WHAT MAKES CARBON THE BUILDING BLOCK OF LIFE ON EARTH?

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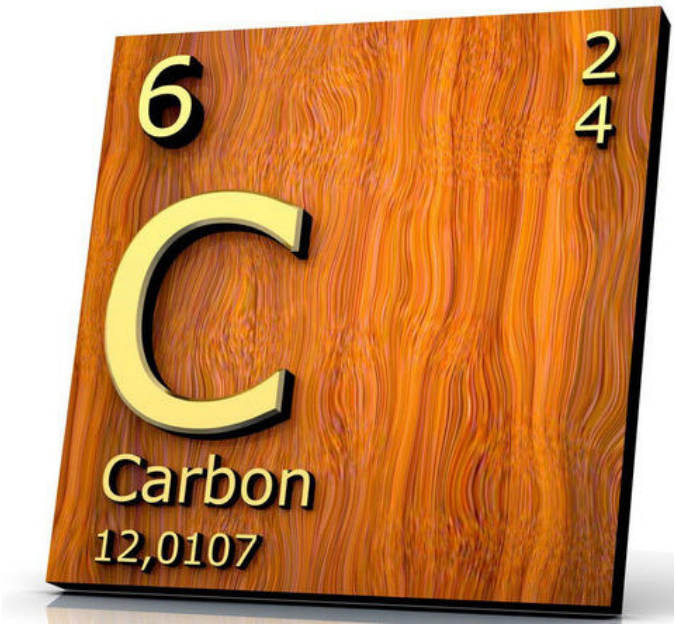
Carbon has been known to us for a long time. Recently, interest in carbon has increased for many reasons. People are researching carbon fibre composites and smart materials, like Carbon Nano tubes, more than ever. Although carbon looks simple on the periodic table, it acts in interesting ways. This has led to the development of organic chemistry, a new branch of chemistry.

Do you know that the single common thing that unites the whole life on the earth is Carbon? Be it a human being, an animal, the smallest bacteria, a tree, a plant, or a tiny insect. For decades, scientists have been curious about whether life exists elsewhere in the universe. Carbon is an essential element in the universe, playing a crucial role in the formation of life. Carbon is the fourth most abundant element in the universe. It comes after hydrogen, helium, and oxygen. But what makes carbon so unique? Let's explore.



FORMATION OF CARBON

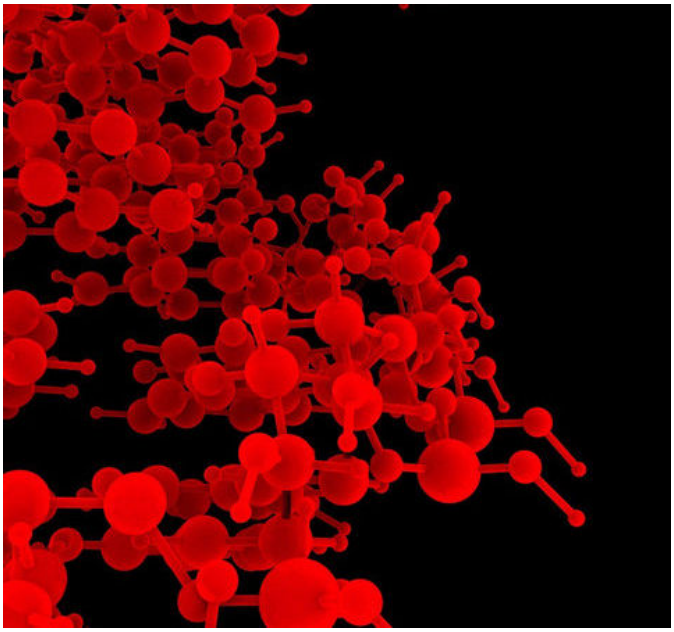
Carbon was created during the Big Bang. It was formed from nuclear fusion reactions. These are the reactions that happened between helium and hydrogen. However, this process only produced small amounts of carbon. The majority of carbon was created through nuclear fusion reactions inside stars.

As stars go through their life cycle, they produce energy by fusing hydrogen atoms to form helium. When stars use up their hydrogen, they begin to fuse helium atoms. This is because of their immense gravity. This process creates heavier elements, such as carbon and oxygen. When these stars end their life, they explode as supernovas. This explosion releases all elements they created into space. This includes carbon. Main source of carbon on our earth is the same.

CARBON CHEMISTRY

Atoms always try to reach a lower energy state to become stable. They do this by combining with other atoms. This process is what chemistry is all about.

