Nobel Prize in Medicine 2023

For Prelims: Nobel Prize, mRNA Vaccine, Base modified mRNA, **Covid-19**

For Mains: Mechanism of Vaccine in Treating Viral Infection, Scientific Innovations & Discoveries

Source: TH

Why in News?

The **Nobel Prize in Medicine or Physiology** for 2023 has been awarded to **Katalin Karikó and Drew Weissman** for their groundbreaking work on **nucleoside base modification of** messenger Ribonucleic Acid (mRNA).

- The discoveries by the two Nobel Laureates were critical for developing effective **mRNA vaccines against** Covid-19 during the pandemic that began in early 2020.

What Did Katalin Karikó and Drew Weissman Discover?

- **Understanding the Challenge:**
  - Cells possess an inherent capability to **detect foreign materials. Dendritic cells,** which play a crucial role in our immune system, had the ability to recognize **in vitro transcribed mRNA as foreign,** setting off an i**nflammatory response.**
    - This reaction could potentially lead to harmful side effects and **undermine the vaccine's efficacy.**
  - Furthermore, another challenge stemmed from the fact that in vitro transcribed mRNA was highly unstable and susceptible to degradation by enzymes within the body.

Note

- **In vitro transcribed mRNA** is a type of synthetic RNA that is **produced in the laboratory** by using a DNA template and an RNA polymerase.
- It can be used for various purposes, such as **making RNA probes, vaccines, or proteins.**

- **Katalin Karikó and Drew Weissman's Discovery**:
  - Karikó and Weissman observed that **dendritic cells identify in vitro transcribed mRNA as foreign,** activating them and causing the release of inflammatory signals.
  - They questioned why this **mRNA was considered foreign, unlike mRNA from mammalian cells**, which didn't trigger the same response.
    - Mammalian cells are **eukaryotic cells** that belong to the **animal kingdom** and have a nucleus and other membrane-bound organelles.
  - This led them to realize that **there must be distinct properties separating the two mRNA types.**
  - **The Breakthrough:**

- RNA, like **Deoxyribonucleic acid (DNA)**, consists of **four bases: A, U, G, and C.** Karikó and Weissman noticed that **natural RNA from mammalian cells often had chemical modifications in its bases.**
- They hypothesized that the **absence of these modifications** in lab-made mRNA might **cause inflammatory reactions.**
- To test this, they created various mRNA variants with unique chemical alterations and delivered them to dendritic cells. Their results showed a **significant reduction in inflammatory responses** when **base modifications were included in the mRNA.**
- This discovery transformed our understanding of how cells recognize and respond to different types of mRNA, with profound implications for mRNA's therapeutic potential.
- Their subsequent studies in 2008 and 2010 demonstrated that mRNA with **base modifications led to increased protein production.**
    - This effect was attributed to the **reduced activation of an enzyme involved in protein production.**
- Karikó and Weissman's research removed critical obstacles, making **mRNA more suitable for clinical applications.**

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- **Application of Base-modified mRNA Vaccines:**
    - Interest in mRNA technology grew, and by 2010, several companies were actively developing this method for various purposes.
    - Initially pursued for **vaccines against diseases like** Zika virus**, which is closely related to** SARS-CoV-2.
    - With the onset of the Covid-19 pandemic, base-modified mRNA vaccines encoding the SARS-CoV-2 surface protein were developed at an unprecedented pace.
        - These vaccines demonstrated protective effects of approximately 95% and received approval as early as December 2020.

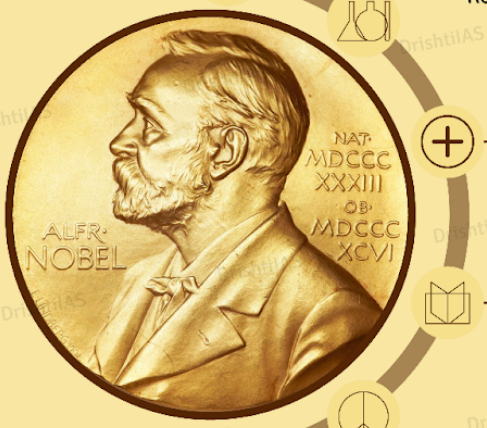
    - The remarkable flexibility and speed of mRNA vaccine development opened doors to potential use against other infectious diseases.
    - Collectively, more than **13 billion Covid-19 vaccine doses** have been administered worldwide, saving millions of lives and preventing severe illness.
    - This **transformative development during a major health crisis** highlights the critical role played by this year's Nobel laureates in recognizing the importance of base modifications in mRNA.

What are mRNA Vaccines and How do they Work?

- mRNA stands for **messenger RNA,** a molecule that carries **genetic information from DNA to the protein-making machinery of the cell.**
- mRNA vaccines use synthetic mRNA that encodes a **specific protein from a pathogen,** such as the **spike protein of the coronavirus.**
    - When the mRNA vaccine is injected into the body, some of the cells take up the mRNA and use it to produce the protein. The protein then triggers an **immune response** that produces **antibodies and memory cells that can recognize and fight the pathogen in the future.**
- mRNA vaccines are faster and cheaper to produce, as they do not require cell culture or complex purification processes.
- mRNA vaccines are also more flexible and adaptable, as they can be easily modified to target new variants or strains of pathogens.

Nobel Prize

- Established by the will of Alfred Nobel (inventor of Dynamite)
- Awarded to those who have conferred the greatest benefit to humankind, during the preceding year
- First awards were handed out in 1901



PHYSICS
Royal Swedish Academy of Sciences

CHEMISTRY
Royal Swedish Academy of Sciences

PHYSIOLOGY OR MEDICINE
The Nobel Assembly at Karolinska Institutet

LITERATURE
The Swedish Academy

PEACE
Norwegian Nobel Committee

ECONOMIC SCIENCES
(created in 1968 by Sweden's Central Bank)
Royal Swedish Academy of Sciences

- The Prize Ceremony is held in Stockholm, Sweden, in December every year
  - The Peace Prize is not awarded at Stockholm ceremony but presented annually in Oslo, Norway, on the same day
- Each Nobel laureate receives a gold medal, a diploma, and a monetary award
- Nobel Prize cannot be given posthumously (after death). Also, up to 3 people can share a Nobel Prize award between them
- **First Indian Nobel Laureate:** Rabindranath Tagore for Literature, 1913
  - **First Indian Woman Nobel Laureate:** Mother Teresa for Peace, 1979

UPSC Civil Services Examination, Previous Year Questions (PYQs)

Prelims

Q. In the context of vaccines manufactured to prevent COVID-19 pandemic, consider the following statements: (2022)

1. The Serum Institute of India produced COVID-19 vaccine named Covishield using mRNA platform.
2. Sputnik V vaccine is manufactured using vector based platform.
3. COVAXIN is an inactivated pathogen based vaccine.

Which of the statements given above are correct?

(a) 1 and 2 only
(b) 2 and 3 only
(c) 1 and 3 only
(d) 1, 2 and 3

Ans: (b)

Mains

Q. 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? **(2022)**