

## Ingredients for Life



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Fourteen billion years ago—give or take a billion—the entire universe exploded into existence. But it was a lifeless universe, lacking the two most vital ingredients for life: water and carbon.

Over the next billions of years the universe was gradually transformed into a most congenial home for intelligent life. The missing elements were forged in giant cauldrons deep within evolving stars. Was this an unlikely accident? Or the consequence of incredible design? When you look at the details, it is hard to escape the conclusion, propounded by astrophysicist Sir Fred Hoyle, that a superintelligence was at work.

In the opening minutes of the Big Bang, the cataclysmic explosion that started off our universe produced the two simplest elements, hydrogen and helium. These atoms were formed in huge abundance. But the universe expanded too fast for nuclear collisions to create heavier elements such as carbon and oxygen.

Without oxygen there would be no water, and without carbon no organic chemistry. Without these essential atoms, there would be no you or I. So, where did they come from?

A century ago there was no answer to this question. If you had asked a physicist, he probably would have told you to get lost. In the past fifty years, the answer has been found: giant stars did it.

Most stars shine by hydrogen fusion, using nuclear reactions to change hydrogen into helium. (This is the same energy source exploited by hydrogen bombs.) When the hydrogen fuel inside the core of a giant star is exhausted, the star's core begins to collapse, raising the millions-of-degrees temperature still higher until the helium itself catches on fire. Well, not exactly fire in the terrestrial sense, but a kind of nuclear bonfire where helium atoms smash into each other with such violence that three of them can stick together to form carbon. The more massive stars even-

tually become supernovas, blowing themselves up and scattering the newly formed atoms into space, where they eventually coalesce to form new stars and planets.

Triple collisions are so rare inside stars that the carbon-forming process wouldn't amount to much, except for what physicists call a resonance level, an energy state inside the carbon nucleus that helps the process along. Back in 1953, the young astrophysicist Fred Hoyle predicted the existence of such a resonance, and the nuclear physicist Willy Fowler, to his astonishment, found the level experimentally very close to where Hoyle had predicted it. Had this level been 4 percent lower, there would simply not be enough carbon for organic life on Earth. Had the similar resonance level in oxygen been only half a percent higher, almost all of the carbon would have been turned into oxygen. Either way, we wouldn't be here.

Is the nuclear structure of the oxygen and carbon atoms just a lucky coincidence? Or is it evidence of intelligent design? Fred Hoyle was so impressed by this discovery that he wrote: "Would you not say to yourself, 'Some supercalculating 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 commonsense interpretation of the facts suggests that a superintellect has monkeyed with physics. . . . The numbers one calculates from the facts seem to me so overwhelming as to put this conclusion almost beyond question."

By now scientists have found an impressive array of such "coincidences." Without these many details of the physical and chemical world, intelligent life wouldn't exist in our universe. Scientists have given this observation a name: the anthropic principle. The basic idea is that the

universe simply must be this way, as otherwise we wouldn't be alive to observe it.

Needless to say, for several decades theists and atheists have been wrangling over the meaning of the anthropic principle. For the theists, the anthropic principle may not be a proof of God's existence, but it is surely a pointer to a creative superintelligence at work. They would go along with Walt Whitman, who, when answering the question, "What is grass?" wrote, "I guess it is the handkerchief of the Lord, a scented gift and remembrancer designedly dropt."

Some cosmologists have recently turned up an intriguing counter-argument. The Big Bang explosion may have spawned a vast number of sister universes, with entirely different physical circumstances. Some would have expanded too rapidly for stars and galaxies to form. Others might have very different physical laws, even a different number of dimensions. In the vast majority, life would be impossible or unlikely. In the "multiuniverse" model, we would find ourselves in the rare universe that is suitable for life. Instead of a universe specifically designed for our existence, we would necessarily be in the one that was accidentally right for intelligent life. And that, say the atheists, is that.

The theists point out that any other such universes would be forever invisible. We could only accept them on faith because there would be no possible way to observe them. So, say the theists, everyone must accept something on faith, and it's an interesting choice to make.

For some astronomers, the multiuniverse picture of the cosmos is a consequence of the fluctuations in the light from the most distant parts of the observable universe, and they see no theological implications at all in the idea. Some cosmologists are personally theists, some are atheists. But they are universally awed by the sweep and grandeur of the cosmos.



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