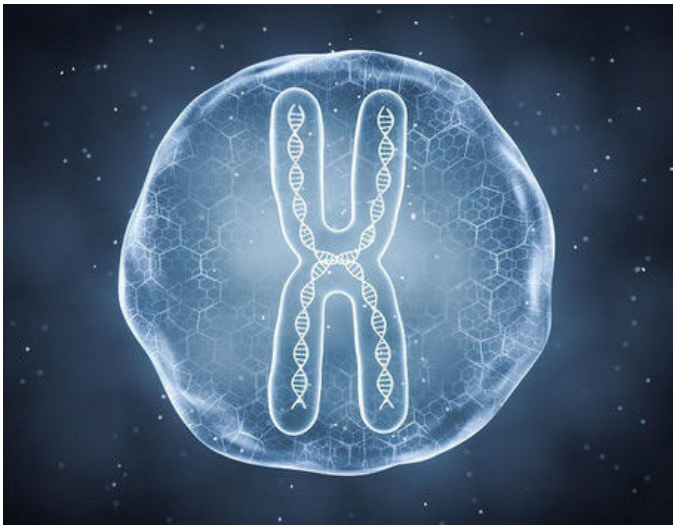
Carbon is neither the most common nor the most stable element on Earth. It has four electrons in its outer shell but needs four more to be stable. This need makes carbon very interactive. It can form strong, stable bonds with many elements. Carbon atoms share or borrow electrons to form various compounds. They do this through covalent bonds. Carbon is in a group of elements in the periodic table that can form up to four bonds. These bonds are called tetravalent bonds. They allow carbon to form many complex compounds. There is a branch of chemistry called Organic Chemistry. It specializes in studying these compounds. This study is extremely important.



ROLE IN LIFE FORMATION

Living things on earth contain a lot more carbon by mass, than Earth does. In fact, they have 10 to 20 times more carbon than that in the earth by percentage. This shows that carbon is paying major role in the formation of life. But why carbon? Why not other elements?

Life on earth might have happened by chance. For life to start, elements need to form complex compounds. Carbon is perfect for life's building blocks. It can form complex compounds because it can make tetravalent bonds. Carbon is common and forms strong bonds.



It's odd that, although many elements can make tetravalent bonds, only Carbon was selected by nature. The reason is that Carbon excels in three important areas compared to other elements. These are its ability to form complex compounds, its abundance, and the strength of its bonds.

THE ABILITY OF CARBON TO MAKE COMPLEX COMPOUNDS

Carbon's unique ability to bond with other elements allows it to form complex molecules essential for life. All known life forms on Earth are based on these carbon compounds.

Carbon bonds are versatile and hence they allow the creation of variety of molecules or compounds. These compounds are complex and have various properties and functions. These bonds can form in various ways. They link together to make chains that are always unique. This leads to the formation of many different compounds. Diversity is essential for life to start. Life needs many complex molecules for various functions. These molecules form the long chains in our DNA.

RELATIVELY ABUNDANT

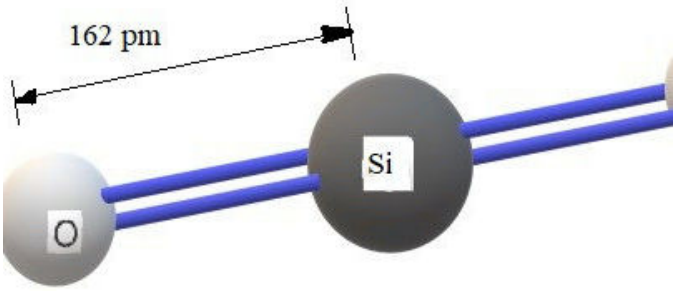
The four most common elements in our body are also the most abundant in the solar system. Carbon is one of these elements. Silicon is another common element on Earth. Like carbon, silicon can form four bonds. However, its bonds are weaker, making it unsuitable for life. The next article discusses this further. Boron, which can form three bonds, could potentially support life. But it is too rare, so nature did not select it for life creation.

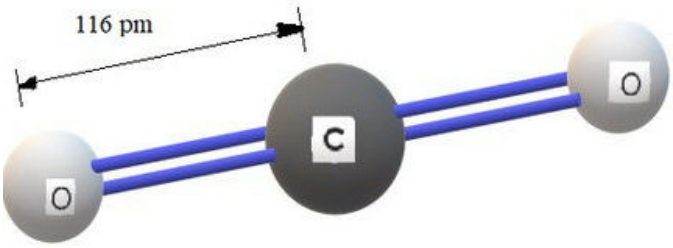
BOND STRENGTH

Bond strength is crucial for the molecules to sustain. For a living matter to flourish the molecule and its chain needs to remain intact. They must work correctly in living tissues. Longer chains tend to break more easily. Therefore, stronger carbon bonds are essential for life creation.

Similar to carbon Silicon is a common element that also requires 4 bonds to achieve stability. Also the abundance of silicon on the earth makes it the biggest contender for life formation is silicon. Yet, silicon cannot form the basis of life. Silicon's valance electrons being in the third shell they create longer bonds which consequently are weaker.

In contrast, Carbon is known for its ability to form strong bonds with other elements, especially with itself. This is due to its small atomic size and the ability to form multiple bonds. The average carbon-carbon bond length is around 154 pm. On the other hand, silicon has a larger atomic size and therefore forms longer bonds. The average silicon-silicon bond length is around 235 pm, which is significantly longer than that of carbon. Carbon's valence electrons occupy the second shell. This makes carbon's bonds both shorter and stronger. As a result, carbon forms more durable bonds, essential for life. Similarly, due to their bond strength other plentiful elements, like Nitrogen, are unsuitable for organic chemistry.





In conclusion, three parameters make carbon the right choice by Mother Nature to build life on Earth. The first reason is that carbon has an atomic structure capable of forming tetravalent bonds. This allows it to create a variety of complex compounds. The second reason is its abundance. The third reason is the most important. Carbon forms stronger bonds than Silicon, its main competitor.

Life might exist with different elements in other parts of the universe. However, Earth's temperatures and pressures make carbon the only choice here. Carbon truly is an incredible element that will keep scientists and researchers fascinated by its properties.

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