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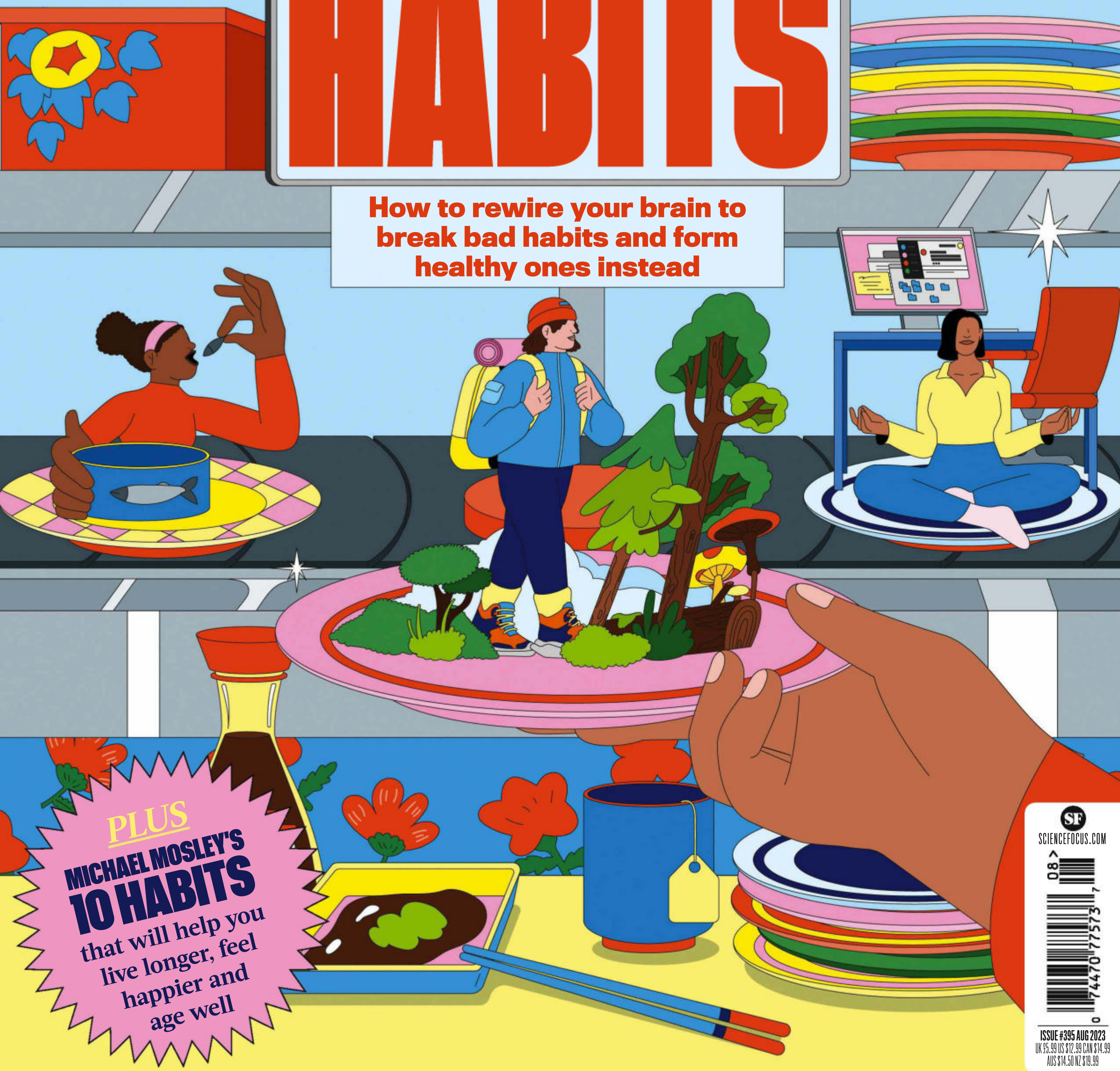

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# WHO'S AFRAID OF THE BIG BANG SINGULARITY?

