MicroRNA and Gene Regulation

Why in News?

2024 Nobel Prize for Medicine was awarded to Ambros and Ruvkun for their discovery of Gene regulation by microRNA.

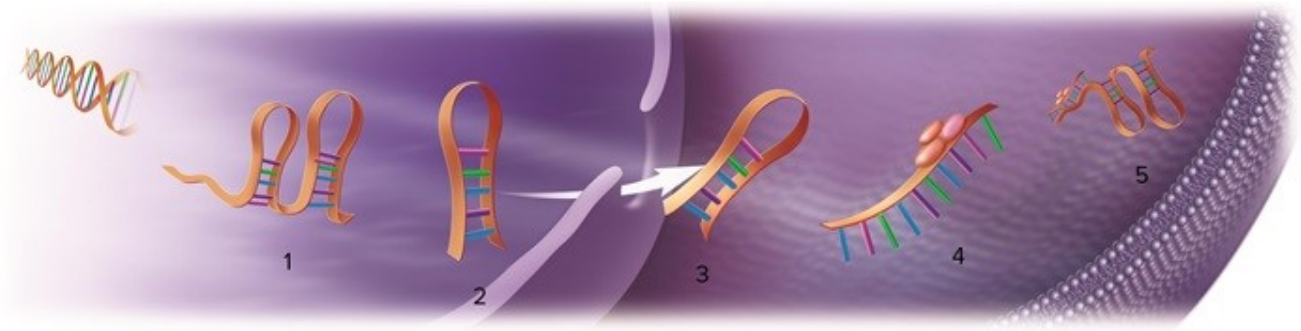
What is MicroRNA?

- **MicroRNA** - These are a new class of tiny RNA molecules that play a crucial role in gene regulation for nearly all multicellular organisms, including humans.
- Human genome codes for over one thousand microRNAs.
- **Function of MicroRNA** - It controls gene expression mainly by binding with messenger RNA (mRNA) in the cell cytoplasm during the transcription process.

Transcription is the flow of genetic information from DNA to messenger RNA (mRNA), and then on to the cellular machinery for protein production.

Gene expression refers to whether a particular gene is making too much, too little or the normal amount of its protein at a particular time.

- Instead of being translated quickly into a protein, the marked mRNA will be either destroyed and its components recycled, or it will be preserved and translated later.
- A single microRNA can regulate the expression of many different genes, and conversely, a single gene can be regulated by multiple microRNAs.
- **MicroRNA Production** - Cells have genes that encode the information for making microRNA.
- Cells make microRNA using a process that resembles the early steps of protein synthesis.
- The microRNA gene is activated, the DNA strand opens up and the gene is copied, or transcribed, in the form of RNA.

