

Books & arts



M. LIVIO AND THE HUBBLE TEAM (STSCI/NASA/ESA)

A cloud of interstellar gas and dust, captured by NASA's Hubble Space Telescope.

From Big Bang to cosmic bounce

A physicist and humanist takes us on a grand tour of all time. **By Philip Ball**

Brian Greene's *Until the End of Time* sits within a tradition of grand, synoptic visions of the Universe, rooted in physics, that feels (to this British reader) distinctively American. Halfway through, I realized why. With its scepticism of religion but openness to humanistic wonder, awe of nature, celebration of the individual and recognition of the power of physical law, the narrative has a strong whiff of transcendentalism. There is an echo of philosopher Henry David Thoreau in Greene's account of lying out at

night, enraptured by the aurora borealis. And essayist Ralph Waldo Emerson's declaration that the "sublime laws play indifferently through atoms and galaxies" could almost be this book's epigraph.

Such qualities lift this work above many accounts of the cosmic story spanning from the Big Bang to the end of time – whether that's a big rip, heat death or cosmic bounce. Greene takes us from quarks to consciousness, and from the origin of life to the genesis of language. He draws from an impressive range of sources, such as poets William Butler Yeats and Sylvia Plath. In attempting to weave in the evolution of physical laws with that of the human mind and cultures, Greene's aim vaults beyond that of his bestselling 1999 book, *The Elegant Universe. Until the End of Time* is packed with ideas; whether they come together as a convincing story is another matter.

This narrative features humanity as a brief moment when matter became self-aware. Current physical and cosmological theories imply that this state of affairs can't last. Eventually proton decay, a dominance of dark energy or thermodynamic heat death will doom all matter and thought. Greene, however, suggests that intelligent beings could eke out their thought processes almost indefinitely by gradually slowing them to minimize their inevitable thermodynamic cost.

He views this extinction of sentience as a cosmic tragedy. It's poignant to see a modern physicist, however girded with string theory, the general theory of relativity and the equations of quantum mechanics, experience the same anguish that goaded ancient monarchs to defy mortality by commissioning monumental tombs. Greene finds the solace that religion typically provides in the idea that the "small collection of the universe's particles" that constitutes humanity can evolve and "with a flitting burst of activity create beauty, establish connection, and illuminate mystery".

His grand tour is sometimes breathtaking, necessarily selective and occasionally superficial. It often lacks the space or rigour to do its vast range of subjects justice. Beyond fundamental physics, Greene is a lucid summarizer of other popular accounts, but little more. That can leave his story patchy, and even misleading at times. His explanation for why water is a special solvent required for life attributes it all to the molecule's polar nature – in which case it would not be special at all. (Hydrogen bonding is left out,

and although that does not tell the whole story, neglecting it means we get almost no story at all.) To explain the origin of myths, the book offers a bit of obsolete early-twentieth-century anthropology from the likes of folklorist James George Frazer, that is given a contemporary gloss of evolutionary psychology.

The biggest shortfall is in the account of how biology works, which seems to be derived largely from physicist Erwin Schrödinger's 1944 book *What Is Life?* and biologist Richard Dawkins's 1976 *The*

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Selfish Gene. Life in Greene's reckoning is all encoded in the genome, and once molecular replicators appeared on the planet, the rest was just evolutionary history. He adds that non-equilibrium thermodynamics can give us a head start: its tendency to create spontaneous knots and patterns of local order are a stepping stone towards life's organization. But what's missing – foreshadowing a wider lacuna in the book – is any sense that intermediate levels of that organization, particularly the cell, are equally fundamental.

When it comes to human behaviour – creativity, art, story, religion – Greene places a reductive faith in evolutionary psychology. He is probably right to say that many of our complex behaviours are underpinned by rather basic adaptive impulses, but he doesn't adequately acknowledge how culture shapes them. For instance, he supports psychologist Steven Pinker's notorious description of music as "auditory cheesecake". This posits that music is enjoyable because it piggybacks on capacities that evolved for other reasons, such as the ability to separate our auditory experience into comprehensible chunks. This might or might not be true, but

to appreciate what music really means, we need to consider its cultural, historical and social specifics, and not just attribute it to "our ancient adaptive sensitivity to sounds with elevated information content".

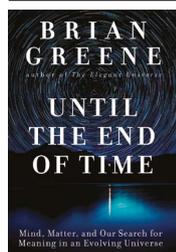
Whether in cell biology or a musical tradition, asking why any specific feature is the way it is demands that we consider a causal explanation. And therein lies the problem with Greene's approach: where it seeks out cause.

It's true that when he enlists physics as the underpinning theory of everything ("Life is physics orchestrated"), this is not the physicist's standard hubristic claim. Indeed, he points out that we need "overlapping narratives" for explanations of phenomena at different scales of size and complexity, from subatomic particles to galaxies, each of which must at least be consistent with the one below. And Greene acknowledges that an account of human behaviour at the level of fundamental particles would be pointless. But he still implies that causation flows upwards through the hierarchy of scales. We lack genuine free will, he says, because there is no such factor at play among the fundamental forces.

Thus, Greene remains wedded to the idea that the most reductive view has ultimate authority – that it all comes down to particles, entropy and evolution. "Perhaps one day we will invoke a unified theory of particulate ingredients to explain the overwhelming vision of a Rodin," he writes. He doesn't recognize that in complex systems, new properties and causative mechanisms that arise at only the higher levels of the hierarchy are as real and fundamental as, say, the strong and weak nuclear forces. This is what physics Nobel laureate Philip Anderson argued in his 1972 essay 'More Is Different'.

If we accept Anderson's position, we have to call into question the entire programme that Greene articulates here. By the time we get to, say, the human impulse to create stories, are Big Bang cosmology and quantum mechanics meaningful parts of the narrative? Perhaps, then, by setting out a vision of the world as seen by a thoughtful, humanistic fundamental physicist, Greene has offered not so much a state-of-play panorama as a tour showing where that view works spectacularly and where it falls short. It is an eloquent invitation to debate.

Philip Ball is a science writer and author; his latest book is *How To Grow a Human*.
e-mail: p.ball@btinternet.com



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Brian Greene
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