The Big Bang marks the beginning of the Universe, right? The physicists brave enough to look beyond it aren't so sure

Why does something exist rather than nothing? This profound question lies at the heart of both science and philosophy, inviting us to explore the origins of our existence.

In the field of evolutionary theory, we understand that all life on Earth can be traced back to a common ancestor known as the last universal common ancestor (LUCA). The search for LUCA captivates researchers investigating the origin of life. Our curiosity doesn't end there, though. We can delve further into the origins of Earth itself, and the Universe around it.

From a cosmological perspective, we discover a breathtaking connection between the birth of stars, the formation of planets and the expansion of the Universe. The dance of cosmic creation unfolds through a delicate interplay between the Universe's expansion rate, the gravitational collapse of dark matter and the capture of hydrogen – the life-giving element necessary for star formation. Without this intricate cosmic choreography, life as we know it wouldn't have come into existence.

Thus, our cosmic origin story begins with a fundamental question: What was the origin of the expanding spacetime of the Universe?

The prevailing model of the expanding Universe is often referred to as Big Bang Cosmology. Coined by the English astronomer Fred Hoyle during a BBC Radio broadcast in March 1949, this theory suggests that all matter in the Universe originated from a colossal explosion at a specific time in the distant past.

The idea of an expanding Universe is supported by Einstein's well-tested theory of general relativity, which portrays spacetime as a flexible medium capable of bending, expanding and collapsing. If we were to rewind the cosmic tape, we would witness the Universe contracting into an infinitesimally small point of infinite temperature, energy and spacetime curvature – an event known as the Big Bang singularity.

Stephen Hawking and his colleagues dedicated much of their careers to comprehending the perplexing nature of this singularity. After all, if everything, including time itself, came into being at the Big Bang, how can we discuss what transpired before time existed?

Fortunately, bold cosmologists have peered beyond the Big Bang singularity, seeking alternative explanations that transcend the conundrums of infinities and the origin of time.

One intriguing notion suggests that a cosmic epoch preceding the Big Bang gave rise to a new physics paradigm, effectively replacing the singularity. We know that Einstein's theory adheres to the principles of classical

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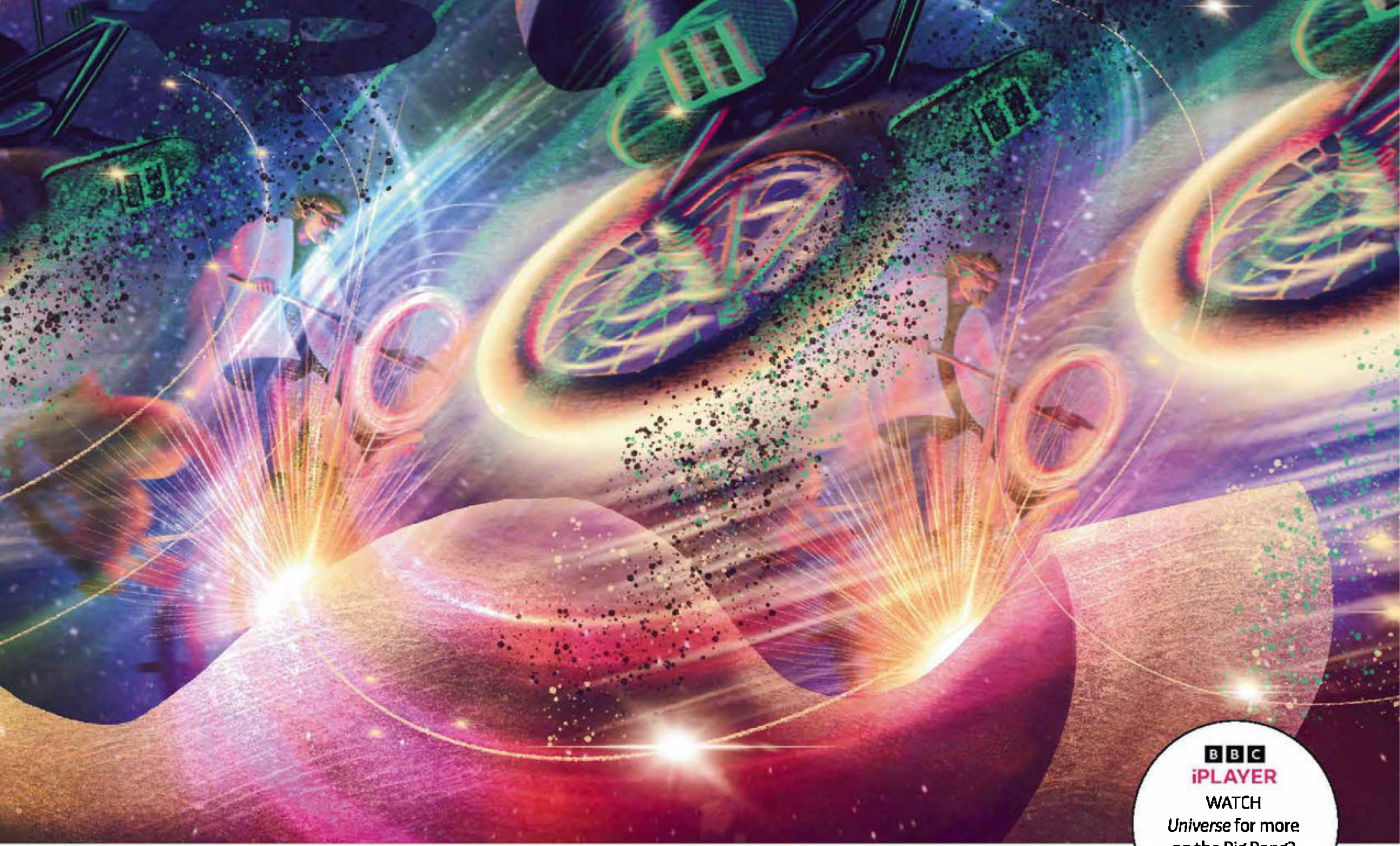