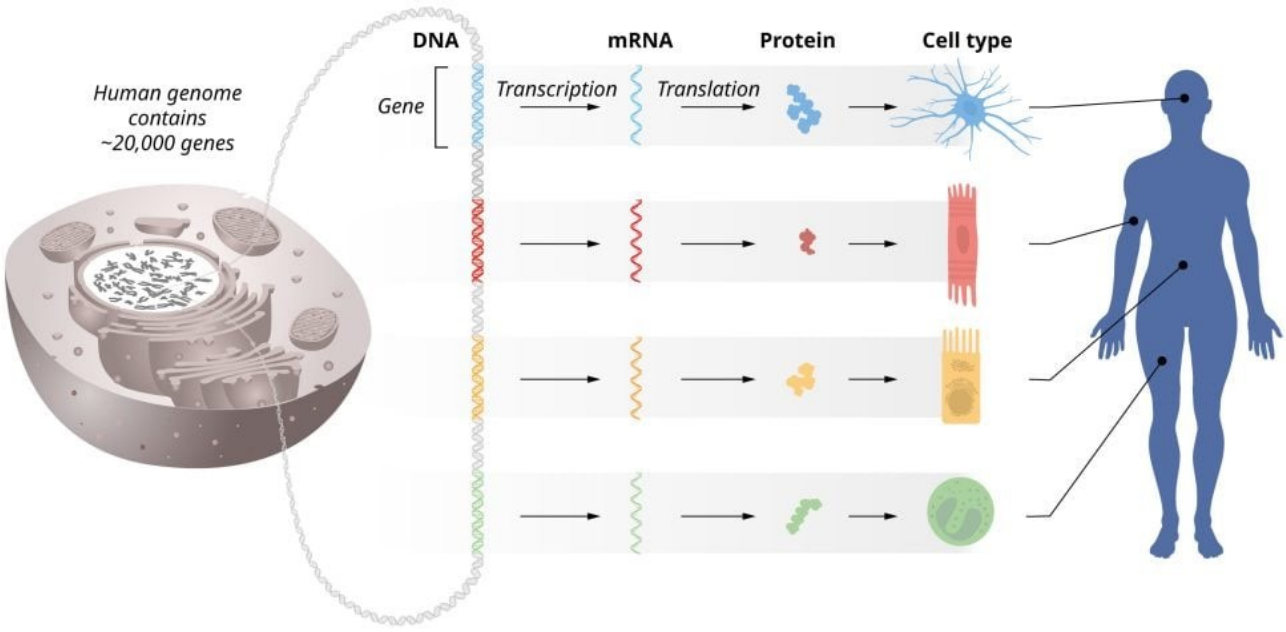


What is gene regulation?

- **Gene Regulation** – It is the fundamental principle governing how gene activity is regulated.
- Chromosomes inside the nucleus of each cell carry genetic information in the form of DNA.
- Every cell in the body has the same chromosome, containing same identical genes.
- But different cells need to use different genes depending on their function and Different tissues in the body create different proteins, depending on their specific functions.

Proteins handle all kinds of important jobs in the body, such as making muscles contract or helping nerves communicate.

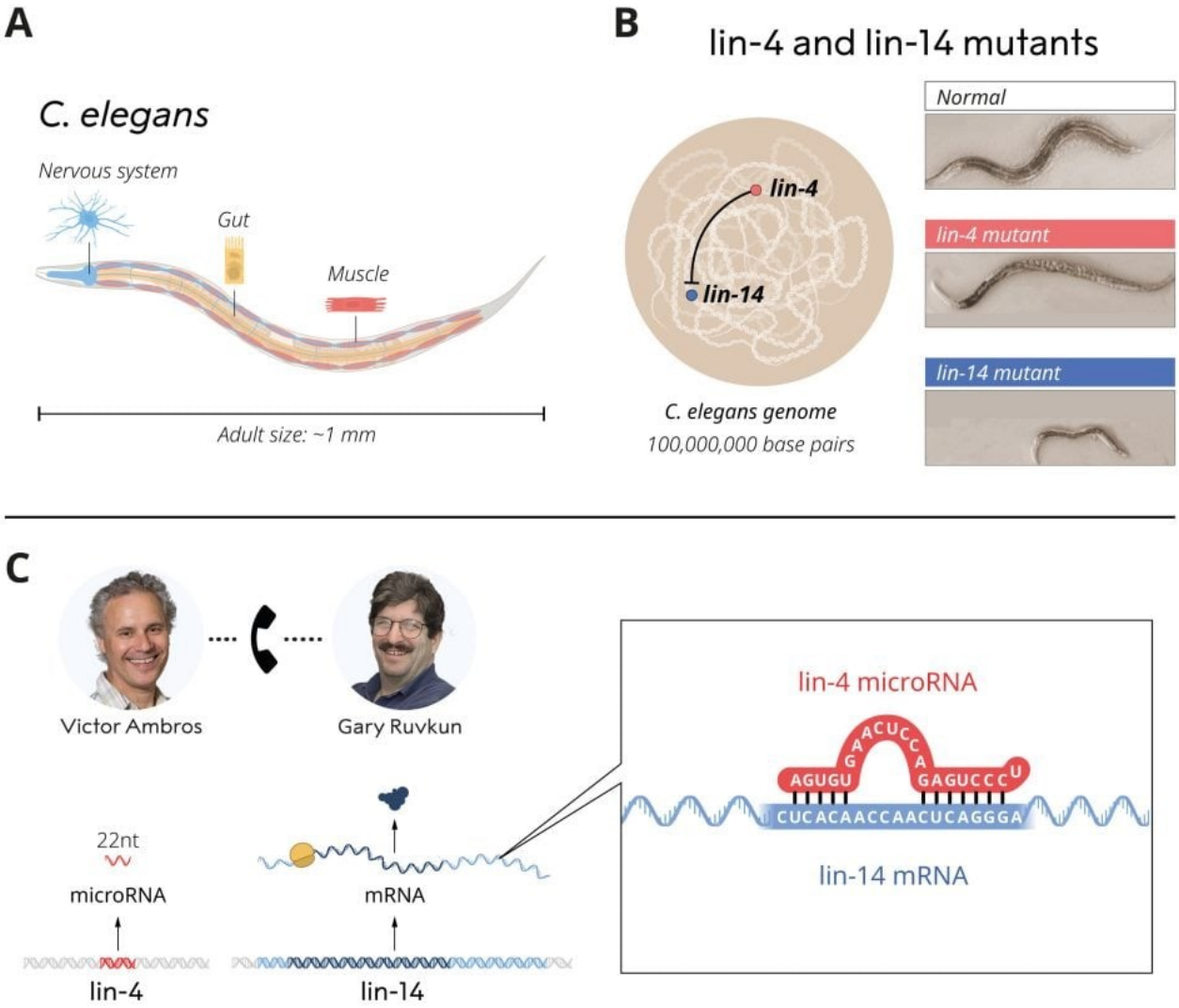
- Gene regulation process helps each cell pick the right gene from its chromosome for its specific tasks and activate appropriate set of genes in each type of cell.
- This enables, for example, muscle cells, intestinal cells, and different types of nerve cells to perform their specialized functions.



