Fred Hoyle on Carbon Dioxide

It has long been suggested that certain conditions prevailing in the universe encourage the development of life. These include, among others, the gravitational constant, which allows for the formation of galaxies and stars; the fine-tuned expansion rate of the universe; and the nuclear reaction rate in stars, which is responsible for creating the rich abundance of elements found throughout the universe. The notion describing this life-accommodating universe is called the anthropic cosmological principle.

Astronomers know that the abundance of carbon in today's universe was produced largely in the interiors of red giant stars, and without just the right amount of carbon, carbon-based life that's us would be impossible.

English astronomer Fred Hoyle primarily remembered today for his contribution to the theory of stellar nucleosynthesis and his often controversial stance on other cosmological and scientific matters, in particular his rejection of the Big Bang hypothesis.

An early paper of Hoyle's made an interesting use of the anthropic principle. In trying to work out the routes of stellar nucleosynthesis, he observed that one particular nuclear reaction, the triple-alpha process, which generated carbon, would require the carbon nucleus to have a very specific energy for it to work. The large amount of carbon in the universe, which makes it possible for carbon-based life forms (e.g. humans, in fact all life as we know it), to exist, demonstrated that this nuclear reaction must work. Based on this notion, he made a prediction of the energy levels in the carbon nucleus that was later borne out by experiment.

However, those energy levels, while needed in order to produce carbon in large quantities, were statistically very unlikely. Hoyle later wrote:

Would you not say to yourself, "Some super-calculating intellect must have designed the properties of the carbon atom, otherwise the chance of my finding such an atom through the blind forces of nature would be utterly minuscule." Of course you would . . . A common sense interpretation of the facts suggests that a super intellect has monkeyed with physics, as well as with chemistry and biology, and that there are no blind forces worth speaking about in nature. The numbers one calculates from the facts seem to me so overwhelming as to put this conclusion almost beyond question.

Hoyle, an atheist until that time, said that this suggestion of a guiding hand left him "greatly shaken", and then converted to being a Christian. Those who advocate the intelligent design hypothesis sometimes cite Hoyle's work in this area to support the claim that the universe was fine tuned in order to allow intelligent life to be possible.

His co-worker William Alfred Fowler eventually won the Nobel Prize for Physics in 1983 (with Subramanyan Chandrasekhar), but for some reason Hoyle's original contribution was overlooked, and many were surprised that such a notable astronomer missed out. Fowler himself in an autobiographical sketch affirmed Hoyle's pioneering efforts:

The concept of nucleosynthesis in stars was first established by Hoyle in 1946. This provided a way to explain the existence of elements heavier than helium in the universe, basically by showing that critical elements such as carbon could be generated in stars and then incorporated in other stars and planets when that star "dies". The new stars formed now start off with these heavier elements and even heavier elements are formed from them. Hoyle theorised that other rarer elements could be explained by supernovas, the giant explosions which occasionally occur throughout the universe, whose temperatures and pressures would be required to create such elements.

The process that creates carbon is called the "triple-alpha process." This is a nuclear reaction in which three helium atoms fuse to form carbon (helium nuclei are known as alpha particles). The force that acts to fuse the constituents of these atoms protons and neutrons is the strong nuclear force, which is one of the four fundamental forces of nature.

Physicists Heinz Oberhummer of Technical University in Vienna, Attila Csoto of Eotvos University in Budapest, and Helmut Schlattl with the Max-Plank Institute for Astrophysics, Garching, Germany, wanted to know how sensitive changes in the triple-alpha reaction rate were to variations in the nuclear force that binds particles together. How much of a change in the strong nuclear force would be needed to critically alter the production of carbon, which is so critical to producing life in the universe?

They found that, in red giant stars with low, medium, and high masses, a change of only 0.4 percent in the strong nuclear force would have made it impossible for carbon-based life to evolve. Given even this slight variation, all stars would have produced either carbon or oxygen, but not the necessary abundance of both elements so critical to organic life.

Ronald Kitching
P.O. Box 9809
Frenchville QLD 4701
Australia
10 November 2008