RNA Editing

Source: TH

Why in News?

Recently, **Wave Life Sciences**, a **biotechnology** **company** in the US, became the **first company** to treat a **genetic condition** by **editing Ribonucleic acid (RNA**) at the clinical level.

What are the Key Facts About RNA Editing?

- **About: RNA editing** is the process of modifying **Messenger RNA (mRNA) nucleotides**, after **Deoxyribonucleic acid (DNA)** creates mRNA but before it begins **protein synthesis**.
    - mRNA is made up of portions called **exons and introns. Exons** eventually code for a **protein** whereas the **introns** are **non-coding parts** and are **removed** from the RNA before it's used to make a protein.
- **Types:** There are three types of RNA modifications i.e., **addition, deletion, and substitution.**
    - **Addition** is when a **nucleotide is inserted. Deletion** is when one is removed while **substitution** refers to the replacement of one nucleotide with another.
- **Mechanism**: The technique involves a group of enzymes called **adenosine deaminase acting on RNA (ADAR)**.
    - Scientists pair **ADAR's effects with a guide RNA (or gRNA)** that guides ADAR to a specific part of the **mRNA**, where the ADAR does the **designated job.**
- **Clinical Use**: Wave Life Sciences used RNA editing to treat **α-1 antitrypsin deficiency (AATD)**, an **inherited disorder** through a therapy dubbed as **WVE-006**.
    - RNA editing shows **promise** for treating **Huntington's disease, Duchenne muscular dystrophy, obesity, Parkinson's disease,** neurological conditions, heart diseases, and more.

Note:

- Challenges persist due to its temporary nature requiring **repeated treatments, current delivery systems**, such as **lipid nanoparticles** and **adeno-associated virus (AAV)** vectors, face limitations in accommodating large molecules.

Ribonucleic acid (RNA)

- **Definition and Structure**: RNA is a nucleic acid present in **all living cells.**
    - It is **structurally similar to DNA** but typically **single-stranded.**
    - Its backbone consists of alternating **phosphate groups and ribose sugars**, with bases **adenine (A), uracil (U), cytosine (C), and guanine (G).**
- **Types of RNA**:
    - **Messenger RNA (mRNA)**: Carries genetic information from DNA to ribosomes for protein synthesis.
    - **Ribosomal RNA (rRNA)**: Forms the core of the ribosome's structure and catalyses protein

synthesis.
    - **Transfer RNA (tRNA)**: Transfers amino acids to ribosomes during protein synthesis.
    - **Regulatory RNAs**: Play roles in gene expression regulation.
- **Functional Significance**: RNA plays essential roles in cellular processes like building cells, immune responses, and transporting amino acids.
- **Role in Viruses**: Certain **viruses** use RNA as their **genetic material.**

How do RNA and DNA Editing Differ?

Aspect	DNA Editing	RNA Editing
Permanence vs. Temporariness	**Permanent:** Alters an individual's **genome permanently**, which may lead to **irreversible errors** if issues occur.	**Temporary:** Makes temporary changes in RNA that **fade over time,** providing **flexibility** to discontinue therapy if problems arise, reducing long-term risks.
Immune Response	Often uses **CRISPR-Cas9** or other tools derived from **bacteria**, which can **trigger immune reactions** due to foreign proteins.	Utilises **ADAR enzymes** naturally present in **human cells**, posing a **lower risk of immune or allergic responses**. Suitable for repeated treatments and those with immune sensitivities.

UPSC Civil Services Examination, Previous Year Questions (PYQs)

Q. In the context of recent advances in human reproductive technology, “Pronuclear Transfer” is used for (2020)

(a) fertilization of egg in vitro by the donor sperm

(b) genetic modification of sperm producing cells

(c) development of stem cells into functional embryos

(d) prevention of mitochondrial diseases in offspring

Ans: (d)

Q. What is Cas9 protein that is often mentioned in news? (2019)

(a) A molecular scissors used in targeted gene editing

(b) A biosensor used in the accurate detection of pathogens in patients

(c) A gene that makes plants pest-resistant

(d) A herbicidal substance synthesised in genetically modified crops

Ans: (a)

Q. With reference to the recent developments in science, which one of the following statements is not correct?(2019)

(a) Functional chromosomes can be created by joining segments of DNA taken from cells of different species.

(b) Pieces of artificial functional DNA can be created in laboratories.

(c) A piece of DNA taken out from an animal cell can be made to replicate outside a living cell in a laboratory.

(d) Cells taken out from plasma and animals can be made to undergo cell division in laboratory petri dishes.

Ans: (a)