVID-19 forced India to run that craft at national scale with **Covishield** and **Covaxin**, plus other platforms in the pipeline.

Body

Basic principle of vaccine development

- Identify an **antigen** (protein, sugar, whole killed microbe, or genetic code for that protein) that is **immunogenic but not pathogenic** in the form given.
- **Combine it with a platform:** live attenuated, inactivated whole virus, subunit/protein, toxoid, viral vector, or nucleic acid (mRNA/DNA).
- Add **adjuvants** where needed so the innate system notices the antigen.
- Prove **safety, immunogenicity and efficacy** in phased clinical trials, then **pharmacovigilance** after approval.
- **Manufacture** under GMP, cold chain, and strain update when the pathogen evolves (influenza yearly; COVID boosters as variants rose).

- **Ethics:** informed consent, and **correlates of protection** when efficacy trials become hard.

How vaccines work

- **Innate** cells at the injection site take up antigen and present it to **T cells** in lymph nodes.
- **B cells** make **antibodies** that can neutralise the pathogen; **memory B and T cells** remain after the shot.
- On later exposure, memory cells respond **faster and stronger**, preventing disease or reducing severity.
- Vaccines do not typically 'cause the disease' when inactivated, subunit, vector (non-replicating) or mRNA; live attenuated vaccines use a weakened organism and have specific contraindications.
- **Herd effects** appear when enough people have memory that transmission falls; they are a population result, not a promise to one unvaccinated person.

Indian COVID-19 approaches

- **Covishield:** Serum Institute of India manufacture of the Oxford-AstraZeneca **chimpanzee adenovirus vector** carrying the SARS-CoV-2 spike gene. Non-replicating vector; spike protein is produced in the vaccinee's cells.
- **Covaxin (BBV152):** Bharat Biotech with ICMR-NIV; **inactivated whole virion** plus alum-like **adjuvant** (Alhydroxiquim-II). Traditional kill-and-inject logic, indigenous strain work.
- Other Indian lines included **protein subunit** (for example Corbevax-type receptor-binding domain), **DNA** (**ZyCoV-D**, first plasmid DNA COVID vaccine authorised in India), and later **mRNA and nasal** candidates in development or limited use.
- **National rollout:** **CoWIN**, staggered age groups, and later **precaution doses**; mix-and-match was studied as evidence evolved.
- **Public communication must stay factual:** vaccines cut **severe disease and death**; they are not a 100 per cent shield against all infection, especially as variants changed.

Principle illustrated

- **Vector and inactivated platforms are two validated answers to the same principle:** present spike (or the whole virus) **without COVID disease**, then rely on memory.

Flow diagram

Antigen platform -> Trials GMP
Trials GMP -> Vaccine
Vaccine -> Memory B and Trials GMP cells
Memory B and T cells -> Faster response on exposure
India -> Covishield vector
India -> Covaxin inactivated
India -> DNA subunit mRNA pipeline

Conclusion

Vaccine development isolates a safe antigen, tests it, and manufactures it. In the body it builds antibody and cellular memory. India's COVID mainstays were **Covishield** (adenoviral vector) and **Covaxin** (inactivated virion), with DNA and subunit approaches alongside. That is platform diversity, not a single miracle shot.

Facts & figures

Covishield

Serum Institute production of Oxford-AstraZeneca ChAdOx1 nCoV-19 adenoviral vector vaccine.

Covaxin

Bharat Biotech BBV152 inactivated SARS-CoV-2 vaccine developed with ICMR-National Institute of Virology.

ZyCoV-D

Zydus plasmid DNA COVID-19 vaccine; India authorised this platform during the pandemic.

CoWIN

Digital registration and certificate system for India's COVID vaccination programme.

Adjuvant

Substance added to some vaccines (including inactivated ones) to strengthen innate recognition of the antigen.

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