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Home and dry

Water was probably the last thing the first life needed, says Colin Barras

"SOME warm little pond." Charles Darwin's speculative description of life's cradle, in a letter written to the botanist Joseph Hooker in 1871, still chimes today. Seed a watery environment with the right ingredients, Darwin mused, then cosset it with a little light, heat or electricity, and a purely chemical miracle of creation might occur.

Hard and fast evidence of how and where on Earth inanimate matter became animate is hard to come by. Other backdrops for life's first steps have gained in popularity since Darwin's time – around submarine hydrothermal vents, in ice or on Earth's radioactive first beaches,

Did life's cradle look like Death Valley?

for example. If pressed, though, most of us would still plump for the primordial soup.

In the intervening years, we have devised more detailed recipes showing how the early Earth might have cooked up simple organic molecules, and how these might have reacted further to form the more complex building blocks of life: things like amino acids, DNA and RNA. Besides the right chemical ingredients, the process needs warmth, sunlight, perhaps a little lightning and, most importantly, H_2O. Water is, after all, the essential solvent that underpins carbon-based life.

For Steven Benner, that is all a fairy tale. "We tend to think that water's properties are ideal for life, but the opposite is true," he says. "Water is corrosive." Benner is a chemist at the Westheimer Institute of Science and Technology in Gainesville, Florida, and for three decades he has been doing pioneering work in synthetic biology, which aims to recreate life's chemistry in the test tube. And he is no lone voice. As water's deleterious effects have become more apparent, many researchers are asking: is it time to dry out life's recipe?

Around 70 per cent of our planet's surface is ocean, and water makes up 60 per cent of our body weight. Few living things can survive for long without water: it is a perfect medium in which organic molecules can dissolve and react to sustain the core processes of life on Earth.

But this perfect solution is also a problem. Life's molecules don't just dissolve in water; the electron-rich oxygen of its molecules attacks them, and they begin to fall apart. "In your body right now, the DNA in your cells is losing an amino group many times a second because of the action of water," says Benner. Living things keep their molecules intact only through clever chemical strategies that perpetually repair the breakages.

Tricky when wet

The first life on Earth wouldn't have had time to develop those strategies. According to the widely accepted "RNA world" theory, RNA was the first self-replicating molecule, and a precursor to today's DNA-based life. Like DNA, RNA is built up from nucleotides, complex organic molecules that are themselves formed from two simpler components, a nucleobase and a sugar called ribose. Decades of research have shown that making nucleotides in water is a very tricky business. Individual steps can be made to work, but they don't all gel together. "We are still at the stage of scraping out the product of step seven, and carefully spooning it into the flask to begin step eight," says Benner. Fail to spoon in just the right amounts of various molecules at the right time, and the end result is a gunky mess (*New Scientist*, 13 August 2011, p 32).

A decade ago, Benner made a breakthrough. He showed that borates – minerals containing varying proportions of boron and oxygen – could act as scaffolds for the construction of ribose, making that part of the chemistry a much more hands-off, naturally plausible process (*Science*, vol 303, p 196). The problem of attaching the ribose to the nucleobases remained, however, until in 2012 Benner made a simple and bold suggestion: to make life, just remove water. By replacing it with an organic solvent richer in carbon and poorer in oxygen such as formamide (CH_3NO), the right components would, in theory at least, stick together spontaneously to make RNA (*Accounts of Chemical Research*, vol 45, p 2025).

Formamide would have been created when hydrogen cyanide in Earth's early atmosphere mixed with water. Its boiling point is higher than that of water, so in a hot environment the formamide would have become more concentrated as the water evaporated away. Borates are scattered across Earth's surface today, where they result mainly from the ›