

EXCERPT FROM *SPECIES OF ORIGINS*

THE SCIENTIFIC CREATION STORY

The contemporary scientific account of the creation mirrors many a great tale, beginning with a vague "once upon a time" and gradually unfolding into a remarkable story, full of surprise, excitement and meaning. Fifteen billion years ago an event occurred that lies tantalizingly beyond the long reach of science. Something erupted, banged, exhaled, flared forth, exploded, and gave birth to our universe. The event remains scientifically opaque for two reasons: (1) there does not yet exist a viable theory that combines the relevant ingredients in a satisfactory way, and (2) the experiments that would model the birth of the universe require energies that exceed any equipment that could be built on earth.

Despite these not-insignificant limitations, we do have a surprisingly complete picture of the event as they unfold from a time very (and we do mean very!) shortly after the big bang – 10^{-43} seconds after, to be exact in the way that only science can be. Prior to the so-called Planck Time, all the possible physical interactions in nature were part of a unified whole that contained within it the electromagnetic, strong and weak nuclear interactions, and gravity. The electromagnetic interaction is the source of the familiar attraction between particles with opposite charges; the strong nuclear reaction holds the particles in the nucleus together, despite the fact that many of them – the protons – repel each other electrically. The weak nuclear interaction is responsible for radioactivity, gently prodding certain unstable nuclei to disintegrate

spontaneously. The familiar gravity is the fourth interaction. All of the changes in the universe, from the shining of a star to the recollection of a childhood memory take place under the “guidance” of the four fundamental interactions.

When these different interactions are examined in regions of very high energy, they are found to merge together – to “melt” if you will. The incredibly high energies of the early Big Bang “melted” the various interactions into one homogeneous mix. Then, as the Big Bang proceeded and the universe expanded, the fundamental laws of physical interactions crystallized and acquired their present form, which we recognize today as gravity, electromagnetism, strong and weak nuclear forces.

Because the early universe was so incredibly hot, there was no matter of any form – only “pure” energy (if energy can be said to be pure). In far less than a second, however, matter began to precipitate out of the “energy bath” as things started to cool down. Electrons with charges of -1 and quarks with charges of $+2/3$ and $-1/3$ appeared. Newly minted laws of nuclear physics received their first application as they “gathered” the isolated quarks into protons and neutrons. The curious rules for this process required that quarks unite in combinations with either no charge or a charge of $+1$; isolated particles with fractional charges disappeared from the universe, never to reappear. One second had passed.

The hydrogen atoms were randomly arranged. Some locations in the new universe held concentrations that grew as other atoms, attracted by the increased gravity, began to move toward them.

There were many centers of attraction, of varying size, randomly distributed throughout a universe still expanding and cooling. As the centers of attraction grew, they formed great clouds of hydrogen gas. A universe once packed almost solid with particles evolved slowly into one that was largely empty, save for a few billion vast clouds of hydrogen gas, separated by distances of unimaginable size. These clouds of hydrogen gas were enormous – trillions of miles in diameter. Under the relentless prodding of gravity the clouds began to shrink, growing steadily more dense, occasionally fracturing into multiple smaller clouds. The larger clouds shrank the fastest, compressing the hydrogen atoms into smaller and smaller volumes; this caused the temperature to increase as the atoms moved about with increasing speed, even while being pulled ever closer together. Eventually, the electrons, unable to continue orbiting in the developing thermal maelstrom, were ripped off the atoms. A certain critical temperature was reached and the furiously moving atoms – now just bare nuclei – began to collide with each other and fuse, their great speed overcoming their mutual electrical repulsion. Stars and galaxies were born. The universe was two billion years old.

The next major transformation in the universe was driven by the process of fusion as nuclei were bound together by the strong nuclear force. The fusion reaction converts a bit of mass into energy via $E = mc^2$, while steadily making larger atoms from smaller ones. Two hydrogens combine to make a helium. Add another hydrogen and you have lithium. As the temperature in the newborn stars increased still further, even the heavier combinations began to move about rapidly enough to collide with each other. The fusion of

two heliums makes beryllium. A beryllium and a helium make a carbon. A carbon and a hydrogen make a nitrogen. And so on down the periodic table of elements until we get to iron, where the fusion reactions run out of steam, to use a metaphor strangely unsuited for a universe yet without water. Iron is heavy and hard to move. It also has a large positive charge that strongly repels other protons, resisting any increase in its size.

