Origin of Carbon

Why in news?

A study on 'white dwarfs' has provided new insights on the origins of the carbon in the Milky Way galaxy.

What are white dwarfs?

- White dwarfs are the dense remnants of a star after its death, whose nuclear energy supplies have been used up.
- They consist of degenerate matter with a very high density due to gravitational effects.

What is the importance of carbon?

- Carbon is essential for life.
- It is the simple building block of all the complex organic molecules that organisms need.
- It is known that all the carbon in the Milky Way came from dying stars that ejected the element into their surroundings.
- However, there is a debate on what kind of stars made the major contribution.

How does carbon come from stars?

- Most stars, except the most massive ones, turn into white dwarfs.
- When the massive ones die, they go with a spectacular bang known as the supernova.
- Both low mass and massive stars eject their ashes into the surroundings before they end their lives.
- These ashes contain different chemical elements, including carbon.

How carbon is released?

- In both the type of stars, carbon is synthesised in its deep and hot interiors through the triple-alpha reaction.
- [Triple-alpha reaction = Fusion of three helium nuclei]
- **In low-mass stars,** the newly synthesised carbon is transported to the surface from the interiors via gigantic bubbles of gas.

- From the surface, the carbon is injected into the cosmos through stellar winds.
- **Massive stars** enrich the interstellar medium with carbon before the supernova explosion, when they also experience powerful stellar winds.

What did the study find?

- In 2018, the researchers analysed a few white dwarfs belonging to open star clusters of the Milky Way.
- They measured the masses of the white dwarfs, derived their masses at birth, and from there calculated the "initial-final mass relation".
- [Initial-final mass relation is a key astrophysical measure that integrates information of the entire life cycles of stars.]
- They found that the more **massive the star** at birth, the more **massive the white dwarf** left at its death.
- So far, stars born roughly 1.5 billion of years ago in our galaxy were thought to have produced white dwarfs about 60-65% the mass of Sun.
- Instead, they were found to have died leaving behind more massive compact remnants, about 70-75% solar masses.

What explains this?

- The stripping of carbon-rich outer mantle of these stars occurred slowly.
- This is slow enough to allow the central cores of these stars, the future white dwarfs, to grow considerably in mass.
- By analysing the initial-final mass relation, the size range for the stars that contributed carbon to the Milky Way was concluded.
- Stars more massive than 2 solar masses contributed to the galactic enrichment of carbon.
- Stars less massive than 1.65 solar masses did not spread its carbon-rich ashes upon death.
- Having fixed the minimum initial mass for the production of carbon in low-mass stars is great, since it helps putting the pieces together.

Source: The Indian Express