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> **"Fortunately, bold cosmologists have peered beyond the Big Bang singularity"**

physics, so one plausible escape route involves the existence of a quantum 'bridge' connecting an expanding Universe to one that collapses into a Big Bang – an event commonly referred to as the Big Bounce.

Exploring this path requires extending Einstein's theory into the realm of quantum gravity, and both string theory and loop quantum gravity offer potential variants of the Big Bounce within the framework of quantum gravity.

In a previous column, I touched upon the paradigm of cosmic inflation – a period of rapid expansion that holds fascinating connections to such things as the cosmic microwave background and the origin of structure in the Universe. But mathematical theorems established by Hawking and Roger Penrose reveal that inflation fails to escape the initial singularities present in the Big Bang.

In fact, inflation itself succumbs to its very own Big Bang singularity!

One idea that captures my imagination is the concept of cyclic inflation – a framework that combines cosmic inflation with the notion of cyclic collapse and expansion, or bounces. This captivating idea, conceived by former postdoctoral researcher Dr Tirthabir Biswas and myself, suggests that the Universe undergoes infinite cycles of collapse and expansion.

After a critical cycle, with sufficient entropy accumulated, the Universe experiences a rapid acceleration of spacetime known as inflation. By incorporating cycles of bounces, cyclic inflation embraces the benefits of inflation while offering a potential escape from the Big Bang singularity.

With cosmologists unafraid to look beyond the confines of the Big Bang, a thrilling challenge lies before us: to identify observational predictions that differentiate between these competing models of the early Universe and our origins. These distinctive predictions hold the key to determining which model accurately describes the origins of our existence.

Personally, I find a tantalising hint in the fact that supermassive black holes seem to form too early to be accounted for by our current cosmological standard model. Perhaps a specific bouncing or cyclic model can elegantly explain this cosmic anomaly?

The further we go on this intellectual journey, the more the mysteries of our cosmic origins unfold, inviting us to delve deeper into the enigmatic tapestry of the Universe. With each discovery, we inch closer to unravelling the secrets that illuminate our existence and shed light on the timeless question: why is there something rather than nothing?

**PROF STEPHON ALEXANDER**

*(@stephstem)*
*Stephon is a professor of physics at Brown University, an author and an accomplished jazz saxophonist.*