Billions of years are needed for a star to make heavier elements from hydrogen. During this time, the star grows steadily denser as light elements disappear, replaced by heavier ones. Eventually, for many stars, the density becomes so great that the star collapses under its own weight. The result is a supernova explosion that spreads the chemically rich material from the star into a vast cloud, to once again be converted by gravity into a collection of smaller pieces. Our solar system is one such piece. Its rich chemical resources testify to its origin in a supernova. Planet Earth, thanks to a remarkable origin in a supernova cloud, is a “chemical Fort Knox.” Our planetary home was born five billion years ago. The universe was ten billion years old.

The planets in our solar system were made from star dust, in the ultimate recycling project. What had once been but a huge cloud of hydrogen had been transformed through stellar fusion into a pantheon of chemical elements. These elements, many of them now comfortably incorporated into planets, quivered on the edge of a new voyage of discovery, waiting to explore new possibilities. One of the planets newly formed from the debris of the former star happened to be at a location where its temperature allowed water in

the liquid form. As this new planet – the earth – cooled, its unusually rich and diverse chemical inhabitants began to combine in new ways. Simple molecules like water, nitrogen, and carbon dioxide combined to form large molecules with complex structures and new capabilities. Facilitated by this unusually rich chemistry and liquid environment, complex molecules, like amino acids, formed. The environment was dynamic; the same processes that led to the formation of large molecules dismantled these newly formed molecules as fast as they could form. An equilibrium was established, in the midst of the active chemical explorations. Molecules were coming and going.

As the chemical environment of the early earth explored the possibilities open to it, a very special molecular structure appeared, a structure with the amazing ability to replicate itself: ribonucleic acid (RNA). Now, instead of simply assembling and disassembling, these molecules started to make copies of themselves. These structures took over the environment of the early earth and transformed it into an “RNA world.” They were at a clear advantage over other molecules, which simply assembled and disassembled at random.

Among the many possibilities open to the chemically rich RNA world was the spontaneous formation of tiny spheres encapsulated within thin membranes. Such spheres created tiny “worlds within the world,” separating the interior of the sphere from the external world, while allowing the passage of some chemical ingredients through the membrane. It was perhaps inevitable that at some point some RNA would get trapped inside such tiny spheres and

would flourish while protected from the rigors of the external RNA world. With the emergence of “replicating molecules protected within a membrane,” the earth had what can only be called its first “life-form.” A single cell capable of reproducing itself appeared on planet Earth about four billion years ago. It may very well have been the first life form to appear anywhere in the universe. The universe was just over ten billion years old. The long process of conception was about complete. Life, it should be noted, could not exist in a universe any younger.

The reproduction of the first cell was made possible by the extraordinary ability of RNA to copy itself. But this first cell was able to do more than simply copy itself. The RNA-driven reproductive process is both stable and flexible – stable enough that basic structures, once established, would persist, but flexible enough to explore nearby options and thus “evolve” into more optimum configurations. The options that proved to be most effective in making copies of themselves dominated at the expense of the less effective. Nature had begun the process of selection thanks to RNA – “the miracle molecule.”

The single-cell option remained viable, and countless variations of that basic concept developed over the next three billion years. But then, just over a half billion years ago, a more interesting option emerged – multicellularity. The structure of the cells was such that joining together created new possibilities. A cluster of such cells has an “inside” and an “outside,” for example, that creates the possibility of specialization – exterior cells to deal with the environmental interface, interior cells to manage the affairs of the

organism. Specialization creates the possibility of additional complexity, and soon the earth was populated with a variety of complex organisms that, over the course of a few hundred million years, discovered ways to see, smell, taste, hear, and feel the astonishing universe from which they had arisen. Almost every time an organism reproduced, the offspring were a bit different; this difference opened the door to the exploration of new ecological niches.

Species came and went; new species tried new ways of being in the world. Some were successful, some were not. Many became extinct and, with their exodus, opened territories for other species. About five million years ago, on the rich terrain of Africa, one species of mammal – an ape-like primate – learned to walk upright and Mother Nature smiled on the innovation. Other successful species employing the new bipedalism appeared; about two and a half million years ago some of these “bipeds” began to use their newly available “hands” to make tools. A million years later, in what remains a mysterious part of natural history, their brains began to increase in size. Something akin to language arose. At some point our ancestors gave way to *Homo sapiens*. Perhaps one hundred thousand years ago, a brief moment on the cosmic clock, human beings emerged with all of their rich complexity, to contemplate and ponder their fragile presence in this vast universe.

That, in a nutshell, is the contemporary creation story told by our modern scientific culture. The story is remarkable, with episodes of great tension, suspense, and mystery. There are, of course, other creation stories. Every culture has at least one; indeed they form the

stuff out of which cultures are made. But the scientific creation story is the only one that claims to be firmly based on strong empirical evidence.