How was it discovered?

- **C. elegans** – It is a small roundworm of length 1mm.
- Despite its small size, it possesses many specialized cell types such as nerve and muscle cells that are found in larger, more complex animals.
- It is a useful model for investigating how tissues develop and mature in multicellular organisms.
- Ambros and Ruvkun studied the two mutant gene strains of worms, lin-4 and lin-14 that displayed defects in the timing of activation of genetic programs during development.

- The lin-4 gene produced an unusually short RNA molecule that lacked a code for protein production.
- Using this short RNA , lin-4 gene acted as the negative regulator of the lin-14 gene by blocking it's activity.
- Over the following years, more than a thousand genes for different microRNAs in humans were discovered.



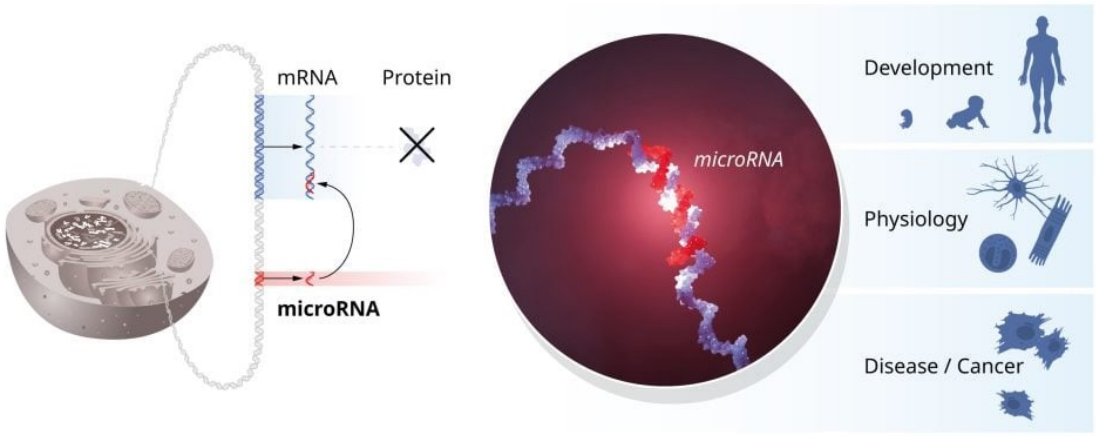
What are the Significances of Micro RNA?

- Discovery of microRNA helped in understanding how bodies of complex organisms such as humans function work.
- **Role in Evolution** - Gene regulation by microRNA has enabled the evolution of increasingly complex organisms.
- **Role in Development** - MicroRNA enabled the differentiation of cells to form different types of cells.
- **Understanding diseases** - Faults in gene regulation can result in serious diseases like cancer, diabetes, or autoimmune conditions.
- Understanding gene regulation helps in understanding and potentially treating many of these conditions.

Mutations in one of the proteins required for microRNA production result in the DICER1 syndrome, a rare but severe syndrome linked to cancer in various organs and tissues.

- **RNA production** - Cellular machinery for producing functional microRNAs is used to produce other small RNA molecules in both plants and animals, for example as a means of protecting plants against virus infections.

Andrew Z. Fire and Craig C. Mello, awarded the Nobel Prize in 2006, for RNA interference, where specific mRNA-molecules are inactivated by adding double-stranded RNA to cells.



References

1. The Indian Express | Nobel Prize for Medicine
2. Nobel Prize | Discovery of microRNA